domain with frozen Devonian fabrics was decoupled from stabilised southward dipping fabrics of the mantle lithosphere along a flat rheologically weak lower crustal horizon. Thus, the observed discrepancy between orientation of the upper crustal boundaries and the deep crustal orogenic fabrics on one side, and the large-scale fabric of the mantle lithosphere root on the other side, may be explained by the proposed kinematic model.

Acknowledgements

The research is partly supported by a grant Nos. 205/98/K004 and 205/01/1154.

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Contacts Between High-P Eclogites and Gneisses in the Lądek-Śnieżnik Metamorphic Unit, the West Sudetes

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In the Lądek-Śnieżnik Metamorphic Unit (LSMU), amidst mostly orthogneises and metasediments, there are Carboniferous (U)HP rocks forming small dispersed eclogite bodies and a vast granulite massif. A mechanism for their exhumation from a depth of c. 100 km is poorly understood. It is unknown if and how much of the surrounding rocks have also undergone similar P-T paths. Having identified a Grt(Gros30-50)-Zo-Ti(Rt)-Qtz assemblage in quartz-plagioclase-mica rock immediately adjacent to eclogites, Bröcker and Klemd (1996) suggested that at least part of the LSMU gneisses also underwent the (U)HP metamorphism but the critical mineral assemblages have been obliterated during exhumation. Similar suggestions were made by Smulikowski (1979), Borkowska et al. (1990), Dumicz (1991, 1993) and Steltenpohl et al. (1993). Tectonic emplacement of eclogites inside the adjacent gneisses is also assumed but the interpretations of their exhumation differ in important details (Don, 1989; Żelaźniewicz and Bakun-Czubarow, 2002).

In hope for the elucidating the above problems, the present author has started detailed studies at the contact zones between eclogites and gneisses in the LSMU. Three occurrences have been examined: one in the Międzygórze gneiss unit, and two in the Gierałtów gneiss unit (Strachocin and Sowia Kopa near Stronie Śląskie – the last one was mapped earlier as amphibolites of the Stronie fm.).

In both the gneissic units, (U)HP metabasites occur as long, narrow belts inside gneisses, parallel to their foliation (Frąckiewicz and Teisseyre, 1973; Cymerman and Cwojdziński, 1986). The eclogites are usually mantled by amphibolites, often strongly deformed and showing signs of migmatisation. According to the present author, the surrounding gneisses are mylonitised and often migmatised metagranites. In Stronie Śląskie, post-eclogite amphibolitic rocks also occur within mica schists. Eclogites of both units strongly differ in their provenance, peak P-T conditions, textures and mineral composition (Smulikowski, 1967; Bakun-Czubarow, 1998). The eclogites from Międzygórze have MORB protolith and underwent the UHP metamorphism (P>29 kbar, T = 660–780 °C) followed by retrogression under the amphibolite facies conditions, whereas those from the Gierałtów unit (granulite massif) have calc-alkaline basalt provenance and underwent higher temperature metamorphism (P>28 kbar, T = 700 to 800 °C), but along different P-T paths involving granulite facies episode. In the case of eclogites from Strachocin and Sowia Kopa no evidence for UMPM has been found yet (Bakun-Czubarow, 1998).

In the Międzygórze unit, the inner parts of metabasitic lenses are built of fresh or weakly retrograded UHP eclogites, sometimes having laminated texture, with locally changing proportions within the assemblage of Grt-Omp-Rt±Qtz±Phe±Ky±Hbl±Dol±Zo (Bakun-Czubarow, 2001). The outer parts are built of amphibolites touched by migmatisation. They are composed of Amp-Pl-Bt-Qtz-Ti-Ep-Ap-Zr. Amphiboles occur as pargasite-magnesiohornblende and younger actinolite; plagioclases contain An15-35. P-T conditions for hornblende-plagioclase pairs are estimated at T=635±30 °C (Holland and Blundy, 1994) and

P = 8–9 kbar (Hammmerstrom and Zen, 1986; Hollister et al., 1987). The results correlate with estimations obtained for the adjacent mylonitic orthogneisses composed of the assemblage Kfs-Pl(Olig)-Qtz-Bt-Ti-Ep-All-Ap-Zr±Ms±Grt±Chl± ±Phe±Rt±Mon, which is also found in other gneisses having mylonitic or migmatic textures. For the gneisses temperature of 630±20 °C and pressure of 8.5 kbar were estimated by correlating the results of Bt-Grt geothermometer (Hoinkes, 1986) and phengite geobarometer (3.25-3.32 Si p.f.u.) (Massonne and Schreyer 1987). Garnet is the most interesting mineral in the studied gneisses. It has unusual composition (Alm40-60-Grs38--52-Sps1-5-Prp1-3.5), which matches that of garnet occurring in the gneisses next to the eclogites, but with different texture (Bröcker and Klemd, 1996). The high grossular content makes these authors to suggest that gneisses enclosing eclogites also have undergone UHP metamorphism. Unfortunately, it also causes problems in thermobarometric estimations, what makes the calculated results uncertain.

Structural records in the eclogites and outer amphibolites from the Międzygórze unit are in many outcrops distinctly different. In eclogites, foliation S1E dipping toward the NNW, usually hardly recognizable, has different orientation from foliation S1A in amphibolites that dips toward E/SE. On the other hand, penetrative structures (S1A, l1A) in retrograded metabasites have the same mylonitic character and orientation as those in adjacent gneisses (S1G, l1G). In both types of rocks mylonitic foliations dip toward the E/ESE, whereas stretching lineation is usually subhorizontal, trending N-S. This consistency is due to shearing processes that introduced eclogites into gneisses. Different orientation of foliation in the eclogites testifies to their exotic origin and tectonic emplacement into the surrounding gneisses.

Eclogites from the Gierałtów unit are retrograded stronger than those in the Międzygórze unit. At present, they are amphibolites with numerous relics of high-pressure minerals (garnet, rutile, zoisite). Their mineral composition includes Amf-Pl-Bt-Qtz-Ti±Ep±Chl±Grt±Rt±Ilm±Zo-Ap-Zr. There is a strong diversity of textures and mineral assemblages in amphibolites, connected with different degrees of retrogression (Smulikowski, 1967; Stawikowski, 2001). Falling P-T conditions are accompanied by decrease of Mg and increase of Si in Ca-amphiboles and appearance of actinolite and cummingtonite. There is also a decrease of Ca content in plagioclases. At the contacts with gneisses amphibolites are strongly sheared. P-T conditions for two shear zones with different mineralogical assemblages were estimated: (1) 715 ± 30 °C, 7±1 kbar for tschermakite-andesine pair and (2) 550± 30 °C, 2,5 ±1 kbar for actinolite-oligoclase pair (Holland and Blundy, 1994; Hammmerstrom and Zen, 1986; Hollister et al., 1987). The discrepant results can be due to diachronic origin or activity of the shear zones. The higher estimate is possibly a record of P-T conditions during emplacement of eclogites into surrounding rocks. The studied gneisses are usually texturally similar to the gneisses from Miedzygórze. They have slightly different mineral composition, i.e. more muscovite and other composition of garnet relics: Alm 65-75-Gros6--29-Sps1-13-Py1- 4. The usage of Grt-Bt thermometers gave inconsistent and improbable results, supposedly because of disequilbrium between garnets and biotites. Phengite included in garnet has 3.15 Si p.f.u. In mica schists from Sowia Kopa (Ms--Qtz-Pl-Bt-Ti-Grt-Ap) garnets of different composition occur (Alm68-73-Grs9,5-16-Py10.5-14.5-Sps1-10). P-T conditions obtained with the GPMB barometer and Grt-Bt geothermometer (Bhattacharya et al., 1992) are 580 °C, 9 kbar.

The structural record from the eclogite facies period in the Gierałtów unit, due to strong retrogression has not been recognized yet, however directional arrangement of HP mineral inclusions is in evidence. Amphibolites have sometimes granoblastic texture. They usually contain foliation S1A moderately dipping to the NE with stretching lineation parallel to its dip. These features are in agreement with the orientation of foliation S1G and lineation l1G in the surrounding gneisses. Mylonitic mica schists from Sowia Kopa have been found only as loose blocks.

Summing up, the rocks of contact zones in both gneiss units show some differences in mineral composition and structural record. Higher temperatures for amphibolite facies contact rocks (more consistent with observed migmatisation) were obtained for the Gierałów unit. In both units records of shearing along the contacts between eclogites and gneisses have been recognized in the outer amphibolites and adjacent gneisses. Stretching lineation is strike-parallel in the Międzygórze unit and dip-parallel in Gierałtów unit. In Międzygórze, the fresh eclogites have structural record different from that of amphibolites and surrounding gneisses, which suggests tectonic emplacement of UHPM rocks.

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Geochronology of Mid-Devonian Clastic Sediments in the Barrandian, Bohemian Massif

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The deposition of Givetian siliciclastic turbidites and calciturbidites in the Teplá-Barrandian Zone in Central Bohemia is often interpreted as resulting from an early stage of Variscan orogeny (Kukal and Jager, 1988; Strnad and Hladil, 2001). The sediments contain variable amounts detrital silicate minerals and carbonate component. K-Ar age of detrital muscovites in this formation is ca 490 Ma (Ahrendt et al., 1998), however ages and source of other detrital components have not been previously studied. Clastic minerals include mostly angular and subangular grains of quartz and alkali feldspar. Biofragments such as spicules of sponges, radiolaria, dacryoconarids and other non-identified calcareous organic detritus are also present. Illite crystallinity (Ahrendt et al., 1998) and optical microscope study suggest that the mid-Devonian clastic sediments experienced only a weak diagenetic transformation. The heavy mineral assemblage recovered from six sediment samples consists of several size, shape and colour populations of garnet and zircon, pyroxene, tourmaline, apatite, hornblende, leukoxene and Fe-sulphides. Size of zircon grains does not usually exceed 200 microns. Rounded elongate and spherical zircons are present in all studied samples and often show extensive mechanical abrasion, idiomorphic crystals are less common. The U-Pb isotopic system in zircons hence represents an ideal tool to study the provenance of the Givetian sediments in the Barrandian.

The U-Pb and Pb-Pb laser ablation ICP MS isotopic data from studied detrital zircons indicate that the source area included Archean to early Palaeozoic rocks with ages between 3.0–0.4 Ga. The secondary and backscattered electron images of zircons suggest that the Archean (3.0 and 2.6 Ga) and early Proterozoic ages (2.2–2.0 Ga) represent a strongly reworked and recycled Gondwana material. Detrital zircons of Grenvillian age (ca 1.65 Ga) are scarce in the studied sediments. The late Proterozoic – early.

Fig. 1. U-Pb Concordia plot of detrital zircon analyses from samples of Barrandian Mid-Devonian sediments.

Palaeozoic (Pan-African) ages between 800–550 Ma correspond to zircons with variable shapes and internal zoning. The c. 600 Ma zircon data may correspond to ages on granitic magmatism, the relics of which are also found in the Cambrian and Neoproterozoic conglomerates (Dörr et al., 1992). The late Cambrian ages of ca 500 Ma correspond to idiomorphic elongate zircons crystals such as are found in magmatic and metamorphic rocks along the south-western margin of the Teplá-Barrandian (Bowes and Aftalion, 1991; Zulauf et al., 1997; Dörr et al., 1998). This may suggest that in the Mid-Devonian times a significant amount of material was transported to the Barrandian basin from the south and southwest. The youngest identified zircons so far yielded Lower Devonian ages.