EARLY STAGES OF THE CARPATHIAN BASINS DEVELOPMENT

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Abstract: The basement of most of the plates, which play important role in the Mesozoic-Cenozoic evolution of the circum-Carpathian area was formed during the Late Paleozoic collisional events. The Mesozoic rifting events resulted in the origin of the oceanic type basins like Meliata, Vardar-Transilvanian and Ligurian-Penninic-Pieniny Oceans. During the Late Jurassic-Early Cretaceous time the Outer Carpathian rift had developed.

Keywords: plate tectonics, Tethys, Carpathians, Late Paleozoic, Mesozoic, basins.

The basement of most of the plates, which play important role in the Mesozoic-Cenozoic evolution of the circum-Carpathian area was formed during the Late Paleozoic collisional events. The older, Cadomian and Caledonian basement elements experienced Hercynian tectono-thermal overprint (Rakuš et al., 1998). Moesia, Rhodopes and the Alcapa superterrane which includes Eastern Alps, Inner Carpathian, Tisa and adjacent terranes, were sutured to the Laurasian arm of Pangea, while Adria and adjacent terranes were situated near the Gondwanian (African arm). The Paleotethys Ocean was situated between northern, Laurussian (N. America, Baltica and Siberia) and southern, Gondwanian branch (Africa, Arabia and Iranian terranes) of Pangea (Golonka, 2000). Mountains formed on the northern margin of Paleotethys, as results of these events, were connected with the Hercynian orogen in Europe. North-dipping subduction developed along the Paleotethys margin. This subduction was a major force driving Late Paleozoic and Early Mesozoic movement of plates in this area. It caused Triassic back-arc rifting in the proto-Black Sea area forming the Tauric basin between the Pontides and the Dobrogea-Crimea. According to Muttoni et al.(2000) Moesia was probably marginally separated, but not detached or rotated away from Europe by the North Dobrogea transtensional trough, which is also interpreted as a back-arc basin resulting from the northward subduction of the Tethys Ocean. This trough was perhaps connected with the rift situated in Poland. The Polish rift, also known as the Polish-Danish Aulacogen has SE-NW direction parallel to the Transeuropean Suture Zone.

The oceanic system was established in Southern and Central Europe during the Permian-Triassic time. The narrow branch of Neotethys separated the Apulia-Taurus platform from the African continent. The Apulia platform was connected with European marginal platforms. Its northernmost part was possibly separated from the Umbria-Marche region by a rift. The incipient Pindos Ocean separated the Pelagonian, Sakariya and Kirsehir block from the Ionian-Taurus platform (Golonka et al., 2000). The Vardar-Transilvanian Ocean separated the Tisa (Bihor-Apuseni) block from the Moesian-Eastern European Platform (Săndulescu, 1988). There is a possibility of existence of the embayment of Vardar-Transilvanian oceanic zone between Inner Carpathian, and European Platform (Golonka et al., 2000). The pelagic Triassic limestones in the exotic pebbles in the Pieniny Klippen Belt (Birkenmajer *et al*., 1990) and Magura Unit (Soták, 1986) could have originated in this embayment. The embayment position and its relation to the other parts of Tethys, Vardar Ocean, Meliata-Halstatt Ocean, Dobrogea rift and Polish-Danish Aulacogen remain quite speculative.

According to Rakús et al. (1998) two oceanic units were located south of the Inner Carpathian plate. One was open during the Triassic time, closed during the Late Triassic as a result of the Early Cimmerian collision. Another, represented by sequences at the classic profile of Meliata in Southern Slovakia, opened during Early-Middle Jurassic as a back-arc basin and closed during Late Jurassic time. The position of the Meliata Ocean, time of closing and a role of the Tisza unit in the Mesozoic collisional events is still the subject of lively discussion (see e.g. Kozur, 1991; Stampfli, 2001; Plašienka; 1999, Golonka et al., 2000; Wortman et al., 2001).

Continued sea-floor spreading occurred during the Jurassic time within the Neotethys. The Pelagonian plate, Kirsehir and Sakariya (and perhaps the Lesser-Caucasus-Sanandaj-Sirjan plate) were drifting of the Apulia-Taurus-Arabia margin. The Ligurian Ocean, as well as the central Atlantic and Penninic Ocean were opening during Early – Middle Jurassic. The oldest oceanic crust in the Ligurian-Piedmont Ocean is dated as late Middle Jurassic in Southern Apennines and in the Western Alps**.** Pieniny data fit with the supposed opening of the Ligurian and Penninic Ocean basins (Golonka et al., 2000). Stampfli (2001) recently postulates single Penninic Ocean separating Apulia and Eastern Alps blocks from Eurasia. We proposed similar model for the Pieniny Klippen Belt Ocean in the Carpathians. The orientation of this ocean was SW-NE (see discussion in Golonka & Krobicki, 2001). The Pieniny Ocean was divided into the northwestern and southeastern basins by the Czorsztyn Ridge. The deepest parts of both basins are documented by deep water, extremely condensed, Jurassic-Early Cretaceous pelagic limestones and radiolarites. The shallowest ridge sequences are known as the Czorsztyn Succession. In this succession the Early Jurassic *Bositra* ("*Posidonia"*) marls are followed by

Middle – Jurassic-earliest Cretaceous crinoidal and nodular limestones and the Late Cretaceous pelagic marl facies. The transitional slope sequences between deepest basinal units and ridge units consist of mixed cherty, limestone and marly facies. This Jurassic Ocean was connected with older, Triassic embayment of Vardar-Transilvanian Ocean.

Major plate reorganization happened at the end of Jurassic. The Central Atlantic began to propagate to the area between Iberia and the New Foundland shelf. The Meliata-Halstatt was closed and subduction jumped to the northern margin of the Inner Carpathian terranes and began to consume the Pieniny Klippen Belt Ocean (Birkenmajer, 1986). The Outer Carpathian rift had developed with the beginning of calcareous flysch sedimentation. The Western Carpathian Silesian Basin probably extended in the Eastern Carpathian (Sinaia or „black flysch") as well as to the Southern Carpathian Severin zone (Sandulescu, 1988). The remnants of carbonate platforms with reefs (Štramberk) along the margin of Silesian Basin were results of the fragmentation of the European platform in this area. The Silesian Ridge separated the Silesian and Magura basins. The subsidence and spreading in the Silesian Basin was accompanied by the extrusion of basic lavas (teschenites) in the Western Carpathians during Hauterivian-Barremian and diabase-melaphyre within the „black flysch" of the Eastern Carpathians (Golonka et al., 2000; Lucińska-Anczkiewicz et al., 2000). The extension of the Silesian-Sinaia basin is mark by the beginning of the sedimentation in the Skole-Tarcau area.

The Jurassic separation of Bucovino-Getic microplate from European plate is perhaps related to the origin of the Silesian Ridge. The direct connection is obscured however by the remnants of the Transilvanian Ocean in the area of the eastern end of Pieniny Klippen Belt Basin. These remnants are known from the Iňačovce-Krichevo unit in Eastern Slovakia – and Ukraine (Soták et al., 2000). In this area existed a junction of the different basinal units – PKB-Magura-Ocean, Transilvanian Ocean and Outer Carpathian Basin. The eastward-northeastward subduction along the Silesian Ridge and Bucovinian-Getic Terrane was perpendicular or oblique to the southward subduction at the northern margin of the Inner-Carpathian-Eastern Alps terrane. The Silesian – Sinaia basin developed as a back-arc basin. The eastward subduction of Getic-terranes is connected with the northward subduction under Rhodopes-Moesia plate mentioned above. The displacement within Transilvanian Ocean which is began in Barremian is perhaps also related to this subduction.

The Outer Carpathian basin reached its greatest width during the Hauterivian-Aptian time. With the widening of the basin, several subbasins (troughs) began to show their distinctive features. These subbasins, like Silesian, Sub-Silesian, Skole, Dukla, Tarcău, were locally separated by uplifted areas, e.g. Inwałd-Andrychów zone. The general downwarping of the Silesian Basin was probably due to the cooling effect of the underlying lithosphere. The sedimentation of calcareous sediments pass upwards gradually into black shales with turbiditic sequences in the Silesian trough.

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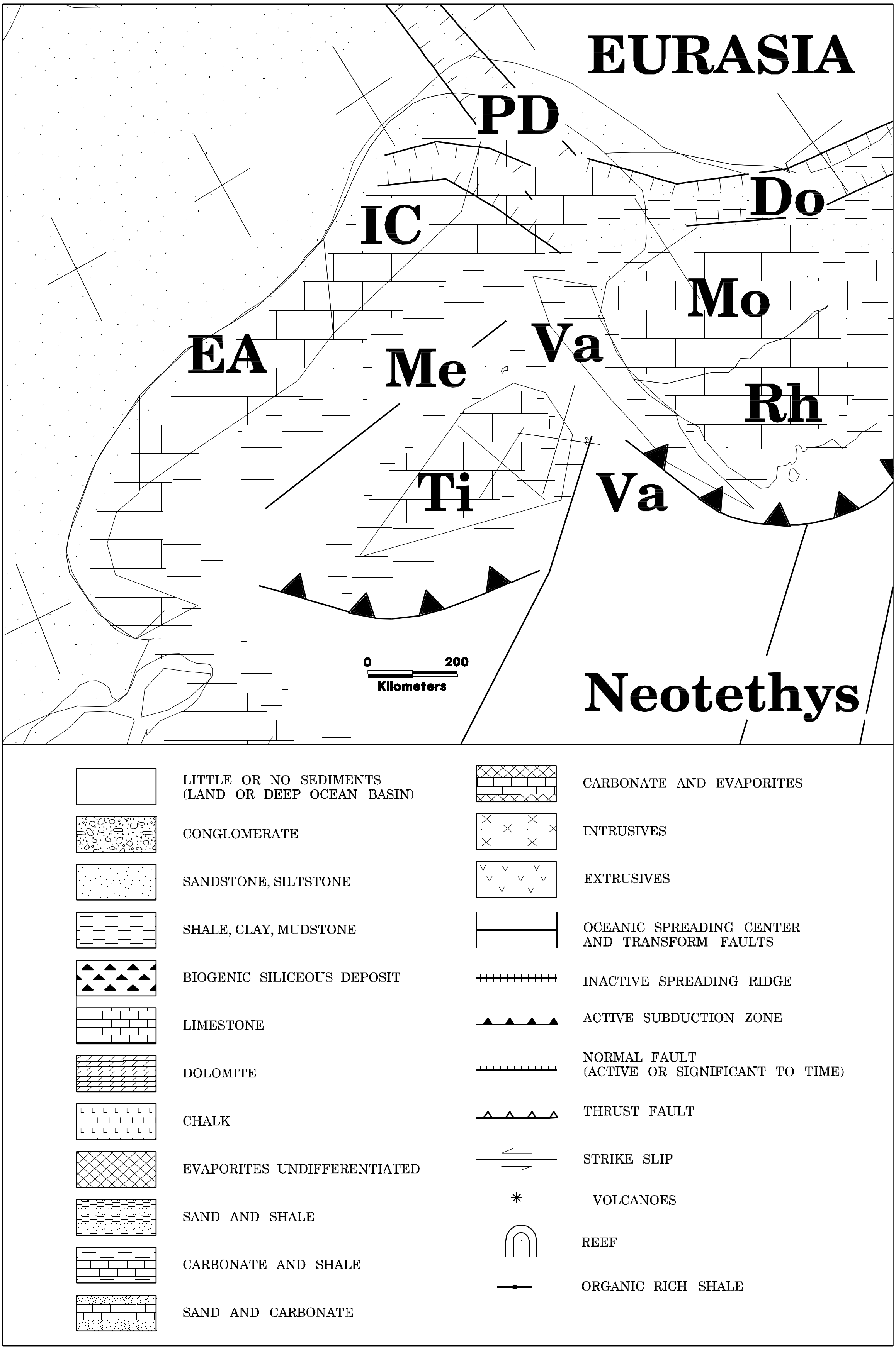
Fig. 1. Palaeogeography of the circum-Carpathian area during Late Triassic; plates position at 225 Ma. Abbreviations of oceans and plates names: Ad – Adria (Apulia), Bl – Balkans, Br – Briançonnais terrane, Cr – Czorsztyn Ridge, Do – Dobrogea, EA – Eastern Alps, IC – Inner Carpathians, Li – Ligurian (Penninic) Ocean, Me – Meliata/Halstatt Ocean, Mg – Magura Basin, Mo – Moesia plate, PB – Pieniny Klippen Belt Basin, PD – Polish-Danish aulacogene, Rh – Rhodopes, SC – Silesian Ridge (cordillera), Si – Silesian Basin, SM – Serbo-Macedonian terrane, Ti – Tisza plate, Va – Vardar.


EURASIA
PD
Do
IC
Mo
EA
Me
Va
Rh
Ti
Va
0 200
Kilometers
Neotethys
LITTLE OR NO SEDIMENTS (LAND OR DEEP OCEAN BASIN)
CONGLOMERATE
SANDSTONE, SILTSTONE
SHALE, CLAY, MUDSTONE
BIOGENIC SILICEOUS DEPOSIT
LIMESTONE
DOLOMITE
CHALK
EVAPORITES UNDIFFERENTIATED
SAND AND SHALE
CARBONATE AND SHALE
SAND AND CARBONATE
CARBONATE AND EVAPORITES
INTRUSIVES
EXTRUSIVES
OCEANIC SPREADING CENTER AND TRANSFORM FAULTS
INACTIVE SPREADING RIDGE
ACTIVE SUBDUCTION ZONE
NORMAL FAULT (ACTIVE OR SIGNIFICANT TO TIME)
THRUST FAULT
STRIKE SLIP
VOLCANOES
REEF
ORGANIC RICH SHALE