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Tracking traces of "hidden" UHPM rocks in deep Earth

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Ultrahigh pressure metamorphic rocks (UHPM) are an integral characteristic of collisional orogens, recording transient or even permanent subduction of continental margins into the mantle. Studies of these rocks in outcrops and laboratoris from microstructures, experimentally established phase transformations, mineral reaction kinetic principles to the extent and rates of metamorphic and tectonic events during deep subduction, elements partioning and geochemical diversity of mantle-crustal rocks-fluid interactions have provided new insights into global geodynamic processes operating in Earth's deep interior.

Experiments and observations on the natural UHPM rocks/minerals integrated with results of deep drilling (CCSD project) demonstrated that though huge volumes of UHPM rocks are returned back to the surface from depth ∼150-250 km, some fragments have sunk down into the mantle and stagnated there. Furthermore, experimental studies show that part of them can be chemically “assimilated” into the surrounding mantle, and part of them might be stagnated at the bottom of the mantle transition zone. The latter is because some felsic continental rocks will be denser than mantle rocks by about 0.2 g/cm3 at conditions corresponding to depth 410-450 km. Experiments also showed that at P–T conditions below 660 km depth the felsic rocks will be less dense than surrounding mantle rocks by about 0.15 g/cm3, and therefore they will not sink further into the lower mantle. This suggests that the 660 km seismic discontinuity boundary can be interpreted as a place where continental materials are stagnated.

Recently there were several new finds of the UHP minerals and UHPM rock-fragments within geological settings “fodidden” by mainstream concepts for such UHP mineral associations. Diamond was reported from an oceanic island, a mid-oceanic ridge ophiolite, and a forearc site, which are not suitable places for the diamond formation. The first finding of diamond in melt inclusions in mantle-derived grt-pyroxenite xenolith from Hawaii. Diamonds of 20-nm-size occur within the Si-rich glass together with Fe Cu, FeS, FeS2, ZnS, AgS phases. Yet, another diamond was discovered inside the OsIr inclusion from chromite pod from dunite-harzburgite section of the Luobasa ophiolite, Tibet. The polycrystalline coesite found in the same chromite ore suggests its replacement after stishovite. Other forms of UHP-HP carbon-bearing minerals such as moissonite (SiC) as well as metal nitrides [osbornite (TiN) and cubic boron nitride (cBN)] are discovered within UHPM rock-fragment incorporated in the mantle section of the Loubasa ophiolite of Tibet. The new finding demonstrates that some fragments of oceanic lithosphere also include UHP phases derived from deep within the upper mantle, but that their protolith probably had a near-surface origin according to carbon isotopes signatures of moissanite.

Diamond in CPx from a Cenozoic lamprophyre dike was discovered in a forearc setting, Japan. A pressure of 5.5 GPa was calculated for the forearc diamond formation; it suggests that the diamond-bearing rocks rose to the forearc region from depths of about 160 km. This implies that mantle flow in convergent plate boundaries occurs on a larger scale than was previously recognized. We need a new understanding the interactions among magma generation and mantle convection and upwelling beneath oceanic islands, forearcs, and the mid-oceanic floor.