POST-OROGENIC UPLIFT AND EROSION OF THE POLISH CARPATHIAN FOREDEEP – CONSTRAINTS FROM COMPACTION ANALYSIS

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Abstract: Reconstructed post-orogenic uplift and erosion of the Carpathian Foredeeep are relatively low in the northern part of the basin, where it equals ~0-200 m and ~300-400 m respectively. Along the orogen margin uplift and erosion equals ~800-1000 m and ~1100-1300 m respectively for the eastern part of the basins, while for its western part it equals ~500-600 m and ~800-1000 m respectively. Obtained results suggest that peculiarly narrow foredeep in the vicinity of Cracow is not an effect of erosion.

Key words: Carpathian foredeep, Miocene, compaction analysis, erosion, uplift

The analysed part of the Carpathian foredeep (Fig. 1), roughly 200 km long, is 100 km wide at maximum in its eastern part and significantly narrows towards the west. Thickness of predominantly shallow marine, silicictastic sediments reaches ~3500 m at maximum in the SE part of the basin. The Carpathian orogen and its foreland, including foredeep basin, were subject to post-orogenic differential uplift and erosion during the late Miocene, Pliocene and Quaternary. Magnitude of the uplift and thickness of the eroded Miocene sediments, as well as their lateral distribution is a matter to dispute. However e.g. analysis of illite/smectite diagenetic transitions for the for approx. 400-800 m (Środoń, 1984; Dudek, 1999).

In the presented contribution erosion and uplift were quantified by means of analysis of mechanical compaction of siliciclastic sediments (c.f. Oszczypko & Woźnicki, 1981; Oszczypko et al., 1993; Poprawa et al., 2000). Relatively thick and facially uniformed basin-fill, characterised by volumetric predominance of fine-grained siliciclastic sediments (shales, with less contribution of mudstone, quartz and polimiktic sandstone, and graywakies; e.g. Jasionowski, 1999), deposited during very

short period of geological time make the basin, particularly its eastern part, very suitable for compaction analysis. This is evidenced also by lack of any significant loos of porosity due to chemical diagenesis (Jasionowski, 1999), general lack of overpressure zones, as well as by common presence of structures from differential compaction (Poprawa & Krzywiec, 1999; Krzywiec, 1999).

Compaction analyses were conducted with use of well log data for 79 wells (see Fig. 2 for location). Intervals of the profiles representing shale and sandstone lithologies were differentiated with use of natural gamma log. Based on acoustic logs and neutron logs porosity of shale and sandstone was calculated separately along the analysed well sections. Calculations were calibrated with laboratory measurements of porosity, conducted with helium method. For certain sub-regions of the basin characteristic, local compaction curve development was observed. Compaction curves were related to regional reference curves. Thickness of eroded section was calculated by extrapolation of compaction curve to theoretical surface value. Baldwin & Butler (1985) algorithm was used for calculation. Error bars for erosion measurements presented below are only a rough estimation and represent significant uncertainties related to the applied methodological approach.

According to obtained results the magnitude of erosion of the Miocene sediments increases from the outer, distal part of the basin, towards its inner, proximal part, i.e. towards Carpathians (Fig. 2). On seismic section this is clearly confirmed by observation that towards the south systematically older horizons are erosionally truncated (Poprawa et al., 2000). In the outer zone of the basin erosion calculated here with the compaction analysis approach reaches ~0-200 m (? -300 m) on average. In the eastern part of proximal zone (east of Wisłoka river), erosion reaches values of ~800-1000 m (±100-200 m). In the central part of the inner zone of the basin (between Dunajec and Wisłoka rivers) erosion could be as high as ~700 m (±100-200 m). Further west along the orogen's front (west of Tarnów town) thickness of missing section estimated from compaction curves decreases to values of ~500-600 m (±100). Calculated erosion is generally higher then previous estimations based on comparative analysis of acoustic logs (Poprawa et al., 2000).

As it was documented by sedimentological observations the peculiarly narrow foredeep in the vicinity of Cracow is not an effect of selective erosion, but an original feature of the basin (Gradziński, 1963; Radwański, 1968). Here obtained results

clearly confirm this interpretation. This is presented on the map of pre-erosional thickness of the basin sedimentary fill (Fig. 3), being a compilation of the thickness of the Miocene sediments and the map of erosion magnitude (Fig. 2). Such a shape of the foredeep is difficult to explain by classic models of orogen-forelad relations. The narrowing foredeep near Cracow coincides with the location of the Kraków-Lubliniec Zone, being a border between major basement units, i.e. Małopolska Massif and Moravo-Silesian Terrane. This indicates strong influence of the basement structure on flexural bending of the orogen's foreland plate.

Marine sediments of the foredeep basin-fill are recently topographically elevated by ~100-200 m.a.s.l. This effect corrected for global sea level changes and combined with lateral distribution of the thickness of eroded sedimentary cover allows calculating total post-orogenic uplift of the Carpathian foredeep. The magnitude of uplift rises towards the Outer Carpathians, paralleled by its increases from West to East along the front of orogen (Fig. 4). In the distal zones of the basins it could be calculated for ~300-400 m (±100 m), while in its proximal zones it reaches up to 1000 m and 1300 m (±200-400) in the west and east respectively. Mechanism of the uplift is related here to post-orogenic isostaic rebound of the whole orogen-foreland system, as well as to elastic relaxation of flexularly bounded foreland plate. Relative importance of both mentioned mechanisms is a subject to ongoing research.

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Figure 1
Location of the analysed part of the Carpathian foredeep basin (black rectangle) with the background of the main tectonic units of the Pannonian-Carpathian system.

Figure 2
Thickness of the eroded Miocene sediments calculated from compaction curves according to Baldwin & Butler (1985) algorithm.

Figure 3
Reconstructed pre-erosional thickness of the Miocene sediments filling the foredeep, presenting original geometry of the basin. Note narrowing of the foredeep towards the west.

Figure 4
Amount of post-orogenic uplift of the Carpathian foredeep basin, being a compilation of the amount of erosion and the topographic elevation.

Figure 1
(Poprawa, Pelczarski, Szewczyk)

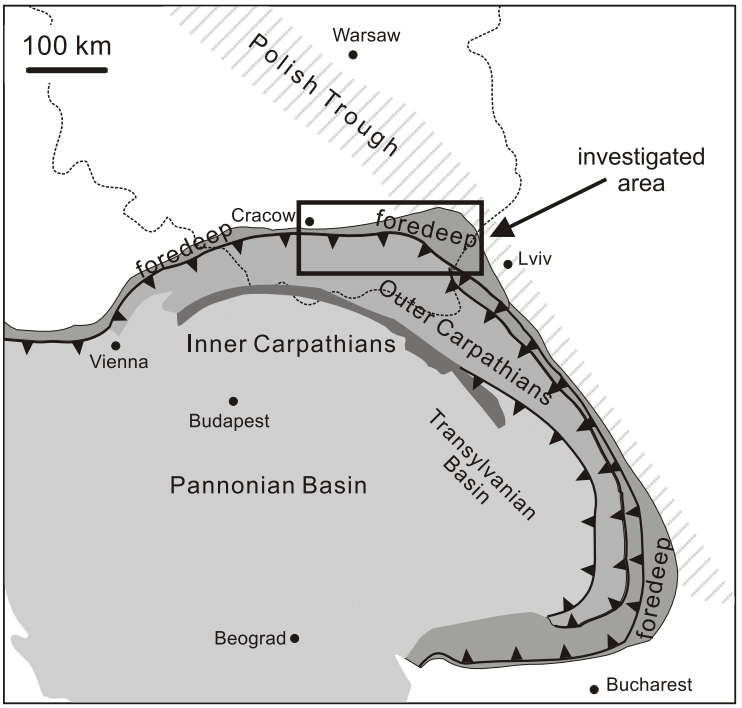

Figure 2
(Poprawa, Pelczarski, Szewczyk)

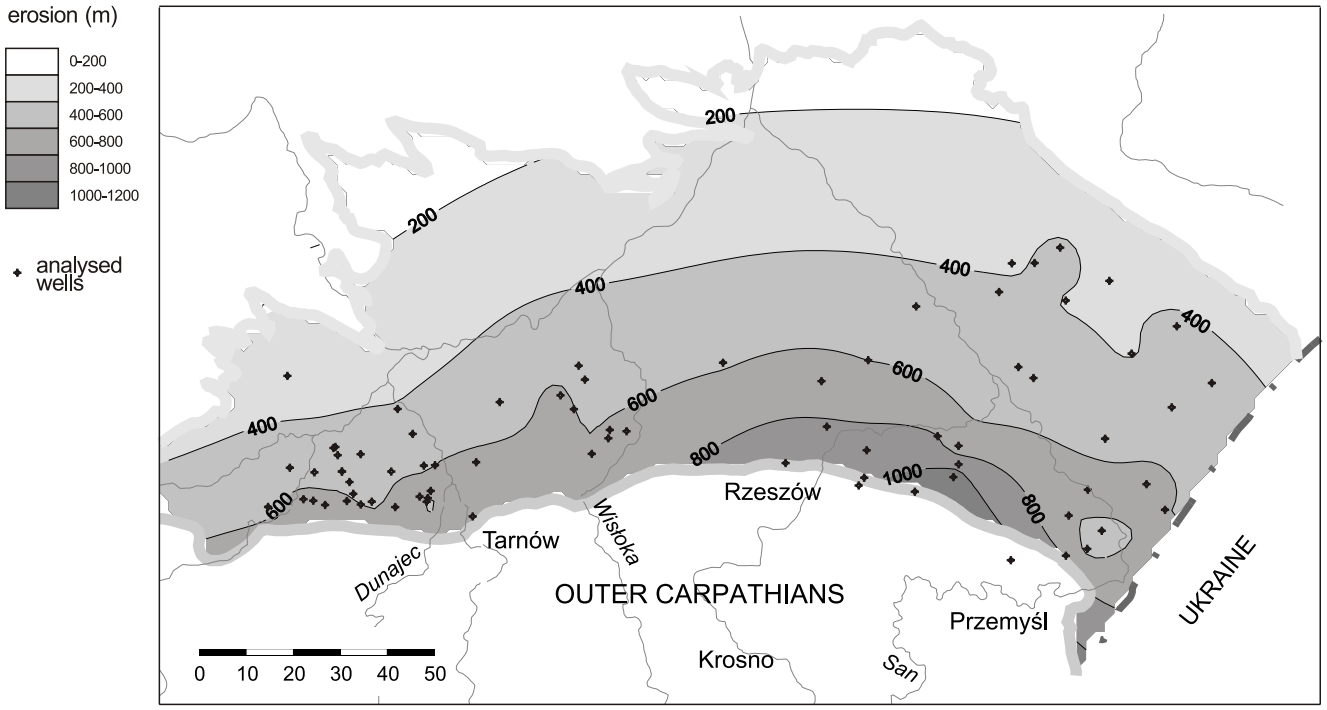

Figure 3
(Poprawa, Pelczarski, Szewczyk)

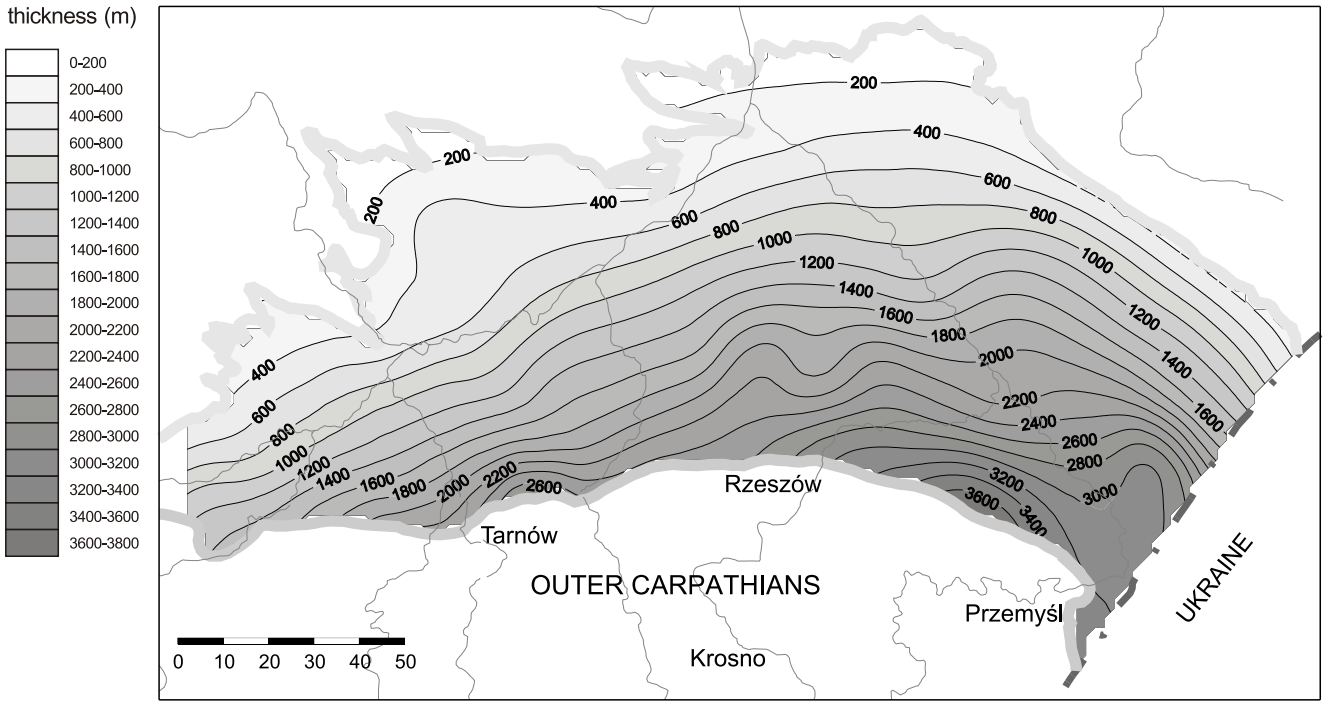

Figure 4
(Poprawa, Pelczarski, Szewczyk)