with westward kinematics producing main S_2 metamorphic foliation and L_2 lineation in non-eclogitic lithologies. Buttressing of the allochthonous body from the west is responsible for the development of late, large-scale F_2 folds with N–S-trending hinges and vertical axial planes (Mědĕnec and Oberwiesenthal synforms). The D3 event is associated with N–S compression leading to large-scale folding of both the autochthonous and allochthonous units. This deformation produces km-scale antiforms (Mědĕnec and Klínovec antiforms) and is associated with the development of the L_3 lineation as a result of complete reworking of the D2 fabric in the limb zones. The development of numerous D3 structures can be recognized in the basement rocks. These structures range from ductile F_3 folds up to brittle-ductile kink bands suggesting a decrease in temperature, and thus uplift of the whole study area during the D3. The last stage of deformation (D4) is characterised by the development of kink-band F_4 folds. These kink bands developed almost exclusively in those parts of the structure where D3 folding produced steep planar fabric, and their geometry suggests subvertical direction of principal compression.

Our observations suggest three main deformation events. An early westward compression which was responsible for the emplacement of an allochthonous orthogneiss body with eclogites on its base. Following this event, the principal compression became orientated N–S producing large-scale D3 folding of both the allochthonous and autochthonous units. The final stage of structural evolution was marked by the disappearance of the horizontal D3 compression, and an increase in the role of the overburden which lead to the appearance of subvertical stresses and formation of brittle-ductile D4 structures.

Evidence for High Exhumation Rate in Central European Variscides: U–Pb Ages of Granulite Metamorphism of Clasts Deposited in Upper Visean conglomerates

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Pebbles and/or boulders of crystalline rocks occurring within post-orogenic sedimentary sequences provide a unique material for studies of geotectonic evolution of orogenic belts. Visean conglomerates of the Variscan flysch (Culm) at the eastern margin of the Bohemian Massif containing highly variable rock assemblage in pebbles provide a unique material for such studies. The most important source of magmatic and metamorphic rock pebbles is represented by several kilometers thick Myslejovice Formation in the southern part of the Drahany Upland. Its subdivision into the lower Račice Conglomerate and upper Luleč Conglomerate is based on a change in material composition.

In the Luleč Conglomerate, clasts of crystalline rocks such as granulites (Štelc 1960; Vrána and Novák 1998), durbachites (Zachovalová and Leichmann 1999) and metabasic rocks have been found. Granulite mineral assemblages evidence equilibration at variable crustal depths, always at high temperatures. Mineral assemblages and reaction textures that are analogous to the granulites exposed in the Bohemian Massif suggest that some of these rocks were exhumed along near-to-ITD (isothermal decompression) P-T path over at least 24-km depth. The age of sedimentation of conglomerates with shale intercalations in the interval 327–334 Ma (based on paleontology) constrains well the minimum age of the exhumation of crystalline rocks at the surface. Along with the age of the crystalline rock formation/metamorphism it provides basis to infer the exhumation rates of rock complexes.

Single and multigrain U–Pb dating of accessory phases from granulite and durbachite samples from the Luleč and Olšany (durbachite only) quarries was carried out in NIGL. Zircon from seven samples and monazite and rutile, when available, were dated. All zircon fractions were abraded. Garnet-bearing felsic granulite LU-A-20 (Grt-Sill-Qtz-Afs-Pl-Bt±Crd) and garnet-bearing intermediate granulite LU-A-3 (Grt-Sill-Qtz-Afs-Pl-Crd-Bt±Ms) contain uniform population of clear, lustrous, multifaceted, largely spherical zircons (size up to 200–300 mm) typical of growth during high-grade metamorphism. This zircon type prevails in Opx-bearing granulite LU-A-28 (Grt-Bt-Opx-Qtz-Afs-Pl±Crd), where also long prismatic zircon grains occur, up to 250 mm long, commonly with rounded edges. Mainly shorter prismatic up to 300–400 mm long, clear or clouded zircons are typical for felsic granulite LU6 (Grt-Qtz-Afs-Pl), garnet-rich granulite with biotite LU4 and cordierite granite/migmatite (Qtz-Afs-Pl-Crd-Bt-Grt±And±Ms). All three samples also contain small clear equant zircons (100–150 mm). Durbachite contains mainly long prismatic, larger (up to 600 mm long) and smaller, even acicular, generally transparent zircons, and subordinate flat crystals (up to 200mm), all with igneous morphology. Yellow-green clear monazite crystals from LU-A-20 and LU-A-2 and dark brown-black (opaque) elongated crystals of rutile up to 400 mm long (LU-A-20) and reddish brown translucent longer prismatic rutile crystals (LU4) were also dated.

Zircon, monazite and rutile of garnet-rich felsic granulite yielded Variscan ages, ranging between 336 and 339 Ma (zircon) and 329 ± 4 Ma (rutile). Monazites (337–330 Ma) are younger or overlap within the error with concordant rounded zircons. Rounded zircons from the intermediate granulite and various zircon types (short prismatic, oval-shaped) from the Opx-bearing granulite are largely concordant at 336 ± 2, closely corresponding to the above given data. These ages are interpreted as ages of granulite metamorphism.

High-U prismatic zircons from LU6 felsic granulite are both discordant beside 304–316 Ma, with $^{207}Pb/^{206}Pb$ ages of 332–362 Ma, difficult to interpret. Garnet-biotite-rich granulite (LU4) contains prismatic zircons showing inheritance from Precambrian and 500 Ma old sources; the zircon magmatic age is not certain based on these data. Rounded zircons slightly discordant at 334 Ma and rutiles concordant at 331 Ma probably date the HP granulite metamorphism. Cordierite-bearing LP granite/migmatite contains a Proterozoic component (zircon discordia U.I. at 1160 ± 85 Ma). There is also evidence for an earlier Variscan event (zircon discordia L.I. at 372 ± 9 Ma, rounded zircons concordant at 380 Ma) and a later Variscan one (321–330 Ma, monazite).

Durbachite is also of Variscan age – longer and shorter prismatic zircons of magmatic origin are discordant at 325–332 Ma, with U.I. at 360 Ma. These data are difficult to interpret. For comparison, Holub et al. (1997) reported Pb/Pb zircon age of 340 ± 8 Ma for the Třebíč durbachite.

The age of granulite clasts is consistent with numerous ages of HP granulites exposed in the Moldanubian Zone of the Bohemian Massif (e.g., Aftalion et al. 1989; Wendt et al. 1994; Kröner et al. 1996). Very high average exhumation rates of 4.8 mm/yr have to be envisaged if the zircon ages are attributed to the peak pressure event during granulite metamorphism. Due to the persisting HT on the order of the T_C of the U–Pb system in zircon and monazite during the exhumation, these ages could also reflect the MP granulite overprint. Independent constraints, such as microtextural study, are needed for the interpretation. Important is also a unique evidence for two HT metamorphic events found in the granite/migmatite.

Acknowledgements

Two granulite samples (LU4, LU6) were provided by dr. Vrána and dr. Novák (see references), which we gratefully acknowledge. Our research was financed by the Czech Grant Agency (project No 205/99/0567) and by Europrobe Travel Grant to J.Kotková.

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Petrology and Microstructural Evolution of Orthogneisses in the Eger Crystalline Complex

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Orthogneisses in the Eger Crystalline Complex are exposed at the boundary between two tectonometamorphic units of the Bohemian Massif – the Erzgebirge Crystalline Belt and the Teplá–Barrandian Unit. Stable mineral assemblage in these rocks consists of Q, Plg, Kf, Grt, Bi, ± Mu, ± Ky and suggests amphibolite- to granulite-facies conditions of metamorphism.

Several types of orthogneisses coexist in a small area and indicate particular stages of progressive metamorphic evolution. Four microstructural rock types can be identified: 1) coarse-grained augen orthogneiss, 2) banded anatectic orthogneiss, 3) fine-grained migmatitic gneiss, 4) granulitic gneiss. Coarse-grained augen orthogneiss is composed of monomineralic polycrystalline layers of equigranular Plg and Kf grains meeting at triple points and mica-bearing domains separating these layers from less deformed quartz lenses. Subsequent stage of microstructural evolution is characterized by lining of K-feldspar boundaries by quartz. Quartz films grow and, together with plagioclase, progressively destroy monomineralic K-feldspar aggregates. The resulting texture is characterized by polymineral aggregates separated by discontinuous domains of mica and abundant crystals of garnet. The last stage is characterized by completely recrystallized fine-grained omnidirectional granulitic structure with abundant garnet porphyroblasts. In comparison with other rock types, decreasing amount of biotite is typical for this stage.

Textural and metamorphic relations were studied with special attention to computer processing of digitized SEM-images which represent datasets necessary for quantitative textural analysis (grain size, grain shape, aspect ratio, shape-preferred orientation, grain-boundary orientation, grain-contact frequencies).