Fig. 1. Map of the northern part of Moravian Karst with averaged lineation, axial culmination and main shear zones.

lineation, which corresponds to movements on Moravian shear zone (Moldanubian thrust), usually accompanies the foliation.

In the framework of tectonics related to the younger phase of thrusting, we can neglect several highly strained zones with NNE-SSW strike and with sense of movement to NNE (Fig. 1):

1. The first one is approximately 1.5 km long zone west of Vavřinec village. This west-dipping zone forms a sheet incorporated into granodiorites of the Brno massif. Devonian limestones were strongly mylonitized, low-temperature plastic flow of the rocks is documented by development of significant foliation and stretching lineation, isoclinal folding and boudinage of shells, which indicates extension more than 300%.
2. The second zone with subhorizontal ductile foliations was found S of the Sloup village. This zone is accompanied by close-to-isoclinal and sheath folds.
3. The third shear zone is situated at the eastern margin of the Moravian Karst at the contact with the Culm (close to Ostrov village). Limestones bedding in this brittle-ductile shear zone is overturned and cut by spaced cleavage, so originally bedded limestones look like nodular rocks. Cetral part of the shear zone is cut by large fault and the strained Devonian rocks are thrust over the Culmian siliciclastic rocks.

The trend of maximal stress ó1 could be estimated from the interval N-S to NE-SW.

The subsequent brittle deformations pass in several phases. One of them, development of nearly symmetrical pairs of kink bands whose axes form angles of 30°, is connected with compression NE-SW (type D, Ramsay and Huber, 1987). Later phases of fragile deformations were accompanied by the development of undeformed veins and stylolites.

The change of plunge/trend of the structural cylindricity axe and the corresponding lineation are an interesting problem to deal with discuss. In the northern and northeastern part of the studied area the lineation plunges mainly to NNE, while SSW dip prevails in the southwestern part. The parts with different plunge/trend are separated by zone of axial culmination with horizontal lineation and cylindricity axe (•ďár–Ostrov, see Fig. 1). Similar axial culmination is in the surroundings of Vratikov village (Melichar and Kalvoda, 1997). Its origin is related to the development of the Valchov trough (halfgraben), where bedding of Cretaceous sandstones was rotated together with Variscan tectonic basement (anomalous plunge to the south). Similary, we can use the same model to explain the described axial flexure with the neotectonic origin of the Blansko trough.

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Compositional Zoning in Garnet, a Tool for Understanding of Tectono-Metamorphic Evolution of Metamorphic Complexes: a Case Study from Metabasites of the Kraubath Massif (Eastern Alps)

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Metabasalts from the Kraubath mafic and ultramafic massif contain chemically zoned relic magmatic clinopyroxene, amphibole and garnet. A weak compositional variation at rims and along cleavage of clinopyroxene grains resulted from partial reequilibration during metamorphism. Difference in composition of clinopyroxene is expressed mainly in the higher XMg (0.9) in the cores compared to the rims (XMg = 0.8). Pargasitic amphibole shows three zones that gradually change from dark core to rim. The dark-green cores have higher XMg (0.83) and Altot (2.221 a.f.u.) then the light-green rims (XMg = 0.6 – 0.7, Alt = 2.111 a.f.u.).

Back-scattered electron images of garnet allowed identification of two garnet generations (Grt I and Grt II).The older garnet (Grt I) has high Mg contents (Py13–15, Alm53–55, Grs29–30). Some large porphyroblasts of this garnet have dark-gray domains with slightly lower Fe (Alm48–50) and higher Ca (Grs31–34). By contrast, the younger garnet (Grt II), which rims or forms veinlets in Grt I, has high Ca and low Mg (Grs40–45, Py0.2–0.5, Alm46–51). Textural relations and mineral composition in combination with available geochronological dating, indicate multi-stage igneous and metamorphic origin of minerals in the studied metabasite. (1) Magmatic stage is characterized by relicts of clinopyroxene in amphibolite. (2) First (Variscan) metamorphism is represented by older amphibole (amph1) and garnet (Grt I) and reequilbrated parts of clinopyroxene. Temperature of 713 ± 7 °C was calculated for this metamorphism. Pressure estimated only from Al content in amphibole and high Ca and Mg content in garnet were > 7 kbar. Chemical zoning in garnet and amphibole indicate retrograde P-T path for this metamorphism. (3) A new metamorphic event is manifested in the formation of Ca-rich and Mg-poor garnet (Grt II) which appears to be in textural equilibrium with amph2, epidote and chlorite. Pressure and temperature of 550 °C and 10.2 kbar were calculated for this metamorphism.

Fracturing and formation of veinlets in garnet were probably imposed by volume increase during retrogression along an exhumation path where temperature decreased. In the situation where retrogression is driven by hydration reactions, strong gradients in fluid composition may occur. The new garnet derived by dehydration reactions of hydrous phases that had been already formed during retrogression from amphibolite facies metamorphism. Mass balance calculations on Si, Al, Mg+Fetot, Ca and H_2O indicate formation of the garnet from epidote and chlorite. However more Fe-rich chlorite and epidote are needed to balance Fetot and Mg contents.

To analyse diffusion exchange between older and younger (rim and veinlet) garnet, concentration profiles across interfaces of these garnet varieties were measured by microprobe beam at 2 µm steps. Very sharp contact between these two garnets with contrasting composition provides the opportunity to put constraints on the duration and rate of uplift. Modelling the observed diffusion profiles gave a time span of about 2×10^5 years for cooling of garnet Grt II from 550 to 450 °C along the uplift path from 10 to 4 kbar.

Layered Metaigneous Complex of the Veporic Basement with Features of the Variscan and Alpine Metamorphism (the Western Carpathians, Slovak Republic).

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Geological setting

The Veporicum is an internal part of the central domain of the Western Carpathians and it is an area consisting of several tectonically approached units with different age. The layered metaigneous complex (LMC) is a part of the Veporic basement of the Central Western Carpathians. This complex is regionally widespread in the northwestern part of the Slovenské Rudohorie Mts. and the eastern part of the Nízke Tatry Mts. The studied basement complex was originally termed as the gabbro-peridotite-basalt formation (Miko and Putiš, 1989 in Krist et al., 1992) in the area of the eastern Low Tatra Mts. It was included into the leptynite-amphibolite complex (LAC, Hovorka and Méres, 1993). The layered metamagmatic-amphibolitic rocks are part of the pre-Alpine Čierny Balog (CB) supracrustal complex. The CB complex is mainly represented by Ky-Grt gneisses, migmatitic gneisses and common to partially melted amphibolites.

Lithological composition of the layered metaigneous complex

Layered metaigneous complex is mainly represented by porphyric Qtz meta-diorites, which were dated approximatelly at 346 Ma, U – Pb on Zr. Layered metadiorites, in form of layered (banded) amphibolites, appear to be an inseparable part of metadiorites. Thus, at least a part of layered amphibolites appear to have magmatic origin in dioritic protoliths. Strongly layered parts of metadioritic body contain rare 2–3 dm fragments of metagabbros (Amph – Px + Pl). Amph-rich layers of metadioritic composition, or pale tonalitic to trondhemitic layers are also present within the metadioritic bodies less than 100 m thick. Undifferentiated dioritic parts have composition which is an average of the dark (Amph, Pl, Ttn, + Qtz) and pale (Pl, QTz, Mgt, + Amph, + Bt) bands. A special lithological member appears to be layered amphibolite (resembling leptynite-amphibolites, e.g., Neubauer, 1989; Hovorka et al., 1992; Putiš, 1992) thus representing a characteristic pre-Alpine lithological feature of the layered mataigneous complex.

The most likely mechanism of the relic magmatic layering appears to be magmatic laminar flow, accompanying differentiation and alignment of Pl and Am mega- and microcrysts parallel to the direction of flow, e.g., in porphyric (meta)diorites (e.g., Parsons, 1987; Fountain et al., eds. 1992; Percival et al., 1992; Shelley, 1992; Hall, 1996). The development of layering was influenced by the extensional emplacement conditions of the magmatic sills into the shear zone accompanying an extensional detachment fault. Thus a continuous evolution of the magmatic to subsolidus and solidus foliation might have