A Ramp-and-Flat Geometry of Thrust Faults in the Pavlov Hills, Western Carpathians, Czech Republic

Ivan POUL[1] and Rostislav MELICHAR[2]

[1] Institute of Geotechnics, Faculty of Civil Engineering, Brno University of Technology, Veveří 331/95, 602 00 Brno, Czech Republic
[2] Institute of Geological Sciences, Faculty of Science, Masaryk University, Kotlářská 2, 611 37 Brno, Czech Republic

The Pavlov Hills are situated in the westernmost part of the West Carpathians at their contact with the Eastern Alps. The Jurassic to Cretaceous pre-flysh sediments form slices incorporated in the Paleogene flysh nappe (Ždánice unit). The Upper Jurassic part consists of dark gray deep marine claystones to limestones (Klentnice Formation), which prograde into light shallow-marine limestones (Ernstbrunn Limestone). The Cretaceous mostly siliciclastic sediments overlie these limestones. The structure of Pavlov Hills was produced by thrusting in the Carpathian acretionary wedge during the younger phase of the Alpine orogenesis (lower Miocene).

During our tectonic research in the Pavlov Hills the orientation of bedding in sedimentary rocks was studied. Two main maxima of bedding orientation were recognized. The bedding planes were buckled into several upright anticlines with fold axis very gently plunging to NE. Very well documented large brachyanticline is situated in the eastern part of Mikulov (Svatý kopeček). This structure was recognized during the new reinterpretation of seismic sections under the surface.

New geological mapping (with more detailed stratigraphic division) and compass data together with the data in old boreholes (Nové Mlýny-3) show several thrusts with stratigraphic inversions and tectonic duplications of the Jurassic formations. Thrusts are marked by high-strain zones with large amount of small tectonic slices of different age (Jurassic, Cretaceous, Paleogene).

The anticline structure is accompanied by duplexes. Thrusts are usually subparalell to bedding and mostly striking in NE-SW direction and dipping to the SE. Detachments are distinguished in the Klentnice Formation, in the “nodular limestones” (middle Tithonian) and at the top of the Ernstbrunn Limestone. Some more steep parts situated in the Ernstbrunn Limestone are interpreted as ramps. The angle Φ between the flats and the ramps is 20°. This value was obtained by the weighted average of friction angles of the failure-tested Jurassic rock using Mohr-Coulomb failure model?

The anticlines were formed in a ramp-and-flat geometry regime, so the balanced cross-section could be constructed based on seismic data across the Pavlov Hills.

Late Neogene Tectonic Activity of the Central Part of the Carpathian Foredeep, South Poland

Marta RAUCH-WŁODARSKA[1], Witold ZUCHIEWICZ[2] and Wojciech WŁODARSKI[3]

[1] Institute of Geological Sciences, Polish Academy of Sciences, Senacka 1, 31-002 Kraków, Poland
[2] Institute of Geological Sciences, Jagiellonian University, Oleandry 2A, 30-063 Kraków, Poland
[3] Institute of Geology, Adam Mickiewicz University, Maków Polnych 16, 61-686 Poznań, Poland

Normal faults of different orientations appear to be the youngest manifestations of faulting in the Polish Outer Carpathians, composed of the Lower Cretaceous trough Lower Miocene strata, and the related Carpathian Foredeep which is filled with the Lower to Middle Miocene sediments. In the Outer Carpathians, the folds and thrusts produced by accretion-related shortening were formed between the Palaeocene and early Late Miocene. The origin of normal faults is still debatable, since it is not known whether these faults were a result of multidirectional extension produced in a single collapse event, or differently oriented extension proceeding in a series of successive events.

Structural studies of the Late Miocene-Pliocene(?) fresh-water molasses of the Witów Series and the overlying Pleistocene loessial complex provide a possibility to reconstruct the Late Neogene – Pleistocene (to Recent?) stress field in the central part of the Polish Carpathian Foredeep and, indirectly, in the central part of the Polish Outer Carpathians. The strata of such an age are unique features in the Polish Carpathian Foredeep, providing thereby a key record of structural deformation during the latest stages of orogenic evolution of the Carpathian orogen. The molasses are cut by joints, and normal and strike-slip faults which were formed in two successive events: (1) a syn-depositional one for the molasses (Late Miocene-Pliocene?), proceeding under NNW-SSE to N-S oriented horizontal compression, possibly coeval with reactivation of a NE-striking sinistral fault of the Kurdwanów-Zawichost Fault Zone in the basement; (2) a post-depositional one for the molasses (Pliocene to Middle Pleistocene) during N-S to NE-SW- oriented extension, and (3) both syn- and post-depositional ones for the loessial complex (Late Pleistocene).

In the first event, reactivation of the NE-striking sinistral fault led to formation of N-S- oriented joints, as well as NW-striking dextral, and NNW-trending normal faults. This event was probably contemporaneous with sinistral reactivation of some thrusts in the Western Outer Carpathians, induced by eastward-directed extrusion of crustal blocks in the Carpathian internides. In the second event, both W-E and NW-SE- oriented joints and WNW-striking normal faults were formed. The latter most probably originated due to reactivation of the Early Palaeocene WNW- and NW- striking normal faults in the basement. In the third event, both NE-SW and NW-SE- oriented joints and NE-striking normal faults were formed as a result of reactivation of the SW- and WSW-striking faults in the basement. Therefore, normal faults detected in the Outer Carpathians and Carpathian Foredeep appear to be a result of not a single collapse event but of different successive events. This extensional episode lasted at least to the late Pleistocene.

We also provide evidence for the recent, N- to NNE-directed, tectonic compressive stress, typical for that segment of the Carpathian arc. This stress resulted in the formation of an orthogonal system of joints striking N-S and W-E, produced during the (4) event.

Pattern of the Mesoscopic Thrust Faults in the Eastern Part of the Silesian Nappe (Polish Western Outer Carpathians)

Marta RAUCH-WŁODARSKA

Polish Academy of Sciences, Institute of Geological Sciences, Kraków Research Centre, Senacka 1, 31-002 Kraków, Poland

Polish Western Outer Carpathians are a stack of nappes composed of Lower Cretaceous to Lower Miocene flysch sediments. One of the biggest nappe is the Silesian nappe. The outcrop of this nappe forms the bend convex to the North. The eastern part of this nappe, located to the southeast of the Wisłoka River, is the object of the research. In the Polish Outer Carpathians the folding and thrusting were connected with the two shortening events, which were characterized by different orientation of horizontal compression: 1) NNW- (N), and 2) NE- (NNE) directed ones. During the first event the thrusting has in-sequence character and the deformational front migrated approximately from the south to the north. The regional folds were formed during this event. During the next event, the previous thrust faults and related folds were overprinted and refolded. The regional fold axes in the Silesian nappe are approximately parallel to the frontal thrust of this nappe. In the eastern part of the Silesian nappe the regional fold axes and the strikes of the regional thrust faults are directed WNW-ESE and NW-SE.

The tectonic structures were investigated in 34 outcrops. The studied mesoscopic thrust faults were divided into two groups formed in: 1) horizontal strata and 2) tilted strata. Numerous thrust faults of (1) group were tilted, together with the host strata during folding. Such faults were backtilted at the beginning of the structural analysis. There were measured 572 thrust faults, 255 faults of (1) group and 317 faults of (2) group.

The thrust fault planes dip mostly about 25°. The dip angles of the (1) group faults are clustering around the value 25°. The dip of the (2) group fault planes is characterized by bigger changes and ranging between 15 and 70°. The strike of thrust faults usually varies between N 60°E and N140°E, showing single prevailing orientations N 125°E in the both groups of thrust faults. Other fault planes of the (2) group are striking WNW-ESE, W-E and more rarely ENE-WSW. The orientation of the strikes of the (1) group fault planes are mostly clustering around the direction N 125°E. The direction of thrusting varies mostly from N-S to NE-SW. The dominant direction of thrusting along the (1) group faults is NNE-SSW and along the (2) group faults is NE-SW. The differences of the thrust fault strikes and the thrusting direction between the (1) and (2) group of thrust faults are visible but not significant. According to crosscutting relationship older thrust faults are commonly these faults striking WNW-ESE and younger are these faults striking ESE-WNW. The reconstructed orientation of the horizontal compression is N 18°E for the older thrust faults of the (1) group and N208°E for the younger thrust faults of the (2) group.

The dominant age relationship of the thrust faults could be caused by clockwise rotation of the horizontal compression. Numerous thrust faults of (1) group vary in strike orientation with the host strata, this fact may suggest that the rotation of the horizontal compression took place locally before folding. There is also second explanation of such thrust faulting: the NE-oriented, stable horizontal compression and counterclockwise rotation of host strata.

In the eastern part of the Silesian nappe the differences between the orientations of the older thrust faults of the (1) group and the younger ones of the (2) group are smaller comparing such differences, which are observed in the central part of this nappe. Therefore in the eastern part of the Silesian nappe the total amount of the rotation was smaller. When we are taking into consideration that the host strata rotated counterclockwise, then the bending of the whole Silesian nappe could cause the clockwise rotation of the eastern part of the Silesian nappe. Such clockwise rotation of the eastern part of this nappe could decrease the effect of couterclockwise rotation of the whole nappe.