2000, Maros and Pásztor 2001). The samples represent a large depth interval (50–500 m). The average declination of more than 50 oriented samples is approx. 180°, the inclination is about 10° indicating low paleo-lattitude position of the Mórágy Granite in the Carboniferous. Our results are in good agreement with the previous data of Márton and Márton (1989) on "granite" samples from surface outcrops. The new data imply that there was no significant time difference between the emplacement of the pluton and the crosscutting leucocratic dykes from paleomagnetic point of view.

The magmatic complex suffered regional metamorphism resulting in the formation of an (E)NE-(W)SW striking, steeply dipping (generally >80°) foliation (S_1), that is overprinted in many places by a less steep (dip angle between 40–75°) foliation (S_2) transposing S_1 foliation in various degrees. Both foliations dip in the same direction, mostly to the NW, in certain zones to the SE, which might reflect a late folding event (Maros et al. 2004, Király and Koroknai 2004).

Rarely occurring, narrow (cm to some dm scaled) mylonitic shear zones are mostly parallel to the S_2 foliation (Maros et al. 2004). Kinematic indicators show top-to-the-(S)SE (or top-to-the-N in the case of SE dipping foliation, respectively) thrusting in the XZ sections. However, occasionally oblique to pure strike slip movement (both sinistral and dextral motions) occur as well. The mylonitic shear zones occur preferentially in fine-grained aplites/microgranites suggesting strong strain-partioning between these rheologically weaker leucocratic dykes and the surrounding host rocks at (upper-)middle crustal levels.

The anisotropy of magnetic susceptibility (AMS) in the Mórágy Granite was also measured in oriented samples collected from two boreholes (Üh-26 and Üh-29). The results gave the orientation of the magnetic fabrics to a depth of 400 meters, hence, a relatively large volume of rock mass could be checked for the homogenity. Although the anisotropy (max/min susceptibility) is rather low (<1.2), a consistent relationship was found between the orientation of the foliation formed by solid-state deformation during metamorphism and the magnetic fabrics: the minimum susceptibility is practically perpendicular to the foliation in all samples, clearly indicating that magnetic fabrics reflects the influence of regional metamorphism which obliterated the previous magnetic fabrics formed at the magmatic stage. However, the paleomagnetic directions seem not to be changed during the metamorphism.

Finally, a case study demonstrates the interrelationship between paleomagnetic directions and late brittle tectonics in the pluton. The paleomagnetic data from two nearby drillhole sections (Üh-2 and Üh-22) suggest a slight block tilting on the different sides of a strike-slip zone of probably Miocene age.

References

BUDA Gy., 1985. Formation of Variscan collisional granitoids. (in Hungarian) Candidate thesis, Eötvös University, Budapest, Hungary.

KIRÁLY E. and KOROKNAI B., 2004. The magmatic and metamorphic evolution of the north-eastern part of the Mórágy Block. Annual Rep. of Geol. Inst. of Hung. from 2003, pp. 299–318.

KLÖTZLI U.S., BUDA Gy. and SKIÖLD T., 2004. Zircon typology, geochronology and whole rock Sr–Nd isotope systematics of the Mecsek Mountains granitoids in the Tisia Terrane (Hungary) *Mineralogy and Petrology*, 81: 113-134.

MAROS Gy. and PALOTÁS K., 2000. Evaluation of planar features in Boreholes Üveghuta Üh-22 and Üh-23 with Core-Dump software. Ann. Report of the Geol. Inst of Hungary from the year 1999, pp. 315–340.

MAROS Gy. and PÁSZTOR Sz., 2001. New and oriented core evaluation method: IMAGEO. *European Geologist*, 12: 40-43.

MAROS Gy., KOROKNAI B., PALOTÁS K., FODOR L., DUDKO A., FORIÁN-SZABÓ M., ZILAHI-SEBESS L. and BÁN-GYŐRY E., 2004. Tectonic analysis and structural evolution of the north-eastern Mórágy Block. Annual Rep. of Geol. Inst. of Hung. from 2003, pp. 371–394.

MÁRTON E. and MÁRTON P., 1989. A compilation of paleomagnetic results from Hungary. *Geophys. Transact.*, 35/1-2: 117-133.

Surface Exposures of Pre-Mesozoic Basement in the Ipeľ Depression: Geological Structures, Polymetamorphism, and CHIME Dating of Monazite

Martin KOVÁČIK and Patrik KONEČNÝ

Slovak Geological Survey, Mlynská dolina 1, 817 04 Bratislava, Slovakia

The Pre-Cenozoic basement of Ipeľská kotlina Depression is built up by Veporic Unit – one of the principal tectonic units of the West Carpathians. The Veporicum Unit has been divided into two parts – the Southern and the Northern Veporicum, which was based essentially on the different lithostratigraphic records of the Mesozoic cover formations (Biely 1964, Biely et al 1996). Generally, the areal extent of cover rocks was strongly reduced by erosion. Veporicum in the basement of Ipeľská kotlina Depression corresponds to the Southern Veporicum part as being shown by geographic space relations and many analogous geologic features. Basement rocks

beneath the Tertiary formations is formed predominately from basement metamorphites, which cropping out on the NE from the local town Šahy. This basement built the core of the NE-SW trending Šahy elevation (Vass et al. 1963), which is covered by 400–600 m thick formations of Neogene. Investigated rocks outcrop in the valley of Berinčenský – and Ólvárský potok Brook and they show the only possibility to measure directly their mesoscopic structural elements. These diaphtoresed basement metamorphites consist mostly of mica schists, quartzitic schists, and amphibolites, locally. Several boreholes penetrating below the Cenozoic cover evidenced also variegated types of metamorphic rocks in the wider area.

The foliation planes are conformably inclined under shallow to middle angles to the NW (310°–340°/ 35°–45°) and they represent a superimposed diaphtoric (phyllonitic) foliation s_2. The b–axes of microfolds pass sub-horizontally mostly in ENE–WSW directions (50°–230° to 80°–260°), the course of lineations is similar. In places, micas oriented along the b–axes microfold express stretching lineation testifying propagation of the linear anisotropy. Crossing of two lineations or subordinate cleavage foliation planes appear seldom, too. Dominant cleavage foliation (s_2) and the linear structures show many features in common with the Alpine (Cretaceous) tectodeformation of the Veporicum Unit. In phyllonitised metamorphites, relic, steeply dipping structures with usually coarse grain banding are to be recognized, locally. The pre–Alpine domains of X-dm in size presumably express Hercynian metamorphic foliation fabrics (s_1).

However, in the uprised adjacent Southern Veporicum area dip of phyllonitic foliation to NW is rare, on the contrary, dipping to S and SE is dominant, here. The reason of the opposite strike of dip of Šahy elevation metamorphites may be caused by block rotation along the horizontal axis, resulting in formation of a half-horst structure. Another explanation of the NWN – NW dipping of basement structures may stem from parallelisation with the northerly dipping southern flank of the "Tuhár tectonic fan" (Fusán 1962, Plašienka 1983). Apart from structural interpretations, this basement inclination signalises an extensional normal faulting of Šahy elevation towards north in time of its formation.

Synsedimentary Badenian fault-system of NNW-SSE direction together with an earlier NW-SE faults belong to more than once reactivated tectonic systems controlling the formation of the Ipeľ depression (Vass 1963, Vass et al. 1993). The Šahy elevation was transversally faulted/segmented in this manner, too. In investigated crystalline rocks was observed expressive joint systems of this course very frequently. It may be classified according to Sander (1948) as ac joint systems perpendicularly oriented to the genetically related fold b-axis and lineation. Thus, this joint system was presumably associated with Alpine (Cretaceous) linear fabrics.

Reliable indicators of the Hercynian metamorphism represent 0,5-1 cm large metablasts of almandine type garnet showing progressive metamorphic zoning. Common pre-Alpine mineral assemblages (metapelites: ga-bt-ms-qtz-pl; amphibolites: hbl-plg-qtz) and their chemical composition evidence achieving of metamorphic condition about the boundary greenschist/ amphibolite facies. Alpine reworking is characterized by penetrative deformation manifested mainly by new cleavage planes and replacement mineral assemblages (msII- btII-chl; chl-ep-bt). Garnet porphyroblasts were frequently cataclased by the Alpine shear deformations and their relic fragments were stretched into ellipsoid-shaped formations. This micro-phenomenon together with mesoscopic deformational structures point out the transpressive regime of the Alpine diaphtoresis. Fine-grained fragments of garnet were not recovered by grossularite enriched rims as symptomatic in Southern Veporicum basement. Fading of Alpine thermal reworking in the Kohút Zone from NE to SW (Kováčik et al. 1996) may continue also in the basement of Ipeľ kotlina depression.

In the muscovite – quartzitic metamorphites there was analysed Th, U, Pb and Y in monazites by means of electron microprobe (Cameca SX-100). Aggregates of tiny monazite grains indicate growth on expense of a Th – REE mineral-precursor: xenotime relics were tentatively proved. Preliminary results of "CHIME" geochronology enabled to confirm the two staged metamorphic genesis of the investigated rocks. Results of chronological recalculation (Montel et al. 1996) of the main mass of monazite crystals gather between values 343–386 Ma (sample 1) or 296–360 Ma (sample 2), thus reflecting Hercynian thermal history. Newly formed irregular selvages around the monazites show a compositional contrast with the core and yield ages in between 112–120 (±34) Ma. These Alpine ages, recrystallisation phenomena, and bimodal monasite age a spectrum resembles to leucophyllite forming (88–134 Ma) in the central part the southernmost Veporicum (Kováčik 1996). From this CHIME dating can be inferred a relatively low thermal origin/recrystallisation of Alpine monazite phases, which can be confined in the middle part of the greenschist facies.

References

BIELY A., 1964. Ueber die "Veporiden". *Geol. Sbor.*,15: 263-266.

BIELY A., BEZÁK V., ELEČKO M., GROSS P., KALIČIAK M., KONEČNÝ V., LEXA J., MELLO J., NEMČOK J., POTFAJ M., RAKÚS M., VASS D., VOZÁR J. and VOZÁROVÁ A.,1996. Explanation to geological map of Slovakia 1:500,000. Geological Survey of Slovak Republic, Dionýz Štúr Publishers, Bratislava, 6-76.

FUSÁN O., 1962. Stratigrafické postavenie karbonátového súvrstvia medzi Tuhárom a Ružinou, s. od Lučenca. *Geol. Práce – Zošity*, 62.

KOVÁČIK M., 1996. Kyanite – Mg-chlorite schist and its petrogenetic significance (Sinec massif, Southern Veporic Unit, Central Western Carpathians). *Geol. Zb. Geol. Carpath*, 47: 245-255.

KOVÁČIK M., KRÁĽ J. and MALUSKI H., 1996. Metamorhic rocks in the Southern Veporicum basement: their Alpine metamorphism and thermochronologic evolution. *Mineralia Slov.*, 28: 185-202.

MONTEL J. M., FORET S., VESCHAMBRE M., NICOLLET CH. and PROVOST A., 1996. Electron microprobe dating of monazite. *Chemical Geology*, 131: 37-53.

PLAŠIENKA D., 1983. Geologická stavba tuhárskeho mezozoika. *Mineralia slovaca*, 15: 49-58.

SANDER B., 1948. Einfuehrung in die Gefuegekunde der geologischen Koerper. Wien u. Innsbruck, 215 s.

VASS D., 1963. Tectonic mobility and its efect upon the miocene sedimentation of the Ipeľská kotlina basin. *Geol. Práce, Správy*, 28: 145-450.

VASS D., HÓK J., KOVÁČ P. and ELEČKO M., 1993. The Paleogene and Neogene tektonic events of the Southern Slovakia depression in the light of stress-field analyses. *Miner. Slovaca*, 25: 79-82.

New $^{207}Pb/^{206}Pb$ Zircon Ages from the East Karkonosze Metamorphic Complex, West Sudetes – Evidence of the Late Cambrian – Early Ordovician Magmatism

Wiesław KOZDRÓJ[1], Krzysztof TURNIAK[2], Marion TICHOMIROVA[3], Klaus BOMBACH[3], Vaclav KACHLÍK[4] and Małgorzata ZIÓŁKOWSKA-KOZDRÓJ[2]

[1] Polish Geological Institute, Lower Silesian Branch, Al. Jaworowa 19, 53-122 Wrocław, Poland
[2] Institute of Geological Sciences, University of Wroclaw, pl. M.Borna 9, 50-204 Wroclaw, Poland
[3] Technische Universitat Bergakademie Freiberg, Institute of Mineralogy, Brennhausgasse 14, 09599 Freiberg, Germany
[4] Department of Geology, Faculty of Science, Charles University, Albertov 6, 128 43 Praha 2, Czech Republic

The East Karkonosze Metamorphic Complex located in the Rudawy Janowickie Mts with continuation in the Rychory Mts (West Sudetes) forms an eastern envelope of the Carboniferous Karkonosze granite and is composed of two main litho-tectonic units: Kowary-Czarnów Unit (KCU) and Leszczyniec Unit (LU) (Kozdrój 2003).

The Kowary-Czarnów Unit is built of a metamorphosed sedimentary – volcanic succesion of Neoproterozoic (?) to Cambrian age which hosts several elongated bodies of ortho-gneisses representing S-type granite intrusions. One body from Kowary was dated on c. 492–481 Ma (U-Pb, zircon: Oliver et al. 1993). Comparable Karkonosze gneisses from the South Karkonosze Metamorphic Complex yielded an age of c. 503–505 Ma (Pb-Pb zircon ages: Kröner et al. 2001). The Cambrian age of KCU meta-sediments was recently confirmed by recognition of Lower Cambrian archaeocytha remnants found in crystalline limestones nearby Dolni Albeřice in Rychory Mts (Hladil et al. 2003). Volcanics of KCU prevailingly occur at the top of the succession and are represented by metabasites (from alkaline, within-plate to tholeiitic N-MORB types) and subordinate interlayers of acid metavolcanics (= porphyroids, leptynites) which are of extrusive or subvolcanic origin. Porphyroids from Dolni Albeřice were dated on 501±8 Ma (Rb-Sr, whole rock; Bendl and Patočka 1995). All these rocks are strongly sheared and metamorphosed up to amphibolite facies (partly in HP blue-schists conditions) due to Variscan nappe stacking.

The Leszczyniec Unit is devoid of sedimentary strata and consists exclusively of a few km thick meta-volcanogenic, Na-rich spilite-keratophyre association (originally: tuffs, volcaniclastics and lavas) penetrated by meta-igneous rocks, numerous bodies of so called Paczyn gneisses and less frequent meta-gabbros and diorites. Spilites, at present epidote-amphibolites, greenstones and greenschists, showing mostly N-MORB chemical characteristics, are closely interbedded with keratophyres – now laminated quartz-albite-chlorite schists or massive granofelses – derived from dacite - rhyodacite - rhyolite suite. These rocks are metamorphosed up to higher level of the greenschist facies but show less intense shearing than observed in KCU. Paczyn gneisses form concordant, sill-like or cross-cutting, irregular intrusions (within, in between the) spilite-keratophyre association. They represent different petrographic varieties including granodiorites, granites and leucotonalites but are chemically rather uniform and very similar to keratophyres. They resemble Na-rich plagiogranites interpreted as intrusives of the ocean ridge ophiolitic sequence (Szałamacha & Szałamacha 1991) or trondhjemites - magmatites related with volcanic arc (Narębski et al. 1986). The age of one small pod of these acid rocks was determined at 505±5 Ma (U-Pb, zircon: Oliver et al. 1993). The youngest rocks of the LU are hornblende-zoisite amphibolites derived from gabbros and diorites which intruded at c. 494±2 Ma (U-Pb, zircon: Oliver et al., op.cit.). These meta-gabbros & diorites have low Zr and Y concentrations and a distinct Nb negative anomaly typical of primitive low-K island arc basalts.

New isotope datings using the zircon evaporation $^{207}Pb/^{206}Pb$ method were performed with the aim to check out previous geochronological results and to precise the time of magmatic events in the East Karkonosze Metamorphic Complex. Single zircons or groups of 3 to 10 crystals were evaporated and for the following samples – listed below – a mean age from 5 to 8 measurements for each rock was obtained.

Samples from Kowary-Czarnów Unit:

- leptynite, locality: Janowice Stare (sample JSTR); pinkish, fine-grained quartz-feldspar schists with well developed foliation, possible protolith: acid subvolcanic rock, mean age: 493±11 Ma,
- meta-porphyroid, locality: Dolni Albeřice (sample HA-KVK2); yellowish, thinly laminated gneiss with a perfect mylonitic foliation, possible protholith: acid subvolcanic rock with porphyritic fabric, mean age: 512,0±8 Ma,