Environment dynamics during PETM in northeastern Peri-Tethys deciphering from high-resolution micropaleontological and geochemical study

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Introduction

It is widely known for the last 2 decades that sediments, corresponding to the Paleocene-Eocene Thermal Maximum (PETM) interval in the whole eastern Peri-Tethys are displayed as a sapropelitic bed rich in TOC in different extend throughout the area. According to the previously obtained results, the sapropelitic bed corresponds to the CIE-event (negative carbon isotope excursion), decline of benthic foraminifers, occurrence of "excursion taxa" of calcareous nannofossils *Rhomboaster* spp. and asymmetric discoasters and the acme of dinocyst genus *Apectodinium* (Gavrilov et al., 2003). To better understand the environmental dynamics during the PETM in the eastern Peri-Tethys area and reveal exact consequence of all events detected, a new high-resolution study of calcareous nannofossils and dinocysts from a key section exposed along Kheu River, Kabardino-Balkaria Republic, Northern Caucasus has been made.

Material

The upper Paleocene sediments of the Kheu section are incorporated into Nalchik Fm. and composed of homogenous soft greenish marl. In the uppermost part of this succession (~ 4 m below the top of Nalchik Fm.), 0.58 m thick sapropelitic bed (TOC > 8%) is intercalated. It is built up of alternated dark thinly laminated non-calcareous and slightly calcareous clays lack in borrows. During our field trip 2009, we made thorough sampling of sapropelitic bed and embedded sediments. 3 m of underlying and 2 m of overlying sediments were sampled with 15 cm frequency and sapropelitic bed was taken as a block divided into 2 cm-thick lamina in the laboratory. All 56 samples obtained provided carbon and oxygen isotope analyses and nannofossil study. Percentage of nannofossil taxa were counted mostly from 300 specimens, but in few samples from sapropelitic bed with rare nannofossils calculation from 100 specimens was made. Dinocysts were examined with lower frequency (34 samples).

Results and discussion

Underlying the sapropelitic bed greenish marl in the Kheu secion shows gradual δ13C decrease from ~2.5‰ to ~1.5‰ with minor fluctuations just below sapropelitic bed (Fig. 1). Dramatic δ13C drop for ~3‰ occurred at the base of sapropelitic bed and low values persist throughout the bed showing weak variations which magnitude does not exceed 1‰. The δ18O decrease is much greater and comprises an excursion for 6‰ and even more reaching unusual value in -11.6‰ at individual level of sapropelitic bed. Detected δ18O excursion corresponds to global oxygen isotope anomaly related to significant warming during PETM (e.g., Zachos et al., 2006), although its extremely large magnitude is evidently caused by diagenetic effect which mechanism is still poorly understood. Both δ13C and δ18O excursions persist in 30 cm-thick interval above the sapropelitic bed and overlying sediment displays ~2.5 m thick interval of very gradual δ13C and δ18O recovery followed by new stage of their weak relative decrease at ~ 3,2 m above the sapropelitic bed. These results indicate much longer recovery period than the main CIE during PETM.

Nannofossil assemblage of underlying the sapropelitic bed sediment is abundant and diverse including diverse *Fasciculithus*, *Toweius*, and *Discoaster*, while dinocysts from this part of the section are rather poor and are characterized mostly by long-lived taxa (especially, *Spiniferites* spp. and *Achomosphaera* spp.). Lower occurrence of *Rhabdosphaera sola*, *Zygrhablithus bijugatus* and *Rhomboaster intermedia* nannofossils (Fig. 2) suggests initial environmental changes preceded significant variations in δ13C and δ18O. The first representative of *Rhomboaster* lineage (*R. intermedia*) occurs ~1.3 m below the sapropelitic bed and first specimens of *R. cuspis*, which is believed to be "excursion taxon", were found at the level corresponded to minor positive δ13C and δ18O peaks prior to the main CIE body occurred within the sapropelitic bed.

Dramatic biotic change corresponds to the onset of PETM and sapropelitic bed accumulation. Nannofossils disappear in few cm below the sapropelitic bed and persist to be absent in lower 15 cm of the bed where abundant dinocysts dominated by *Apectodinium* appear. Low abundant nannofossil assemblage of sapropelitic bed is dominated by eutrophic *Toweius* (up to 38%) or warm-water *Discoaster* (up to 40%) at the individual

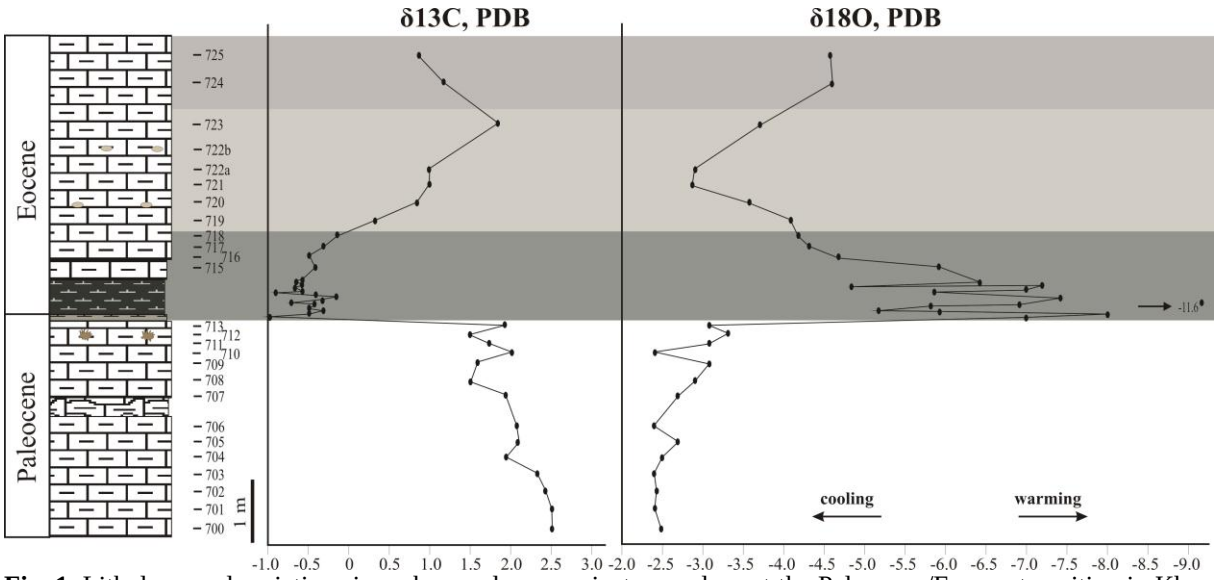

Fig. 1. Lithology and variations in carbon and oxygen isotope values at the Paleocene/Eocene transition in Kheu section. Dark field - sapropelitic bed associated to PETM, light grey - interval of post-PETM recovery, middle grey - new stage of carbon isotope decrease and warming.

levels in the middle part and shows more common *Rhomboaster* and *Thoracosphaera* calcareous dinocysts in the upper part. PETM interval in Kheu section is characterized by radiation of rhomboasters (*R. cuspis, R bramlettei, R. calcitrapa, R. spineus*), appearance of asymmetric discoasters (*D. anartios, D. araneus* and *D. mahmoudii*) and first occurrence of pontosphaerids and *Campylosphaera eodela*. Abundant and diverse dinocyst assemblage shows first occurrence of *Apectodinium augustum* and *Wilsonidium pechoricum* featured for PETM in many areas of the World. The sapropelitic bed corresponding to the maximum of δ13C excursion shows an increase in abundance (acme) of low salinity resistant gonyaulacoid dinocysts (*Polysphaeridium* spp., *Homotryblium* spp.) and peridinoid dinocysts (Wetzelielloids).

Above the sapropelitic bed, nannofossil assemblage corresponding to post-PETM recovery displays wide occurrence of *Fasciculithus, Rhomboaster* and *Coccolithus*, while *Toweius* and *Thoracosphaera* significantly decline. In this interval, all pre-PETM taxa including typically Paleocene taxa Heliolithus, Neochiastozygus, Placozygus sigmoides a.o. become recovered in minor abundance, but they successively disappear toward the top of Nachik Fm. and become extinct in the overlying siliceous sediments of Abaza Fm. Dinocyst assemblage of sediments overlying the sapropelitic bed is characterized by significant decline of *Apectodinium* abundance and general domination of open-marine *Spiniferites*-group accompanied by higher abundance of *Polysphaeridium* spp., *Homotryblium* spp., and *Apectodinium* spp. at individual levels. Nannofossil and dinocyst extinction occur below the base of Abaza Fm. where a switch to enhanced biogenic silica accumulation implies a regional environmental collapse. It comprises that the Paleocene nannofossil taxa disappearance in this area corresponding to their extinction worldwide might be more likely caused by long-termed global lower carbon balance and residual oceanic acidification (e.g., Zachos et al, 2005), than abrupt change in regional ecological system.

Conclusion

High-resolution micropaleontological study of the Paleocene/Eocene transition in Kheu section showed that biotic changes related to PETM ranges much larger time span than sedimentological and geochemical variations detected in the basin of NE Peri-Tethys. Reentrance of nannofossil species after PETM and their successive extinction during recovery period might suggest more critical effect of long-lived and slow environmental restoration onto the microbiota than drastic but short-lived perturbations caused by PETM.

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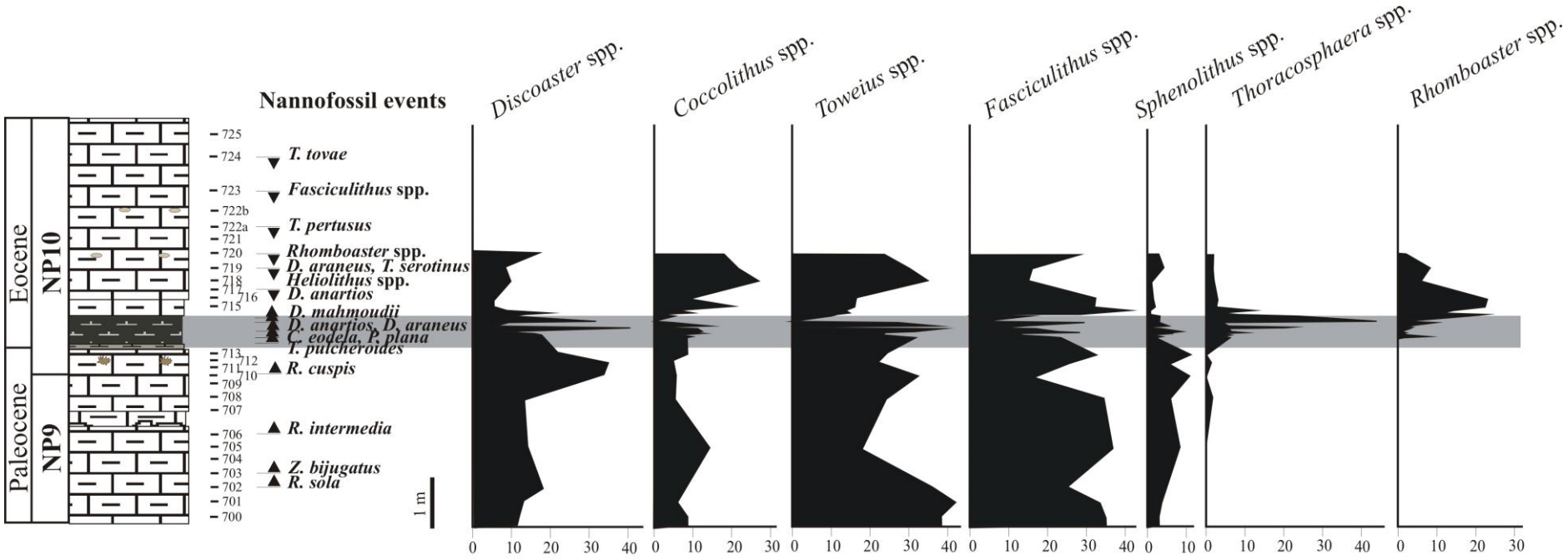

Fig. 2. First and last occurrences of nannofossil species and percentage of nannofossil taxa at the Paleocene/Eocene transition in Kheu section

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