# CLIMATIC CHANGES ACROSS THE EOCENE-OLIGOCENE BOUNDARY: PALEOENVIRONMENTAL PROXIES FROM THE CENTRAL–CARPATHIAN PALEOGENE BASIN

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**Abstract:** The Paleogene sequence of the Central Carpathian Basin comprises records of global climatic deterioration during the Eocene/Oligocene transition. This cooling event before 33.7 Ma, related to the Antarctica first glaciation, switched rebuilding of global climatic regime from temperature optimum towards icehouse conditions. In this basin, climatic deterioration is inferred from demise of carbonate platform and oligotrophic biota in the SBZ 19. Late Eocene formations already indicate isotopic signals of lower temperature, cool-water productivity, and eutrofication increase (Bryozoan Marls, Globigerina Marls). Stepwise cooling during the earliest Oligocene (Oi-1 event) led to carbonate depletion, sapropelitic and biosiliceous deposition, fresh water influx and continental runoff, water mass stratification, anoxy of bottom waters, eutrofication, current water circulation and upwelling, intoxication and mass faunal mortality, etc.

**Key words:** Central Western Carpathians, Terminal Eocene Event, climatic cooling, platform drowning, productivity changes, isotopic records, eutrofication,

## Introduction

The Late Eocene was a transitional period between the Middle Eocene climatic optimum and the Oligocene icehouse. By the Oligocene, the climate system tended to "icehouse" word. Gradual cooling of the Earth climate resulted in expansion of Antarctic glaciation. Climatic deterioration starting already since the Middle/Late Eocene boundary (Oberhänsli 1996) was followed by the major cooling event in the Early Oligocene (Pomerol & Premoli-Silva 1986, Kennet & Barker, 1990, Miller et al. 1991, Diester-Haass & Zahn 1996, Zachos et al., 1996, Salamy & Zachos 1999, etc.). The climatic cooling led to significant paleoenvironmental changes in the Carpathian basins.

## Demise of carbonate platform

Carbonate platform was established under a sea-leve rise during the Middle Eocene climatic optimum. Initial transgression with a highly erosive ravinements led to the formation of Nummulitid-rich ramp (SBZ 16). Nummulitic ecosystems were adapted to clear-water and oligotrophic conditions, requiring temperatures above 20°C. Life strategy of large foraminifers was also strongly dependant on trophic regime, which must be oligotrophic due to their algal-bearing symbionts. Therefore, the large foraminifers were not competitive in more nutrient-rich waters (Hallock et al. 1991). As a consequence of cooling and nutrification, warm-water carbonate factory turned off in the CCPB during the P16 Zone (latest nummulites – Köhler, 1998), being suffocated and drowned by mud-rich deposition. Nevertheless, the Late Eocene deposition persisted in carbonate cool-water productivity under a dominancy of bryozoans, known as the most abundant organisms on cool-water shelves. Prosperity of the bryozoan fauna usually indicates an elevated resources of land-derived nutrients or availability of nutrients via upwelling.

## Climate-productivity changes

Near the Eocene/Oligocene transition, the sequence shows a prominent increase of productivity in the Globigerina Marls. Their microfauna consist of globigerinids with cool-water preference (Olszewska 1983). Initial increase of plankton productivity in the Globigerina Marls resulted in high abundance, large size and low diversity of r-strategists (*Globigerina praebulloides – Globigerina officinalis* group). Later on, the abundance and size decrease, and planktonic foraminifers tend towards the k-mode of strategy and a higher species diversity. The change in life-history strategies resulted from trophic resources (Hallock et al. 1991), which changed from nutrient-rich (eutrophic) to nutient-poor (oligotrophic) conditions. Biogenic maxima at the Eocene/Oligocene boundary, like the Gobigerina Marls, resulted from the cool-water productivity (Diester-Haass & Zahn 1996).

## Major climatic turnover

Climatic changes culminated in the ”Terminal Eocene Event”, which corresponds to the global cooling. Ocean temperature fell in the Late Eocene of about 2-5°C world-wide scale

(Shackleton & Kennett 1975). Cool-water influx and continental runoff into the CCPB led to fundamental paleoenvironmental changes. Nannofossil assemblages lack a discoasterids, keeping a dominance of cool-water taxa). Foraminiferal communities of the Early Oligocene sediments are also different from those in prior formations (Blaicher 1973). Foraminiferal diversity gradually decreased untill the Lower Oligocene, when the number of species dropped to a minimum.

Under cooling and continental runoff, the water mass became stratified, developing a shallow termocline and chemocline. The water-colum stratification facilitated an oxygen deficience due to organic carbon oxidation and eutrofication of surface water. This process resulted in expansion of the Oxygen minimum zone (anoxia and fertility crisis) and surface-water nutrification favorable for eutrophic nannofossils and dinoflagellates. Water-bottom anoxia led to the deposition of laminitic sediments in the Menilite and related formations (Šambron Beds, Szaflary Beds), indicating the lack of benthic life.

**Eutrofication and TA4 euxinity**

Early Oligocene is considered as a time of TA4 euxinity and eutrophication of the West Carpathian basins, which led to sapropelitic and biosiliceous deposition in the Menilitic facies. Early Rupelian sediments still reveal the cool-water influence, salinity decrease and semi-isolation, as is indicated by wetzeliellacean dinoflagellates, diatom oozes and „low oxygen“ fauna. Nannoplankton crisis in the menilite facies has been interrupted by episodes of coccolitophorid-rich productivity (Tylawa-type limestones). Fish fauna is common. Their mortality resulted probably from intoxication by $H_2S$-rich water, which come to surface water from $O_2$ minimum zone via upweling. Eutrofication could also increase via upwelling, preferentially regenerated nutients from organic matter under anoxic conditions. Widespread anoxia led to precipitation of manganese, iron sulfide and uranium in the CCPB (e.g. manganese ores in Kišovce-Švábovce District).

**Isotopic records of climatic changes**

Oxygen isotopic composition of the nummulitic limestones ($\delta^{18}O$ = - 2‰) provides a seawater temperature around 22°C. This isotopic temperature corresponds well with temperature derived from nummulitic tests in Hungary by the Ca/Mg method (21.4 - 25°C see Berlin et al. 1976). Supranummulitic sequence shows an isotopic reequilibration due to vital effects, mineralogy and diagenesis. Nevertheless, the high productive horizon of the

Globigerina Marls from above the nummulitic limestones shows a positive shift of $\delta^{18}$O (0.4 ‰), known from high-resolution isotope stratigraphy across the Eocene/Oligocene boundary in the ODP Sites (Diester-Haass & Zahn 1996) and type localities (Oberhänsli et al. 1984). This positive $\delta^{18}$O excursion links with the Oi 1 shift to cooler temperatures (see Ambreu & Anderson 1998), which is coeval with maximum productivity increase of surface waters (Salamy & Zachos 1999, Diester-Haas & Zahn 1996). The $\delta^{18}$O shift in the Globigerina Marls also indicates a sharp temperature drop of seawater (~ 11º C).

**Conclusions**

Sedimentary record of the CCPB provides the following proxies of climatic changes around the Eocene/Oligocene transition: - demise of carbonate platform resulted from climatic deterioration and eutrofication of the Carpathian basins during the Terminal Eocene Event; - growth potential of carbonate platform ceased due to overfeeding stress of oligotrophic organisms (e.g. nummulitids); - cool-water productivity in the Bryozoan Marls and Globigerina Marls, indicating a nutrient supply from richer runoff or via upwelling; - plankton productivity reflects a changes in life-mode strategy, diversity, temperature preference and CCD paleodepth; - peak abundance of the Globigerina Marls links with climate-productivity maximum at 33.7 Ma, which reveals the increase of $\delta^{18}$O (cooling) and decrease of $\delta^{13}$C ($CO_2$ respired due to metabolism); - positive shift of oxygen isotopes indicates a decrease in seawater temperature at the Eocene/Oligocene boundary (12 – 15˚C); - major climatic turnover took place in the Early Oligocene (Oi-1 event), when the cooling and humidity led to temperate/wet condititions; - runoff excess is inferred in water-column stratification (reduced salinity and nutrification of surface waters), expansion of the oxygen-minimum zone (anoxia) and seasonal upwelling activity ($H_2S$ toxication and a high mortality); - widespread of anoxia and stagnant regime in the Early Oligocene resulted in sapropelitic deposition of menilite shales, fish shales and manganese layers; - nannoplankton blooms indicate a period of runoff stillstand and higher carbonate sources; - coccolithophorid-rich productivity occurs together with a positive $\delta^{13}$C excursions, indicating a short-lived greenhause events and/or decrease rate of $^{12}$C from organic matter; - relative sea-level lowstand, eutrophication and semi-isolation culminated in the lower part of NP 23 Biozone, marked by dinoflagellate-rich productivity, appearance of Parathetys-endemic nannofossils and biosiliceous deposition (diatom oozes).

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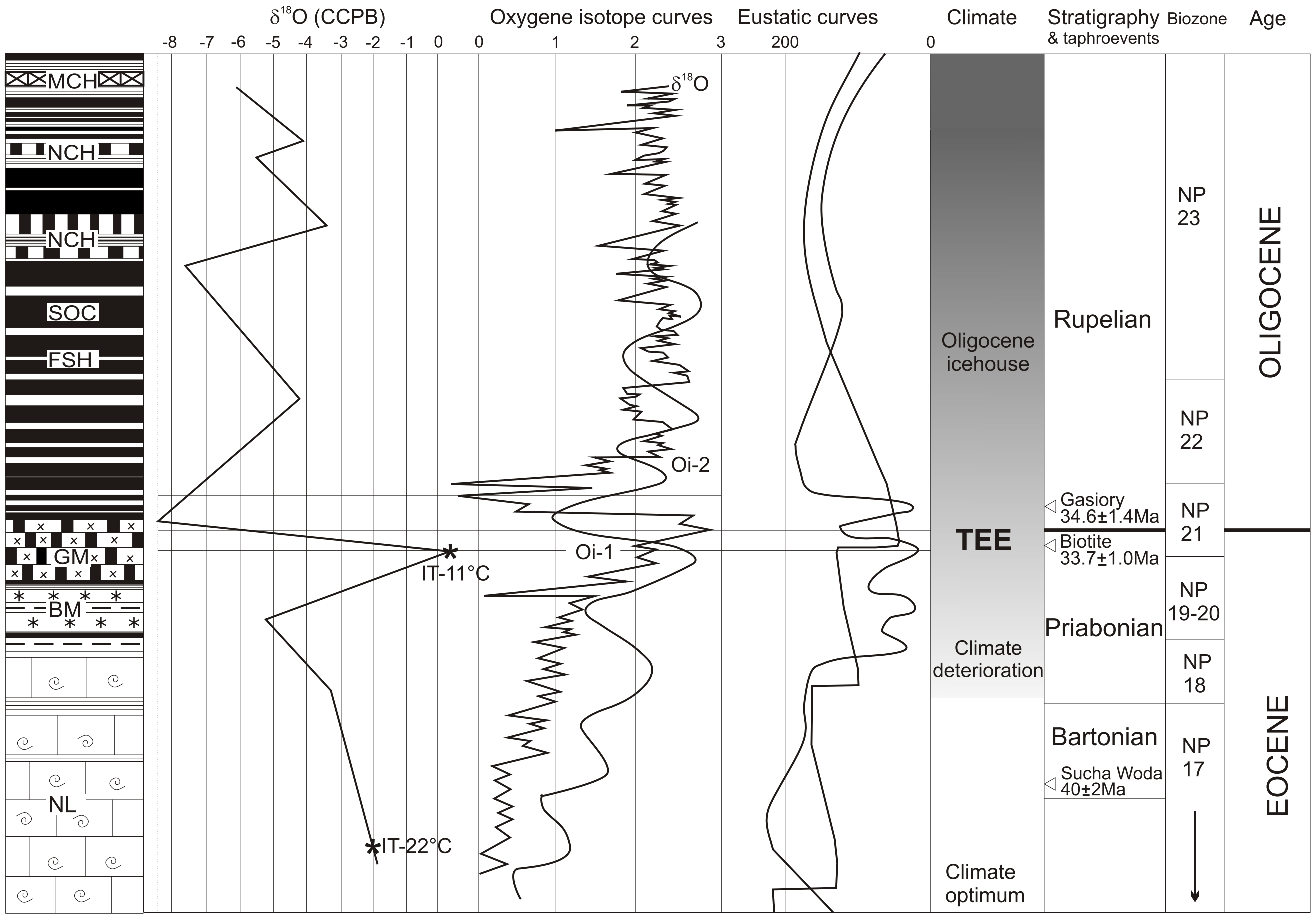
**Fig. 1** Paleoclimatological records in the sedimentary sequence of the Central-Carpathian Paleogene Basin, related to the Eocene/Oligocene cooling. Interpretation is based on the productivity changes, oxygene isotopes, paleotemperatures (IT), cryochrons (Oi-1, Oi-2), eustatic cycles, taphroevents, etc. (isotope curve - Diester-Haas & Zahn 1996, eustatic curve - Haq et al. 1988). Abbreviations: NL – nummulitic limestones, BM – Bryozoan Marls, GM – Globigerina Marls, FSH – fish shales, SOC – sapropelitic organic-rich claystones (Menilites), NCH – nanno-chalks, MCH – menilitic cherts (biosilicites), TEE – Terminal Eocene Event.

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