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The Genesis of Blue Diamonds

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Introduction:

Blue diamonds are among the rarest type of gems: <0.1% of the extracted diamonds. Mainly from South Africa (Cullinan mine) and India (Kollur mine), Central Africa, South America and Borneo. Their blue color is due to trace amounts of boron in the lattice structure and the near absence of nitrogen, thus defined as type IbB diamonds [1].

It is proposed that blue diamonds are of ultra-deep origin, from the lower mantle, and exclusively formed in subduction settings [2]. Boron would be inherited from slab dehydration and carried to lower mantle (>660 km) in dense hydrous silicate minerals (DHMS).

→ Boron cycle in the mantle is relatively unknown and the study of these boron-bearing diamonds brings new insights on this deep cycle.

Materials

Cullinan mine in South Africa
Boron: 0.22 to 0.38 ppm B
Four diamonds:
- 1 x 3 mm for ~0.10 ct
- Two with primary inclusions
- Two with primary and secondary inclusions

Methodology: in situ investigations

Boron content measurement:
- Infrared spectroscopy (FTIR)
Mineral phase identification:
- μ-Raman spectroscopy (532 nm)
- Synchrotron X-Ray diffraction

Results

Inclusions I

Contemporaneous to the diamond growth or at least trapped during the growth

A unique water-C-rich fluid present in both primary and secondary inclusions

Inclusions II

Healed fractures: Post-growth event

Central Hexagonal Mineral

Outer Colorless Halo

Discussion

Forming fluid: Primary and secondary inclusions may be the witness of a H2O-C-rich parent fluid

Mineral assemblage: Inclusion of ilmenite: Eclogitic paragenesis at lithospheric depth

Inclusion of walstromite (retrogressed Ca-Perovskite (CaTiO3): >9 Gpa): Sub-lithospheric depth

Boron: inherited from sea water through the subduction zone: H2O + C + boron, available in the lithosphere after slab dehydration: Data suggest a deep recycling of marine fluids that may be the parents of blue diamonds

We suggest that blue diamonds are not exclusively ultra-deep and may form at any depth in the mantle, from lithosphere (150km) down to the lower mantle (~750 km), in subduction-related B-C-H2O-rich fluids.

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