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Genesis of diamond inclusions: An integrated cathodoluminescence (CL) and Electron backscatter diffraction (EBSD) study on eclogitic and peridotitic inclusions and their diamond host.

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Diamond inclusions are potentially fundamental to understanding the formation conditions of diamond and the volatile cycles in the deep mantle. In order to fully understand the implications of the compositional information recorded by inclusions it is vital to know whether the inclusions are proto-, syn-, or epigenetic and the extent to which they have equilibrated with diamond forming fluids. In previous studies, the widespread assumption was made that the majority of diamond inclusions are syngenetic, based upon observation of cubo-octahedral morphology imposed on the inclusions. Recent work has reported the crystallographic relationship between inclusions and the host diamond to be highly complex and the lack of crystallographic relationships between inclusions and diamonds has led some to question the significance of imposed cubo-octahedral morphology.

This study presents an integrated EBSD and CL study of 9 diamonds containing 20 pyropes, 2 diopsides, 1 forsterite and 1 rutile from the Jwaneng and Letlhakane kimberlite clusters, Botswana. A new method was developed to analyze the crystallographic orientation of the host diamond and the inclusions with EBSD. Diamonds plates were sequentially polished to expose inclusions at different levels in the diamond. CL imaging at different depths was performed in order to produce a 3D view of diamond growth zones around the inclusions. Standard diamond polishing techniques proved too aggressive for silicate inclusions as they were damaged to such a degree that EBSD measurements on the inclusions were impossible. The inclusions were milled with a Ga+ focused ion beam (FIB) at a 12° angle to clean the surface for EBSD measurements.

Of the 24 inclusions, 9 have an imposed cubo-octahedral morphology. Of these inclusions, 6 have faces orientated parallel to diamond growth zones and/or appear to have nucleated on a diamond growth surface, implying syngenesis. In contrast, other diamonds record resorption events such that inclusions now cut diamond growth zones. In most cases, the growth zonation around inclusions is not well defined due to CL haloes but some inclusions clearly disrupt diamond growth.

Crystallographic orientations of diamond and the inclusions, determined using EBSD, revealed that each inclusion has a homogeneous orientation and record no compositional zonation. The diamonds also showed no angular deviations despite many having multiple growth and resorption zones; implying epitaxial growth of diamond. Crystallographic alignment between diamond and inclusions was not recorded for the principle planes and limited to 3 possible coincidences on minor planes from the 24 inclusions studied. The CL data show no evidence of syngenesis for these 3 inclusions. Analyses of two diamonds with inclusion clusters in different growth zones, ~400 μm apart, revealed the same chemical composition and orientation, potentially implying they originated from an original larger inclusion.

Combined EBSD and CL data suggest that there is no direct orientational correlation (epitaxial growth) between silicate inclusions and the host diamond, even when the mineral phases are of the same symmetry group. The presentation will provide a detailed evaluation of the genesis of individual inclusions.