overthrusting of medium-grade Devonian? metabasites over the Cambro-Ordovician low-grade volcanosedimentary sequence of the Gemer Unit.

The Alpine Orogeny started by Late Jurassic overthrusting of subduction melange over the continental margin represented by the Gemer Unit. The continuous N–S convergence resulted in development of an internal thrust within the sub-Gemer basement in the Cretaceous. Propagation of this thrust into the overlying low-grade metasediments of the Gemer Unit produced an asymmetrical cleavage fan with narrow southern and wide northern flank with decreasing deformation intensity towards the north. The irregular shape of the Vepor basement started to play a significant role during further shortening of the weak Gemer sequence. Large NE–SW-trending margin of the western Vepor basement took the role of an oblique indenter at these times. Consequently, at the contact with this crystalline basement, the whole Gemer and Mesozoic successions were exceptionally shortened, which resulted in the development of transpressional deformation that overprinted early cleavage fan. Geometry of planar structures, subhorizontal stretching and numerous sense-of-shear criteria suggest sinistral transpression. This zone propagates farther NE, where it forms the major Central Gemer Shear Zone (CGSZ) and cross-cuts the central part of the Gemer domain. The major effect of this transpressional sinistral movement is overthrusting of southern part of the Gemer Unit on eastern Vepor basement, buckling of cleavage fan structure with a wavelength of ~60 km and formation of new N–S-striking clevage in the hinge zone of a large buckle fold.

The Alpine reworking of the western Vepor basement margin is also very intense. Here, the Vepor gneisses show strong greenschist-facies sinistral transpressive reworking with northward decreasing intensity of deformation. Internal part of the Vepor basement has been also affected by two major NE–SW-striking steep transpressive shear zones several kilometres wide, often associated with complete transposition of the early Variscan fabric. Major result of transpressional tectonics is a vertical extrusion of micaschists, which have been emplaced into supracrustal levels while the surrounding high-grade gneisses were affected by intense greenschist transtensional shearing with flat planar fabrics and E–W-trending stretching. This transtension is associated with dragging of overthrust Gemer and Mesozoic sequences by sinsitral movements of the CGSZ.

Deformation in the Henryków Gneiss (East Fore-Sudetic Block) – Further Evidence for the SW-directed Extensional Collapse in the East/West Sudetes Boundary Zone

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The structural evolution of the East/West Sudetes contact zone involved several deformation events, the sequence and character of which remains a matter of controversy. In the Fore-Sudetic Block, an additional difficulty arises from poor exposure of the Variscan basement which is mostly concealed beneath the Cenozoic sediments. Therefore, each outcrop of basement rocks in that area is worth of being studied. This paper presents results of structural study on the gneisses from the vicinity of Henryków in the southernmost part of the Lipowe Hills. The obtained data indicate an important role played by late extensional deformation which has modified the earlier fabric in the East/West Sudetes boundary zone.

The Lipowe Hills massif is exposed in the eastern part of the Fore-Sudetic Block between the Niemcza–Kamieniec Ząbkowicki metamorphic unit in the west and the Strzelin crystalline massif in the east. It is composed of four main types of gneisses (Wójcik 1973; Wroński 1975; Oberc-Dziedzic 1995): (1) chlorite Henryków gneiss; (2) fine- to medium-grained light gneiss with sillimanite nodules; (3) light, coarse-grained or augen gneiss and (4) dark, thinly layered to migmatitic gneiss. Gneisses are accompanied by minor amphibolites, calc-silicate rocks, marbles, biotite-muscovite schists and quartzites. The metamorphic rocks are intruded by Variscan granitoids.

The Henryków gneiss is grey-green, fine-grained. It is usually layered and shows locally augen structure. The rock is composed of quartz, K-feldspar, plagioclase, muscovite and chlorite. Apatite, zircon and opaque minerals are main accessories. Individual layers, which define the main foliation, are up to 1.5 mm thick and consist of quartz, quartz + feldspars and muscovite + chlorite. Augens, elongated parallel to the layering, are composed of quartz or feldspar. Both K-feldspar and plagioclase are often strongly sericitized or saussuritized. Two generations of chlorite were distinguished. The first one comprises plates replacing biotite and orientated parallel to the main foliation, whereas the second generation fills brittle joints.

Effects of four deformational events were documented within the Henryków gneiss. The oldest D_1 deformation structures are represented by crenulated relics of the S_1 foliation, locally preserved between planes of the main S_2 foliation. The S_1 foliation is marked by elongation of quartz aggregates and white mica plates. In places, quartz veins, oblique or perpendicular to the main S_2 foliation, parallel the orientation of the S_1 planes. These quartz veins are sometimes deformed by isoclinal rootless F_2 folds, up to 2–3 cm in size. The main S_2 foliation is developed parallel to axial planes of the F_2 folds and dips to the W at angles of 30–40°. It is defined by layering and alignment of muscovite and chlorite (replacing primary biotite).

The S_2 foliation was subsequently reactivated during the D_3 event. In consequence, the L_3 mineral stretching lineation was developed on the S_2 foliation. The L_3 lineation is defined by parallel alignment of elongated quartz–feldspar aggregates and muscovite flakes. It plunges toward the SW at angles of 25–35°. Kinematic indicators originated during the D_3 event – S-C structures, mica fish, extensional shear bands and asymmetric pressure shadows – indicate a top-to-SW sense of shear during the D_3 deformation.

The youngest deformation structures D_4 are kink folds, brittle joints and zones of brecciation. The joints are filled with second generation of chlorite or with quartz. Joints and axial planes of kink folds, orientated obliquely to the S_2 foliation, are subvertical.

The main fabric of the Henryków gneiss developed due to the D_2 event under a flattening strain, indicated by the presence of crenulated S_1 relics. This fabric was subsequently subjected to a significant modification by the D_3 event, involving the SW-directed simple shear. The relatively late D_3 event produced a distinct asymmetry of fabric, typical of the Henryków gneiss. The present orientation of the S_2 foliation, dipping W at moderate angles, suggests a dip-slip normal kinematics of the D_3 deformation. Similar kinematics characterizes the SW-directed extensional collapse, documented in the eastern part of the Fore-Sudetic Block (Mazur et al. 1997; Szczepański and Józefiak 1999) and in the Jeseniki Mts. (Cháb et al. 1994). The extensional deformation probably resulted in the juxtaposition of the Henryków chlorite gneiss and, exposed immediately to the north, sillimanite-bearing variety of gneisses.

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Emplacement of Mantle Rocks into the Lower Crust: Constraints from Elastic Anisotropy and Geochronological Studies in the Moldanubian Zone

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Although there is sufficient evidence for exchange of material between the crust and the mantle, the exact mechanisms of juxtaposition of the mantle and lower crustal rocks are yet not clear. Here, we present results of combined petrological, isotopic and elastic anisotropy studies of juxtaposed mantle and lower crustal rocks in the Moldanubian Zone of the Bohemian Massif. The Moldanubian Zone (the Gföhl Unit) contains numerous segments of lower crust (Grt, Ky, Opx, Cpx and Bt-bearing granulite and eclogite facies gneisses) that are spatially associated with upper mantle rocks (Grt and Spl peridotites and eclogites). Petrographic evidence from the lower crustal rocks and geochronological data from associated garnet peridotites suggest that they evolved along a clockwise P-T path with the peak P and T conditions of ca. 16–20 kbar and 900–1100 °C, respectively at ca. 354 Ma (Carswell and O'Brien 1993; Košler et al. 1998). The HP–HT metamorphism was followed by a rapid isothermal decompression and MP(LP)–HT metamorphism (6–8 kbar, 700–800 °C) at ca. 340 Ma and near-isobaric cooling down to 300 °C at ca 330–320 Ma (Carswell and O'Brien 1993; Becker 1997; Kröner et al. 2000). The structural and Ar–Ar isotopic data from micas in the adjacent Moldanubian gneisses suggest that the final stages of exhumation were linked to thrusting followed by cooling to ca. 300 °C at 325 Ma (Fritz et al. 1996) in the southern Bohemian Massif. Garnets in felsic granulites have often preserved prograde growth zoning that is indicative of fast growth and cooling (Becker 1997). Diffusion modelling suggests that the garnets could have spent only a very short time period (<< 1 Ma) in the peak metamorphic conditions and that the heat could not have been conducted to the crust but was rather convected from the mantle. A possible mechanism of heat transfer is by means of emplacement of mantle rocks into the Moldanubian lower crust, implying that the studied parts of lower crust may have not followed a smooth P-T path. They rather evolved along a path with a series of short-lived thermal spikes reflecting the input of mantle material.

The granulite facies rocks in the studied part of the Moldanubian Zone have two intersecting planar fabrics that corre-

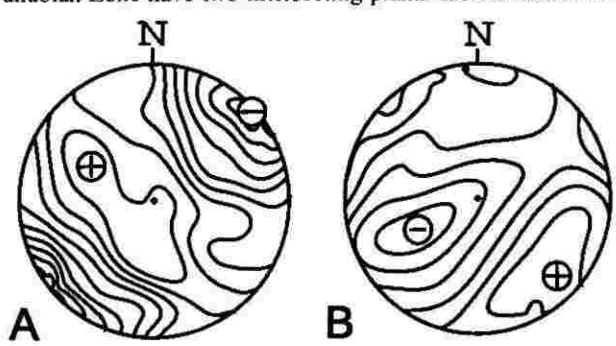

Fig. 1. Distribution of P-wave velocities in Lambert's equal-area projection for a garnet peridotite inclusion (A, measured at confining pressure of 2 kbar) and its host leucocratic granulite (B, measured at confining pressure of 1 kbar) from the Blanský les massif, Moldanubian Zone of the Bohemian Massif.