TOPOGRAPHY OF THE MAGURA FLOOR THRUST SURFACE AND ORPHOTECTONIC BEHAVIOUR OF THE POLISH OUTER CARPATHIANS

W. ZUCHIEWICZ and N. OSZCZYPKO

Institute of Geological Sciences, Jagiellonian University, Oleandry 2A, 30063 Kraków, Poland; witold@ing.uj.edu.pl, nestor@ing.uj.edu.pl

Abstract: Neotectonic (Pliocene-Quaternary) elevations and depressions detected on maps of subenvelope surfaces of the topography of the Outer West Carpathians of Poland are, to a certain extent, portrayed on the map showing topography of the Magura floor thrust, particularly in the western segment of the study area. This coincidence is most probably related to both the thickness of the Magura Nappe and possible reactivation of fault zones in the basement.

Key words: neotectonics, Pliocene-Quaternary, Magura thrust, Outer Carpathians, Poland

The aim of this paper is to discuss mutual relationships between the pattern of uplifted and subsided neotectonic structures in the Polish Outer Carpathians with highly changeable topography of the Magura floor thrust, the most extensive nappe of that region.

Differentiated values of morphometric parametres characterizing the present-day topography provide indirect evidence in favour of diversified neotectonic tendencies. Analysis of river-bed gradients, Hortonian indices, hypsometric curves and hypsometric integrals, drainage basin asymmetry, valley floor width to valley height ratios, mountain front sinuosity and other parametres proved helpful in identification of uplifted/subsided zones in the Polish segment of the Outer Carpathians (cf. Zuchiewicz 1995, 1999; and references therein).

In 1965 Klimaszewski published a map showing generalized topography of the Outer Carpathian drainage pattern by plotting isohypses of the main river valley bottoms. This pattern suggested differentiated Pliocene-Quaternary uplift of the Outer West Carpathians, since the elevations of valley bottoms rose from 200 m a.s.l. in the foothills area up to 400-500 m a.s.l. in the Beskidy Mts. A similar technique was applied by Jahn (1992) to the East Carpathians.

Another cartometric approach to morphological manifestations of young tectonic activity is represented by construction of envelope and subenvelope maps (R¹czkowski et al. 1984, Keller and Pinter 1996; and references therein). The former portray the highest elevations of a terrain, the latter reconstruct the level to which the streams have eroded by connecting points of equal elevation between the streams. A series of such maps produced for drainage networks classified according to the Horton-Strahler hierarchy, and called base-level surface maps, makes it possible to compute maps of residuals between individual surfaces of different orders and to hypothesize about either uplift or subsidence tendencies, indicated by dense/sparse pattern of isobases and increased/decreased relief portrayed on residual maps (cf. R¹czkowski et al. 1984, Zuchiewicz & Oaks 1993). Reliable interpretation of such maps, however, is impossible without knowledge about the number and age of geomorphic cycles that affected the study area. Therefore, both envelope and subenvelope maps should complement traditional geomorphic mapping (see, for instance, arguments listed by Starkel 1985).

The 4th-order base-level map shows several areas of high isobase concentration, including the uplifted Beskid ¯ywiecki, Tatra, Pieniny, Gorce, Beskid S¹decki and Bieszczady Mts. Broadely-spaced isobases within intramontane depressions are indicative of subsiding tendencies. The 5th-order map, in turn, displays two regions of contrasting isobase pattern. In the western area isobases of 250 to 850 m a.s.l. run close to one another; the eastern area is characterized by low isobase density and lower elevations (200-700 m a.s.l.). Slightly higher elevations (650-750 m a.s.l.) occur only in the axial part of the Bieszczady Mts. The 6th-order map shows a distinct boundary between the West and East Carpathians. In the western part, a southern region encircled by the 550 m a.s.l. isobase, is well pronounced. Farther to the north base-level values diminish to 250 m a.s.l. Isobases are broadly spaced within the intramontane depressions of ¯ywiec and Nowy S¹cz. The general E-W trending pattern of isobases is disturbed by “depressions” associated with transversal, deeply-cut valleys of So³a (NNE-SSW), Dunajec (NNE-SSW), and San (NW-SE) rivers.

Base-level surfaces of different orders are very difficult to date: in many cases the represent different fragments of a mature landscape, formed during different time-spans (like, e.g., upper valley reaches within watershed areas), although being assigned to one base-level surface. Nevertheless, differences among base-level maps of different orders appear to reflect both lithological control and young tectonic processes. The uplifted regions are marked on maps of residuals as longitudinal elevations (Beskid ¯ywiecki, Tatras, Beskid S¹decki, S³onne Mts.) or block/dome-like uplifts (Gorce Mts., western Bieszczady Mts., Beskid ŒI¹ski Mts.).

Summing up, the hitherto-published geomorphological maps of the Polish Carpathians feature a few longitudinal elevated areas (Starkel 1980, R¹czkowski et al. 1984, Zuchiewicz 1995). More prominent subsiding structures are located along the So³a river course, in the Orava - Nowy Targ Basin, in the Jas³o-Sanok Depression and following the lower course of the San river valley in the eastern portion of the Outer Carpathians.

The floor thrust of the Magura Nappe is highly uneven, its position changing from 500 m a.s.l. to more than 7,000 m b.s.l. The most prominent depression is located in the medial segment of the Polish Outer Carpathians (2-7 km b.s.l.), and its axis trends NW-SE from the eastern margin of the Mszana Dolna tectonic window to the Poprad river valley. Another, much more shallower, Jordanów depression (2 km b.s.l.) is to be found NW of the Mszana Dolna tectonic window, shortly north of the Skawa river valley. Elevated structures, in turn, include the Mszana Dolna tectonic window, Sól-Skomielna (on the west), and Limanowa-Klêczany (on the east) elevations of subparallel orientation. Still farther to the east, a longitudinal elevation extending between the Klêczany-Pisarzowa and Œwi¹tkowa tectonic windows is to be seen some 10-15 km south of the Magura frontal thrust. South of this area, the Magura floor thrust slopes steeply down to more than 4 km b.s.l.

The Magura thrust has developed in several stages. The first episode of thrusting occurred in Late Oligocene times when the nappe, together with the Grybów Unit, was thrust upon the Dukla Nappe. In the early Burdigalian the Magura frontal thrust was situated at the southern periphery of the Silesian basin. The subsequent episodes of thrusting took place in the Ottnangian and after the middle Badenian. The last episode, including some 12 km of thrusting, was that which controlled the present-day intersection of the thrust and was responsible for the strike-slip character of the contact between the Magura Nappe and the Pieniny Klippen Belt (cf. Oszczypko 1998). The post-Badenian thrusting has finally shaped the duplex structure of the Mszana Dolna tectonic window (Oszczypko 2001), being postdated by normal faulting (Oszczypko & Zuchiewicz 2000), controlling subsidence of the Late Badenian - Sarmatian troughs of the Orava-Nowy Targ and Nowy S¹cz Basins.

A comparison between the pattern of elevated and subsided structures of the Magura floor thrust and subenvelope sufaces of different orders shows that in the western part of the Polish Outer Carpathians the highest-elevated neotectonic structures (in the southern portion of that area) coincide with depressions of the Magura thrust, whereas farther north a reverse pattern becomes dominant: neotectonic elevations coincide either with the Magura frontal thrust or with elevations of its surface. This is particularly true for an area comprised between 20° and 20°30'E meridians. Moreover, the strongly uplifted region in this part of the Outer Carpathians, i.e. the Gorce Mts., is situated shortly south of the main elevation of the Magura floor thrust, represented by the Mszana Dolna tectonic window. Farther to the east, no clear relationship between the discussed surfaces can be seen, except that the highest orogen-parallel neotectonic structures appear to coincide with the greatest thicknesses of the Magura Nappe.

The origin of such relationships is difficult to explain. We infer that one of possible factors could be Pliocene-Quaternary reactivation of faults cutting he Magura floor thrust, and particularly that which appears to separate the western-medial segment of the Outer Carpathians from the more eastern portion. This zone strikes NW-SE between Limanowa and the Poprad river valley, dividing regions showing contrasting pattern of both subenvelope surfaces and the Magura floor thrust.

References

Jahn A. 1992. Geomorphology of the Eastern Carpathians (in Polish with English summ.). Acta Univ. Wratisl., Prace Geol.-Miner. 27: 1-48, Wroc³aw.

Keller E. A. & Pinter N. 1996. Active tectonics. Earthquakes, uplift, and landscape. Prentice Hall, Upper Saddle River, New Jersey: 1-338.

Klimaszewski M. 1965. Views on the geomorphological development of the Polish West Carpathians during the Quaternary. Geomorphological Problems of Carpathians, vol. I, VEDA, Bratislava: 91-121.

Oszczypko N. 1998. The Western Carpathian Foredeep - development of the foreland basin in front of the accretionary wedge and its burial history (Poland). Geologica Carpathica 49: 415-431.

Oszczypko N. 2001. Magura Unit. General geology. In: K. Birkenmajer & M. Krobicki (Eds.), Field Trip C. 12th Meeting of the Association of European Geological Societies, Kraków, 13-15 September 2001. Pañstw. Inst. Geol., Kraków: 173-177.

Oszczypko N. & Zuchiewicz W. 2000. Jointing in Eocene flysch strata of the mid-eastern Magura Nappe, Polish outer Carpathians: implications for the timing of deformation. Slovak Geol. Mag. 6: 441-456.

R¹czkowski W., Wójcik A. & Zuchiewicz W. 1984. Late Neogene-Quaternary tectonics of the Polish Carpathians in the light of neotectonic mapping. Tectonophysics 108: 51-69.

Starkel L. (Ed.) 1980. Geomorphological map of Poland, 1:500,000. IGiPZ PAN, Warszawa.

Starkel L. 1985. Controversial opinions on the role of tectonic movements and climatic changes in the Quaternary evolution of the Polish Carpathians. Studia Geomorphologica Carpatho-Balcanica 19: 45-60.

Zuchiewicz W. 1995. Selected aspects of neotectonics of the Polish Carpathians. Folia Quaternaria 66: 145-204.

Zuchiewicz W. 1999. Morphometric techniques as a tool in neotectonic studies of the Polish Carpathians (southern Poland) [in Polish with English summ.] Przegl¹d Geologiczny 47 (9): 851-854.

Zuchiewicz W. & Oaks R. Q., Jr. 1993. Geomorphology and structure of the Bear River Range, north eastern Utah: a morphometric approach. Zeitschrift für Geomorphologie, Suppl.-Bd. 94: 41-55.