Paleoenvironmental changes of the Carpathian Flysch Sea during the transition from the Peri-Tethyan to Black Sea-type basins

JÁN SOTÁK, Geological Institute, Slovak Academy of Sciences, Severná 5, 974 01 Banská Bystrica, Slovak Republic; sotak@savbb.sk

Paleoenvironmentálne zmeny v systémoch karpatských flyšových morí pri ich transformácii z peri-tetydných paniev na panvy typu Čierneho mora

The Carpathian Paleogene basins were differentiated in sea-floor topography, bathymetry and water exchange. During the Eocene/Oligocene transition, the differentiation was recorded by the Globigerina Marls, which deposition was controlled by the Calcite Compensation Depth. The CCD declines in the conditions of enhanced productivity, which correspond to a peak of productivity near 33.5 Ma (Diester--Haass and Zahn, 1996), and this caused the CCD drop near the Eocene/Oligocene boundary (Thunell and Corliss, 1986; Tripati et al., 2005). Following the downslope excursion of the CCD, the Globigerina Marls occur suddenly in carbonate--free deep-water sediments of the Carpathian Paleogene basins. Successive cooling resulted in shoaling of the CCD due to a higher saturation of cold bottom-water by CO_2. As a consequence, the seawater became more acid and corrosive to the calcareous components. Above the Globigerina Marls, the carbonate dissolution increased considerably, leading to a non-calcareous deposition of the Menilite Formation.

The Early Oligocene period was a time of widespread anoxia and eutrophication in the Carpathian basins, and this led to sapropelitic and biosiliceous deposition of the Menilite facies. These basins imply a cool-water influence, estuarine--type circulation, eutrophication, dinoglagellate- and diatom--based productivity, high export flux, bottom water anoxia, elevated chemocline, upwelling activity and monsoonal precipitation (Fig. 1). The expansion of the OMZ to surface--water is inferred from the impoverishment of planktonic foraminifera, and in proliferation of euryoxibiont forms in the Carpathian basins. Lower oxygen conditions are expressed by blooms of chiloguembelinids (stress-sensitive opportunists like *Guembelitria*), which dominated during the early Rupelian. Evidence of similar conditions is provided by wetzeliellacean dinoflagellates, diatoms and bacterioplankton.

The Oxygen Minimum Zone (OMZ) revealed the southward weakening of anoxia towards the Kiscellian Sea in the Buda Basin. Considering this, the northern part of the Carpathian Paleogene basins seems to be more isolated, humid, eutrophicated, oxygen depleted and cooled by Boreal waters. On the contrary, the southern part of this basin represents the neritic and nearshore zone of the North Buda Paleogene Basin (Nagymarosy, 1990), influenced by the Tethyan waters. The circulation model of the Paratethyan basins (Dohman, 1991; Schulz et al., 2005) presumed a mixture of the Boreal deep water and the Tethyan surface water. The restricted seaway connection with the Mediterraean Tethys during the Early Oligocene resulted in fresh water overflow in the Paratethyan basins. The high runoff and separation of the Carpathian basins by the intrabasinal highs (e.g. Low Tatra Highland), indicates an estuarine-type circulation with an inflow of warm saline bottom waters and an outflow of fresh surface waters. Here, the Carpathian basins revealed features of Black Sea-type basins similar to other basins in the Paratethyn Sea (Schulz et al., 2005).

Widespread anoxic and eutrophic conditions in the Carpathian Paleogene basins most likely resulted from a high runoff and a positive water balance similar to that in the Black Sea. Dissolved silicate, nitrate, ammonium, manganese may have been supplied from continental sources. Trophic resources could also have increased via upwelling, which preferentially regenerated nutrients from organic matter under anoxic conditions. Both, this runoff and upwelling resulted in eutrophication of surface-waters. Biomass productivity of surface waters in the Paratethyan basins resembles a drifting flora and conditions similar to those in the Sargasso Sea.

During the Early Oligocene, the Paratethyan basins survived the anoxic regime everywhere, including the

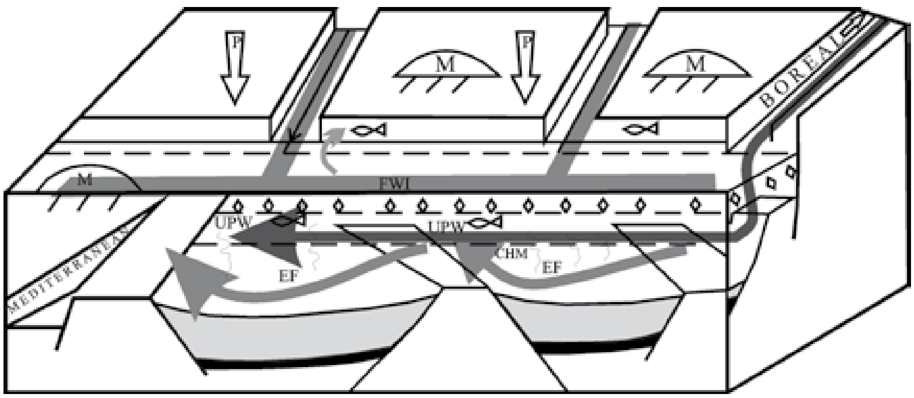

Fig. 1. Synoptic model of the Carpathian Paleogene basins implying the Tethyan – Boreal water exchange or semi-isolation, water column stratification (CHM – chemocline), bottom-water anoxia, surface-water owerflow (FWI – fresh water influx), deep-water circulation (UPW – upwelling), eutrophication (EF), diatom-based productivity, fish fauna, precipitation (P), humidity and monsoonal activity (M), etc.

Hungarian Paleogene Basin (Tard Clays), Slovenian Basin (Socka Beds), Central- and Outer Carpathian basins (Menilite shales) and Austrian foreland basin (Häring Beds), Transylvanian Basin (Ileada Shale), etc. Nevertheless, the central Paratethyan basins were reconnected with the Mediterranean Tethys, and this is indicated by the Lower Oligocene biohermal limestones containing nummulitids in the Slovenian and Hungarian Paleogene Basins (Gornji Grad Beds, Szépevölgy Limestones), but not/or very rarely from the the Central-Carpathian Paleogene Basin. On the other side, the Spiratella-rich fauna of the Hungarian Paleogene Basin (Tard Clay) provide evidence of the cold-water influence of the Boreal Sea. This implies that Tethyan-Boreal communication, most likely via the Mid-Hungarian corridor and Slovenian Strait, which is indicated by the mixed mollusc fauna in the Kiscellian Clay (Báldi, 1984).

The intra-Carpathian system of the Paleogene basins was disturbed during plate-tectonic reorganization of the ALCAPA terranes. The Slovenian and Hungarian Paleogene basins were accommodated more southerly, and later on they have been shifted to their present position (Czontos et al., 1992). The Hungarian and Central-Carpathian Paleogene basins are quite different (epicontinental-type basin vs. marginal basin of the Carpathian Flysch Sea), exhibiting no direct paleogeographical connection between them. The northern limit of the Hungarian Paleogene Basin is inferred in the Šahy antiform, which represents a nearshore zone of the Kiscellian Sea containing sebhka-type facies (Vass, 2003). The Central-Carpathian Paleogene Basin was confined with the Veporic borderland. It is most likely that the Hungarian and Central-Carpathian Paleogene basins came to tectonic juxtaposition due to NE-directed displacement of the Pelso Unit (Nagymarosy, 1990). This unit attained its present position by tectonic and rotational movement since the Late Oligocene to Early Miocene (Vass et al., 1996). This is also the case in the Hungarian and Transylvanian Paleogene basins, which were jointed by large-scale tectonic movement of the ALCAPA and TISIA-DACIA blocks.

References

Báldi, T., 1984: The terminal Eocene and Early Oligocene events in the Hungary and the separation of an anoxic, cold Paratethys. *Eclogae geol. Helv., 77, 1, 27.*

Diester-Haass, L. & Zahn, R., 1996: Eocene-Oligocene transition in the Southern Ocean: History of water mass circulation and biological productivity. *Geology, 24, 2, 163–166.*

Dohmann, L., 1991: Die unteroligozänen Fischschiefer im Molassebecken. PhD thesis, Ludwig-Maximilian-Universität, Munich.

Nagymarosy, A., 1990: Paleogeographical and paleotectonical outlines of some intracarpathian Paleogene basins. *Geol. Zbor. Geol. carpath., 41, 3, 259–274.*

Schulz, H. M., Bechtel, A. & Sachsenhofer, R. F., 2005: The birth of the Paratethys during the Early Oligocene: From Tethys to an ancient Black Sea analogue? *Global and Planetary Change, 49, 163–176.*

Thunell, R. C. & Corliss, B. H., 1986: Late Eocene-Early Oligocene carbonate sedimentation in the deep sea. *In: Ch. Pomerol & Premoli-Silva (ed.): Terminal Eocene Events. Developments in Paleontol. Stratigr., 9, Elsevier, 363–380.*

Tripati, A., Backman, J., Elderfield, H. & Ferretti, P., 2005: Eocene bipolar glaciation associated with global carbon cycle changes. *Nature, 436, 341–346.*

Vass, D., 2003: The Šahy Antiforms and its role in the tectonics and paleogeography of the Hungarian Paleogene Basin and the Novohrad/Nógrad Basin (Souther Slovakia and Northern Hungary). *Acta geol. hung., 46, 3, 269–289.*

Vass, D., Túnyi, I. & Márton, E., 1996: Young Tertiary rotation of the megaunit Pelso and neighbour units of the Western Carpathians. *Slov. geol. mag., 3–4, 363–367.*