Mesozoic sedimentary basins, current systems and life domains in northern part of the Mediterranean Tethys Ocean

JOZEF MICHALÍK

Earth Science Institute, Slovak Academy of Sciences, Bratislava, Slovakia; geolmich@savba.sk

Abstract: Contact of the Mediterranean Tethys with Paleoeurope has been affected by tension, rifting, and by left lateral shift since the Early Triassic. The Late Triassic/Early Jurassic evolution was controlled by convergence along border of the Meliata Ocean and by contemporaneous divergence along the Middle Atlantic/Penninic rift. During Mid Cretaceous, the convergence between Africa and Paleoeurope started, which finally resulted in collision of the Alpine–West Carpathian microcontinent with the Paleoeuropean margin and in the formation of the Alpine nappe pile.

Keywords: lithofacies, paleogeography, Mediterranean Tethys, Western Carpathians, Mesozoic.

Triassic development

Since the Early Permian, the Mediterranean Tethys area becomes a playground of subcrustal movements with variegated microcontinental blocks (Stampfli et al. 2001; Cavazza & Wezel 2003). During the Triassic, Alpine–Carpathian sequences were deposited on fragmented Variscan crust remnants. They formed the Palaeoeuropean shelf between the Armorican and Bohemian massifs and the Ukrainian Shield (Feist-Burkhardt et al. 2008). The Central West Carpathian block, together with the Eastern Alpine fundament, were rimmed by the Meliata Ocean on the south. Triassic sequence of this area is composed of several megacycles deposited under changing climatic, eustatic, and paleoceanographic regime.

The Scythian clastics accumulated in a huge (>100 000 km^3) deltaic fan system. The source of considerable laterally dispersed terrigenous clastic sediments is assumed to be located in the northern "Vindelician Land" (Michalík 1992, 1993, 2011; Michalík in Feist-Burkhardt et al. 2008). Quartz sandstones, lithic sandstones, and greywackes with conglomeratic layers fining in a southward direction accumulated in a complex delta system (Mišík & Jablonský 2000) with proximal, more terrigeneous sediments in the north, and more distal marine facies on the southern margin (Csontos & Vörös 2004). The material was transported by periodical river systems from the area between the Bohemian and the Armorican massifs.

Arid Triassic climate caused accumulation of thick carbonate ramp- and platform complexes, with only several inserted terrigeneous clastic formations, indicating more humid intervals during the Scythian, the Early Carnian, and the Rhaetian. The subsidence (20–30 mm/ka) of wide (300×1000 km) Anisian carbonate ramp of the Gutenstein limestones and dolomites on a submerged alluvial plain was controlled by gradual sea level rise and by compaction of underlying pelitic complexes (60–70 mm/ka). An increasing in late Anisian tectonic activity is documented by tsunamite layers and slump breccias (Michalík et al. 1992). Ladinian carbonate platforms were affected by tensional stress (Michalík 1993, 1994). Sedimentation in intrashelf pull-apart basins was rather slow (4–15 mm/ka) as compared with the rapidly growing reefal margins keeping up with the subsidence rate (up to 400 mm/ka). Differential sedimentation rates accentuated the basinal morphology: the basins attained depths of 1200–1500 m at end of the Ladinian, when sea level began to fall. The Julian humid event was the time of mass transport of clastics (about 10 000 km^3) that completely filled former tensional basins in the Slovako-Carpathian–Austro-Alpine shelf. Rapidly (500–700 mm/ka) accommodated material has been carried under occasional monsoonal climate from the adjacent Paleoeuropean continent.

Late Triassic regression and tectonic rise in an arid climate led to a re-establishment of carbonate platform system with a continuous reef margin. Extensive backreef flats (Dachstein Lst and Hauptdolomit formations) separated the sea from Dead Sea-type dry basins with Carpathian Keuper sedimentation. However, the sedimentation rate of the Carpathian Keuper was seven times slower than the sedimentation rate of the Germanic Keuper.

At the end of the Triassic, the Penninic Rift (a continuation of the Mid-Atlantic Oceanic Rift) expanded and detached Mediterranean microcontinents from its

Paleoeuropean foreland. Disintegration of Tethyan shelf resulted in the "mega-shear" model of numerous mega-blocks separated by strike-slip faults (Michalík 1993, 1994). Lakes and swamps with terrestrial flora and fauna formed in river valleys and depressions, flooded by transgression (Lintnerová et al. 2013). Koessen-type shallow basins have been filled by marine sediments with abundant neritic fauna (Michalík et al. 2013). The Triassic–Jurassic boundary is marked by: termination of carbonate sedimentation; occurrence of spherulite containing beds; C and O isotope excursions; and by the onset of clastic input due to changing climate at beginning of the Hettangian transgression (Michalík et al. 2010). On the other hand, subduction of the Meliata Ocean led to convergence of both Alpine–Carpathian and Adriatic microcontinents.

Jurassic evolution

The onset of Jurassic sedimentation was affected by emersion and non-sedimentation (Michalík in Pieńkowski et al. 2008). During the Meliata Oceanic crust subduction, the southern margin of the Austroalpine–Central Carpathian microcontinent collided with small blocks in its foreland. Carbonate platforms have been emerged and karstified. The Tatric and Veporic domains much more distant of it have been uplifted. On the other hand, the subsidence continued in the Fatric Domain that was located between these two domains. At the beginning of the Jurassic, marine claystones with occasional sandstone and sandy organodetrital limestones have been deposited in this basin. During the Sinemurian and Lotharingian, quartz-rich sandstone passing distally into sandy limestones documents the last phases of riverine influx in the Central West Carpathians. Crinoidal limestones have been deposited on the slope, while deeper hemipelagic setting was characterized by the deposition of bioturbated marlstones. Red nodular limestones and marls of the Adnet Fm indicated slower sedimentation rate at the end of Early Jurassic. The Lower Jurassic sedimentary cycle in the Hronic Basin started with crinoidal limestones and was terminated with red nodular limestones.

New middle Jurassic sedimentary cycle started with the deposition of organodetrital limestones with calciturbidites, passing basinward into siliceous limestones, radiolarites and dark marls. During the Oxfordian, the bottom of the Fatric Zliechov Basin was covered by dark marlstones, but the adjacent elevated bottom was the location where the Ammonitico Rosso limestones were deposited. The Mid-Jurassic sedimentary cycle of the Hronic Unit consists of crinoidal limestones. During Late Jurassic, the Ammonitico Rosso facies formed on the shallows. The southermost part of the West Carpathian inner block is characterized by the deposition of pelagic facies. On the other hand, several elevations with neritic limestone sedimentation have been recorded. The sedimentary record here was terminated by Late Cimmerian deformation of the area.

Lower Cretaceous evolution

Scarcely preserved source platform limestone complex consists of microsparitic peletal wackestones with rare oncolites and bioclasts. Shallow marine limestone sequence on more distal elevated blocks starts with Kimmeridgian and Tithonian condensed "Ammonitico Rosso" complex of red nodular limestone. On the other hand, the majority of Lower Cretaceous sequences in the Western Carpathians represents mostly hemipelagic ("Neocomian") limestones (Vašíček & Michalík 1999) containing calciturbidite debris. The pull-apart Fatric Basin was filled by Upper Jurassic dysoxic marls (Michalík 2007), covered by pelagic Berriasian "biancone" limestones. Hemipelagic limestones are of Late Valanginian age in the Manín Unit, but they comprise Valanginian to Aptian in basinal infillig of the Zliechov Basin. The Late Cimmerian compression on south is indicated by input of quartz debris with abundant chromium spinel grains (Michalík in Voigt et al. 2008).

Upper Hauterivian–Lower Albian sequence starts with the deposition of slope- and submarine delta fans derived from carbonate platforms prograding basinwards (Michalík & Soták 1990). The carbonate platforms were mostly destroyed by erosion. Warming during Aptian caused decreasing oxygenation and increasing of carbon content in the basinal sediments.

Mid-Cretaceous synorogenic formations

During Middle Albian, carbonate platforms submerged being covered by dark marls. The basins in central Carpathians were mostly filled by thick (300–600 m) brownish, often bioturbated gray marls with siltstone intercalations, or even olistoliths, passing into Cenomanian rhytmic sandstone-claystone sequence. At this time, convergence between Gondwana- and Laurasian margins resulted by subduction of the Penninic oceanic bottom, by destruction of former basinal systems and folding. A complex stacked pile of superposed units comprising the pre-Alpine basement, its Mesozoic cover, and superficial nappes originated during Turonian in Central Carpathians.

The Upper Cretaceous "Gosau" developments

After the major compression have released, fold structures collapsed. New basins evolved in the middle of orogenic system (Plašienka et al. 1997). Variegated breccias of local material, cemented by yellowish and red argillaceous matrix and Turonian/Lower Coniacian fresh-water algal limestones filled cavities and depressions on surface of carbonate complexes. Marine sequence started by braided river- and subaerial delta clastics composed of alternating graded calcareous sandstones, variegated marls and flysch complexes. In Outer Carpathians, tension and basin opening continued until Oligocene when Alpine and Carpathian orogenetic arcs began to form.

References

Cavazza W. & Wezel F.C. 2003: The Mediterranean region — a geological primer. *Episodes* 26, 3, 160–168.

Csontos L. & Vörös A. 2004: Mesozoic plate tectonic reconstruction of the Carpathian region. *Palaeogeogr. Palaeoclimatol. Palaeoecol.* 210,1–56.

Feist-Burkhardt S., Gőtz A.S., Szulc J., Borkhataria R., Geluk M., Haas J., Hornung J., Jordan P., Kempf O., Michalík J., Nawrocki J., Lutz R., Ricken W., Rőhling H.G., Ruffer W., Tőrők Á. & Zühlke R. 2008: 13. Triassic. In: Mc Cann T. (Ed.): The Geology of Central Europe, vol. 2: Mesozoic and Cenozoic. *Geological Society Book*, London, 749–821.

Lintnerová O., Michalík J., Uhlík P., Soták J. & Weissová Z. 2013: Triassic–Jurassic climate humidification and Rhaetian kaolinite formation (Western Carpathians, Tatric Unit, the Červený Úplaz section). *Geological Quaterly* 57, 4, 701–728.

Masaryk P., Lintnerová O. & Michalík J.1993: Sedimentology, lithofacies and diagenesis of the sediments of the Reifling intraplatform basins in the Central Western Carpathians. *Geologica Carpathica* 44, 4, 233–249.

Michalík J. 1993: Mesozoic tensional basins in the Alpine–Carpathian shelf. *Acta Geol. Hungarica* 36, 4, 395–303.

Michalík J. 1994: Notes on the paleogeography and paleotectonics of the Western Carpathian area during the Mesozoic. *Mitteilungen Österreichisches Geologisches Gesellschaft* 86 (1993), 101–110.

Michalík J. 2007: Rock record and microfacies indicators of the latest Triassic to mid-Cretaceous tensional development of the Zliechov Basin (central Western Carpathians). *Geologica Carpathica* 58, 5, 443–453.

Michalík J. 2011: Mesozoic paleogeography and facies distribution in the N Mediterranean Tethys from Western Carpathians view. *Iranian Journ. Earth Sci.* 3, 185–193.

Michalík J. & Soták J. 1990: Lower Cretaceous shallow-marine build-ups in Western Carpathians and their relation to the pelagic facies. *Cretaceous Research* 11, 211–227.

Michalík J., Masaryk P., Lintnerová O., Papšová J., Jendrejáková O. & Reháková D. 1992: Sedimentology and facies of a storm-dominated Triassic carbonate ramp (Vysoká Fm, Malé Karpaty Mts, Western Carpathians). *Geologica Carpathica* 43, 4, 213–230.

Michalík J., Biroň A., Lintnerová O., Götz A.E. & Ruckwied K. 2010: Climate change at the T/J boundary in the NW Tethyan Realm (Tatra Mts., Slovakia). *Acta Geologica Polonica* 60, 4, 535–548.

Michalík J., Lintnerová O., Reháková D., Boorová D. & Šimo V. 2012: Early Cretaceous sedimentary evolution of a pelagic basin margin (the Manín Unit, central Western Carpathians, Slovakia). *Cretaceous Research* 38, 68–79.

Michalík J., Lintnerová O., Wójcik-Talerzak P., Gaździcki A., Grabowski J., Golej M., Šimo V. & Zahradníková B. 2013: Paleoenvironments during the Rhaetian transgression and the colonization history of marine biota in the Fatric Unit, Western Carpathians. *Geologica Carpathica* 64, 2, 39–62.

Mišík M. & Jablonský J. 2000: Lower Triassic quartzites of the Western Carpathians: Transport directions, source of clastics. *Geologica Carpathica* 51, 4, 251–264.

Pieńkowski G., Schudack M.E., Bosák P, Enay R., Feldman-Olszewska A., Golonka J., Gutowski J., Herngreen G.F.W., Jordan P., Krobicki M., Lathuiliere B., Leinfelder R.R., Michalík J., Mönnig E., Noe-Nygaard N., Pálfy J., Pint A., Rasser M.W., Reisdorf A., Schmid D.U., Schweigert G., Surlyk F., Wetzel A. & Wong T.E. 2008: 14. Jurassic. In: Mc Cann T. (Ed.): The Geology of Central Europe, vol. 2: Mesozoic and Cenozoic. *Geological Society Book,* London, 823–922.

Plašienka D., Grecula P., Putiš M., Kováč M. & Hovorka D. 1997: Evolution and structure of the Western Carpathians: an overview. *Mineralia Slovaca — Monographs*, 1–24.

Stampfli G.M., Borel G.D., Cavazza W., Mosar J. & Ziegler P.A. 2001: Palaeotectonic and palaeogeographic evolution of the W Tethys and PeriTethyan Domain (IGCP Project 369). *Episodes* 24, 4, 222–228.

Vašíček Z. & Michalík J. 1999: Early Cretaceous ammonoid paleobiogeography of the West Carpathian part of Paleoeuropean shelf margin. *Neues Jahrbuch für Geologie und Paläontologie, Abhandlungen* 212, 1–3, 241–262.

Voigt S., Wagreich M., Surlyk F., Wałaszczyk I., Uličný D., Čech S., Voigt T., Wiese F.,Wilmsen M., Michalík J., Jagt J.W.M. Felder P.J. & Schulp A.S. 2008: 15. Cretaceous. In: McCann Tom (Ed.): The Geology of Central Europe, 2: Mesozoic and Cenozoic. *Geological Society Book,* London