Faults, Block Rotations and the Origin of the Orava Basin in the Western Part of the Polish Outer Carpathians

Jan GOLONKA[1], Marek CIESZKOWSKI[1], Rafał CHODYŃ[1] and Monika CHRUSTEK[1]

[1] *Jagiellonian University, Institute of Geological Sciences, Oleandry Str. 2a, 30-063 Kraków, Poland*

Introduction

The dominant tectonic phase that affected the outer Carpathian was a Miocene tectonic phase. The Miocene tectonic movement took place during the collision between the overriding Alcapa plate and the North European plate (Cieszkowski, 2003). The boundary between these plates is the Pieniny Klippen Belt. As a result of the intense Neogene orogeny the sediments filling the outer Carpathian basins were folded and detached from their substrate and several uprooted nappes were created that reflect the original configuration of the basins. During folding and thrusting the main nappes have been partially differentiated and subdivided to smaller tectonic units. Outer Carpathian nappes, thrust one upon another, all together overthrust onto the North European Platform. The Carpathian foredeep has been formed in front of steeply northward advancing nappes (Golonka and Lewandowski, editors, 2003).

Faults and block rotations

The Carpathian nappes are cut by several major faults of different origin. Some of these faults are local, some form the huge systems sometimes over one hundred kilometers long . These systems affected all outer Carpathian nappes, the Pieniny Klippen Belt and the Alcapian Inner Carpathians. According to Marko (2003) the WSW-ENE mesoscale dextral strike-slips exist along the boundaries and within the Pieniny Klippen Belt in Slovakia. It proofs existence of dextral shearing between Alcapa and North European platform during the Early Miocene time.

During the Early-Middle Miocene the Outer Carpathian nappes became detached from the basement and were thrust northwestward in the west and northward onto the North European platform in the western part of Polish Carpathians (Cieszkowski, 2003). The strike direction of nappes and major structures is SW-NE turning gradually eastwards into W-E (Golonka, 1981). The major faults dissect nappes perpendicularly, sometimes obliquely. The main faults directions are N-S, NNW-SSE. They originated as strike-slip faults. The age of these faults is younger than the formation of the Pieniny Klippen Belt. The major right-lateral strike slip faults displaced the Klippen Belt in the Zazriva area (Potfaj, 2003). This fault system extends northwards toward the Żywiec Tectonic Window and the Carpathian border in Bielsko-Biała area. It divides the Silesian Nappe into the present day morphotectonoc units – Beskid Śląski and Beskid Mały (Golonka, 1981). The major fault system runs along the Skawa River. It displaces the Silesian and Subsilesian Nappes as well as the Carpathian front in the Wadowice area. Several faults ran in the NNW-SSE, sometimes N-S and NW-SE direction in the Beskid Żywiecki south from the Magura Nappe front. This faults displace the thrust front of the Bystrica Unit. These nappes and thrusts displacements indicate that the age of the faults is younger or contemporaneous to the main Badenian (Serravallian) phase of the Outer Carpathian fold-and-thrust system formation.

The strike-slip movement caused the rotation of blocks along the faults planes. The rotation are especially well visible in the Beskid Wysoki where the huge rigid bodies of sandstones existed (Golonka, 1981). The Upper Eocene Magura thick-bedded sandstones reach in the Babia Góra and Pilsko mountains 1500 m of thickness. They overlay the less competent flysch rocks of the Late Cretaceous to Eocene age. These rocks often form diapirs between the Magura sandstones rotation blocks. The Late Cretaceous red Cebula shales reach the surface in such a diapiric scale located southwest of the rotated block of the Magura Sandstone building the Pilsko Mt. The so-called Sopotnia Mała Window represent also part of the diapir related to the rotated block. The center of the diapir is built of the Upper Cretaceous Cieszyn Beds and Paleogene Krosno Beds representing the Silesian or Fore-Magura unit originally located below the Magura Nappe. The strike-slip related block rotation is responsible for the paleomagnetic change in the declination and azimuth of rocks within the Outer Carpathian flysch. Ma Márton (2003) recognized two phases with a total of 90° rotation in the western part of the Carpathians.

Origin of the Orava Basin

Further south-westward the Vienna Basin opened during the Badenian (Serravallian) time due to the pull-apart activity of major NE–SW sinistral strike-slip faults (Royden et al., 1982). The situataion is little more complicated with the Orava basin. The Neogene sediments cover all major faults in the Pieniny Klippen Belt and Magura nappe. The age of the oldest sediments within the Orava Basin (Baumagart-Kotarba, 2002) is Late Badenian (Serravallian). The NNW-SSE strike-slip fault in the Outer Western Carpathian wear reactivated during the late Miocene time of extension as the normal ones. The elevation of the Babia Góra and Pilsko and the present-day morphotectonic depression between these two mountains is probably related to the extensional regime. The depocenter of the Orava Neogene sediments is located in the Czarny Dunajec area in the western part of the basin. It indicates the syntectonic sedimentation along the extensional border fault oriented perhaps N-S. Later tectonic development reactivated also the WSW-ENE strike slip faults and normal faults oaf the same direction producing the present day Orava-Nowy Targ basin filled with the Quaternary deposits on top of Miocene-Pliocene sediments. According to Golonka (2003) a possible astenosphere upwelling contributed to the origin of the Orava depression – kind of rift combined with the strike-slip pull-apart process. 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 (Golonka and Lewandowski, editors, 2003).

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The Magnetic Fabric of the Veľká Fatra Mts. Part Two: Emplacement Mode of the Hercynian Granitic Pluton and its Relation to the Alpine Sedimentary Rocks, Based on AMS Study

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

[1] *Geophysical Institute, Slovak Academy of Sciences, Bratislava, Slovakia*
[2] *Institute of Petrology and Structural geology Charles University, Prague, Czech Republic*
[3] *Dionýz Štúr Institute of Geology, Mlynská dolina 1, 817 04 Bratislava, Slovakia*

The anisotropy of magnetic susceptibility (AMS) is one of the most powerful tools for study of rock fabrics. It has widely been used in the Central Western Carpathians (CWC); the basic results of magnetic fabric study and/or magnetic susceptibility from nearly all granitic plutons of the CWC are available in Hrouda et al. (2002) and Gregorová et al. (2003a). The magnetic fabrics are often coaxial in granitic, metamorphic and covering sedimentary rocks, being partly or entirely deformational in origin within most of Core Mountains CWC (Hrouda et al., 2002). However, the first AMS data from various granite types of the Ľubochňa pluton in the Veľká Fatra Mts. displayed non-coaxial pattern (Gregorová et al., 2003b). The Veľká Fatra Mountains typifying the Core Mountains of the Tatricum, a major tectonic unit in the CWC consists of crystalline basement, Mesozoic cover unit, overthrust by two nappes – the Krížna and Choč ones. The crystalline basement is represented by the Ľubochňa granitoid massif, consisting of four principal Hercynian granitic rock types building a multistage composite pluton, and of orthogneisses – the older sheared granites – that are preserved at the eastern border. The Smrekovica tonalite (ST) is represented by fine to medium-grained biotite tonalite with scarce xenoliths of wall rocks paragneisses. The Kornietov granodiorite (KGD) typify medium-grained, porphyric biotite and muscovite-biotite granodiorite, whereas slightly porphyric medium-grained two mica granites represent the Lipová granite (LG). The Ľubochňa leucogranite (LLG) is typical fine- to medium-grained felsic muscovite granite. 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. The Lower Carboniferous ages of magmatism were determined for the KGD – 340 ± 2 Ma and LG – 356 ± 25 Ma (Kohút et al., 1997) or – 337 ± 9 Ma (Poller et al., 2000). On the contrary, an Upper Carboniferous age – 304 ± 2 Ma was detected for the ST (Poller et al., l.c.).

The present AMS study was performed on 741 oriented samples, collected at 64 localities from the crystalline basement and Mesozoic sedimentary rocks. The measurements were carried out on the KLY-3S Kappabridge (Jelínek and Pokorný, 1997). The mean values of the bulk susceptibility decrease in order: