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Carbon and nitrogen isotopes and mineral inclusions in diamonds from chromitites of the Mirdita ophiolite (Albania) demonstrate recycling of oceanic crust into the mantle

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Abstract

Geophysical investigations and laboratory experiments provide strong evidence for subduction of ancient oceanic crust, and geological and mineralogical observations suggest that subducted oceanic crust is recycled into the upper mantle. This model is supported by some direct petrologic and mineralogical evidence, principally the recovery of super-deep diamonds from kimberlites and the presence of crustal materials in ophiolitic chromitites and peridotites, but many details are still unclear. Here we report the discovery of ophiolite-hosted diamonds in the podiform chromitites of the Skenderbeu massif of the Mirdita ophiolite in the western part of Neo-Tethys. The diamonds are characterized by exceedingly light C isotopes ($\delta^{13}C_{PDB} \sim -25‰$), which we interpret as evidence for subduction of organic carbon from Earth's surface. They are also characterized by an exceptionally large range in $\delta^{15}N_{air}$ (–12.9‰ to +25.5‰), accompanied by a low N aggregation state. Materials sparsely included in diamonds include amorphous material, Ni-Mn-Co alloy, nanocrystals (20 × 20 nm) of calcium silicate with an orthorhombic perovskite structure (Ca-Pv), and fluids. The fluids coexisting with the alloy and Ca-Pv provide clear evidence that the diamonds are natural rather than synthetic. We suggest that the Skenderbeu diamonds nucleated and grew from a C-saturated, NiMnCo-rich melt derived from a subducted slab of ocean crust and lithosphere in the deep mantle, at least in the diamond stability field, perhaps near the top of the mantle transition zone. The subsequent rapid upward transport in channeled networks related to slab rollback during subduction initiation may explain the formation and preservation of Skenderbeu diamonds. The discovery of diamonds from the Mirdita ophiolite not only provides new evidence of diamonds in these settings but also provides a valuable opportunity to understand deep cycling of subducted oceanic crust and mantle composition.

Keywords: Mirdita ophiolite, diamond, NiMnCo alloy, calcium silicate perovskite, carbon and nitrogen isotopes, subduction, West Albania