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Geological Occurrence of Diamond-bearing Ophiolites

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Diamonds and other ultrahigh-pressure (UHP) minerals exist in ophiolitic mantle peridotites and podiform chromitites from different orogenic belts. Most ophiolite-hosted diamonds are small (~ 200-500μm across), and some contain distinctive inclusions (i.e., coesite, NiMnCo alloys, spessartite, tephroite). All of the analysed diamonds have extremely light carbon isotope compositions ($\delta^{13}C$ = -28.7‰ to -18.3‰), and variable trace element contents. These diamonds can be distinguished from most kimberlitic and UHP metamorphic varieties on the basis of these characteristic. A wide range of highly reduced minerals, such as native elements, Ni-Mn-Co alloys, Fe-Si and Fe-C phases and moissanite (SiC) also occur as accompanying mineral separates confirming the super-reducing conditions of their environment of formation. The presence of exsolution lamellae of diopside and coesite in some chromite grains suggests chromite crystallization depths around >380 km, near the mantle transition zone. Carbon and other recycled crustal materials at these depths are considered to have been derived from previously subducted material. The peridotites encapsulating the podiform chromitites and diamonds were transported to shallow mantle by convection cells beneath oceanic spreading centers. The chromitites may have formed in the deep mantle or in shallow suprasubduction zone environments. On the basis of our findings, we suggest that diamonds, UHP minerals and recycled crustal material are likely ubiquitous in the oceanic mantle.

In this paper we present a detail account of the occurrence of diamonds, ultrahigh pressure (UHP) minerals and other recycled crustal material in the chromitites of four different ophiolites with different ages in different orogenic belts. The first-order significance of the findings of this study, as reported here is that: (1) diamonds, UHP minerals and recycled crustal material are likely to be much more widespread in the oceanic mantle than previously thought, and (2) ophiolitic peridotites and chromitites may have multi-stage development histories involving both deep and upper mantle melting events prior to their emplacement onto continental margins or into accretionary complexes. The latter inference is particularly important for the petrogenetic evolution of oceanic lithosphere. In the first part of the paper we summarize chromitite types and their occurrence and characteristics as background information. We then document the internal structure and geochemistry of the four different ophiolites and the types, petrography and geochemistry of chromitites and diamonds in them. In the last part of the paper, we evaluate the existing models for the formation of ophiolite-hosted diamonds, present our new model, and discuss its implications.

The new data, observations and interpretations on the occurrence of ophiolite-hosted diamonds and other unusual UHP minerals in ophiolitic chromitites, as reported here should stimulate new discussions on the shallow mantle origin of oceanic peridotites. The search for in-situ diamonds in peridotites and chromitites of ophiolites around the world with different ages and tectonic settings of formation during the next several years and their results will be highly critical for the course of these discussions.

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