

Insights from Super-Deep Diamonds: Evidence of Ca-Rich Environments in the Lower Mantle

MR. EDUARDO NOVAIS RODRIGUES, MSC.¹, PROF.
FABRIZIO NESTOLA¹, MAXWELL C DAY¹, MARTHA G.
PAMATO¹, DAVIDE NOVELLA¹, GRAHAM PEARSON²,
THOMAS STACHEL², ROBERT W LUTH² AND JEFFREY
W HARRIS³

¹University of Padova

²University of Alberta

³University of Glasgow

Super-deep diamonds (SDDs) crystallize at depths of 300–800 km and are the deepest natural materials formed on Earth. These rare diamonds, found in kimberlites from most cratons, are crucial for understanding deep mantle dynamics and their relation with the supercontinental cycle. This study investigates two SDDs [AZ_2 from Juína, Brazil, and KK33 from Kankan, Guinea] both sourced from Neoproterozoic-Paleozoic deposits (450–650 Ma).

In-situ single-crystal X-ray diffraction measurements show that AZ_2 diamond hosts periclase, merwinite, and diopside. Surprisingly, the KK33 diamond has the same periclase, merwinite, and diopside assemblage. Significantly, this is the first reported occurrence of the merwinite + diopside assemblage in diamonds outside Juína. The Mg-rich periclase composition of AZ_2 supports a lower mantle origin. In KK33, the periclase is inferred to have the same composition as that in AZ_2.

FTIR analyses show that AZ_2 diamond is nitrogen-free (Type IIa), whereas KK33 has a low-nitrogen content but is a fully aggregated (Type IaB) diamond. This high aggregation state indicates a high minimum average mantle residence temperature of ~1400 °C, consistent with thermodynamic modeling results.

Integrating data from these two distinct diamonds with preliminary thermodynamic modeling of the CaO-MgO-SiO₂ system suggests that the periclase + merwinite + diopside assemblage formed at transition zone pressures and at temperatures >1400 °C. These findings indicate metasomatic interactions between subduction-derived Ca-rich carbonatite melts and peridotitic mantle occurred at extreme depths.