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Petrogenesis and Lu–Hf dating of (ultra)mafic rocks from the Kutná Hora Crystalline Complex: implications for the Devonian evolution of the Bohemian Massif

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Orogenic garnet peridotites with associated garnet pyroxenites and eclogites in the (U)HP-(U)HT terranes provide insight into mantle melting and subduction-related metamorphism in collisional orogenic belts. Here we demonstrate that they also represent unique tracers of early subduction processes in the internal part of the European Variscan Belt, where subsequent high-temperature processes affect thermochronometers in crustal rocks. Our study focused on several localities within the Kutná Hora Crystalline Complex (KHCC), a key area for the evolution of the Variscan Bohemian Massif due to its position, evidence for a deep crustal subduction (diamond in granulites) and complete geochronological record.

The mantle rocks show highly variable petrographical and geochemical characteristics reflecting derivation from contrasting mantle sources which have undergone both mantle melting and enrichment due to subduction-related metasomatism. While the Úhrov lherzolite has trace element and Sr–Nd–Hf composition similar to depleted oceanic asthenospheric mantle, the composition of the Bečváry lherzolite reflects extensive refertilization by basaltic melts associated with Grt±Cpx precipitation. Multiple solid inclusions (MSI) trapped in garnet, dominated by Ti and Fe–Ti oxides (rutile, ilmenite), represent relics of Ti-rich low-degree basaltic partial melt. Minor hornblende/phlogopite and carbonate reflect mantle metasomatism by H₂O±CO₂-bearing fluids. Highly to mildly radiogenic Sr–Nd–Hf–Os isotopic compositions along with negative HFSE anomalies in clinopyroxene indicate only a very small contribution of recycled crustal component. The Doubrava peridotites exhibit marked petrographic variability ranging from harzburgite to composite dunite-wehrlite/olivine-bearing pyroxenite assemblage and contrasting geochemical patterns. This can be best explained by interaction between depleted protolith and SiO₂-undersaturated melt with small proportion of recycled crust (~5 % when subducted oceanic crust is considered). The KHCC eclogites show diverse origins, involving products of high-pressure crystal accumulation from mantle-derived basaltic melts, or a fragment of MORB-like gabbroic

cumulate and crustal-derived material both metamorphosed at HT-HP conditions.

The Úhrov peridotite yields Lu-Hf age of 395 ± 23 Ma, interpreted as dating garnet growth based on detailed examination of trace element garnet zoning. By contrast, eclogites yield younger Lu-Hf ages of ~ 350 and 330 Ma, respectively, representing mixed ages as demonstrated by garnet trace element zoning and a strong granulite-facies overprint.

We propose a refined model for Devonian-Carboniferous evolution of the Bohemian Massif, with the subduction of the oceanic crust and associated oceanic asthenospheric mantle beneath the Teplá-Barrandian at ~ 400 Ma related to closure of the Saxothuringian ocean between Gondwana-derived microcontinents. The overlying lithospheric mantle wedge was refertilized by fluids/melts. Oceanic subduction passed to continental subduction of the Saxothuringian crust (~ 370 - 360 Ma?) accompanied by the break-off of the eclogitized oceanic crust facilitating incorporation of the upwelling asthenospheric mantle into the Moldanubian lithospheric mantle wedge. Subsequent collision and coeval exhumation of mantle and crustal rocks occurred at ~ 350 - 330 Ma and might be associated with mixing/mingling of crustal-derived melts and mafic lithologies producing the observed geochemical and geochronological signatures.