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Orientation relationship between diamond and magnesiochromite inclusions

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The correct determination of the relative crystallographic orientations of single crystals has many applications. When single crystals undergo phase transitions, especially at high pressures, the relative orientations of the two phases yields insights into transition mechanisms (Dobson et al 2013). On the other hand, determination of the crystallographic orientations of minerals included in diamonds can provide insights into the mechanisms of their entrapment and the timing of their formation relative to the host diamond (e.g. Nestola et al. 2014, Milani et al. 2016).

The reported occurrence of non-trivial orientations for some minerals in diamonds, suggesting an epitaxial relationship, has long been considered to reflect contemporaneous growth of the diamond and the inclusion (e.g. syngenesis). Correct interpretation of such orientations requires (i) a statistically significant crystallographic data set for single and multiple inclusions in a large number of diamonds, and (ii) a robust data-processing method, capable of removing ambiguities derived from the high symmetry of the diamond and the inclusion. We have developed a software to perform such processing (OrientXplot, Angel et al. 2015), starting from crystallographic orientation matrixes obtained by X-ray diffractometry or EBSD data.
Previous studies of inclusions in lithospheric diamonds, by single-crystal X-ray diffraction and EBSD, indicate a wide variety in the orientations of different inclusion phases with respect to their diamond host (Futergendler & Frank-Kamenetsky 1961; Frank-Kamenetsky 1964; Wiggers de Vries et al. 2011; Nestola et al. 2014, Milani et al. 2016). For example, olivine inclusions in lithospheric diamonds from Udachnaya do not show any preferred orientations with respect to their diamond hosts, but multiple inclusions in a single diamond often show very similar orientations within few degrees. In the present work on magnesiochromite inclusions in diamonds from Udachnaya, there is a partial orientation between inclusion and host. A (111) plane of each inclusion is sub-parallel to a {111} plane of their diamond host, but with random orientations of the magnesiochromite [100], [010] and [001] relative to the diamond. In one case, where a single inclusion comprised a magnesiochromite-olivine touching pair, the magnesiochromite was oriented as noted above and the olivine showed a random orientation. The implications of these observations for the mechanisms of diamond growth will be explored and the results will be compared and combined with previous work.

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