Geodynamics and paleogeography of the Silesian Ridge in the Outer Carpathians

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Abstract

The complex Mesozoic and Cenozoic tectonics of the Outer Carpathians produced series of ridges separating deep water basins.The Silesian Ridge existed since from Jurassic till Oligocene times. Today this ridge is destroyed totally and is known only from olistoliths and exotic pebbles in the Outer Carpathian flysch. It separated the proto-Silesian Basin from the Alpine Tethysduring Jurassic-Early Cretaceous times.The carbonate platform was initially developed on this submarine ridge providing excellent conditions for organic life, represented by calcareous algae, sponges, corals, bryozans, brachiopods, bivalves, ammonites and crinoids. The Late Cretaceous uplift of the Silesian Ridge produced a tremendous amount of clastic material.The submarine fragments of the Silesian Ridge provided favorable conditions for development of shallow banks with the carbonate platform sedimentation during Paleocene-Eocene times. Shallow water, probably narrow shelf locally was dominated by Paleocene and Eocene reefs built of red algae together withbryozoans, brachiopods, sometimes corals and foraminifers. Patchily distribution of these faunas is confirmed by local occurrence of redeposited organic limestones within siliciclastic material. The accretionary prism of Outer Carpathians reached the Silesian Ridge during latest Eocene-Early Miocene. The uplifted part of the nappes produced big olistoliths, which glided down into the adjacent, more distal basins. Finally, the ridge collapsed as a result of the lithosphere flexure in the southern part of the Silesian basin and was destroyed during Neogene times.

Keywords: *Carpathians, Paleogeography, plate tectonics, flysch, carbonates*

Introduction

The complex Mesozoic and Cenozoic tectonics of the Outer Carpathians produced series of ridges separating deep water basins. These ridges were providing favorable conditions for development of shallow banks with the carbonate platform sedimentation. The orogenic processes in the Northern Outer Carpathians produced an enormous amount of the clastic material that started to fill the basins. The material was derived from the northern and southern margins as well as from the inner ridges and swells. The present authors investigated geodynamics and paleogeography of the most prominent elevated area – the Silesian Ridge, which existed since from Jurassic till Oligocene times. Today this ridge is destroyed totally (collapsed during subduction processes) and is known only from olistoliths and exotic pebbles in the Outer Carpathian flysch (Cieszkowski et al. 2009, 2012 and references therein).

Methods

The assessment of the Outer Carpathian paleogeography was based on evaluation of existing published and archive data, plate tectonic analysis, and correlation of lithostratigraphic units with the global sequence stratigraphy scheme. The plate tectonic model used (PLATES and PALEOMAP software) incorporates the relative motions between approximately 300 global and about 20 Circum–Carpathian plates and terranes (Golonka et al. 2006). Information from several general and regional paleogeographic papers was assessed and utilized. The calculated paleolatitudes and paleolongitudes were used to generate computer maps in the Microstation design format using the equal area Molweide projection. The arrangement of the lithostratigraphic units is related to their paleogeographic position within the original basins. It is partially based on previously published papers (Golonka et al. 2008; Waskowskaet al. 2009; Golonka 2011).

Geological setting

The Northern Carpathians are subdivided into an older range known as the Inner Carpathians and the younger one, known as the Outer or Flysch Carpathians. The Outer Carpathians are built up of a stack of nappes and thrust-sheets showing a different lithostratigraphy and tectonic structures. From the South they are: the Magura Nappe, Fore-Magura Group of nappes, the Dukla Silesian, Subsilesian and Skolenappes (Ślączka et al. 2006; Golonk 2011 and references therein). Each Outer Carpathian nappe represented separate or partly-separate sedimentary subbasin. The enormous continuous sequence of flysch type sediments were deposited in these subbasins, their thickness locally exceeds 6 km. The sedimentation spanned the time between Late Jurassic and Early Miocene. During the folding and overthrusting sedimentary sequences were uprooted and generally only sediments from the central parts of basins are preserved (Ślączka et al. 2006). The Outer Carpathians nappes thrust over each other and over the North European Platform, a large continental plate amalgamated during Precambrian-Paleozoic time. Proterozoic and Paleozoic fragments could be distinguished within the folded and metamorphosed basement of this plate. The sedimentary cover consist of the autochthonous Upper Paleozoic, Mesozoic and Cenozoic sequences covered by the allochthonous Jurassic-Neogene rocks. The Inner Carpathians are built of the continental crust of Variscan Late Paleozoic age and Mesozoic-Cenozoic sedimentary cover. The uppermost Paleozoic-Mesozoic continental and shallow marine sedimentary sequences of this plate are folded and thrust into a series of nappes (Ślączka et al. 2006).

Origin of the Silesian Ridge

The Outer Carpathian rift (proto-Silesian Basin) had developed with the beginning of the Uppermost Jurassic-Lower Cretaceous calcareous flysch sedimentation. The Jurassic-Early Cretaceous Silesian Ridge (Książkiewicz 1962; Golonka et al. 2005; Golonka 2011) originated as a result of the fragmentation of the European platform in this area. The proto-Silesian basin was formed during the synrift process with a strong strike-slip component. The complex system of rotated block was born. The emerged fragment of these blocks supplied material to the basin. The opening of the basin is related to the propagation of the Atlantic rift system (Golonka et al. 2005). The Silesian Ridge separated the proto-Silesianbasin from the Alpine Tethys (Fig. 1). A part of the clastic source area for the proto-Silesianbasin was situated on the islands at the southern margin of this basin and related to the northern margins of the Silesian Ridge (Książkiewicz 1962; Ślączka et al. 2006; Cieszkowski et al. 2012). The carbonate platform was initially developed on this submarine ridgeproviding excellent conditions for organic life, represented by calcareous algae, sponges, corals, bryozans, brachiopods, bivalves, ammonites and crinoids. The debris-flow uppermost Jurassic-lowermost Cretaceous sediments include clasts of bioclastic limestones. The existence of coarse-grained facies of the Upper Cieszyn Limestones as well as the appearance of mass-movement debris-flow deposits indicate the significant vertical movements during the Neo-Cimmerian activity. The Early Cretaceous development of the proto-Silesian Basin, perhaps from rifting into spreading phase, as suggested by the presence of teschenitic magmatism was probably another effect of this Neo-Cimmerian activity. The carbonate facies within the proto-Silesian Basin were replaced by clastic deposits (Golonka et al. 2005).

The Cretaceous reorganization

During the Cenomanian and Turonian, compression embraced the Inner Carpathians and several nappes with northward polarity developed. In the Outer Carpathians during this stage several ridges have been uplifted as an effect of the orogenic process. These ridges distinctly separated several subbasins, namely Magura, Dukla-Fore-Magura, Silesian, Charnahora-Audia, Skole-Tarcausubbasins. More outer subbasins (Skole, Silesian, Dukla-Fore Magura) reached diagonally the northern margin of the Outer Carpathians and successively terminated towards the west. From uplifted areas, situated within the Outer Carpathian realm as well as along its northern margin, enormous amount of clastic material was transported by various turbidity currents.The sedimentation and subsidence rate in the Silesian Basin and were accompanied by a continuous uplifting. The uplift of the Silesian Ridge produced a tremendous amount of clastic material. Sedimentation started during the Late Turonian-Early Coniacian and lasted up to the Early Eocene in the Silesian Basin being mainly represented by thick bedded, coarse-grained turbidites and fluxoturbidites (Ślączka et al. 2006; Golonka 2011). The submarine fragments of the Silesian Ridge provided favorable conditions for development of shallow banks with the carbonate

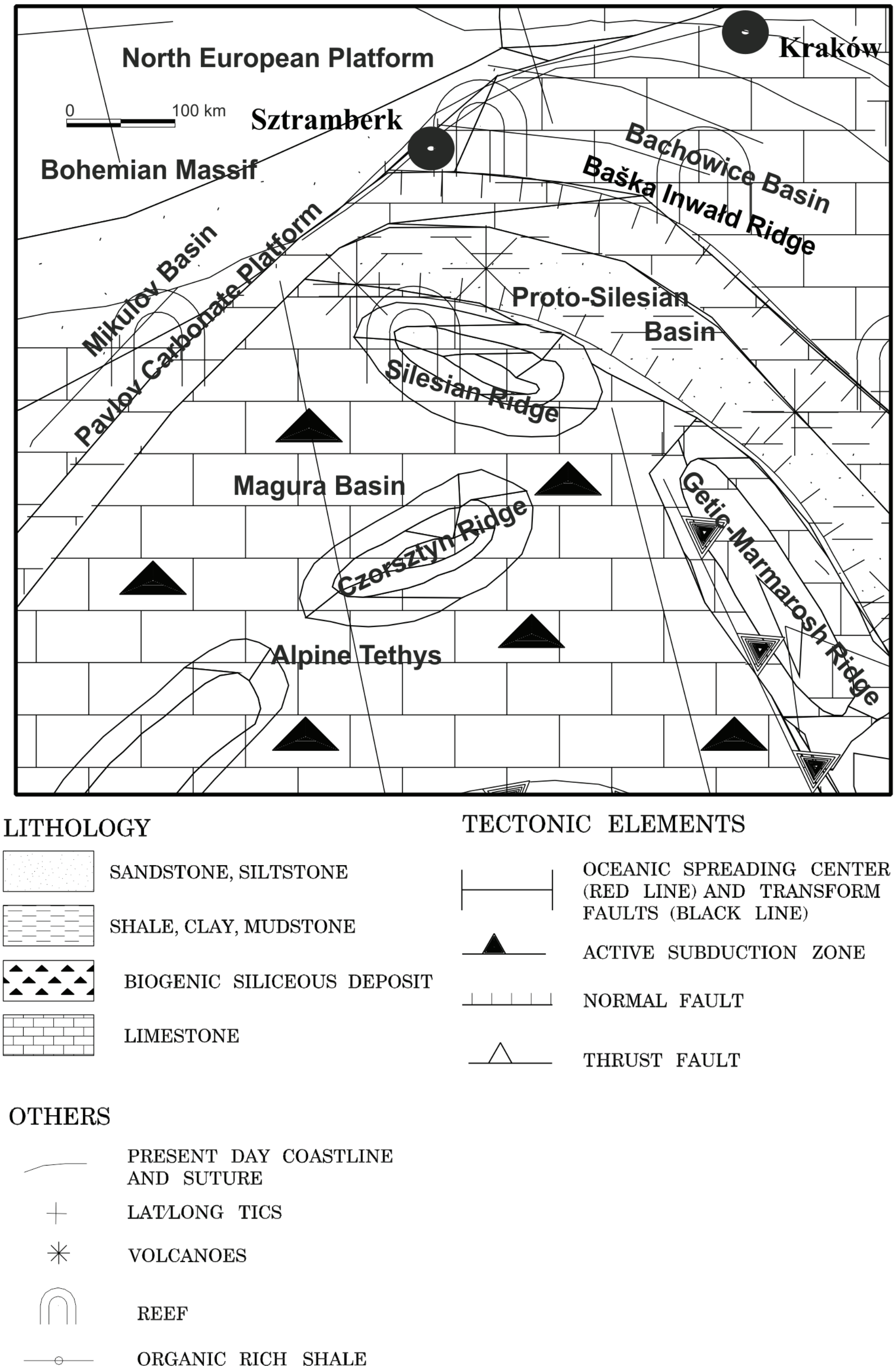

Figure 1. Paleolithofacies with main paleogeographical element of the West Carpathians and adjacent areas during the latest Jurassic – Early Cretaceous (from Golonka 2011, modified). Plate position 140 Ma.

platform sedimentation during Paleocene-Eocene times. Shallow water, probably narrow shelf locally was dominated by Paleocene and Eocene reefs built of red Corallinaceae algae Lithothamnium. Lithophyllum, Arhaeolithothamnium, Paleothamnium, Ethelia, together with bryozoans, brachiopods, sometimes corals and foraminifers. Patchily distribution of these faunas is confirmed by local occurrence of redeposited organic limestones within siliciclastic material.

The destruction of the Silesian Ridge

The oblique collision of the Inner Carpathian terranes with the North European Plate led to the farther development of the accretionary prism of Outer Carpathians during latest Eocene-

Early Miocene times.The front of the overriding Magura Nappe reached the Silesian Ridge, which collapsed as a result of the lithosphere flexure and in southern part of the Silesian Basin, in front of the advancing nappe huge olistoliths were deposited. The Silesian Ridge was destroyed totally and is known only from olistoliths and exotic pebbles in the Outer Carpathian flysch (Cieszkowski 2012 and references therein). They destruction is related to the advance of the accretionary prism. The outer, marginal part of the advanced nappes was uplifted during overthrusting. Big olistoliths glided downfrom the uplifted part of the nappes into the adjacent, more distal basins. The nappes became detached from the basement and were thrust northward in the west and eastward onto the North European platform with its Miocene cover. The Outer Carpathian allochthonous rocks, as result of Miocene tectonic movements, have been thrust over the platform for a distance of 50 to more than 100 km. The olistostromes formed during the final collisional and postcollisional stages are known from outcrops as well from numerous wells in the marginal part of the Northern Carpathians. Tectonic movements caused final folding and the Carpathian nappes became uprooted from the basement. The allochthonous flysch nappes were trust over the North European platform for the distance of 50 km to more than 100 km. Overthrusting movements migrated along the Carpathians from the West towards the East. The inner part of the platform, in the eastern part also with the marginal part of the flysch basin started to downwarp in front of the advancing Carpathians nappes and tectonic depression formed during the Early Miocene times. That basin became overthrust by the Carpathians. At the end of Burdigalian and a new, more external one, developed. Clastic and fine-grained sedimentation of the Carpathian and foreland provenance prevailed with a break during the Late Langhian to Early Serravallian, when younger evaporate basin developed. In the west, sedimentation terminated already in Langhian and in the east lasted till Pliocene. These events mark the postcollisional stage in the Outer Carpathian (Golonka et al. 2006; Ślączka et al. 2006).

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