



## Diagnostic First and Last Occurrences of Mesozoic and Cenozoic Planktonic Foraminifera

MARCELLE K. BOUDAGHER-FADEL

OVPR, UCL, Gower Street, London WC1E 6BT, UK

Email: [m.fadel@ucl.ac.uk](mailto:m.fadel@ucl.ac.uk)

**Abstract:** The diagnostic first and last occurrences of Cretaceous, Paleogene and Neogene planktonic foraminifera species are given, and have been calibrated against the most recent biostratigraphical time scale and radio-isotope data.

The major planktonic foraminiferal bioevents for the Late Mesozoic and the Cenozoic (as defined by BouDagher-Fadel, 2012) are calibrated against the biostratigraphical time scale and the radio-isotopes (as defined by Gradstein *et al.*, 2012). Those of the Cenozoic are compared with the earlier zonations of Berggren and Pearson (2005) and Wade *et al.* (2011). The biostratigraphic resolution of the alpha-numeric biozonations is determined by distinct evolutionary lineages of morpho-species and has been deduced through extensive industrial work, calibrated against Sr-isotopes and other biostratigraphic markers, involving global offshore wells by the present author and compared to already published works (for further details see BouDagher-Fadel, 2012).

Three figures are presented. Fig. 1 shows the diagnostic calibration based on species of planktonic foraminifera for the Cretaceous biozonations as defined by BouDagher-Fadel (2012). First occurrences and last appearances of index foraminiferal taxa are plotted against the biostratigraphical time scale of Gradstein *et al.* (2012).

Figs 2 and 3 shows respectively the diagnostic calibration of planktonic foraminifera of the Paleogene and Neogene biozonations as defined by BouDagher-Fadel (2012). First

occurrences and last appearances of index foraminiferal taxa are plotted against the biostratigraphical time scale of Gradstein *et al.* (2012) and compared against the earlier zonations of Berggren and Pearson (2005) and Wade *et al.* (2011).

### References

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DIAGNOSTIC FIRST AND LAST OCCURRENCES OF PLANKTONIC FORAMINIFERA

Age (Ma)	Period, Epoch, Stage	Planktonic zonation	Diagnostic First Occurrence of Planktonic Foraminifera		Diagnostic Last Occurrence of Planktonic Foraminifera			
			Age (Ma)	Species	Age (Ma)	Species		
66	Cretaceous	Late	Maast.	3	66.2	<i>Ventilabrella multicamerata</i>	66.0	<i>Globotruncana spp./Rugoglobigerina spp.</i>
				2	67.0	<i>Plummerita reicheli</i>	66.2	<i>Contusotruncana plicata</i>
					70.0	<i>Racemiguembelina powelli</i>	67.0	<i>Rugotruncana subpennyi</i>
				1	71.0	<i>Contusotruncana plicata</i>	70.0	<i>Globotruncana lapparenti</i>
					72.1	<i>Plummerita hantkeninoides</i>	72.1	<i>Radotruncana subspinoso</i>
				3	74.5	<i>Rugotruncana subpennyi</i>	74.5	<i>Globotruncanita atlantica</i>
					77.0	<i>Globotruncanita stuarti</i>	77.0	<i>Radotruncana calcarata</i>
				2	80.3	<i>Radotruncana calcarata</i> <i>Globotruncanita atlantica</i>	80.3	<i>Rugoglobigerina subrugosa</i>
					83.6	<i>Globotruncana mariei</i>	83.6	<i>Concavototruncana asymetrica</i>
				2	84.9	<i>Rugoglobigerina subrugosa</i>	86.3	<i>Marginotruncana paraconcovata</i>
					85.6	<i>Globotruncana linneiana</i>		
				1	86.3	<i>Concavototruncana asymetrica</i>		
				2	88.0	<i>Globotruncana lapparenti</i>	89.8	<i>Sigalitruncana biconvexiformis</i>
					1	89.8	<i>Marginotruncana paraconcovata</i>	
				3	91.3	<i>Dicarinella primitiva</i>	91.3	<i>Helvetoglobotruncana helveticae</i>
					2	92.8	<i>Helvetoglobotruncana helveticae</i>	
				1	93.9	<i>Sigalitruncana biconvexiformis</i>	92.8	<i>Concavototruncana elata</i>
					95.1	<i>Rotalipora cushmani</i>	93.9	<i>Rotalipora cushmani</i>
				2	97.2	<i>Thalmaninella reicheli</i>	95.1	<i>Favusella washitensis</i>
					98.8	<i>Thalmaninella greenhornensis</i>	99.6	<i>Alanlordella bentonensis</i>
				1	100.5	<i>Thalmaninella globotruncanoides</i>	100.5	<i>Hedbergella rischi</i>
					101.5	<i>Thalmaninella gandolfi</i>	102.2	<i>Ticinella praeticinensis</i>
				4	102.2	<i>Ticinella maedecassiana</i>	106.7	<i>Blefuscuiana aptiana</i>
					104.4	<i>Pseudothalmaninella subticinensis</i>		
				3	106.7	<i>Ticinella praeticinensis</i>	113.0	<i>B. maslakovae/ L. globulifera</i>
					109.8	<i>Ticinella roberti</i>		
				1	111.4	<i>Ticinella primula</i>		
				1	113.0	<i>Hedbergella rischi</i>	119.5	<i>Praehedbergella ruka</i>
					115.0	<i>Blefuscuiana kuznetsovae</i>		
				4	116.5	<i>Lilliputianella kuhryi</i>	122.9	<i>Gorbachikella anteroapertura</i>
					119.5	<i>Praehedbergella tatianae</i>	126.3	<i>Gorbachikella grandiapertura</i>
				3	122.9	<i>Blefuscuiana infracretacea</i>	129.0	<i>Praehedbergella tuschepsensis</i>
					126.3	<i>Blefuscuiana maslakovae</i>		
				3	127.0	<i>Lilliputianella globulifera</i>	133.9	<i>Praehedbergella handousi</i>
					129.0	<i>Blefuscuiana daminia</i>		
2	130.8	<i>B. aptiana/Pr. tuschepsensis</i>	136.65	<i>Conoglobigerina gulekhensis</i>				
	132.5	<i>Gorbachikella anteroapertura</i>						
1	133.9	<i>Praehedbergella handousi</i>	139.4	<i>Conoglobigerina sp. A</i>				
	136.6	<i>Gorbachikella grandiapertura</i>						
2	136.6	<i>Gorbachikella grandiapertura</i>	145.0	<i>Conoglobigerina conica</i>				
	139.4	<i>Conoglobigerina sp. A</i>						
1	145.0	<i>Conoglobigerina gulekhensis</i>						
	145.0	<i>Conoglobigerina conica</i>						
145	Jurassic	Tith.	152.1	<i>Conoglobigerina conica</i>				

Fig. 1. Diagnostic First and Last Occurrences of Cretaceous Planktonic Foraminifera.

DIAGNOSTIC FIRST AND LAST OCCURRENCES OF PLANKTONIC FORAMINIFERA

Age (Ma)	Period, Epoch, Stage	Berggren and Pearson 2005	Wade et al., 2011	Planktonic Zonation (this study)	Diagnostic First Occurrence of Planktonic Foraminifera	Diagnostic Last Occurrence of Planktonic Foraminifera
66.0	Early Danian	P1c, P1b, P1a, P1, Pa and P0	P1c, P1b, P1a, P1, Pa and P0	c, b, a, d, g, O	Subbotina fringa, S. triloculoides, Parasubbotina varianta, Turbogloboborotalia polycamera, Praemurica inconstans, Subbotina simplicissima, Parasubbotina pseudobulloides, Parvulariglobigerina eugubina, Globanomalina planocompressa	Hedbergella holmdelensis, H. monmouthensis, Parvulariglobigerina eugubina, Guembellina cretacea
61.6	Middle Selandian	P2, P1c, P1b, P1a, P1, Pa and P0	P2, P1c, P1b, P1a, P1, Pa and P0	c, b, a, d, g, O	Subbotina triangularis, Praemurica uncinata, Subbotina fringa, S. triloculoides, Parasubbotina varianta, Turbogloboborotalia polycamera, Praemurica inconstans, Subbotina simplicissima, Parasubbotina pseudobulloides, Parvulariglobigerina eugubina, Globanomalina planocompressa	Eoglobigerina eobulloides /Globocornusa daubjergensis
59.2	Late Thanetian	P3, P2, P1c, P1b, P1a, P1, Pa and P0	P3, P2, P1c, P1b, P1a, P1, Pa and P0	b, a, c, b, a, c	Morozovella acuta, Morozovella velascoensis, Morozovella conotruncata, M. aequa, Igorina albeari, Acarina praesphaerica, Igorina pusilla, Morozovella angulata	Zeuuigerina reuria, Parasubbotina variospiral/Igorina pusilla, Eoglobigerina spiralis
56.0	Early Ypresian	P4, P3, P2, P1c, P1b, P1a, P1, Pa and P0	P4, P3, P2, P1c, P1b, P1a, P1, Pa and P0	b, a, c, b, a, c	Morozovella formosa, M. crater, Morozovella queira, Morozovella subbotinae, Igorina broedermannii, Globanomalina australiformis, Acarina wilcoxensis	Morozovella occlusa, Subbotina velascoensis
47.8	Middle Lutetian	E8, E7b, E7a, E6, E5, E4, E3, E2, E1, P5	E8, E7b, E7a, E6, E5, E4, E3, E2, E1, P5	b, a, b, a, b, a, c	Truncatoloides haynesi, Igorina anapetes, Aragonella nuttalli, Globigerina haugi, Morozovella caucasica, Dentoglobigerina galavisi, Acarina collectea, Guembellina higginsii, Acarina decepta, Acarina peritacamerata, Acarina aragonensis, Morozovella formosa, M. crater, Morozovella queira, Morozovella subbotinae, Igorina broedermannii, Globanomalina australiformis, Acarina wilcoxensis	Morozovella caucasica
41.2	Middle Bartonian	E9, E8, E7b, E7a, E6, E5, E4, E3, E2, E1, P5	E9, E8, E7b, E7a, E6, E5, E4, E3, E2, E1, P5	b, a, b, a, b, a, c	Hankenina alabamensis/Truncatoloides toplensis, Hanckenina mexicana, Acarina spinuloinfiata, Turborotalia centralis	Acarina decepta
37.8	Late Pradabanian	E14, E13, E12, E11, E10, E9	E14, E13, E12, E11, E10, E9	b, a, b, a, b, a, c	Globorotaloides eovariabilis, Praetenuitella impariapertura, Subbotina angiporoides, Carnoturborotalia cocoensis, Orbulinoides beckmanni	Morozovella spinulosa/Truncatoloides toplensis
33.9	Late Rupelian	E15, E14, E13, E12, E11, E10, E9	E15, E14, E13, E12, E11, E10, E9	b, a, b, a, b, a, c	Turborotalia pseudoampliapertura, Turborotalia cunialensis, Carnoturborotalia impariapertura, Globorotaloides eovariabilis, Praetenuitella impariapertura, Subbotina angiporoides, Carnoturborotalia cocoensis, Orbulinoides beckmanni	Orbulinoides beckmanni/Morozovella lehneri
28.1	Early Chattian	O6, O5, O4, O3, O2, O1, E15, E14, E13, E12, E11, E10, E9	O6, O5, O4, O3, O2, O1, E15, E14, E13, E12, E11, E10, E9	b, a, b, a, b, a, c	Paragloboborotalia mayeri, Globigerina brazieri, Globoturborotalia woodi, Paragloboborotalia pseudokugleri, Globigerinita praestairforthii, Turborotalia praequinqueloba, Tenuitellina juvenilis, Paragloboborotalia opima, Tenuitella neoclemenciae, Tenuitella clemenciae, Globoturborotalia fariasi, Globigerina selli, Tenuitella gemma, Globigerina ampliapertura, Carnoturborotalia cunialensis, Turborotalia pseudoampliapertura	Globigerina selli
23.0	Late Chattian	P22, P21, P20, P19, P18, P17, P16, P15, P14, P13, P12, P11, P10, P9, P8, P7, P6, P5, P4, P3, P2, P1c, P1b, P1a, P1, Pa and P0	P22, P21, P20, P19, P18, P17, P16, P15, P14, P13, P12, P11, P10, P9, P8, P7, P6, P5, P4, P3, P2, P1c, P1b, P1a, P1, Pa and P0	b, a, b, a, b, a, c	Paragloboborotalia mayeri, Globigerina brazieri, Globoturborotalia woodi, Paragloboborotalia pseudokugleri, Globigerinita praestairforthii, Turborotalia praequinqueloba, Tenuitellina juvenilis, Paragloboborotalia opima, Tenuitella neoclemenciae, Tenuitella clemenciae, Globoturborotalia fariasi, Globigerina selli, Tenuitella gemma, Globigerina ampliapertura, Carnoturborotalia cunialensis, Turborotalia pseudoampliapertura	Tenuitella gemma/Paragloboborotalia opima

Fig. 2. Diagnostic First and Last Occurrences of Paleogene Planktonic Foraminifera.

DIAGNOSTIC FIRST AND LAST OCCURRENCES OF PLANKTONIC FORAMINIFERA

Age (Ma)	Period, Epoch, Stage	Berggren and Pearson, 2005	Wade et al., 2011	Planktonic Zonation (this study)	Diagnostic First Occurrence of Planktonic Foraminifera	Diagnostic Last Occurrence of Planktonic Foraminifera												
23.03	Early Miocene	M1	M1	N4	Turborotalita quinqueloba, Paragloborotalita continuosa, Paragloborotalita kugleri, Globobulimina brazeri, <del>Globobulimina parvulata</del>	Globigerina angulistralis, Globigerina ciperoensis												
22.0																		
15.97	Middle Miocene	M2	M2	N5	Globobulimina praescitula, Paragloborotalita zealandica, Tenuitella minutissima, Globigerinita incrusta	Globigerinita praestainforthi												
							21.0											
							N6	M3	M3	N6	Prosphaeroidinella disjuncta	Globigerina connecta						
													18.0					
													N7	M4	M4	N7	Paragloborotalita bimageae, Globigerina diplostoma, Globorotalia miozea, Catapsydrax parvulus	Dentoglobigerina praedeheiscens
													N8	M5	M5	N8	Paragloborotalita peripheroronda, Praeorbulina sicana, Globigerinoides bisphericus	Globigerina connecta
													N9	M6	M6	N9	Orbulina suturalis, Praeorbulina glomerosa	Globobulimina semivera,
N10	M7	M7	N10	Paragloborotalita peripheroacuta, Globorotalia rifensis	Globobulimina semivera,													
						14.5												
N11	M8	M8	N11	Globobulimina glomerosa	Globobulimina semivera,													
						13.7												
N12	M9	M9	N12	Globobulimina lobata, Globigerinoides bollii	Globobulimina semivera,													
						12.8												
N13	M10	M10	N13	Globobulimina lobata, Globigerinoides bollii	Globobulimina semivera,													
						12.0												
N14	M11	M11	N14	Globobulimina lobata, Globigerinoides bollii	Globobulimina semivera,													
						11.8												
N15	M12	M12	N15	Globobulimina lobata, Globigerinoides bollii	Globobulimina semivera,													
						11.6												
N16	M13	M13	N16	Globobulimina lobata, Globigerinoides bollii	Globobulimina semivera,													
						9.0												
N17	M14	M14	N17	Globobulimina lobata, Globigerinoides bollii	Globobulimina semivera,													
						8.6												
N18	M15	M15	N18	Globobulimina lobata, Globigerinoides bollii	Globobulimina semivera,													
						7.2												
N19	M16	M16	N19	Globobulimina lobata, Globigerinoides bollii	Globobulimina semivera,													
						5.3												
N20	M17	M17	N20	Globobulimina lobata, Globigerinoides bollii	Globobulimina semivera,													
						5.3												
N21	M18	M18	N21	Globobulimina lobata, Globigerinoides bollii	Globobulimina semivera,													
						4.2												
N22	M19	M19	N22	Globobulimina lobata, Globigerinoides bollii	Globobulimina semivera,													
						3.4												
N23	M20	M20	N23	Globobulimina lobata, Globigerinoides bollii	Globobulimina semivera,													
						3.4												
1.81	Pleist.	PT1	PT1	N23	Globobulimina neoflexuosa, Sphaeroidinella excavata, Hastigerinella digitata, Beella digitata	Globobulimina flexuosa, Truncorotalita hessi, Truncorotalita tosaensis, Globobulimina pertenuis												
							0.12											

Fig. 3. Diagnostic First and Last Occurrences of Neogene Planktonic Foraminifera.

This article should be referred to as:

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