the northern part of the Magura Basin (Poprawa et al., 2002). The Paleocene – Middle Eocene subsidence In the Magura Basin was related to the uplift of the Pieniny Klippen Belt and formation of an accretionary prism, which caused a shift of depocenters towards the north. The northern, deepest part of the basin, often lying below the CCD, was dominated by basinal turbidites and hemipelagites. During the Eocene, the axes of subsidence of the Magura Basin migrated towards the north.

The Latest Eocene – Burdigalian – orogenic stage is characterized by a collision, perhaps terrane–continent, with the accompanying convergence of two large continents. Terranes in the circum-Carpathian region Adria–Alcapa (Inner Carpathians) continued in their northward movement during the Eocene – Early Miocene (Golonka et al., 2000). Their oblique collision with the North European plate led to the development of the accretionary wedge of Outer Carpathians. During the Priabonian and Rupelian, a prominent uplift was recorded in the Outer Carpathian basin. The Outer Carpathian remnant oceanic basins turned into foreland basins (Oszczypko, 1999). The Oligocene subsidence was accompanied by a progressive migration of axes of depocentres towards the north. After the Late Oligocene folding, the Magura Nappe was thrust northwards onto the terminal Krosno flysch basin. This was followed by the last, minor subsidence event (Oligocene – Early Miocene) which can be partially related to the load of the accretionary wedge. The centres of subsidence were located in the Krosno basin and Magura piggy-back basin.

Africa converged with Eurasia during the Miocene. A direct collision of the supercontinents never happened, but their convergence did not leave much space, leading to the permanent setting of the Alpine–Carpathian system. Tectonic movements caused final folding of the basin fills and created several imbricated nappes which generally reflect the original basin configurations. During thrusting, the marginal part of the advanced nappes was uplifted whereas in inner part sedimentation continued in the remnant basin. Big olistoliths were often sliding down from uplifted parts of the nappes into the adjacent, more outer basins. The nappes became uprooted from the basement and the allochtonous rocks of the Outer Carpathians were thrust northward in the west and eastward in the east onto the North European Platform for a distance of 50 km to more than 100 km. Thrusting migrated along the Carpathians from the west towards the east. The inner part of the platform, including the marginal part of the flysch basin in the east, started to downwarp in front of the advancing Carpathian nappes, and a tectonic depression formed during the Early Miocene. It was filled with thick molasse deposits. At the end of the Burdigalian the basin became overthrust by the Carpathians and a new, more external one, developed. Clastic and fine-grained sedimentation of the Carpathian and foreland provenance prevailed with a break during the Late Langhian to Early Serravallian, when younger evaporate basin developed. Olistostromes were locally deposited (Oszczypko, 1998) with material derived from the Carpathians and the inner margin of the molasse basin. During the Langhian and Serravallian, a part of the northern Carpathians collapsed and sea invaded the already eroded Carpathians. The foreland basin and its depocentre migrated outward and eastward, simultaneously with the advancing Carpathians nappes. As a result, the Neogene deposits show diachroneity in the foreland area. Sedimentation terminated in the Langhian already in the west and continued till the Pliocene in the east. These events mark the postcollisional stage in the evolution of the Outer Carpathians.

Acknowledgements

This research was financially supported by the Polish Committee for Scientific Research (KBN) – grant project 6P04D 04019.

References

GOLONKA J., OSZCZYPKO N. and ŚLĄCZKA A., 2000. Late Carboniferous – Neogene geodynamic evolution and paleogeography of the Circum-Carpathian region and adjacent areas. *Ann. Soc. Geol. Pol.*, 70: 107-136.

OSZCZYPKO N., 1999. From remnant oceanic basin to collision-related foreland basin – a tentative history of the Outer Carpathians. *Geol. Carp.*, 50 (special issue): 161-163.

OSZCZYPKO N., 1998. The Western Carpathian Foredeep – development of the foreland basin in front of the accretionary wedge and its burial history (Poland). *Geol. Carp.*, 49: 415-431.

POPRAWA P., MALATA T. and OSZCZYPKO N., 2002. Tectonic evolution of the Polish part of Outer Carpathian's sedimentary basins – constraints from subsidence analysis. *Przegl. Geol.*, 11: 1092-1108.

European Suture in the Carpathians and the Scientific Problems of the Orava Deep Drilling Project

Jan GOLONKA[1] (reporter), Marek LEWANDOWSKI[2], Andrzej ŻELAŹNIEWICZ[3] and the Orava Deep Drilling Project Scientific Committee

[1] *Jagiellonian University, Institute of Geological Sciences, Oleandry 2a, 30-063 Kraków, Poland*
[2] *Instytut Geofizyki, Polska Akademia Nauk Ul. Księcia Janusza 64, 01-452, Poland*
[3] *Instytut Nauk Geologicznych PAN, ul. Podwale 75, 50-449 Wrocław, Poland*

A significant progress in the investigations of geodynamics and plate tectonics of the Carpathian orogen was achieved in the last years (Birkenmajer, 1988; Golonka et al., 2000; Kováč et al., 1998; Plašienka et al., 1991; Plašienka, 1999). This progress enabled to formulate new scientific ideas and highlight problems that could be solved by scientific drilling. In Poland, Slovakia and the Czech Republic, Carpathian Fold Belt consists of an older unit known as the Central (or Inner) West Carpathians (CWC), and a younger one, known as the Outer West Carpathians (OWC), the latter being thrust over the southern part of the European Platform (Cadomian or Hercynian basement). The depth of the cratonic basement in the suture zone, according to the results of the deep seismic (CELEBRATION profile; Guterch et al., 2001), magnetotelluric and magnetic soundings (Jankowski et al., 1985), is below 6–8 km (basement depth calculated from the platform bending is 10 km). An enigmatic basement uplift exists despite the general southerly dip of the European Platform under NW Carpathians that may be caused by the geothermal uplift of the asthenosphere replacing delaminated lithosphere or by mantle plumes, or by the basement-involved thrust faults. The boundary between the overriding CWC (Alcapa plate) and the European plate is the Pieniny Klippen Belt (PKB), built of the Mesozoic sedimentary successions, once deposited in basins situated between the European craton and the margin of the northern Africa. At present, the PKB is an almost 700 km long, strongly compressed and tectonically complicated suture zone. In this relatively narrow belt (comprising the PKB and adjacent, still poorly recognized units), there is a wealth of unanswered questions that hamper a better understanding of the evolution of the Central European Alpine system. These questions and problems can be grouped into several disciplinary topics, which combine both regional and continental-scale issues.

TOPIC 1. Stuctural position of the PKB within the CFB and its meaning for a reconstruction of the Cenozoic Alpine system of Europe.

The PKB, which is one of the most complicated and enigmatic structures within the CFB, is bounded by probably first-order strike-slip faults both in the north and the south. In-depth structure and geometry of the PKB are unknown. In order to solve fundamental obstacles in the reconstruction of the CFB evolution, the following points need to be addressed:

1. structural relationships between the PKB and adjacent formations;
2. nature of the contact zones, magnitude and relative displacement between contacting units;
3. verification of models, identification of the subduction type (A or B) and direction within the CFB;
4. geometry of the PKB suture at depth;
5. total thickness of the Lower Miocene deposits in the context of the evolution of the foreland basin;
6. identification of the tectonic units beneath the Magura nappes overthrust;
7. paleogeographic disposition of the PKB basins.

TOPIC 2. Relationship between geotectonic and geodynamic setting and magmatogenesis.

The Flysch Belt, adjacent to the PKB from the north, also contains andesitic Neogene (Sarmatian) volcanic rocks, whose origin is interpreted as a combined effect of the mantle uplift and subduction processes. In effect, extensional regime is exerted within generally compressional stress field, a situation unique within the Alpine system of Europe, with yet not fully recognized impact for the orogen evolution. A temporal and spatial definition of the igneous activity, together with precise geochemical and petrological characteristics of whole rocks and mineral phases is of fundamental importance in order to solve the relative contribution of asthenosphere and lithosophere to the magmatic products emplaced during the Alpine orogeny. Worth note is the presence in the study area of OIB-like (OIB = Ocean Island Basalt) mantle melts with extreme geochemical and isotopic features (e.g., extremely unradiogenic $^{87}Sr/^{86}Sr$, coupled with radiogenic $^{143}Nd/^{144}Nd$ and $^{206}Pb/^{204}Pb$ and $^{208}Pb/^{204}Pb$) among the Cenozoic European Volcanic Province (CEVP) products (e.g., Alibert et al., 1987; Bluzstain and Hart, 1989; Wilson and Patterson, 2001; Lustrino, 2002).

TOPIC 3. Nature of the geophysical anomalies.

TOPIC 4. Geothermal issues.

TOPIC 5. Geodynamic reconstruction of the Mesozoic–Cenozoic basins.

TOPIC 6. Oil generation, migration and timing.

TOPIC 7. Regional heat-flow evolution.

TOPIC 8. Identification and definition of the Cadomian–Hercynian basement structure of the Carpathians.

TOPIC 9. Paleostress evolution and its changes in horizontal and vertical section.

All these topics are potential issues to be solved by the drilling. Based on the current stage of knowledge, if the basement of the Alpine orogen is to be reached and the rocks responsible for the anomaly are also to be recognized, the main drilling should reach the depth of 8000 m. Tentatively, we presume that ODDP could be located in the vicinity of the Hyżne village near the Polish–Slovak border to serve both Polish and Slovak scientists and to utilize international cooperation. It would be also situated along the CELEBRATION 2000 deep seismic profile line in the near vicinity of the deep geological cross-sections Kraków–Zakopane and Andrychów–Hyżne, utilizing the series of wells of the Polish Geol. Inst. and Polish Oil Industry.

References

ALIBERT C., LETERRIER J., PANASIUK M. and ZIMMERMANN J.L., 1987. Trace and isotope geochemistry of the alkaline Tertiary volcanism in southwestern Poland. *Lithos*, 20: 311-332.

BIRKENMAJER K., 1986. Stages of structural evolution of the Pieniny Klippen Belt, Carpathians. *Studia Geol. Pol.*, 88, 7: 32.

BLUSZTAJN J. and HART S.R., 1989. Sr, Nd, and Pb isotopic character of Tertiary basalts from southwest Poland. *Geochim. Cosmochim. Acta*, 53: 2689-2696.

GOLONKA J., OSZCZYPKO N. and ŚLĄCZKA A., 2000. Late Carboniferous – Neogene geodynamic evolution and paleogeography of the circum-Carpathian region and adjacent areas. *Ann. Soc. Geol. Pol.*, 70: 107-136.

GUTERCH A. et al., 2001. New deep seismic studies of the lithosphere in Central Europe. POLONAISE'97 and CELEBRATION 2000 seismic experiments. *Biul. Państw. Inst. Geol.*, 396: 61.

JANKOWSKI J., TARŁOWSKI Z., PRAUS O., PECOVA J. and PETER V., 1985. The results of deep geomagnetic sounding in the west Carpatians. *Geoph. J. R.A.S.*, 80: 561-574.

KOVÁČ M. et al., 1998. Palinspastic reconstruction of the Carpathian-Pannonian region during the Miocene. In: M. RAKÚS (Editor), Geodynamic development of the Western Carpathians. Bratislava.

LUSTRINO M., MELLUSO L. and MORRA V., 2002. The transition from alkaline to tholeiitic magmas: a case study from the Orosei-Dorgali Pliocene volcanic district (NE Sardinia, Italy). *Lithos*, 63: 83-113

PLAŠIENKA D., 1999. Tectonochronology and paleotectonic model of the Jurassic – Cretaceous evolution of the Central Western Carpathians. Veda, Bratislava.

WILSON M. and PATTERSON R., 2001. Intraplate magmatism related to short-wavelength convective instabilities in the upper mantle: evidence from the Tertiary-Quaternary volcanic province of Western and Central Europe. In: R.E. ERNST and K.L. BUCHAN (Editors), Mantle plumes: their identification through time. *Geol. Soc. Am. Spec. Paper*, 352: 37-58.

Magnetic Fabric of the Veľká Fatra Mts. Granitic Pluton – A Pilot AMS Study

Dagmar GREGOROVÁ[1], František HROUDA[2, 3] and Milan KOHÚT[4]

[1] *Geophysical Institute, Slovak Academy of Sciences, Bratislava, Slovakia*
[2] *Institute of Petrology and Structural geology Charles University, Prague, Czech Republic*
[3] *AGICO Ltd., Brno, Czech Republic*
[4] *Dionýz Štúr Institute of Geology, Bratislava, Slovakia*

The study of the anisotropy of magnetic susceptibility (AMS) of rocks provides a useful tool for structural geology and tectonics. In the Central Western Carpathians (CWC), basic results from magnetic fabric studies of most granitoid core mountains are available (for summary see Hrouda et al., 2002). However, AMS data from the Ľubochňa granite pluton of the Veľká Fatra Mts. are still missing. The Veľká Fatra Mountains typify the Core Mountains of the Tatricum, a major tectonic unit in the CWC. Their crystalline basement is represented by the Ľubochňa granitoid massif, consisting of four principal Hercynian granitic rock types building a multistage composite massif: the Smrekovica tonalite (ST) with xenoliths and wall rocks of paragneisses and orthogneisses, the Kornietov granodiorite (KGD), the Lipová granite (LG) and the Ľubochňa leucogranite (LLG). Field study as well as petrological and geochemical investigations revealed relative independence of the above granite types (Kohút, 1992) that reflect differences in the evolution of the Hercynian orogeny in the study area. Lower Carboniferous ages of magmatism of 340 ± 2 Ma were found for the KGD and 356 ± 25 Ma for the LG (Kohút et al., 1997) or 337 ± 9 Ma using cathodoluminescence-controlled single-grain (CLC) method by TIMS, as well as Ion-Microprobe (Poller et al., 2000). On the contrary, Upper Carboniferous age of 304 ± 2 Ma was detected for the ST (Poller et al., l.c.). In addition, magnetic properties (susceptibility and NRMP) differing in individual types of granitic rocks were revealed by Kohút (1992).

In this contribution we present results of our recent AMS investigation of 251 orientated samples from 23 localities of the Veľká Fatra Mts. The measurements were performed on the KLY-3S Kappabridge (Jelínek and Pokorný, 1997). Bulk magnetic susceptibility of the ST (84 samples / 8 localities) is the highest among all the rocks investigated. It ranges from 326×10^{-6} to $5{,}270 \times 10^{-6}$ [SI] with the mean value being $2{,}200 \times 10^{-6}$ [SI], suggesting I-type character of this granitoid. Bulk magnetic susceptibility of the KGD (67 samples / 6 localities) ranges from 46 to $3{,}960 \times 10^{-6}$ [SI] with the mean value being 620×10^{-6} [SI] and lying within the susceptibility range of S-type granites. Bulk susceptibility of the LG (90 samples / 8 localities) is slightly lower, ranging from 23 to $1{,}570 \times 10^{-6}$ [SI] with the main value being 160×10^{-6} [SI].

The degrees of magnetic lineation as well as magnetic foliation are relatively low in most of the samples, ranging from 1.02 to 1.05, with the foliation degree being slightly higher (1.05–1.10) only in ST. Planar magnetic fabric prevails in all granitoid types. In the ST, the magnetic lineation forms a well-