'Self-healing' continental roots have implications for precious mineral exploration

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A new study led by University of Alberta geologists is shedding light on a fundamental mechanism of how Earth's continental plates heal, with implications for diamond exploration and locating economically important minerals.

"Cratons are the oldest stable continental land masses on Earth, and are

widely known as repositories for diamonds and metals of economic importance," said Jingao Liu, lead author and visiting scholar in the Department of Earth and Atmospheric Sciences. "Disruptions of the lithosphere beneath these cratons can be key to hosting world-class mineral deposits, especially diamonds and precious metals like platinum."

Cratons have survived billions of years of being dragged around the Earth by tectonic plate movement, undergoing a complex geological life cycle of thinning and healing. This is the first study that provides evidence of the mechanism that heals the lithosphere beneath cratons and creates suitable conditions for precious mineral formation, Liu explained.

"We found direct evidence that the deep mantle root there has been replaced roughly 1.3 billion years ago," said Liu, a visiting professor from the China University of Geosciences (Beijing), who completed the research with collaborator Graham Pearson, Canada Excellence Research Chair Laureate and Henry Marshall Tory Chair in the Department of Earth and Atmospheric Sciences.

"This replacement of an older deep continental root coincides with the appearance of a giant outpouring of basaltic magma in this region—known as the Mackenzie Large Igneous Event, one of the biggest in Earth's history," said Pearson. "This event produced key targets for nickel and platinum metal mineralization in Canada's Arctic, and we are only now beginning to understand its importance for both diamond destruction and formation—the former via removal of the old root and the latter by creating a new thick lithospheric root."

To better understand this process, researchers examined samples erupted from diamond-bearing kimberlite in the Canadian Arctic, east of Kugluktuk in Nunavut. Using simulations based on field findings, the

team showed that leftovers of this geologic melting process were redeposited in the mantle, re-thickening the lithosphere and showing the first firm evidence of the mechanism behind the healing of a continental root.

"Beyond increasing our understanding of the mechanism behind recratonization, these findings have economic significance as well," explained Liu. "We can map out the area of the mantle root affected that might host mineral deposits linked to this event—including areas where diamonds may be present."

The research was supported through the Geomapping for Energy and Minerals program by the Geological Survey of Canada (GSC).

"These programs are a huge help for academics and industry alike," said Liu. "This work required us to assemble a very scientifically diverse team of researchers that included experts in geochemistry, geophysics and numerical geodynamic modeling."

In addition to funding, the GSC also provided research support, including work by co-author and seismologist Andrew Schaeffer.

"Demonstrating that what we once thought were ancient and unaltered cratons are in fact substantially reworked is a major discovery. This implies that there is the potential for numerous other such cratonic regions to have been similarly altered, given the correct circumstances," said Schaeffer. "Furthermore, studies like this are critically important as they combine together multiple facets of geosciences to make a much more robust interpretation."

The research is part of a major collaborative program between the U of A and the China University of Geosciences (Beijing).

"This collaboration serves to explore the origins and evolution of the deep roots to continents and their implications for creating the mineral deposits that humanity requires," said Liu. "Our goal is to continue to better understand how these recratonization events concentrate precious metals in Earth's crust, and where to look for new diamond deposits."

The study, "Plume-driven recratonization of deep continental lithospheric mantle," was published in *Nature*.

More information: Jingao Liu et al. Plume-driven recratonization of deep continental lithospheric mantle, *Nature* (2021). DOI: 10.1038/s41586-021-03395-5

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