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Genesis and Depth of Formation of Ferropericlase Inclusions within Super-Deep Diamonds

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Diamonds containing fluid and mineral inclusions that were trapped during formation are the only natural samples capable of probing the deepest portions of the Earth's mantle (down to ~800 km depth). In order to precisely interpret the mineralogical and geochemical information they provide, the growth relationships between diamonds and inclusions (i.e., whether they formed before or during diamond formation) and the depth at which the inclusions were trapped need to be determined.

Ferropericlase [(Mg,Fe)O] is the most abundant inclusion within super-deep diamonds (i.e., those forming between ~300 and more than 800 km depth). Experiments and numerical models using a pyrolitic bulk composition indicate that ferropericlase, comprising 16-20% of the mantle phase assemblage, is stable at depths between 660 and 2900 km and is Mg-rich with X_{Fe} ranging from 0.10 to 0.27 (*1,2*). However, ferropericlase represents 48-53% of the inclusions reported within super-deep diamonds and has a more variable Fe content, with X_{Fe} between 0.10 and 0.64 (*3*). In spite of different efforts explanations of these discrepancies, the precise origin of ferropericlase-bearing diamonds remains unclear.

In this study we performed in-situ single-crystal X-ray diffraction analyses on a set of ferropericlase inclusions in super-deep diamonds from Juina (Brazil) and Kankan (Guinea), to determine inclusion-host crystallographic orientation relationships. These analyses were coupled with synchrotron X-ray tomographic microscopy in order to apply elastic and elasto-plastic geobarometry and determine the diamond depth of formation. Electron microprobe analyses on a set of inclusions that were released from the diamond hosts were also conducted to investigate possible relationships between crystallographic data and chemical composition. We assess the most likely scenario for the genesis of ferropericlase inclusions in super-deep diamonds, their depth distribution in the Earth's mantle and their implications for mantle geochemistry.

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