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Two stages of mantle metasomatism recorded by diamonds inside xenoliths

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Lithospheric keels of Archean cratons underwent a long history of depletion via melting and re-enrichment via metasomatism by melts and fluids creating a variety of mantle lithologies. Metasomatism can crystallize or destroy diamonds and diamond content drastically varies between mantle lithologies correlating with the composition of indicator minerals particularly garnet. However, thermodynamic modelling predicts a range of mineral compositions during percolation of a single fluid through the same peridotite. This obscures the influence from different metasomatic events on the composition of silicate minerals. Metasomatism also leaves an imprint on diamonds, producing pre-kimberlitic dissolution textures, which can reveal the metasomatic history and relationships among diamond-forming events. Diamond morphologies inside mantle xenoliths are rarely studied and mostly in eclogites. We examined pre-kimberlitic resorption on diamonds from a set of 21 unusual mantle xenoliths from the Liqhobong kimberlite (Lesotho), which resemble eclogites by their high diamond content and garnet + diamond ± pyroxene assemblage. However, their low-Cr megacrystic (G1) garnet and Ca-poor orthopyroxene indicate a megacrystic lithology not typically associated with high diamond potential. We also examined diamonds from three eclogitic xenoliths from Orapa and Ardo mines in southern Africa. X-ray computed tomography showing 3-dimensional distribution of diamonds inside the Liqhobong xenoliths revealed the occurrence of two diamond types – octahedral diamonds and polycrystalline aggregates commonly aligned along veins. Using optical and scanning electron microscope, we examined diamond surfaces outside and inside the xenoliths and established three distinct diamond dissolution styles. Diamonds protruding from the xenoliths display typical kimberlitic resorption with trigonal, tetragonal and circular etch pits, drop-shaped hillocks, and terraces. Diamond faces inside the xenoliths are different. In eclogitic xenoliths, they show stepped-faces with sharp edges, laminations, and negative trigons. In the unusual Liqhobong xenoliths, diamonds combine this “eclogitic” morphology with a second resorption style manifested by deep hexagonal pits, knobs, and cavities often blanketed by films of carbonate-silicate melt. Combination of the two pre-kimberlitic diamond resorption styles and unusual mineralogy captured two distinct metasomatic events: first fluid-metasomatism crystallizing “eclogitic”-type diamonds, followed by melt-metasomatism, destructive for diamonds, and responsible for the corroded “megacrystic” diamond morphology and perhaps composition of the host silicates.

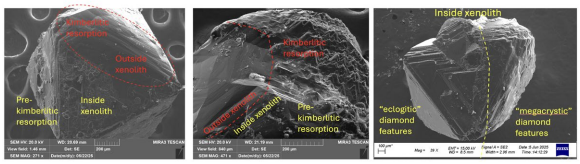

Figure 1 – Diamonds showing different resorption styles on different faces. (A) and (B) Resorption produced by interaction with kimberlite magma on the outside of xenolith, and resorption due to mantle metasomatism inside xenolith. (C) Two different metasomatic events recorded by the faces of a single diamond found inside mantle xenolith.