THE GENESIS OF LITHOSPHERIC BLUE DIAMONDS

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Blue diamonds are among the rarest type of gems (< 0.1% of the extracted diamonds in the most productive area). They were mainly extracted from Indian (Kollur mine) and now mostly from the South African (Cullinan mine) deposits. Their blue color is due to trace amounts of boron (and the absence of nitrogen) in its lattice structure as seen by Fourier-Transform infrared spectroscopy (FTIR), which defined them as type IIb diamonds (see Gaillou et al., 2012 and references therein). They remain poorly studied, because of their rarity and scarce availability. Thus, their genesis and boron source remain misunderstood. The latest research conducted on similar blue diamonds (Smith et al., 2018) concluded to a formation model in the lower mantle (> 660 km), with boron derived from slab dehydration, thanks to the analyses of some inclusions, but no direct analyses of boron.

Here, we studied solid and fluid inclusions in four rough monocrystalline blue diamonds from the Cullinan mine, South Africa. We use a combination of *in situ* non-destructive methods in order to characterize the inclusions trapped in diamonds. FTIR enabled to measure volatile elements (B, N, H_2O etc.) as well as synchrotron x-ray diffraction and micro-Raman (532nm laser) spectroscopy allowed identification of the different mineral phases (Fig. 1 & 2).

These diamonds hold primary (Fig. 1) and secondary (Fig. 2) inclusions of $C_{graphite}$-H_2O composition precipitated from the same parent aqueous fluid and probably reflecting the diamond forming fluid. The secondary $C_{graphite}$-H_2O inclusion set up in a healed fracture and formed as multiple two-phase inclusions (Fig. 2) with H_2O as ice VII and a residual pressure of 2.5 GPa. Alongside, we observed the presence of a lithospheric mineral assemblage. Such a mineral assemblage and the residual pressure (Angel et al., 2014) indicate a genesis for these studied blue diamonds in a B-C-H_2O-rich fluid in the lithospheric mantle, at about 9-10 GPa, for 1000 – 1100°C (~ 200 km) which corresponds to the deep roots of the Kaapvaal craton (Niu et al., 2004). Type IIb blue diamonds therefore may form at any depth below the deep roots of a craton, and are not necessarily "superdeep".

References
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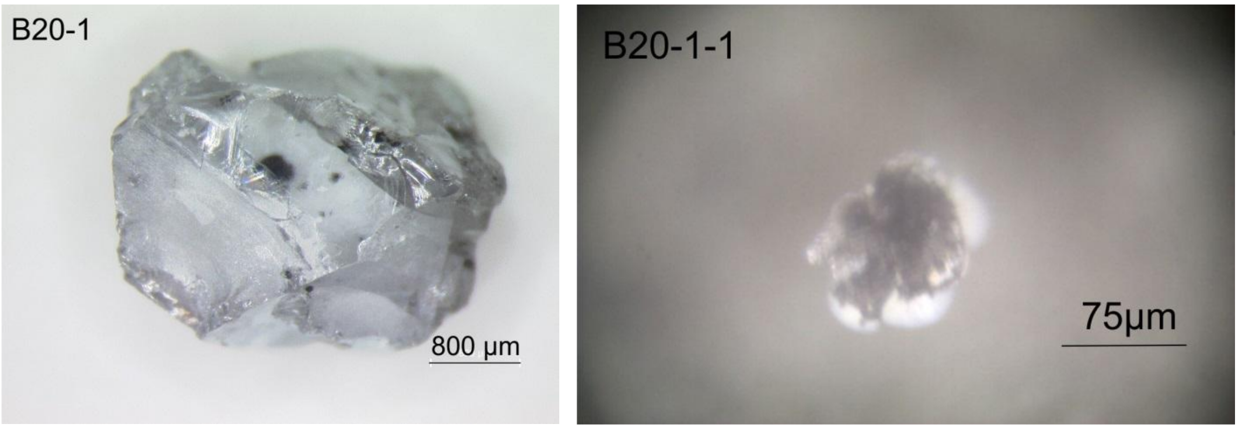

Fig. 1: Left- Full view of type IIb blue diamond B20, containing on average 0.31ppm of boron. Right- Primary inclusion within the same diamond, containing a mixture of graphite and water, as determined by Raman spectroscopy.

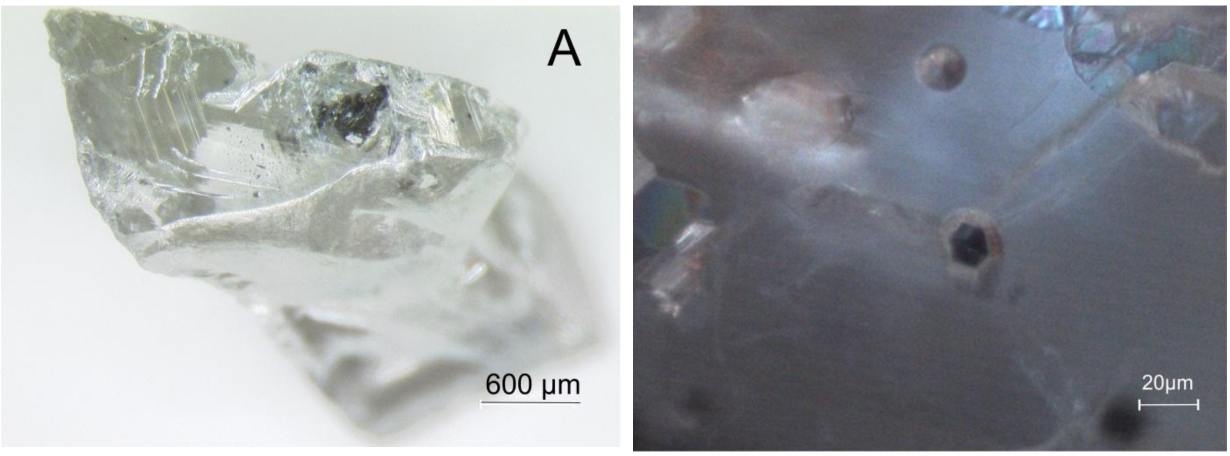

Fig. 2: Left- Full view of type IIb blue diamond B8, containing on average 0.23ppm of boron. Right- Secondary bi-phase hegaxonal inclusion (linked to other inclusions), containing graphite (dark) in its core and a mixture of water and methane in its colorless rim, as recognized by Raman spectroscopy.