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UCT-led study reveals clues to the origin of the world's largest diamonds

The conditions under which the world's rarest and most valuable gem-quality diamonds – referred to as Cullinan-like, large, inclusion-poor, pure, irregular, resorbed (CLIPPIRs) – form have remained poorly understood.

A University of Cape Town-led (UCT) study by the Kimberlite Research Group (KRG) at the Department of Geological Sciences published in the journal Nature Communications has used the chemistry of the mineral olivine in kimberlites as a window into the deep mantle, revealing that kimberlites carrying CLIPPIR diamonds consistently sample anomalous, iron-rich domains at the base of the lithosphere, more than 150 km beneath the surface.

The study was conducted in collaboration with researchers from the Carnegie Institution for Science (Washington, United States of America) and the China University of Geoscience (Beijing, China).

It reveals that these iron-rich domains carry light-oxygen and heavy-iron isotopic signatures that are the hallmark of hydrothermally altered oceanic crust – material that was subducted into the deep Earth and accreted to the base of the continent by buoyant mantle upwelling.

Associate Professor Geoffrey Howarth from the KRG and lead author says interaction between rising kimberlitic melts and these iron-rich domains produced the large olivine and garnet megacrysts that are characteristic of CLIPPIR-bearing kimberlites, while the CLIPPIR diamonds themselves crystallised within these unusual substrates at pressures exceeding 11 Grade point average (GPa), in the mantle transition zone.

Beyond explaining the origin of the world's most exceptional diamonds, these findings show that such iron-rich, isotopically anomalous domains are a widespread and important source of geochemical heterogeneity in volcanic rocks erupted across the planet.

"These extraordinary diamonds – some of the largest and most valuable gems on Earth – have long been a mystery. Our study shows that they grew in an unusual iron-rich environment deep beneath the continents, formed from ancient oceanic crust that was dragged down by subduction and then accreted at the base of the lithosphere," said Howarth.

"By reading the chemical fingerprints preserved in the mineral olivine brought up by kimberlite eruptions, we can now trace where these exceptional diamonds come from and how to find more of them."

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