Geological Quarterly, 2010, **54** (1): 95–98

Cenozoic dynamic evolution of the Polish Platfom (discussion)

Piotr KRZYWIEC

Krzywiec P. (2010) – Cenozoic dynamic evolution of the Polish Platfom (discussion). Geol. Quart., **54** (1): 95–98. Warszawa.

Piotr Krzywiec, Polish Geological Institute – National Research Institute, Rakowiecka 4, PL-00-975 Warszawa, Poland, e-mail: piotr.krzywiec@pgi.gov.pl *(received: January 11, 2010; accepted: March 18, 2010).*

In their interesting paper, Jarosiński *et al*. (2009) summarized the Cenozoic evolution of the Polish Platform. Below, I would like to briefly discuss and comment on some of the points they raised regarding selected aspects of the Miocene evolution of the Polish Carpathian Foredeep Basin (PCFB).

1. Jarosiński *et al*. (2009) analyzed the genesis and timing of formation of deep palaeovalleys incised within the sub-Miocene substratum of the PCFB. They claimed that these palaeovalleys were incised into Mesozoic strata only, while in fact such palaeovalleys are also present e.g., in vicinity of Rzeszów, where Mesozoic cover is not present, and where they have been incised exclusively into the Paleozoic succession (*cf*. Myśliwiec, 2004; Krzywiec *et al*., 2008; Zubrzycka *et al*., 2009). Jarosiński *et al*. (2009) proposed that these palaeovalleys developed in Late Oligocene–Miocene times. Such inferred timing was mostly based on observation that they are filled by Badenian and younger deposits, that post-date their incision. Jarosiński *et al*. (2009) did not however acknowledge that in the Sędziszów–Rzeszów area axial parts of these palaeovalleys are filled by thick Paleogene deposits (Moryc, 1995), and this strongly suggests an older age of their incision. Similar palaeovalleys are present in the Czech part of the Carpathian arc, where they are filled by foreland-derived Paleogene deposits that are in turn covered by orogen-derived Neogene foredeep deposits (Picha *et al*., 2006). Such a configuration of the sedimentary infill of the palaeovalleys, similar to what can be observed in the Sędziszów–Rzeszów area, points to pre/early Paleogene incision (see also below). It should also be stressed that, although the entire PCFB has been intensely drilled during several decades of hydrocarbon exploration, there are very few wells located within the axial parts of such palaeovalleys, and in fact very little is known about the age of the strata infilling their deepest axial parts (*cf*. Krzywiec *et al*., 2008, 2009). Jarosiński *et al*. (2009) also analyzed the possible genesis of these palaeovalleys, and seem to favour a model of their formation during uplift of the flexural forebulge in front of the advancing Carpathian orogenic wedge. They also mentioned an alternative model, based on data from the Czech part of the Carpathian arc mentioned above, with a well-constained age of palaeovalley incision, immediately following Late Cretaceous inversion of the Alpine–Carpathian foreland (i.e., Bohemian Massif). Jarosiński *et al*. (2009) apparently regarded this model as less probable, although they did not give any detailed explanation for this. In my opinion, although a conclusive answer cannot be given at the moment, a post-inversion model, with possible additional pre-Badenian erosion/incision, is much more viable. This is supported by the age of axial deposits from the Sędziszów–Rzeszów area as described above, and the overall similarity of palaeovalley systems from the Czech and Polish segments of the Carpathian arc. Additionally, their size and widespread distribution seem to support a post-inversion genesis. Flexural bulges uplifted in front of advancing orogenic wedges are not usually characterized by high amplitudes (DeCelles and Giles, 1996; *cf*. Krzywiec, 2006), hence incision of rather deep (several hundreds metres or even more) palaeovalleys solely due to uplift of a flexural bulge does not seem to be very probable. By contrast, Late Cretaceous–early Paleogene inversion of the Carpathian foreland (i.e. Mid-Polish Trough) was associated with significant uplift and pervasive erosion of the Mesozoic cover (*cf*. e.g., Scheck-Wenderoth *et al*., 2008 for more detailed information and numerous additional references). Therefore, late/post inversion incision of deep palaeovalleys, as in the Czech segment of the Alpine–Carpathian foreland, seems to be much more probable. During forebulge uplift certain segments of the palaeovalleys might have been additionally incised, in their more distal northern segments a Paleogene infill might have been removed during this phase, and the palaeovalleys might have been deepened.

2. Jarosiński *et al*. (2009) proposed that at the Badenian–Sarmation boundary the PCFB underwent a first phase of compressional deformation. It might be worth adding here that, apart from reverse faulting within the easternmost part of the basin (i.e. within the Wielkie Oczy graben; Krzywiec, 1999, 2001; *cf*. Jarosiński *et al*., 2009 and their fig. 7B) and apart from mesostructures of similar origin from the Machów area (Jarosiński, 1992) as described by Jarosiński *et al*. (2009), there are also strong indications, based on very high quality 2D and 3D seismic data, of significant transpressional activity along the Ryszkowa Wola horst, located within the eastern part of the PCFB (Krzywiec *et al*., 2005; Oszczypko *et al*., 2006). This horst was formed within the restraining bend of two basement faults in late Badenian–early Sarmatian times, and has experienced sinistral strike-slip movements until at least the latest Sarmatian (Krzywiec *et al*., 2005; Nescieruk *et al*., 2007).

3. Jarosiński *et al*. (2009) dated the post-evaporitic sedimentary infill of the easternmost PCFB as Sarmatian (see their fig. 7B), and, accordingly, dated the next phase of basin subsidence (Jarosiński *et al*., 2009, page 13). In fact, the lower part of the post-evaporitic siliciclastic succession contains also upper Badenian strata (see Oszczypko *et al*., 2006 for a more detailed overview), and therefore the onset of the important subsidence phase that was linked with the development of large normal faults and deposition of up to 3 km of the Miocene foredeep infill should be dated as late Badenian, not Sarmatian. During late Badenian subsidence, Miocene sediments were deposited in restricted small sub-basins formed above basement blocks rotated by domino faulting due to the combined effect of normal and reverse faulting (see Krzywiec, 1999 and his figs. 2 and 10). Sarmatian sedimentation was mostly controlled by the large-scale normal faulting that was primarily responsible for thickness reduction of the Sarmatian cover between the Wielkie Oczy graben and the Roztocze area (i.e. NE flank of the basin).

4. Jarosiński *et al*. (2009) used seismic data from the central (Kraków–Tarnów) segment of the PCFB (see their fig. 7A) in order to assess post-depositional erosion of the sedimentary infill of this basin. They claimed that inclination of the post-evaporitic succession, visible on seismic data, is in fact an effect of post-depositional rotation of this part of the basin caused by post-orogenic uplift within the orogenic wedge, and that the foredeep infill was deposited as an essentionally flat-laying cover blanketing varied deeper topography. Although some post-depositional basin-scale rotation might have indeed modified basin geometry, I would like to reiterate my model (not discussed by Jarosiński *et al*., 2009) which suggests that the post-evaporitic siliciclastic succession was shed to the foredeep basin from the eroded orogenic wedge, and that in the central (Kraków–Tarnów) part of the basin a large-scale clinoform related to sediment progradation is still partly preserved (Krzywiec, 2001; Oszczypko *et al*., 2006). In this part of the basin, in the area adjacent to the present-day thrust front, a fairly wide zone of horizontal (not inclined) reflectors can be mapped, north of this zone seismic reflectors become inclined (and this inclination is related to real, not apparent northward downlapping, possibly slightly oversteepened by post-orogenic movements within the orogenic wedge), and farther to the north the inclination progressively diminishes (*cf*. Krzywiec, 2001 and his fig. 9, and Oszczypko *et al*., 2006 and their fig. 23). Such a geometry could be interpreted as reflecting transition from shelf to proximal slope to distal slope, with a general direction of sediment supply from south to north. Such a geometry – clearly visible on many tens of seismic profiles from the central part of the PCFB – would be in my opinion very difficult to explain solely by basin rotation, as proposed by Jarosiński *et al*. (2009), as it would require not only *en-block* rotation of the entire basin infill due to uplift within the orogenic wedge but also short wavelength undulations within the basin, responsible for formation of zones of seismic reflectors of distinctly different inclination. It should be also stressed that a depositional model, basically identical to the model based on seismostratigraphic interpretation (Krzywiec, 2001; Oszczypko *et al*., 2006), was proposed for this part of the basin using borehole data (Porębski, 1999; Porębski *et al*., 2002; Porębski and Steel, 2003). Finally, it is also worth mentioning that the large-scale present-day geometry of the PCFB in e.g. the Rzeszów area is quite different, with essentially flat-laying foredeep deposits and only localized small-scale progradation visible immediately adjacent to the thrust front (see Krzywiec *et al*., 2008 and their fig. 9). Therefore, basin-wide post-depositional rotation, as proposed by Jarosiński *et al*. (2009) clearly did not take place there. Certainly, post-depositional erosion of the topmost part of the Miocene foredeep infill took place in all parts of the basin; its quantitative estimate should, however, be based on other data and models.

REFERENCES

DeCELLES P. G. and GILES K. A. (1996) – Foreland basin systems. Basin Research, **8**: 105–123.

JAROSIŃSKI M. (1992) – The tectonics of the argillaceous rocks of the cover of the sulphur deposit in Machów near Tarnobrzeg in the light of the mesostructural analysis (in Polish with English summary). Geol. Quart., **36** (1): 121–150.

JAROSIŃSKI M., POPRAWA P. and ZIEGLER P. (2009) – Cenozoic dynamic evolution of the Polish Platform. Geol. Quart., **53** (1): 3–26.

KRZYWIEC P. (1999) – Miocene tectonic evolution of the Eastern Carpathian foredeep basin (Przemyśl–Lubaczów) in light of seismic data interpretation (in Polish with English summary). Pr. Państw. Inst. Geol., **168**: 249–276.

KRZYWIEC P. (2001) – Contrasting tectonic and sedimentary history of the central and eastern parts of the Polish Carpathian Foredeep Basin – results of seismic data interpretation. Marine and Petrol. Geol., **18** (1): 13–38.

KRZYWIEC P. (2006) – Geodynamic and tectonic control on evolution of foreland basins, with references to the Carpathian Foredeep Basin (in Polish with English summary). Prz. Geol., **54** (5): 404–412.

KRZYWIEC P., ALEKSANDROWSKI P., FLOREK R. and SIUPIK J. (2004) – The structure of the Outer Carpathian orogenic front: an example of the Miocene Zgłobice unit between Brzesko and Wojnicz – new data, new models, new questions (in Polish with English summary). Prz. Geol., **52** (11): 1051–1059.

KRZYWIEC P., ALEKSANDROWSKI P., RYZNER-SIUPIK B., PAPIERNIK B., SIUPIK J., MASTALERZ K., WYSOCKA A. and KASIŃSKI J. (2005) – Geological structure and origin of the Miocene Ryszkowa Wola Horst (Sieniawa–Rudka Area, eastern part of the Carpathian Foredeep Basin) – results of 3D seismic data interpretation (in Polish with English summary). Prz. Geol., **53** (8): 656–663.

KRZYWIEC P., FLOREK R. and POPADYUK I. (2009) – Polish-Ukrainian Carpathian subthrust prospects – selected problems. AAPG European Reg. Ann. Conf., Paris-Malmaison, France, November 23–24, Book of Abstracts: 71–74.

KRZYWIEC P., WYSOCKA P., OSZCZYPKO N., MASTALERZ K., PAPIERNIK P., WRÓBEL G., OSZCZYPKO-CLOWES M., ALEKSANDROWSKI P., MADEJ K. and KIJEWSKA S. (2008) – Evolution of the Miocene deposits of the Carpathian Foredeep in the vicinity of Rzeszów (the Sokołów–Smolarzyny 3D seismic survey area) (in Polish with English summary). Prz. Geol., **56** (3): 232–244.

MORYC W. (1995) – Lądowe utwory paleogenu na obszarze przedgórza Karpat. Nafta-Gaz, **51** (5): 181–195.

MYŚLIWIEC M. (2004) – Traps for gas accumulations and the resulting zonation of the gas fields in the Miocene strata of the eastern part of the Carpathian Foredeep (SE Poland) (in Polish with English summary). Prz. Geol., **52** (8/1): 657–664.

NESCIERUK P., WÓJCIK A., MALATA T. and ALEKSANDROWSKI P. (2007) – Tectonic deformation structures in the Sarmatian (Miocene) Krakowiec clays at Wylewa near Sieniawa (Carpathian foreland basin): a record of young strike-slip fault activity in the basement (in Polish with English summary). Prz. Geol., **55** (8): 690–698.

OSZCZYPKO N., KRZYWIEC P., POPADYUK I. and PERYT T. (2006) – Carpathian Foredeep Basin (Poland and Ukraine) – its sedimentary, structural and geodynamic evolution. In: The Carpathians and Their Foreland: Geology and Hydrocarbon Resources (eds. F. Picha and J. Golonka). Am. Ass. Petrol. Geol. Mem., **84**: 293–350.

PICHA F. J., STRANIK Z. and KREJCI O. (2006) – Geology and hydrocarbon resources of the Outer Western Carpathians and their Foreland, Czech Republic. In: The Carpathians and their Foreland: Geology and Hydrocarbon Resources (eds. F. Picha and J. Golonka). Am. Ass. Petrol. Geol. Mem., **84**: 49–175.

PORĘBSKI S. (1999) – Depositional setting of a supra-evaporite succession (Upper Badenian) in the Kraków–Brzesko area, Carpathian Foredeep Basin (in Polish with English summary). Pr. Państw. Inst. Geol., **168**: 97–118.

PORĘBSKI S., PIETSCH K., HODIAK R. and STEEL R. (2002) – Origin and sequential development of Badenian–Sarmatian clinoforms in the Carpathian Foredeep Basin (SE Poland). Geol. Carpath., **54** (2): 119–136.

PORĘBSKI S. and STEEL R. (2003) – Shelf-margin deltas: their stratigraphic significance and relation to deepwater sands. Earth-Sc. Rev., **62** (3–4): 283–326.

SCHECK-WENDEROTH M., KRZYWIEC P., ZÜLKE R., MAYSTRENKO Y. and FRIZHEIM N. (2008) – Permian to Cretaceous tectonics. In: The Geology of Central Europe (ed. T. McCann), **2**: 999–1030, Mesozoic and Cenozoic.

ZUBRZYCKA M., CZERWIŃSKA B., NIKIEL-TSHABANGU B. and ZUBRZYCKI Z. (2009) – New perspectives for hydrocarbon prospecting in the Sokołów–Pogwizdów region (Carpathian Foredeep) as show by reprocessing of 3D seismic data (in Polish with English summary). Prz. Geol., **57** (11): 988–995.