

Paleocene-Lower Eocene calcareous nannofossil biostratigraphy of Bulgaria

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Outcrop samples from 50 sections spread all over the territory of Bulgaria, as well as core samples from five offshore wells (W Black Sea shelf) were analyzed for biostratigraphy, using calcareous nannofossils. Martini's (1971) work serves as a reference standard scheme for subdivision and correlation of the studied sections. A complete sequence of nine Paleocene and five Lower Eocene biozones is recorded. Within each biozone, a sequence of successive bioevents of first and/or last occurrences of stratigraphically reliable nannofossil taxa is observed. They are utilized as additional markers in particular parts of the zone.

This detailed study has provided a total of 38 bioevents in the Paleocene and 17 bioevents in the Lower Eocene (Figs 1A, B). The selected bioevents during the present study are among the most significant biohorizons, recently used to refine Paleocene and Lower Eocene calcareous nannofossil biostratigraphic framework (Agnini *et al.*, 2007; Westerhold *et al.*, 2008). Their recognition in the

studied sections allows the reliable correlation between the Bulgarian sections and the sedimentary successions from other parts of the world. The produced biostratigraphy is based on the palaeontological identification of 212 species, belonging to 62 calcareous nannofossil genera, besides the

Age, Ma	Series	Stage	Polarity chron	Martini, 1971	This study		
					Biozones	Nannofossil bioevents	
55	P a l a e o c e n e	T h a n e t i a n	C24	NP 9 <i>D. multi-radiatus</i>	NP 9 <i>D. multi-radiatus</i>	<ul style="list-style-type: none"> ↑ <i>Tr. pulcher</i>, <i>Pontosphaera</i> spp. ↑ <i>Lophodolithus nascens</i> ↑ <i>Campylosphaera eodela</i> ↑↑ <i>D. falcatus</i>, <i>D. limbatus</i> ↑ <i>Discoaster mediosus</i> ↑ <i>Blackites creber</i> ↑ <i>Discoaster multiradiatus</i> ↓ <i>Heliolithus riedelii</i> ↑ <i>Fasciculithus tonii</i> ↑↑ <i>H. megastypus</i>, <i>H. univertus</i> ↑ <i>Discoaster protomultiradiatus</i> 	
				NP 8 <i>H. riedeli</i>	NP 8 <i>H. riedeli</i>	<ul style="list-style-type: none"> ↑ <i>Heliolithus riedelii</i> ↓ <i>Heliolithus kleinpellii</i> ↓ <i>Discoaster bramlettei</i> ↑ <i>Discoaster mohleri</i> 	
			NP 7 <i>D. gemmeus</i>	NP 7 <i>D. mohleri</i>	<ul style="list-style-type: none"> ↑ <i>Heliolithus riedelii</i> ↓ <i>Heliolithus kleinpellii</i> ↓ <i>Discoaster bramlettei</i> ↑ <i>Discoaster mohleri</i> 		
			NP 6 <i>H. kleinpelli</i>	NP 6 <i>H. kleinpelli</i>	<ul style="list-style-type: none"> ↑ <i>Discoaster bramlettei</i> ↑ <i>Heliolithus kleinpellii</i> ↑ <i>Sphenolithus anarrhopus</i> 		
			NP 5 <i>F. tympaniformis</i>	NP 5 <i>F. tympaniformis</i>	<ul style="list-style-type: none"> ↑ <i>Toweius eminens</i> ↑ <i>Heliolithus cantabriae</i> ↑ <i>Fasciculithus billii</i> ↑ <i>Fasciculithus tympaniformis</i> ↑↑ <i>Fasciculithus ulii</i>, <i>F. janii</i> ↑ <i>Neochiastozygus perfectus</i> 		
		C26	S e l a n d i a n	C27	NP 4 <i>E. macellus</i>	NP 4 <i>E. macellus</i>	<ul style="list-style-type: none"> ↑↑ <i>Ch. bidens</i>, <i>Fasc. magnicordis</i> ↑ <i>Sphenolithus primus</i>
					NP 3 <i>C. danicus</i>	NP 3 <i>C. danicus</i>	<ul style="list-style-type: none"> ↑ <i>Ellipsolithus macellus</i> ↑ <i>N. saepes</i>, <i>N. eosaepe</i> ↑ <i>Neochiastozygus modestus</i> ↑ <i>Chiasmolithus danicus</i> ↑ <i>Prinsius martinii</i> ↑ <i>Cruciplacolithus edwardsii</i>
				NP 2 <i>C. tenuis</i>	NP 2 <i>C. tenuis</i>	<ul style="list-style-type: none"> ↑ <i>Cruciplacolithus asymmetricus</i> ↑ <i>Cruciplacolithus tenuis</i> ↑ <i>Cruciplacolithus intermedius</i> 	
				NP 1 <i>M. inversus</i>	NP 1 <i>B. sparsus</i>	<ul style="list-style-type: none"> ↑ <i>Cruciplacolithus primus</i> ↑↑ <i>B. sparsus</i>, <i>Cy. alta</i> 	
				CC 26b <i>M. prinsii</i>	CC 26b <i>M. prinsii</i>	<ul style="list-style-type: none"> ↓ Mass-extinction of Cretaceous species ↑ <i>Micula prinsii</i> 	
60	P a l a e o c e n e	D a n i a n	C28	NP 3 <i>C. danicus</i>	NP 3 <i>C. danicus</i>	<ul style="list-style-type: none"> ↑ <i>Ellipsolithus macellus</i> ↑ <i>N. saepes</i>, <i>N. eosaepe</i> ↑ <i>Neochiastozygus modestus</i> ↑ <i>Chiasmolithus danicus</i> ↑ <i>Prinsius martinii</i> ↑ <i>Cruciplacolithus edwardsii</i> 	
				NP 2 <i>C. tenuis</i>	NP 2 <i>C. tenuis</i>	<ul style="list-style-type: none"> ↑ <i>Cruciplacolithus asymmetricus</i> ↑ <i>Cruciplacolithus tenuis</i> ↑ <i>Cruciplacolithus intermedius</i> 	
65	P a l a e o c e n e	D a n i a n	C29	NP 1 <i>M. inversus</i>	NP 1 <i>B. sparsus</i>	<ul style="list-style-type: none"> ↑ <i>Cruciplacolithus primus</i> ↑↑ <i>B. sparsus</i>, <i>Cy. alta</i> 	
				CC 26b <i>M. prinsii</i>	CC 26b <i>M. prinsii</i>	<ul style="list-style-type: none"> ↓ Mass-extinction of Cretaceous species ↑ <i>Micula prinsii</i> 	
Upper Cret.			C30	CC 26b <i>M. prinsii</i>	CC 26b <i>M. prinsii</i>	<ul style="list-style-type: none"> ↓ Mass-extinction of Cretaceous species ↑ <i>Micula prinsii</i> 	

range of many species is refined.

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References

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Age, \uparrow	Series	Stage	Polarity chron	Martini, 1971	This study	
					Biozones	Nannofossil bioevents
46	Middle Eocene	Lutetian	C21	NP15	NP15	<ul style="list-style-type: none"> ↓ <i>Discoaster sublodoensis</i> ↑ <i>Nannotetrina fulgens</i> ↓ <i>Rhabdosphaera inflata</i>
				NP14 ^b <i>D. sublodoensis</i>	NP14 ^b <i>D. sublodoensis</i>	<ul style="list-style-type: none"> ↑ <i>Nannotetrina cristata</i> ↑ <i>Rhabdosphaera inflata</i> ↑ <i>Discoaster saipanensis</i> ↓ <i>Discoaster lodoensis</i> ↑ <i>Discoaster sublodoensis</i>
50	Lower Eocene	Ypresian	C22	NP13 <i>D. lodoensis</i>	NP13 <i>D. lodoensis</i>	<ul style="list-style-type: none"> ↑ <i>Discoaster mirus</i> ↑ <i>Discoaster monstratus</i> ↑ <i>Discoaster broennimanni</i>
				NP12 <i>T. orthostylus</i>	NP12 <i>T. orthostylus</i>	<ul style="list-style-type: none"> ↓ <i>Tribrachiatus orthostylus</i> ↓ <i>Chiphragmalithus</i> ↑ <i>Reticulofenestra dictyoda</i> ↑ <i>Chiphragmalithus</i> ↑ <i>H. lophota, H. seminulum</i> ↑ <i>Discoaster lodoensis</i>
			C23	NP11 <i>D. binodosus</i>	NP11 <i>D. binodosus</i>	<ul style="list-style-type: none"> ↑ <i>Toweius gammation</i>
55	Palaeocene	Thanetian	C24	NP10 <i>R. bramlettei</i>	NP10 <i>R. bramlettei</i>	<ul style="list-style-type: none"> ↓ <i>Tribrachiatus contortus</i> ↓ <i>D. multiradiatus</i> ↑ <i>Discoaster diastypus</i> ↑ <i>Rhombaster bramlettei</i> ↑ <i>Tr. pulcher, Pontosph. spp.</i> ↑ <i>Lophodolithus nascens</i> ↑ <i>Campylosphaera eodela</i> ↑ <i>D. falcatus, D. limbatus</i> ↑ <i>Discoaster mediosus</i>
				NP9 <i>D. multiradiatus</i>	NP9 <i>D. multiradiatus</i>	<ul style="list-style-type: none"> ↑ <i>Blackites creber</i> ↑ <i>Discoaster multiradiatus</i> ↓ <i>Heliolithus riedelii</i>
			C25			