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Benthic foraminiferal and isotopic patterns during the Early Eocene Climatic Optimum (Aktulagay section, Kazakhstan)

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The early Eocene is characterized by long-term global warming culminating in the Early Eocene Climatic Optimum (EECO). During this time interval, the Peri-Tethys was connected to the Arctic and Atlantic Oceans by north-south and east-west trending seaways. The Aktulagay section in Kazakhstan provides an expanded record of the middle Ypresian (NP11-13, ∼54-50 Ma; King et al., 2013), including the EECO. The marl sequence features a series of sapropel beds, observed throughout the Peri-Tethys, indicative of basin-wide episodic hypoxic events. In order to unravel paleoenvironmental changes, we carried out quantitative faunal studies and stable isotopic (C, O) investigations on excellently preserved foraminiferal assemblages.

The period from 54 to 52.5 Ma (NP11 to lower NP12; Alashen Formation) is characterized by a diverse assemblage of deep outer neritic (∼200-250 m) benthic foraminifera, with common *Pulsiphonina prima* and *Paralabamina lunata*. The initially (54 Ma) well-ventilated oligo- to mesotrophic seafloor conditions gradually changed to more eutrophic and oxygen-limited. These conditions were more permanent in the sapropel-bearing unit at 52.5-52 Ma (middle NP12; Aktulagay B1 unit). This observation is based on the dominance of *Anomalinoides acutus* and *Bulimina aksuatica* and the lower diversity. Also the upward migration of endobenthic species, as suggested by rising $\delta^{13}C_{endobenthic}$, supports this interpretation. These low-oxygen conditions might have been caused by a transgression, flooding lowlands. Benthic foraminiferal assemblages dominated by *Epistominella minuta* at ∼52-50 Ma (top NP12-NP13; Aktulagay B2 unit) suggest an oligotrophic environment, with transient pulses of phytodetritus. Dinoflagellate blooms and *Acarinina* isotope values at ∼50.5 Ma indicate lower salinity (lower $\delta^{18}O$) and higher productivity (higher $\delta^{13}C$), possibly due to riverine input. Large river plumes, episodically reaching the area, in a monsoonal climate context, might explain this basin development. Akhmetiev and Beniamovskii (2009) also found a transition from a paratropical to a monsoonal (seasonal) climate, based on simultaneous land vegetation changes. This change coincides with the peak of the EECO, as indicated by its position close to the base of NP13 and rising $\delta^{13}C_{epibenthic}$ values from 52 to 50 Ma.

Although it is tempting to link the observed patterns to climate change, we cannot exclude that changing paleogeography and variable connections between the Peri-Tethys and the Tethys, Atlantic and the Arctic Oceans largely determined the long-term period of dysoxia and anoxia during deposition of the sapropel beds at the Peri-Tethyan seafloor.

Akhmetiev, M.A., Beniamovskii, V.N., 2009. Geologica Acta 7, 297-309.

King, C. et al., 2013. Stratigraphy 10, 171-209.