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Ophiolites as Archives of Recycled Crustal Material Residing in the Deep Mantle

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1 Abstract

Deeply subducted lithospheric slabs may reach to the mantle transition zone (MTZ, 410-660 km depth) or even to the core – mantle boundary (CMB) at depths of ~2900 km. Our knowledge of the fate of subducted surface material at the MTZ or near the CMB is poor and based mainly on the tomography data and laboratory experiments through indirect methods. Limited data come from the samples of deep mantle diamonds and their mineral inclusions obtained from kimberlites and associated rock assemblages in old cratons. We report in this presentation new data and observations from diamonds and other UHP minerals recovered from ophiolites that we consider as a new window into the life cycle of deeply subducted oceanic and continental crust.

Ophiolites are fragments of ancient oceanic lithosphere tectonically accreted into continental margins, and many contain significant podiform chromitites. Our research team has investigated over the last 10 years ultrahigh-pressure and super-reducing mineral groups discovered in peridotites and/or chromitites of ophiolites around the world, including the Luobusa (Tibet), Ray-Iz (Polar Urals-Russia), and 12 other ophiolites from 8 orogenic belts in 5 different countries (Albania, China, Myanmar, Russia, and Turkey). High-pressure minerals include diamond, coesite, pseudomorphic stishovite, qingsongite (BN) and Ca-Si perovskite, and the most important native and highly reduced minerals recovered to date include moissanite (SiC), Ni-Mn-Co alloys, Fe-Si and Fe-C phases. These mineral groups collectively confirm extremely high¬ pressures (300 km to ⩾660 km) and super-reducing conditions in their environment of formation in the mantle. All of the analyzed diamonds have unusually light carbon isotope compositions ($\delta^{13}C$ = -28.7 to -18.3‰) and variable trace element contents that distinguish them from most kimberlitic and UHP metamorphic varieties. 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.

The carbon isotopes and other features of the high-pressure and super-reduced mineral groups point to previously subducted surface material as their source of origin. Recycling of subducted crust in the deep mantle may proceed in three stages: *Stage 1* – Carbon-bearing fluids and melts may have been formed in the MTZ, in the lower mantle or even near the CMB. *Stage 2* – Fluids or melts may rise along with deep plumes through the lower mantle and reach the MTZ. Some minerals, such as diamond, stishovite, qingsongite and Ca-silicate perovskite can precipitate from these fluids or melts in the lower mantle during their ascent. Material transported to the MTZ would be mixed with highly reduced and UHP phases, presumably derived from zones with extremely low fO_2, as required for the formation of moissanite and other native elements. *Stage 3* – Continued ascent above the transition of peridotites containing chromite and ultrahigh-pressure minerals transports them to shallow mantle depths, where they participate in decompressional partial melting and oceanic lithosphere formation.

The widespread occurrence of ophiolite-hosted diamonds and associated UHP mineral groups suggests that they may be a common feature of *in-situ* oceanic mantle. Because mid-ocean ridge spreading environments are plate boundaries widely distributed around the globe, and because the magmatic accretion of oceanic plates occurs mainly along these ridges, the on-land remnants of ancient oceanic lithosphere produced at former mid-ocean ridges provide an important window into the Earth's recycling system and a great opportunity to probe the nature of deeply recycled crustal material residing in the deep mantle

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