

Fingerprinting carbonatitic metasomatism in ultramafic rocks: Blue Hill, Namibia

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Re-evaluating magmatic complexes in carbonatite hosting regions can reveal undetected carbonatite occurrences, crucial for critical raw materials. The Blue Hill Complex in Namibia serves as a natural laboratory for understanding how ultramafic volcanic rocks are modified by carbonatitic fluids. The least altered rocks at the complex's outer part show olivine, nepheline, and monticellite being replaced by serpentine, phlogopite and chlorite towards the center, while magnetite and perovskite remain stable (Fig. 1A, 1B). A metasomatized vein-like rock cutting through the complex contains phlogopite, hydrogarnet, calcite, apatite, magnetite, perovskite, serpentine (Fig. 1B) and olivine pseudomorphs, suggesting carbonatite melt interaction. This is supported by whole-rock compositions rich in CaO (21.5 wt.%), P₂O₅ (1.3 wt.%) and CO₂ (5.5 wt.%), as well as elevated Ba in phlogopite (up to 4.66 wt.%), typical for carbonatite melts [1]. A second alteration stage is evident at the complex's innermost center, where secondary serpentine, phlogopite, and chlorite (stage I) are replaced by calcite-pectolite and calcite-apatite intergrowths, likely resulting from residual carbonatitic CO₂-rich fluids (Fig. 1C). The complex's multistage alteration history reflects (1) deuteritic alteration, (2) metasomatic interaction with carbonatite melt, and (3) later overprinting by CO₂-rich fluids. These processes define three zones: least altered outer rocks, deuterically altered intermediate-zone rocks and CO₂-modified central rocks (Schematically in Fig. 1D). This suggests revising the previous model of three distinct picrite intrusions [2] in favor of a single primary damtjernite intrusion [3] modified by later carbonatite activity. U-Pb dating indicates an intrusion age of 88.72 ± 5.27 Ma after Pb correction. The uncorrected age (60.68 ± 13.91 Ma) overlaps with the 63.73 ± 8.19 Ma (U-Th-Sm)/He age of the nearby Gross Brückaros carbonatite, marking a possible metasomatism age.

[1] Von Knorring (1962), *Nature* 194, 860-861.

[2] Kurszlaukis, Franz & Brey (1999), *Chemical Geology* 160, 1-18.

[3] Tappe, Foley, Jenner & Kjarsgaard (2005), *Journal of Petrology* 46, 1893-1900.

