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Contrasting Metamorphic Evolution of HP Rocks in the Gföhl Unit of the Kutná Hora Crystalline Complex and the Moldanubian Zone in Austria

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The uppermost part (Běstvina and Malín formations) of the Kutná Hora Crystalline Complex is due to presence of HP/HT granulites, garnet peridotites and eclogites are generally correlated with the Gföhl complex in the Moldanubian zone. We have studied felsic granulites, kyanite-bearing migmatites and migmatitic gneisses of the Gföhl-relted unit in the Kutná Hora Crystalline Complex and in the Moldanubian zone of Waldviertel in Austria. In order to analyse PT evolution of individual lithologies we have constructed pseudosections in the NCKFMASH system using the THERMOCALC software (Powell et al. 1998). The calculated isopleths in the pseudosections were compared with composition of garnet, plagioclase and K-feldspar in different stages of the rock evolution. The overall PT trajectory was further improved by calculation of "Average pT" method (Powell et al. 1998).

Granulites and migmatites occuring in the uppermost parts of the Kutná Hora Crystalline Complex, are characterized by the presence of kyanite, garnet and feldspars and gneisses contain also white mica. The migmatite contains clusters of muscovite and biotite with small grains of garnet and kyanite. Textural relations indicate that biotite was formed during the late stage of metamorphism. It replaces or rims muscovite being in textural equilibrium with garnet and kyanite. Garnet in both migmatite and in gneiss is homogeneous and only weak retrograde zoning was observed in the rims of garnet from granulite. Garnet in migmatitic gneiss is rich in Fe (Alm_{77-83}, Py_{10-13},Grs_{2-6}). Relatively high-Mg garnet is present in granulite (Alm_{56-60}, Py_{28-32},Grs_{5-11}). Analysed muscovite has relatively high phengite component with Si = 3.2 a.p.f.u. Plagioclase is usually rich in Na and the anorthite content ranges between 6–11 mol% in migmatitic gneiss. Granulite has nearly pure albite with $An_{0.07-0.09}$.

The HP/HT metamorphic conditions of 875 ± 95 °C and 15.6 ± 1.4 kbar were calculated, using the average PT (Powell et al. 1998) for the assemblage Ky-Grt-Plg-Kfs-Ms-Qtz ($X_{H2O\ in\ melt}$ = 0.5) in the Malín and Běstvina migmatitic gneisses. The Běstvina granulite gave temperature and pressure of 831 ± 53 °C and 16.5 ± 1.8 kbar ($X_{H2O\ in\ melt}$ = 0.6) for kyanite, garnet core, perthitic feldspars and biotite in garnet. Metamorphic PT conditions for the MP/LT stage were calculated from the matrix biotite, garnet rims and the recrystallized grains of plagioclase, K-feldspar and quartz. The results yielded PT conditions of 712 ± 39 °C and 10.6 ± 1.8 kbar for migmatites and 705 ± 97 °C and 14.4 ± 2.1 kbar for granulites. The calculated PT conditions, consistent with the lack of sillimanite, suggest that the retrogression occurred still at high pressure in the kyanite stability field.

PT conditions obtained for the HP/HT metamorphic stage in felsic granulites from the Moldanubian zone in Austria correspond to 912 °C ± 54 °C and 13,7 kbar ± 1,5 kbar. Their exhumation to the middle custal levels was accompanied by formation of LP/HT mineral assemblages that yield pressure and temperature of 890 °C ± 72 °C and 8,5 kbar ± 2,0 kbar. The Gföhl migmatitic gneisses contain relics of kyanite armoured within feldspars indicating the earlier HP metamorphic stage. The dominant assemblage within the late foliation is Sill-Grt-Plg-Kfs-Bt determining conditions of the metamorphic overprint at 877 °C ± 69 °C and 6,7 kbar ± 1,7 kbar. The development of spinel in the ky-kfs granulites indicates, that the metamorphism continued to shallow depths at still high temperature.

According to the observed mineral assemblages and calculated PT conditions, exhumation of the Kutná Hora Crystalline Complex rocks occurred at different PT path comparing to that of the Moldanubian zone in Austria. In the Moldanubian zone, decompressional anatexis resulted in stabilization of LP mineral assemblages with sillimanite and spinel in migmatites and LP overprint of eclogites and HP granulites. In contrast, the Malín and Běstvina migmatites and felsic granulites are characterized by a PT path implying almost isobaric cooling. The presence of kyanite in leucosomes of migmatites suggests that anatexis occurred already during the high-pressure stage. The kyanite-bearing migmatites and HP felsic granulites of the Malín and Běstvina formations may represent well-preserved segment of extensively granulitized lower crust of the Variscan orogenic root, which was not affected by late LP overprint probably due to very high exhumation and cooling rates.

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Geodynamic Significance of Late Cretaceous Lamprophyres from the Carpathian-Pannonian Region

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Late Cretaceous lamprophyres as dyke swarms have been found in two major locations within the Carpathian-Pannonian Region: 1) Villány Mts situated in Tisza megaunit – S Hungary and 2) NE Transdanubia situated in Alcapa megaunit. Previous studies (Szabó et al. 1993, Nédli 2004, Nédli and M. Tóth, submitted) showed that these dyke swarms petrographically and geochemically are similar and their melts probably derived from the same or very similar asthenospheric mantle sources. The lamprophyric melts originated from significant depth in the upper mantle and show no signs of crustal contamination. In this way they carry specific geochemical, petrologic information about the Late Cretaceous lithosphere-asthenosphere beneath the region. Their xenolith content reveals also the physical-chemical characteristics and processes of the pre-Paleogene crust and mantle. Considering that these dykes are situated on two different microplates (Tisza and Alcapa), their study can contribute to the geodynamic evolution of the microplates composing the Carpathian-Pannonian Region.

Dykes studied petrographically are alkali lamprophyres with porphyritic texture containing olivine and clinopyroxene phenocrysts and a fine-grained, pyroxene-rich groundmass. Whole rock K/Ar data for the dykes indicate Late Cretaceous age (Dunkl 1991, Molnár and Szederkényi 1996). Based on the geochemical characteristics, these dykes are thought to have been originated from an enriched (EM II-type) garnet lherzolite mantle source by low degree partial melting. Significant negative Nb-Ta anomaly, extreme LILE and LREE enrichment, moderate enrichment in HFS elements (Fig. 1) and geochemical similarity to other EM-type mantle sources worldwide (Weaver et al. 1986) suggest the subduction-related origin of the enriched component of the source).

Both dykes contain abundant xenocrysts and xenoliths of lower crust or upper mantle origin (Szabó 1985, Kubovics et al. 1989, Molnár and Szederkényi 1996, Nédli and M.Tóth 1999). Xenoliths from Villány Mts. are mainly four phase spinel lherzolites, whereas in Transdanubian lamprophyres occur a large variety of xenoliths (e.g. pyroxenites, lherzolites, websterites, wehrlites). Some samples from both localities contain OH-bearing minerals suggesting that hydrous metasomatism effected the source mantle region of the xenoliths. Both xenolith series reveal a deformed and re-equilibrated subcontinental mantle.

The significant chemical, petrographic, petrogenetic and age similarities of lamprophyres from the Villány Mts. and NE Transdanubia suggest similar or the same mantle source for these igneous activities. Their mantle source region must be of asthenospheric origin, due to the unequivocally different lithospheric composition of the Alcapa and Tisza units, separated by the Mid-Hungarian Zone (e.g. Csontos and Nagymarosy 1998, Kovács et al. 2006). These lamprophyres carry the evidence of the presence of similar or the same subduction-related, enriched asthenospheric subcontinental mantle component beneath the Tisza and Alcapa microplates in the Late-Cretaceous, which were located about 400 km from each other in the Late Cretaceous (Csontos and Vörös 2004).

On reconstructions of Late Cretaceous structural elements in the Alpine-Carpathian-Pannonian area (Csontos and Vörös 2004), it is clear that the localities containing lamprophyre dykes are aligned along the Peri-Adriatic Fault, with the Villány Mts near Beograd, whereas the Transdanubian Region is situated between the Southern and Central Alps. In time and space the clo-