ond 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-

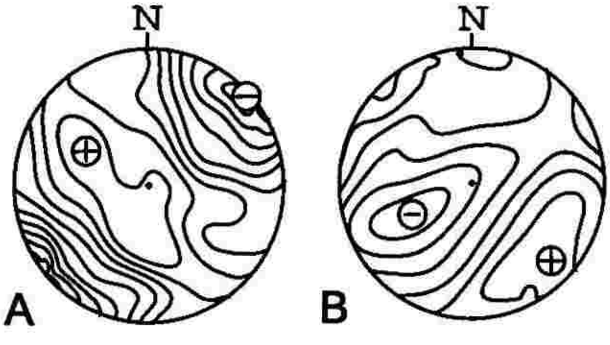

Fig. 1. Distribution of P-wave velocities in Lambert's equal-area projection for a garnet peridotite inclusion (A, measured at confining pressure of 2 kbar) and its host leucocratic granulite (B, measured at confining pressure of 1 kbar) from the Blanský les massif, Moldanubian Zone of the Bohemian Massif.

spond to two separate deformation stages (Svojtka et al. 1999). The early deformation D_1 is constrained by Sm–Nd garnet ages and P-T conditions derived from garnet and ternary feldspar to have a minimum age of 354 Ma corresponding to the HP–HT phase of granulite evolution. The age and P-T conditions of the later deformation are derived from cooling below the Ar–Ar closure temperature in biotite at 326 ± 8 Ma (average of 17 Bt laser spot measurements) and a U–Pb concordant zircon age of a syn-tectonic granite at ca. 320 Ma (Svojtka et al. 1999). This deformation followed the MP(LP)–HT stage of granulite evolution. Inclusions of mantle rocks have often well-preserved magmatic layering that is discordant to the later planar fabric of their host granulites.

In order to determine structural relations between the mantle inclusions and their host lower crustal rocks, we have used the ultrasonic pulse-transmission method (Pros et al. 1998). This method allows us to measure the values of P-wave velocity on rock samples under confining pressure. We can recognize the preferred orientation of propagation of P-waves in an inclusion of garnet peridotite and its host leucocratic granulite (both collected from the same outcrop, ca. 10 meters apart). Garnet peridotite with a macroscopically observed magmatic planar fabric at 86/80 has maximum and minimum velocities of P-waves at 4 kbar of 6,947 m/s and 6,409 m/s, respectively and an anisotropy coefficient of 8.05 %. Although a limited extent of serpentinisation may result in small deviations from typical orthorhombic symmetry of samples composed mostly of olivine, it has only little influence on the orientation of the velocity extremes. The maximum velocity of P-wave in the garnet peridotite corresponds to neither of the macroscopically observed planar fabrics (Fig. 1). The host leucocratic granulite with a macroscopically observed foliation at 296/65 and lineation at 330/54 corresponding to D_2 has maximum and minimum P-wave velocities at 4 kbar of 6,267 m/s and 6,069 m/s, respectively, and an anisotropy coefficient of 3.22 %. Suprisingly the maximum velocity direction in the granulite is near-perpendicular to its foliation and the directions of minimum velocities form a belt that is parallel to the foliation (Fig. 1). Both rock types are likely to have been deformed by an early deformation phase, possibly corresponding to D_1. Given the structural sequence in the granulites (Svojtka et al. 1999), this would suggest that the mantle rocks were emplaced into the lower Moldanubian crust prior to 354 Ma. In addition, another sample of garnet peridotite inclusion yielded a Sm–Nd age of 360 ± 3 Ma (WR and four garnet fractions, including core and rim) and a similar age has been obtained from an eclogite inclusion from the same unit (354 ± 8 Ma, Sm–Nd, WR and two garnet fractions). ε_{Nd}^{355} values of +3.2 and -4.6 and $(^{87}Sr/^{86}Sr)_{355}$ ratios of 0.7013 and 0.7128 for garnet peridotite and eclogite, respectively, suggest that the two inclusions originated from different parts of the mantle or, alternatively, that the eclogite may represent a part of metamorphosed basaltic crust.

Collectively, the available geochronological and structural data suggest that the mantle rocks preserved as inclusions in the granulites could represent a heat source that caused the short-lived thermal spikes on the P-T-t evolution path of the Moldanubian lower crust.

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Mylonites in the Kłodzko Metamorphic Unit – A Record of Pre-Late Devonian Dextral Transpression in the West Sudetes

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Mylonites have been long known in the SW part of the Kłodzko Metamorphic Unit (Fischer and Meister 1938; Wójcik and Gaździk 1958; Wojciechowska 1966). Our recent research has shown, however, that they are much more widespread than reported in previous works. We found a map scale mylonitic band, representing a major shear zone, one among the largest in the Polish Sudetes. Its size is comparable to that of the Niemcza and Złoty Stok–Skrzynka shear zones, which are considered important features in the structure of the Variscan basement. Since the mylonites are unconformably overlain by unmetamor-