ing to the NW and subvertical axial planes. In most of the studied area, the S1 foliation is completely reworked into NW-SE trending, subvertical S2 foliation with ubiquitous closed to recumbent F2 folds with subhorizontal axes. The L2 stretching lineation is mostly subhorizontal, suggesting transpressional regime of deformation. PT conditions during the D2 are characterized by the Grt±Crd±Bt+Sill+Kf+melt assemblages in metasediments, and by partial melting in meta-igneous lithologies. Intrusion of the Amspoort-type granite seems to be coeval with the D2 deformation. Solid-state deformation of the Amspoort-type granite indicates that deformation continued during decreasing temperature. Its D3 origin is manifested by occasional brittle-ductile D3 structures overprinting D2 ductile fabric. However, the stress orientation during the D3 is the same as that during the D2. The difference is only in the temperature conditions of deformation, and the D2 and D3 structures are often indistinguishable in the field.

The orientation of the D1 structures West of the PSZ coincides with that of the main metamorphic foliation in medium-pressure metasediments East of the PSZ. During the D2, the PSZ has developed on the boundary between a westerly migmatitic unit, and an easterly unit of medium-pressure metasediments. The D2 deformation was most intense in the rheologically weak migmatitic unit where it almost completely reworked the older D1 fabric. On the other hand, the medium-pressure metasediments were only re-folded into large-scale open folds. The D2 deformation was associated with extensive melting, resulting in widespread migmatitization and intrusion of the Amspoort-type granitoid body. Continuous deformation and decreasing temperature conditions caused brittle-ductile D3 deformation of migmatitic lithologies. Stress concentration into rheologically weak, biotite-rich Amspoort-type intrusion and surrounding metasediments resulted in the appearance of a secondary transpressional shear-zone parallel to the PSZ.

The observed succession of structures suggests that the orientation of main compression remains the same during the whole tectonic history of the studied area. Major switch from D1 oblique thrusting into D2–D3 transpression is attributed to substantial weakening of the western unit by its low-pressure melting. This process allowed the development of a crustal-scale shear zone at the contact with rheologically more competent medium-pressure metasediments of the eastern unit.

References

DÜRR S.B. and DINGELDEY D.P., 1996. The Kaoko belt (Namibia): Part of a late Neoproterozoic continental-scale strike-slip system. *Geology*, 24: 503-506.

GRUNER B., 2000. Metamorphoseentwicklung im Kaokogürtel, NW-Namibia: Phasenpetrologische und geothermobarometrische Untersuchungen panafrikanischer Metapelite. PhD. Thesis, University of Würzburg, Germany.

Crystalline Rock Clasts from the Visean Conglomerates – the Missing Link in the Evolution of the Moldanubian Zone?

Jana KOTKOVÁ[1], Jaromír LEICHMANN[1], Milan NOVÁK[1] and Stanislav HOUZAR[2]

[1] *Masaryk University, Kotlarska 2, 611 37 Brno, Czech Republic*

[2] *Moravian Muzeum, Dept. of mineralogy and petrography, Zelný trh 6, 659 37 Brno, Czech Republic*

Crystalline rock clasts in the Luleč conglomerates (Upper Visean) of the Drahany culm have been studied in order to shed light on the lithological character and tectonic structure of their source area as well as to constrain the rate at which the potential lower crustal rocks were exhumed to the surface. Based on the presence of migmatitic gneisses, durbachites (dated at 343±7 Ma), cordierite and tourmaline-bearing granites, granulites and graphitic quartzites with V-bearing muscovite it can be concluded, that the Moldanubian Zone (Gföhl unit ± Drosendorf unit) represented a major source for the clastic material. However, this idea is modified by our new data. First, we found exotic rock types not known from the present erosion level. These are calc-alkaline volcanic rocks (dacite-andesite-rhyolite, including volcanic equivalents of durbachites) with geochemical characteristics suggesting a volcanic arc environment, biotite granites which are untypical for Moldanubian pluton and strongly peraluminous garnet-cordierite-sillimanite-bearing granulites. Second, presently outcropping rocks at the surface do not have proper equivalents among the studied clasts: no mafic durbachite types were found, tourmaline granites have slightly different geochemistry. Felsic granulites lack alumosilicate or contain just rare sillimanite, and both acid and intermediate granulite types reflect extensive medium-pressure (re)-equilibration. Moreover, graphitic quartzite is the only representative of the Variegated (Drosendorf) unit. Some of the crystalline rocks have a lower-grade character compared to the Moldanubian – these are abundant muscovite-bearing gneisses and migmatites. Lower-grade rock fragments are present also in the associated greywackes (mica-schists, marbles, volcanites and older sediments in addition to quartz and other mineral fragments).

U-Pb zircon data from granulite clasts (~ 338–339 Ma, Kotková and Parrish, 2000) are consistent with a Neo-Variscan high-temperature event, as typical for granulites from the present erosional level. We suppose that the zircon data record our peak P-T conditions (> 820 °C). The upper limit of the monazite U-Pb ages (337–332) overlap within the error with the zircon data, and the lower one with those from rutile (332±1–3, 329±5 Ma). P-T data indicate isothermal decompression over at least 15 km from depths corresponding to ~ 12 kbar (at min. 820 °C) to about 6.5 kbar and 820 °C, i.e. a region of a perturbed geotherm (> 90 mW/m^2). This lower-pressure event is possibly dated by crystallization of the latest monazite. These data are consistent with a two-stage evolution of the granulites, with the initial rapid exhumation (isothermal decompression) to mid-crustal depths of ~ 20 km, followed by an isobaric cooling stage.

Based on our data we assume, that the clasts were derived from a shallower structural level than represented by present-day surface (e.g. characterized by the presence of volcanic arc rocks). High-pressure rocks (kyanite-bearing granulites, peridotites) occurring now at the highest structural level of the Gföhl unit are absent in the Upper Visean sediments but occur in the Permian sediments of the Boskovice furrow. This can be taken as an evidence for sequential Carboniferous nappe stacking and implies that the present tectonic structure of the E margin of the Bohemian Massif was finalized between the Upper Visean and Stephanian.

This research was supported by the GAČR project No 205/99/0567 and research project CZ:J07/98:143100004.

References

KOTKOVÁ J. and PARRISH R.R., 2000. Evidence for high exhumation rate in Central European Variscides: U-Pb ages of granulite metamorphism of clasts deposited in Upper Visean conglomerates. *Geolines*, 10: 41-42.

Alpine Metamorphism in the Veporicum Unit: Differences in Reaction Mechanisms between Basement and Overlaying Sediments (Inner Western Carpathians)

Martin KOVÁČIK

Štátny Geologický ústav D. Štúra, Mlynská dolina 1, 817 04 Bratislava, Slovakia

The lower metamorphic grade of the clastic Upper Paleozoic-Mesozoic cover sediments in comparison to the Alpine reworking of the basement rocks was apparent a long time ago. However, this fact did not have to necesarilly reflect considerably different metamorphic condition, as suggested by Vrána (1966). Another interpretation of the different Alpine metamorphic assemblages in the basement and the cover sediments is based on a metamorphic zoning of rock pile, composed of the corresponding Veporicum, Gemericum and ultra-Gemericum Units (Plašienka et al. 1999). In the basement metapelites, regionally metamorphosed under prevailing amphibolite facies conditions in the Hercynian time (e.g., Zoubek, 1936), locally newly-formed garnet (enriched in grossularite component), staurolite, kyanite and tschermakitic amphibole have developed, thus reflecting peak conditions of the Alpine regional metamorphism of barrovian type (Vrána 1966, 1980; Méres and Hovorka, 1991; Kováčik et al., 1996, 1997). Absence of these higher-grade metamorphic assemblages in the Permian-Triassic clastic beds was explained by monotonous lithology of the cover rocks (Vrána, 1966). Petrographic observations on regional scale showed that the Alpine metamorphism did not establish equilibrium in the cover metasediments, as the clastic micas, plagioclase, K-feldspar are commonly preserved, and the argilliferous matrix is also frequently poorly recrystallized. Similarly, the Hercynian basement metamorphic assemblages were entirely replaced by the Alpine mineral assemblages only scarcely. Prevailing regional mineral transformations in the basement metapelites include: replacement of pre-Alpine garnet (almandine-spessartine-pyrope) by chlorite, biotite and local grossular-rich rims; chloritization or recrystallization of biotite in fine-grained biotitie mass; sericitization of plagioclase; decomposition of staurolite (or rare Al-silicates) giving rise to white micas and chloritoide. Amphibolites are retrogressed in this manner: chloritization, biotitization, epidotization, silicification, albitization and the pre-Alpine Ca-amphiboles are transformed into actinolitic types.

In the overlaying Alpine units lithologic types of similar bulk-composition as within the basement metamorphites also occur. For example, metamorphic growths of white micas, chloritoide and rare kyanite (Vrána, 1964) are mainly linked to lithologies rich in pelitic compound, which occurred in the overthrust Gemericum Carboniferous Unit (s.l.) and sometimes in the Veporicum Permian cover-rocks. The absence of the highest grade Alpine metamorphic minerals – staurolite, garnet, (biotite) - could have been caused by a higher water content in these sediments, which were not enough dehydrated prior to the Alpine metamorphism. In the Alpine times, these rocks underwent progressive metamorphism, whereas the prior thermally reworked basement rocks suffered only retrograde metamorphism by means of fluid influx (mainly hydration).

Metamorphic crystallization of “wet” sediments run by means of dehydration reactions, which generally show endothermic effects (Bucher and Frey, 1994). Such a need of heat may induce a certain lag of metamorphic reactions path in the sediments. On the contrary, hydration-type of reactions taking part in alterations of “dry” basement mineral assemblages show exothermic effects. From this point of view, it is necessary to expend less amount of heat for the formation of Alpine mineral assemblages in the basement than for the adequate metamorphic reactions in the overlaying (meta)sediments.

References

BUCHER K. and FREY M., 1994. Petrogenesis of Metamorphic Rocks. Springer Verlag, Berlin.

KOVÁČIK M., KRÁĽ J. and MALUSKI H., 1996. Alpínsky metamorfný a termochronologický vývoj juhoveporických predalpínskych metamorfitov. *Miner. Slovaca.*, 28: 185-202.

KOVÁČIK M., KRÁĽ J. and MALUSKI H., 1997. Alpine reactivation of the southern Veporicum basement: metamorphism, 40Ar/39Ar dating, geodynamic model and correlation aspects with the Eastern Alps. In: P. GRECULA, D. HOVORKA and M. PUTIŠ (Editors), Geological evolution of the Western Carparhians. Miner. Slovaca-Monogr., pp.163-174.

MÉRES Š. and HOVORKA D., 1991. Alpine metamorphic recrystallization of the pre-Carboniferous metapelites of the Kohút crystalline complex (the Western Carpathians). *Miner. slovaca*, 23: 435-442.

PLAŠIENKA D., JANÁK M., LUPTÁK B., MILOVSKÝ R. and FREY M., 1999. Kinematics and Metamorphism of a Cretaceous Core Complex: the Veporic Unit of the Western Carpathians. *Phys. Chem. Earth*, 24: 651-658.

VRÁNA S., 1964. Chloritoid and kyanite zone of alpine metamorphism on the boundary of the Veporides and the Gemerides. *Krystalinikum*, 2: 125-143.

VRÁNA S., 1966. Alpidische Metamorphose der Granitoide und der Foederata-serie im Mittelteil der Veporiden. *Zbor. geol. vied, rad ZK*, 6: 29-84.

VRÁNA S., 1980. Newly formed Alpine garnets in metagranitoids of the Veporides in relation to the structure of the Central zone of the West Carpathians. *Eas. miner. geol.*, 25: 41-54.

ZOUBEK V., 1936. Poznámky o krystaliniku Západních Karpat. *Věstník SGÚ*, 12: 207-237.