More of Earth's secrets to be unlocked with new crystal tool research

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New Curtin University research into the way rocks melt in the Earth's mantle layer has uncovered new properties of the key crystal spinel, suggesting previous studies that used it to study mantle melting and tectonics may need to be reviewed.

Published by *Nature Communications*, the research led by Curtin Ph.D.

student Mr Hamed Gamal El Dien, from the Earth Dynamics Research Group in Curtin's School of Earth and Planetary Sciences, demonstrated that the crystal spinel, commonly used by scientists to define melting processes in the mantle, could be modified in ways not previously known, resulting in the need for earlier geological research in this area to be re-evaluated.

"While these results question numerous past research findings, they also offer many future applications, opening the door for a new scientific trend in studying the deep mantle's evolution through Earth's history," Mr Gamal El Dien said.

The Earth's mantle is the middle layer of our planet, and is also the biggest, being about 2900 kilometres thick and making up about 84 percent of the Earth's volume. Researchers believe this layer was formed during the earliest stages of planetary differentiation, when denser metals like iron and nickel sank to form the Earth's core, and lighter materials rose towards the Earth's surface to create the crust, leaving behind what we call the mantle.

"The mantle keeps many of the secrets about how the Earth has evolved over the past four billion years, including what drives plate tectonics as we know it. However we need 'messengers from the deep' to enable us to tap into these secrets, and spinel does just that," Mr Gamal El Dien said.

"Spinel is a commonly found crystal in the mantle rock peridotite, and unlike other common rock-forming minerals, it was believed to be very resistant to chemical alteration during the various geological processes and events that can affect mantle rocks after they first crystallise. Because of this belief, spinel has been used as a type of benchmark or 'messenger from the past' when evaluating geological events happening in the mantle layer, since it was believed to perfectly preserve its original chemical composition.

"On the contrary, our research has uncovered that spinel can be, and most has been, affected, by geological processes after it forms, including changes of temperature and pressure during complex metamorphic processes, which may have an impact on previous research findings."

Research co-author and project leader John Curtin Distinguished Professor and Australian Laureate Fellow Professor Zheng-Xiang Li, also from Curtin's School of Earth and Planetary Sciences, said their new findings suggested researchers need to-revaluate the composition of spinel, especially noting potential compositional changes within the mineral that may have occurred throughout Earth's geological history.

"Previous scientific findings and theories assumed the homogeneity and primary composition of spinel, but our research challenges those assumptions," Professor Li said.

"Excitingly, now that we know this, we can use spinel composition as a tracer to discover new, previously unlocked secrets from Earth's mantle, allowing us to discover even more about our planet.

"For example, our work demonstrated that spinel is a good carrier mineral for fluid mobile elements and volatiles, and has the ability to carry such fluids and volatiles back to the deep mantle, such as what happens during oceanic plate subduction processes where old deep sea floor gets 'sucked back in' to the Earth's mantle.

"Essentially, our findings have the potential to lead to the development of a new way of deciphering deep mantle chemical recycling through analysing the non-traditional isotopes, such as lithium, zinc, titanium and nickel, present in spinel."

Researchers used the nano-scale Geoscience Atom Probe at Curtin University's John de Laeter Research Centre to complete their

investigation in to the chemical heterogeneity of spinel.

More information: Hamed Gamal El Dien et al. Cr-spinel records metasomatism not petrogenesis of mantle rocks, *Nature Communications* (2019). DOI: 10.1038/s41467-019-13117-1

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