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Synorogenic deposition of turbidite fans in the Central-Carpathian Paleogene Basin: evidence for and against sea-level and climatic changes

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Abstract. The Central-Carpathian Paleogene Basin reveals a polystage development that includes the 1) initial faulting and alluvial fan deposition in halfgraben-type basin, 2) carbonate factory in shelf-margin basin, 3) Terminal Eocene Event – cooling, glacio-eustatic regression and semi-isolation in restricted basin, 4) progressive faulting and fault-controlled accumulation of radial fans in tilted basin, 5) highstand aggradation in starved basin, 6) Mid-Oligocene sea-level lowering and retroarc backstepping of depocentres in relic basin, 7) wedging of sand-rich fans and suprafans in over-supplied basin.
Key words: Western Carpathians, Paleogene, submarine fans, climatic events, sequence stratigraphy

The Central-Carpathian Paleogene Basin (CCPB) was formed as a marginal basin of the Paratethys. It shows a fore-arc basin position, extended on the destructive plate-margin and in the rear of the Outer Carpathian accretionary prism.

The CCPB has undergone two third-order cycles of initial transgression (TA 3.5 - 3.6 *sensu* Exxon cycles), that was followed by two second-order cycles of deposition (TA4 and TB1 *sensu* Exxon cycles) - Fig. 1. The initial transgression was preceded by deposition of alluvial-fan and delta-fan sediments. Upper Lutetian transgression in the CCPB (Andrusov & Köhler 1963) led to shallow-marine deposition of nummulitic banks developed in two 3rd order cycles (Bartholdy 1997). The nummulitic cycles of the CCPB, like a large foraminifera demise (Hallock et al. 1991, Hottinger 1997), disappeared due to the inversion of the Middle Eocene warm climate in the beginning of the TA4 supercycle. Climatic changes culminated in the "Terminal Eocene Event", which corresponds to the global cooling and glacio-eustatic regression related to the Antartic cryosphere expansion (Van Couvering et al. 1981). Consequently, the carbonate factory on broad warm shallow shelves was suffocated by terrigenous sedimentation on bypassed shelf areas. The sediments from above the nummulitic limestones are depleted in $CaCO_3$ and enriched in organic matter due to continental runoff of land plants (occurrence of silicified woods). They contain an abundance of cool-water cocoliths (e.g. *Isthmolithus recurvus*, *Zigrhablithus bijugatus*), diatom oozes (Menilite cherts) and *Globigerina*-rich fauna (Globigerina Marls). The small-scale intercalation of non-calcareous black shales and Menilites with Globigerina Marls indicates a short pulses of the high carbonate productivity during the terminal Eocene fertility crisis (precessional cycles).

Climatic control of depositional changes in the CCPB became less significant in time of forced regression. Nevertheless, the influx of cool-water into the CCPB led to carbonate depletion and anoxicity in the Šambron Beds. The appearance of Globigerina Marls in the deep-water siliciclastic deposits (Šambron Beds) indicates the CCD drop described from about the Eocene/Oligocene boundary (Thunell & Corliss 1986). The falling stage of relative sea-level is recorded by a Type-1 sequence boundary on shelves (between carbonate platform deposits and overlying formation), which were eroded by fluvial channels entering the basin through marginal delta-fed fans (cf. Janočko & Jacko 1998). During this time, the basinal slopes were actively tilted and incised by submarine valleys, which fed the basin-floor and slope fans. The Šambron Fan (like the Tokáreň, Szaflary and Pucov Fans) represents a lowstand system tracts consisting of canyon-fill, spillover and mass-failure deposits. The later stage of regression is evidenced by a progradational stacking of the Šambron Beds and by amalgamated sandstone unit (Bachledova Sandstone) representing a sandy toeset deposits of shelf-margin deltas (shingled turbidites).

The TA4 supercycle tended toward the gradual rise of relative sea level during the Early Oligocene. Successive formation of the CCPB (Huty Fm.) corresponds to transgressive and highstand system tracts. The transgression is marked by ravinement surfaces detecting between Eocene Nummulitic banks and Middle Rupelian sediments of NP 23 Biozone. Basal sediments of the transgressive formation still show the cool-water influence, salinity decrease and semi-isolation, as indicated by wetzeliellacean dinoflagellates, inprints of diatoms, brackish nectonic fishes and ostracods. Higher in the section, the carbonate-free sequence reveals the first pulses of nannofossil blooms (e.g. Tylawa Lms. in Blatná dolina section), characterized by reticulofenestrids of NP 23 Biozone, which became flourished due to sea-level rising and renewed circulation. The Lower Oligocene transgression rose up to highest sea-level in time of 32 Ma (Haq et al. 1988), which re-

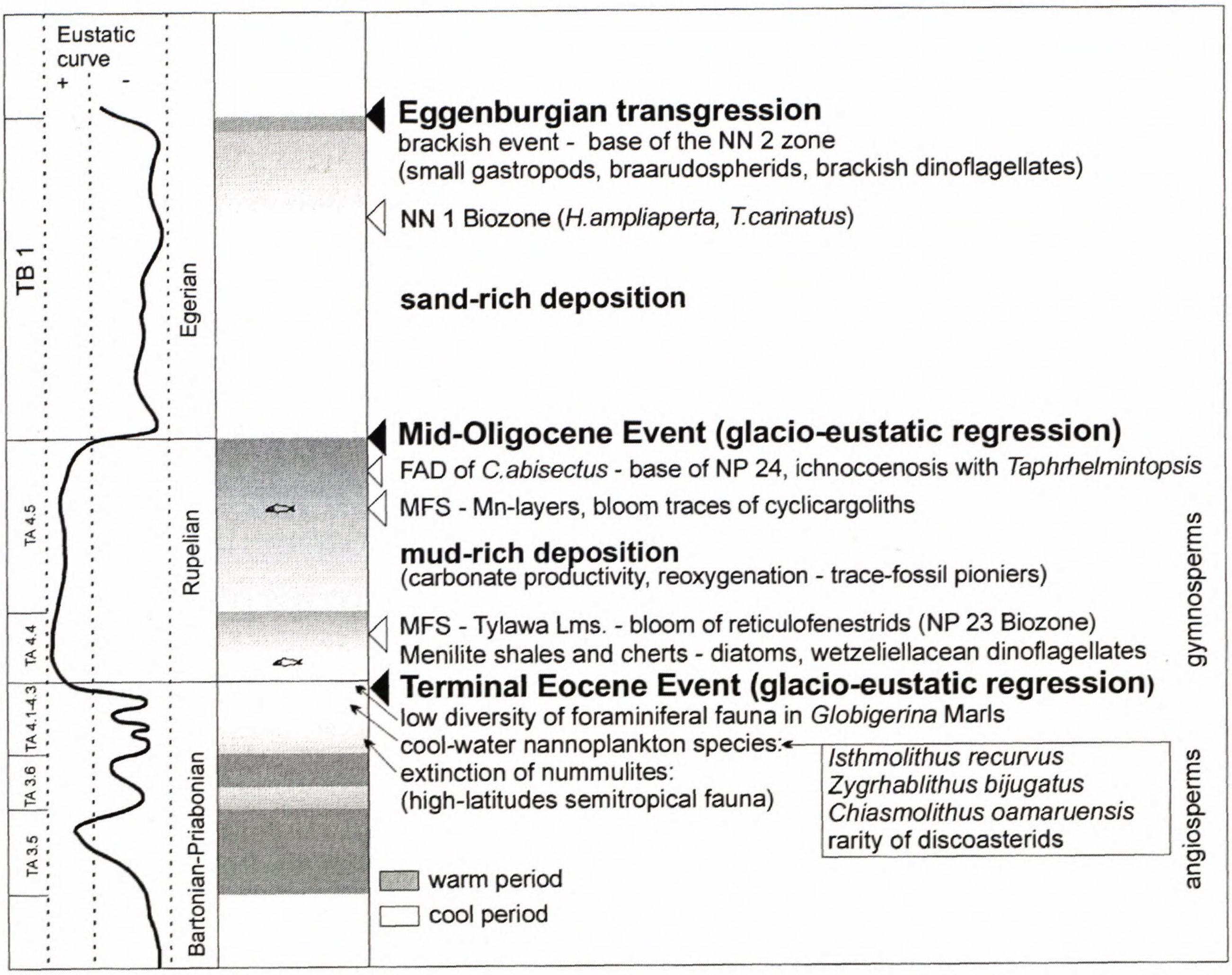

Fig. 1 Climatic changes during the development of the CCPB, as inferred from inversion of the Middle Eocene warm climate, later culmination of cooling in the Terminal Eocene Event which continued during the Early Oligocene, upwardly tended to eustatic rise of sea-level and than its drastical lowering due to glacio-eustatic regression in the Mid-Oligocene Event. Climatic changes are indicated by extinction of semitropical fauna, foraminiferal abundance and nannofossil blooms, cool-water diatom oozes (Menilitic facies) and brackish dinoflagellates.

stored the Paratethyan circulation (Baldi 1984). Consequently, the CCPB became reoxygenated increasing in carbonate precipitation, productivity and fertility (calcareous claystones, abundance of cyclicargoliths, oxygen-related ichnocoenosis). Maximum flooding of this sequence falls into the condensed horizons of manganese layers, that occur in the Orava region and Rajec and Poprad Depressions. Late highstand of this formation is evidenced by small-scale progradational events and megaturbidite beds (e.g. Bysterec and Tichá dolina sections). Such deposition with progradational events (falling stage system tracts) terminated till the FAD of *Cyclicargolithus abisectus* on the base of NP 24 Biozone, where the oxygen-related ichnocoenosis with Fucoides and Taphrhelmintopsis become to appear already in flysch lithologies. The Early Oligocene highstand sedimentation in the CCPB is in accordance with relative sea-level rise in the Outer Carpathian Basin. Supra-Menilite sediments and associated nanno-chalk horizons in the Outer Flysch Carpathians, like the Jaslo, Zagórz and Folusz Limestones and the Štibořice Marl, were deposited during the coeval sea-level highstand in the Late Rupelian (Krhovský & Djurasinovič 1993).

The TB1 supercycle was introduced by the Intra-Oligocene regression. It is in accordance with an abrupt sea-level fall at around 30 Ma (Mid-Oligocene Event), determined as a distinctive drop in sea-level during the major glaciation in Antartica and subsequent cooling in the Northern Hemisphere (Kennett & Barker 1990, Zachos et al. 1993). The falling stage of the Late Oligocene regression in the CCPB is expressed by an offlap break of prior highstand sediments in the upper fan zones (e.g. eroded Mn blocks and Tylawa Lms. in conglomerate-slope accumulations) and related correlative conformity between mud-rich fans (Huty Fm.) and sandy-rich fans (Zuberec and Biely Potok Fm.). The sandy-rich deposition of the CCPB lasted till to the Early Miocene, as has been already indicated by some nannoplankton and foraminiferal species (e.g. *Helicosphaera scissura, H. kamptneri, H. cf. ampliaperta, Triquetrorhabdulus cf. carinatus?*). The regression in the CCPB reached the maximum lowstand on the base of the NN2 zone, when the brackish fauna became to appear in the Paratethyan basins (e.g. braarudospherids in nannoplankton associations, brackish dinoflagellates in phytoplankton – Hudáčková 1998, small gastropods). According to this evidence, the deposition of the Biely Potok Fm. should terminated till to the Early Eggenburgian, i.e. to the lowstand phase at the beginning of the NN2 Biozone, which preceded the next transgression during the cycle TB 2.1 in the Prešov Fm. (Kováč & Zlinská 1998). The time-equivalent sedimentation in the Outer Flysch Carpathians took also place in lowstand setting, recorded by the Krosno Facies (Krhovský & Djurasinovič 1993). The paper is a contrubution to the VEGA grant N_O 7068.

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