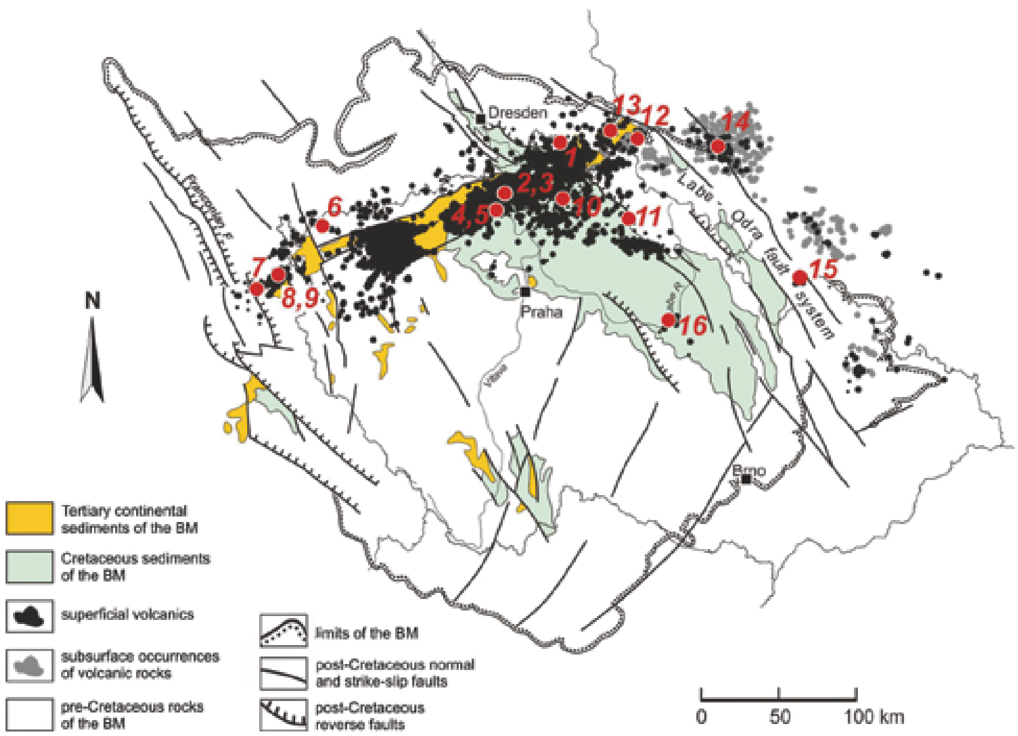
THE COMPOSITION OF UPPER MANTLE BENEATH THE BOHEMIAN MASSIF: THE VIEW FROM MANTLE XENOLITHS

L. Ackerman[1] and L.G. Medaris, Jr. [2]
[1]Institute of Geology, The Czech Academy of Sciences, Rozvojová 269, 165 00, Prague 6, Czech Republic; ackerman@gli.cas.cz; [2]Department of Geoscience, University of Wisconsin-Madison, WI 53706, USA; medaris@geology.wisc.edu

Mantle xenoliths within basaltic, lamprophyric and kimberlitic volcanic rocks provide detailed information about the structure, composition and evolution of the upper mantle in different geotectonic settings (e.g., rift and/or plume-related volcanic centers) throughout the Earth`s history. In central Europe, Cenozoic alkaline volcanic activity is associated with development of the European Cenozoic Rift System (ECRIS), forming the Western and Central European Volcanic Province (CEVP), and the Cenozoic volcanic rocks occurring in the Bohemian Massif represents the easternmost segment of the rift system within the CEVP. Alkaline volcanic rocks (basanite, nephelinite) from the Ohře(Eger) rift system and off-rift volcanic centers contain abundant mantle xenoliths (see Fig. 1), which can be sampled in the Czech Republic, Germany and Poland.

Over the last ~10 years, a large amount of petrological and geochemical data have been published for many xenolith localities, which include Kozákov in NE Bohemia [1-2], several sites within the Ohře/Eger rift [3] and its western flank in NE Bavaria [4,5] and eastern flank in SW Poland [6,7], and off-rift localities associated with the Labe-Odra fault system in SW Poland and E Bohemia [8-12]. Such data provide a important insights into the compositional heterogeneity of the upper mantle beneath the Bohemian Massif arising from a variety of processes.

Mantle xenoliths from the Bohemian Massif are generally small in size (typically a few cm in diameter) with larger sizes (up to 20 cm) occurring only on at the Kozákov locality. Lherzolite is the predominant type of xenolith at Kozákov and NE Bavaria (Zinst, Hirschentanz, Teichelberg), whereas harzburgite predo-



minates

Fig. 1 – Simplified map of the Bohemian Massif showing the occurrences of the Cenozoic volcanic rocks, modified from [13]. Xenolith localities: 1 – Plešný vrch (Brtníky), 2 – Dobkovičky, 3 – Prackovice, 4 – Kuzov, 5 – Medvědický vrch, 6 – Kraslice, 7 – Zinst, 8,9 – Hirschentanz, Teichelberg, 10 – Provodínské kameny, 11 – Kozákov, 12 – Ksieginki, 13 – Steinberg, 14 – Krzeniów-Grodziec-Wilcza Góra, 15 – Lutynia, 16 – Luž.

in the remaining localities. Other types of mantle xenoliths such as dunite, wehrlite and pyroxenite, are rare. All these rock types contain spinel as the major Al-bearing phase indicating their derivation from depths not greater than ~80 km. Garnet-bearing varieties have not been reported so far from the Bohemian Massif, although spinel-pyroxene symplectites after garnet are a predominat feature at Kozákov [14], and complex, symplectite-bearing pseudomorphs after garnet occur in some unique peridotite xenoliths from Zinst [5] and a single specimen of websterite from Kozákov [15]. The xenoliths are anhydrous with the exception of a recent find of rare amphibole-bearing xenoliths from SW Poland [11].

Variable modal proportions and bulk-rock and mineral chemical compositions in the xenoliths arise from variable degrees of partial melting, which range from ~5 to ~30 % among and within localities. The predominance of harzburgite in the xenolith suite requires higher degrees (> 15 %) of partial melting for the upper mantle sampled so far. Based on currently available data, there is no correlation between the extent of depletion and characteristics of overlying individual crustal units or age of volcanic host rocks (centers). However, the predominant harzburgitic lithology of the Bohemian Massif mantle xenoliths contrasts with that in xenolith lithologies in the ECRIS (e.g., Eifel, Massif Central), where lherzolites prevails [12]. Re-Os depletion ages [16] are difficult to interpret, as they are commonly disturbed by more recent metasomatic events and/or host basalt modification, although many samples peak between 0.5 and 0.6 Ga, corresponding to the Cadomian orogenic cycle.

All xenoliths from the Bohemian Massif underwent subsequent large-scale metasomatism, which is predominantly cryptic in nature, as recognized through the bulk rock and mineral incompatible trace element enrichments that are associated mostly with chromatographic fractionation. However, rare modal enrichments occur in orthopyroxene at Kozákov (NE Bohemia) and in amphibole at Wilcza Gora (SW Poland). In general, three major types of metasomatic patterns are recorded in the Bohemian Massif xenoliths: (1) metasomatism by silicate (basaltic) melts at variable melt-rock ratios producing LREE, LILE and HFSE enrichments, (2) (alkaline)-silicate melt Fe-metasomatism, which lowered the Mg # of minerals and locally dissolved clinopyroxene, and (3) metasomatism by carbonatitic-silicate melts at low melt-rock ratios, as indicated by large-scale chromatographic fractionation and HFSE-depletions recorded in clinopyroxene. In addition, complex metasomatism by alkaline and carbonate-rich melts has been documented in the NE Bavaria xenoliths, as expressed by the presence of carbonate-bearing silicate melt pockets due to the fractionation of Na-rich silicate melt. Also, there is growing evidence for melt-rock interactions in the upper mantle beneath the Bohemian Massif between peridotite and percolating depleted, tholeiitic melts [3,7,13] through the presence of LREE-depleted rocks, including lherzolite (Medvědický vrch, Ohře/Eger rift), wehrlite (Steinberg, SE Germany) and pyroxenite (Dobkovičky, Ohře/Eger rift). The upper mantle is compositionally heterogeneous beneath the Ohře/Eger rift, where the central part was metasomatized by silicate melts of basaltic composition at high melt/rock ratios, whereas the rift flanks underwent metasomatism by more evolved melts of alkaline and/or alkaline-carbonatitic composition. Sources of the melts have been traced through limited Sr–Nd–Li isotopic data for clinopyroxene from lherzolites and websterites at several localities (e.g., Kozákov, NE Bavaria, SW Poland). With the exception of NE Bavaria peridotites and Medvědický vrch pyroxenite, all other data overlap in isotopic composition with those reported for Cenozoic volcanic rocks, indicating a similar, enriched mantle source. In contrast, NE Bavaria xenoliths have low to negative δ^7Li values ranging from −2.5 to −9.7‰, coupled with radiogenic $^{87}Sr/^{86}Sr$ and $^{187}Os/^{188}Os$ [17] ratios, which may indicate a significant contribution of recycled crustal material such as eclogite in the infiltrating melts. The LREE-depleted composition of a single Dobkovičky pyroxenite is in agreement with its highly depleted Sr–Nd isotopic signature, similar to depleted MORB mantle.

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