were analyzed by the $^{40}Ar/^{39}Ar$ step heating method. All samples show age spectra with well-behaved plateau. Results of isochrone regression in all cases are concordant with plateau age values. From a hbl+bt granite an amphibole revealed a vell defined age plateau at 351.1±3.7 Ma. A coexisting biotite yielded an oveall plateau age of 349.6±3.8 Ma. Muscovite from bt+ms granite showed a plateau age of 344.6±3.8 Ma whereasthe biotite concentrate of coexisting biotite yielded a corncordant plateau age of 343.1±3.8 Ma. Similar single zircon ages –348 Ma- were obtained by Kröner (unpublished data). These coincidental zircon and amphibole, biotite and muscovite ages imply fast cooling, and could be interpreted as cooling during tectonic exhumation and thrusting after the high pressure and high temperature events.

The work is supported by a research grant no. 6 P04D 011 20 from the State Committee for Scientific Research in Poland

References

BATCHELOR R.A and BOWDEN P., 1985. Petrogenetic interpretation of granitoid rock series using multicationic parameters. *Chemical Geology*, 48: 43-55.

CHAPPELL B.W. and WHITE A. J. R., 1974. Two contrasting granite types. *Pacific Geology*, 8: 173-174.

HARRIS N. B.W, PEARCE J.A. and TINDLE A. G., 1986. Geochemical characteristics of collision-zone magmatism. In: M. P. COWARD and A. C. RIES (Editors), Collision Tectonics, Geological Society Special Publication., 19, 67-81.

PEARCE J.A., HARRIS, N. B.W. and TINDLE, A. G. 1984. Trace element discrimination diagrams for the tectonic interpretation of granitic rocks. *J Petrol.*, 25: 956-983.

Some Remarks on the Geophysical Research of the Lithosphere

Miroslav BIELIK[1], Jozef VOZÁR[2], Ján ŠEFARA[3] and Jana DÉREROVÁ[1]

[1] *Geophysical Institute of the Slovak Academy of Sciences, Dúbravska cesta 9, 845 28 Bratislava 45, Slovak Republic*

[2] *Geological Institute of the Slovak Academy of Sciences, Dúbravska cesta 9, 845 28 Bratislava 45, Slovak Republic*

[3] *Department of Applied and Environmental Geophysics, Mlynska dolina, pav. G, 842 15 Bratislava, Slovak Republic*

The complicated structure of the Western Carpathian lithosphere with specific physical properties is a result of a complex geodynamic development of the orogen. On the surface, the structural pattern is documented by geology, but in the depth can be identified only by means of geophysics. Geophysical methods belong to one of the most important tools for the investigation of the structure and for the reconstruction of geodynamic development of the lithosphere in this region. The research of the Western Carpathian lithosphere consists of the application of the deep range geophysical methods, such as methods of seismic refraction a reflection profiling, seismology, gravimetry, magnetometry, magnetotelurics and geothermics. In our study of the structure and thickness of the lithosphere we used a modern method of integrated lithosphere modeling (Zeyen et al. 2002). 2D numerical models are based on a combined interpretation of heat flow, gravity data and topographic elevation. They have modeled lithosphere thickening underneath the central and eastern parts of the Western Carpathians. The lithosphere increases in thickness to a maximum of 140-150 km. The apparent lithosphere thickening was interpreted as a remnant of a subducted slab(s) of the European plate. Remnants of deep subduction below the Pannonian Basin have been detected earlier (Wortel and Spakman 2000). In addition to the slab detachment can be explained by the continuation of convergent movements between the overriding ALCAPA block and the European platform for a short time period after the slab break-off (Zeyen et al. 2002).

The western part of the Western Carpathians does not show lithosphere thickening (Zeyen et al. 2002). We suggest that the tectonic evolution of continental collision along the Carpathian orogen has changed in time and space. The differences in lithosphere thickness in these both parts of the Western Carpathians could be explained by the different geodynamic evolution during the Oligocene and Miocene. It is assumed that a compressional process during Miocene brought the northern (northeastern) segment of the Western Carpathians into frontal collision with the European platform, whereas the western segment suffered transpressional deformation due to oblique collision with the Bohemian massif (Csontos et al. 1992, Kováč et al. 1993).

Based on our results we constructed a new map of the lithosphere thickness in the ALCAPA region. The central and eastern parts of the Western Carpathians are bordered in the north by a thicker and stronger lithosphere of the European platform (100–150 km), which is underthrust (about of 50 km) beneath the margin of the overriding Carpathian orogen. Modification of the lithosphere depth was done only in the region, in which the profiles I, II, III, IV and V are located. Moreover, in this region we concentrated especially on the Western Carpathian area.

The hinterland of the Western Carpathians is characterized by a thin lithosphere. Typical for the back arc basin. Based on seismic and magnetoteluric measurements, the thinnest lithosphere (40 km) is located beneath the Békés Basin in Hungary (Posgay et al. 1995). The lithosphere under the other subbasins of the Pannonian Basin system reaches thickness of about 60 km (Horváth 1993). The integrated modeling of Zeyen et al. (2002) indicates a little bit larger lithosphere thickness (about 80 km) in this region. The extreme lithosphere thinning was probably caused by stretching of the overriding plate and associated asthenospheric mantle updoming (Bielik 1988).

The knowledge on structure of the crust in the Western Carpathians comes mainly from refraction measurements of the deep seismic sounding (e.g. Beránek et al. 1972; Mayerová et al. 1994) and reflection seismic measurements with the prolonged time of registration from 12 to 16 seconds (Tomek et al. 1987, 1989; Vozár et al. 1996). In our study we also take into account the first preliminary results of the international seismic experiment of the CELEBRATION 2000.

The crust of the Western Carpathians and neighboring tectonics units has a complex structure and is composed of fragments formed during Alpine and Hercynian orogenic cycles. The results of deep seismic refraction profiling indicate that the Moho does not form a sharp boundary but a transient zone up to several kilometers thick. The deep seismic reflection profiling confirmed collisional origin of the Western Carpathians. In generally, profile 2T shows typical nappe structures of the Western Carpathians and the Veporicum was interpreted as an Upper Cretaceous whole-crust collision suture. Profile also brought a new insight into the understanding of the history of the Tertiary deformation processes in the Western Carpathians. The whole crust flexure of the lower European plate can be explained as a result of subduction movements when passive continental margin of the Krosno Sea was subducted beneath the Carpathian-Pannonian plate (Tomek et al., 1987, 1989).

Based on new seismic reflection profiling data (Hrušecký 2000) as well as stripped gravimetric map the crustal thinning is assumed in the Danube basin. The thinning continues until the outer Western Carpathians. The crustal thinning is probably a result of the youngest (from the middle Miocene – Kováč, 2000) extension of the crust in this area, which is at the same time related to the oblique collision and decrease of the transpressing processes. We interpret a similar process also in the Eastern Slovak basin. Essentially, we are talking about a new discontinuity origin by the influence of the thermal conditions changes in the depth (neo-Moho).

The Western Carpathians are characterized by crust thickness of about 30–35 km. The Moho depth increases to 65 km underneath the Tornquist-Teysseyre zone (Gutterch et al., 1984). But the newest results of the POLONAISE and CELEBRATION 2000 experiments indicate that it is of about 45–50 km only. Note that the Carpathians are characterized by relatively thin crust in comparison with other orogens. The thinnest crust (25-30 km) can be observed in the Pannonian Basin System. Based on the results of CELEBRATION 2000, different tectonic units like the Western Carpathians, the European platform, TESZ and the Pannonian basin are characterized by very different the P-wave velocities. The results of CELEBRATION 2000 have also found out large differences in the thickness of the lower crust.

References

BERÁNEK B., DUDEK A., FEJFAR M., HRDLIČKA A., SUK M., ZOUNKOVÁ M. and WEISS J., 1972. The crustal structure of Central and South-Eeastern Europe based on the results of explosion seismology. *Geop. Trans., spec. ed.*: 87-98.

BIELIK M., L988. A preliminary stripped gravity map of the Pannonian Basin. *Physics of the Earth and Planetary Interiors*, 51: 185-189.

CSONTOS L., NAGYMAROSY A., HORVÁTH F. and KOVÁČ M.,1992. Tertiary evolution of the intra-Carpathian area; a model. *Tectonophysics*, 208: 221 - 241.

GUTERCH A., GRAD M., MATERZOK R., PAJCHEL J., PERCUČ E. and TOPORKIEWICZ S., 1984. Deep structure of the Earth's crust in the contact zone of the Paleozoic and Precambrian platforms and the Carpathian Mts. in Poland. *Acta Geophys. Pol.*, 32: 25-41.

HORVÁTH F., 1993. Towards a mechanical model for the formation of the Pannonian Basin. *Tectonophysics,* 226: 333-357.

HRUŠECKÝ I., 2000. Central part of the Danube basin in Slovakia: geophysical and geological model in regard to hydrocarbon prospection. *EGRSE*, VI: 2-55.

KOVÁČ M., 2000. Geodynamický, paleografický a štruktúrny vývoj karpatsko-panónskeho regiónu v miocéne. Veda Bratislava, 202. (in Slovak)

KOVÁČ M., NAGYMAROSY A., SOTÁK J. and ŠUTOVSKÁ K., 1993. Late Tertiary paleogeographic evolution of the West Carpathians. *Tectonophysics*, 226: 401-416.

MAYEROVÁ M., NOVOTNÝ M. and FEJFAR M., 1994. Deep seismic sounding in Czechoslovakia. In: V. BUCHA and M. Blížkovský (Editors), Crustal structure of the Bohemian Massif and the West Carpathians, Academia Press – Springer Verlag, pp. 13-20.

POSGAY K., BODOGY T., HEGEDÜS E., KOVÁCZSVÖLGYI S., LENKEY L., SZAFIÁN P., TAKÁCS E., TÍMÁR Z. and VARGA G., 1995. Asthenospheric structure beneath a Neogene Basin in SE Hungary. *Tectonophysics,* 252: 467-484

TOMEK Č., DVOŘÁKOVÁ L., IBRMAJER I., JIŘÍČEK R. and KORÁB T., 1987. Crustal profiles of active continental collision belt. Czechoslovak deep seismic reflection profiling in the West Carpathians. *Geophys. J. R. Astr. Soc.*, 89: 383-388.

TOMEK Č., IBRMAJER I., KORÁB T., BIELY A., DVOŘÁKOVÁ L., LEXA J. and ZBOŘIL A., 1989. Crustal structures of the West Carpathians on deep seismic line 2T. *Miner. Slovaca*, 21: 3-26 (in Slovak with English summary).

VOZÁR J., TOMEK Č., VOZÁROVÁ A., MELLO J. and IVANIČKA J., 1996. Seismic section G-1. *Geol. Práce, Spr.*, 101: 32–34.

WORTEL M. J. R. and SPAKMAN W., 2000. Subduction and slab detachment in the Mediterranean-Carpathian region. *Science*, 290: 1910-1917.

ZEYEN H., DÉREROVÁ J. and BIELIK M., 2002. Determination of the continental lithospheric thermal structure in the Western Carpathians: integrated modeling of surface heat flow, gravity anomalies and topography. *Physics of the Earth and Planetary Interiors*, 134: 89-104.