

POLISH-UKRAINIAN CARPATHIAN SUBTHRUST PROSPECTS – SELECTED PROBLEMS

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Introduction

Carpathian thrust belt, formed during Jurassic to Miocene shortening events, is a classical petroleum province, where first commercial discoveries of hydrocarbons took place in early 19th century (Slaczka et al., 2006; fig. 1). Structure and stratigraphy of the Carpathian foreland plate is highly diversified. Carboniferous and Permian disintegration of the Hercynian Europe followed by Mesozoic extension led to development of the Tethyan basin system that extended to SE Poland and Ukraine. During Late Cretaceous to Palaeogene this basin system was inverted and uplifted. Inversion led to significant partial or total erosion of the Mesozoic sedimentary cover. Numerous balanced models have been proposed for structural evolution of the Carpathian arc together with its basement, that sometime differ significantly regarding thin- versus thick-skinned basement tectonics and role of orogen-parallel strike-slip movements (e.g. Behrmann et al., 2000; Nemcok et al., 1999, 2000, 2006; Roure et al., 1993; Roca et al., 1995), that are of key importance for proper understanding of development of subthrust prospects.

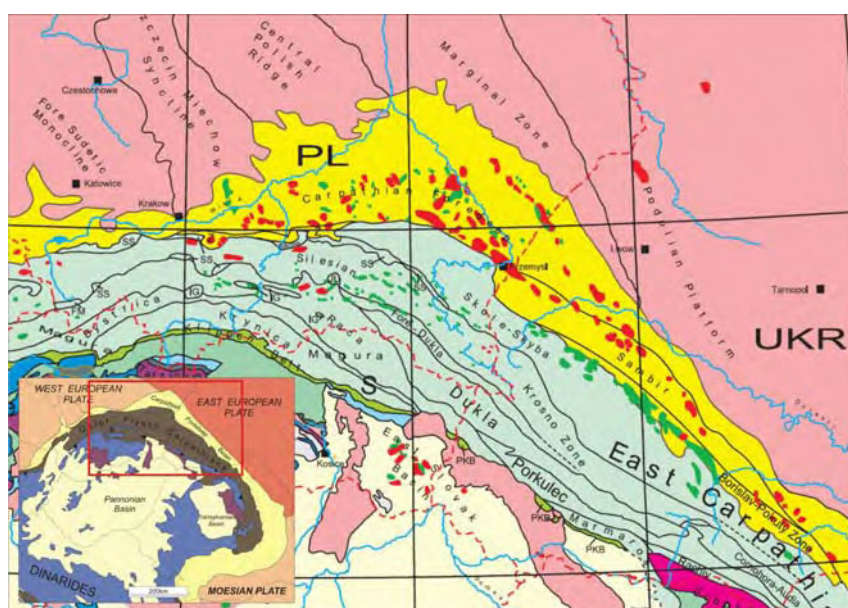


Fig. 1.

Oil and gas fields within the Polish and Ukrainian segments of the Carpathian arc, its foredeep basin and Meso-Palaeozoic basement (from Slaczka et al., 2006).

The Polish Carpathians and the Carpathian foreland

Within the central part of the Polish Carpathians (Krakow – Debica) three possible subthrust prospects have been identified. First two belong to the foreland plate: Upper Jurassic carbonate buildups and Cenomanian sandstones. Oxfordian buildups, identified within wide segment of the Carpathian foreland (Karnkowski, 1999; Gliniak et al., 2004, 2005). They could be characterized by very good reservoir properties, that could be however hampered by quartz cementation (Gliniak et al., 2004). Seismic imaging of such targets beneath the thrust belt remains still major challenge, although recently acquired data allow for better recognition of such targets. Cenomanian sandstones host major oil accumulations with the Carpathian foreland (e.g. Grobla - Pławowice field, cf. Karnkowski, 1999). Beneath the thrust belt Cenomanian sandstones, sometimes together with Upper Jurassic carbonates, form good structural traps within the hinge zones of reverse / thrust fault-related folds (e.g. Lakta field; Karnkowski, 1999). Despite acquisition and processing difficulties, recently acquired seismic data allow for very precise delineation of such targets. Third type of the subthrust prospect is related to the sedimentary infill of deep paleovalleys located beneath the frontal part of the Carpathian orogenic belt (e.g. Krzywiec et al., 2004). These paleovalleys have been eroded after inversion of the Permo-Mesozoic Polish Basin and served as conduits for sediments transport towards the South, into the Carpathian basins. Erosion generally followed NW-SE trending basement fault zones, that have been reinterpreted as normal (often listric) fault zones, rooted within the Palaeozoic or even Precambrian basement (fig. 2). Presently, they are filled by up to several hundreds of sediments, and sealed at the top by the Miocene foredeep evaporites. Potential traps include pinch-out zones along the scarps, and axial coarse siliciclastics, Miocene evaporites might provide additional seal. Similar paleovalleys are producing hydrocarbons in the Moravian part of the Carpathian belt (cf. Picha, 1996).

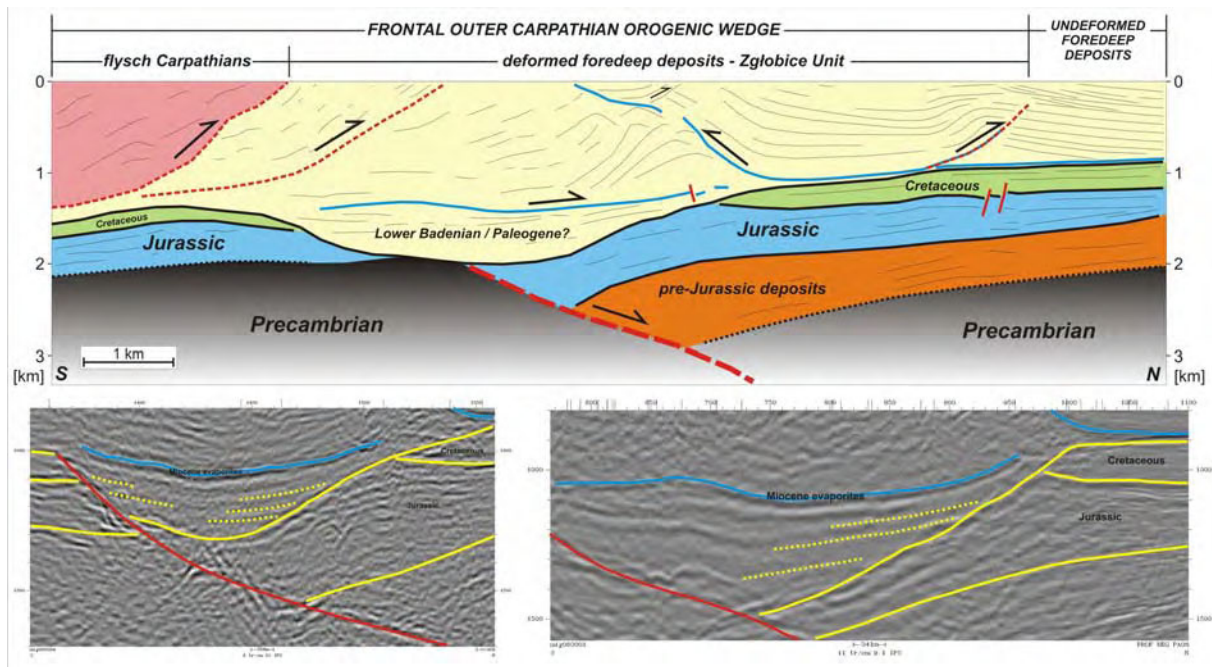


Fig. 2.

Incised valleys filled by the Miocene – Palaeogene(?) beneath the frontal Polish Carpathians (based on Krzywiec et al., 2004, modified and supplemented).

The Ukrainian Carpathians and the Carpathian foreland

In the western part of the Ukrainian Carpathians foreland plate hydrocarbons have been discovered both in the Neogene as well as in the Mesozoic successions. In SE segment of the Ukrainian Carpathians the Mesozoic prospects were unsuccessful until 1983 when Lopushna oil field, located mostly within the Mesozoic rocks was discovered underneath the thin-skinned Carpathians thrust belt (fig. 3).

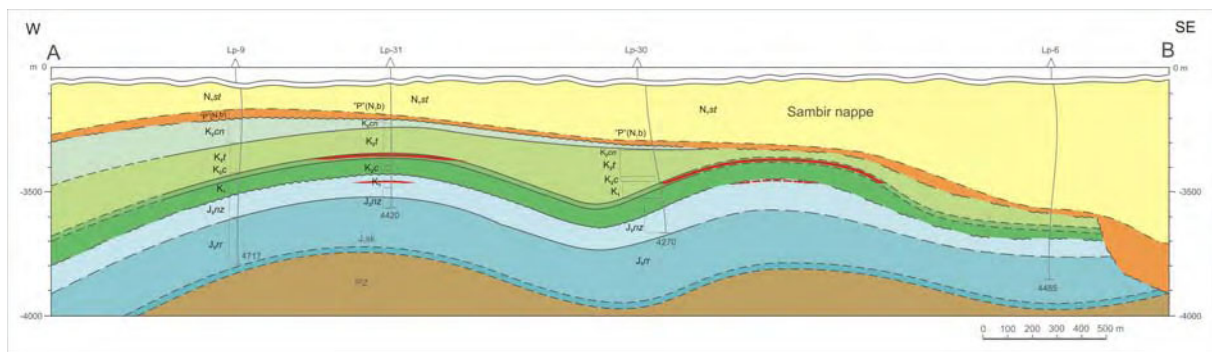


Fig. 3.

Cross-section of the Lopushna field. PZ – Paleozoic; Upper Jurassic: J3sk - Sokal fm (Oxfordian), J3rr - Rawa-Ruska fm (Kimmeridgian), J3nz - Nyzhniv fm (Tithonian); Cretaceous: K1 - Lower Cretaceous (Aptian?-Albian); Upper Cretaceous: K2c - Cenomanian, K2t - Turonian, K2cn – Coniacian; Miocene: "P"(N1b) - badenian, N1st - Stebnyk-Vorotysche fm (Sambir nappe).

The generalized stratigraphy of the Ukrainian Carpathian subthrust (UCS) corresponds to three major sedimentary megasequences bounded by unconformities. These megasequences are as follows: 1. Late Jurassic (Oxfordian-Tithonian), 2. Albian –Late Cretaceous, 3. Middle (?) Miocene. During the Late Jurassic southeastern part of recent UCS evolved as passive continental margin dominated by playa (Oxfordian), lagoon (Kimmeridgian) and shallow marine carbonate (Tithonian) sedimentation. Most likely shallow marine mixed carbonate / siliciclastic sedimentation persisted also during Neocomian. After Neocomian the area was uplifted and the upper portion of sedimentary succession was removed by erosion. The marine sedimentation resumed in Albian, followed by major transgression and deposition of siliciclastics (Cenomanian) and chalk with marls (Turonian – Maastrichtian). Most probably during the Oligocene and Early Miocene the UCS was uplifted and deeply eroded. This erosion, similarly to the Polish segment, led to incision of deep paleovalleys (canyons), later filled by Miocene infill of the Carpathian foredeep basin (cf. fig. 1). In the Late Miocene the entire southeastern part of Ukrainian Carpathian foreland was buried under overthrust Carpathian nappe system. The only potential source rocks in the sedimentary succession drilled in the UCS is believed to be Albian shales, although geochemistry of these rocks has not been studied in detail. The proven reservoir rocks have been found in Tithonian carbonates of Nyzniw formation and Cenomanian. The best seal rocks are Albian shales, Middle Miocene (autochthonous) shales and shales with some evaporites of the Stebnyk-Vorotyshe formation (allochthonous). Despite 26 years passed after the first commercial discovery in UCS the petroleum system is poorly studied, and the subthrust play is practically frozen. At least 11 closures were revealed by seismic survey in the southeastern part of UCS in late 1970' – 1980', however, almost all of these structures are at depth 6 - 7 km that restrain the exploration activity in the area.

Acknowledgements

Studies of the Polish segment of the frontal Carpathian arc have been co-funded by PGNiG S.A. and Ministry of Science and Higher Education (grant No 03764/C.T12-6/2005 and 54.5305.0701.00.8). PGNiG S.A. kindly provided seismic data.

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