Major intensification of Atlantic overturning circulation at the onset of Paleogene greenhouse warmth

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Supplementary information

Supplementary Tables

Supplementary Table 1. Overview of ocean drilling sites used in this study

program	Exp.	Site/ Hole	Ocean	Region	Latitude, Longitude	Water depth (m)	Paleo depth (m)	Age model[a]	Notes
DSDP	72	516F	South Atlantic	Rio Grande Rise	30°16.59'S 35°17.10'W	2109[1]	500–1000[1]	Shipboard[1]; Magnetostratigraphy[2,3]	
DSDP	74	525A	South Atlantic	Walvis Ridge	29°04.24'S 02°59.12'E	2467[4]	~1300[4, 5]	Shipboard[4]; Magnetostratigraphy[6,3]	ε_{Nd} data 69.2–72.0 Ma[7]
ODP	208	1267	South Atlantic	Walvis Ridge	28°5.88'S 1°42.66'E	4355[8]	~3000[8]	Precession cycles[9]; Magnetostratigraphy[8,3]	Precession for Paleocene only[9]
DSDP	41	369	North Atlantic	Canary Islands	26°35.5'N 14°59. 'W	1752[10]	1500–1700[8]	Shipboard[10]	
IODP	342	U1403	North Atlantic	Newfound-land	39°56.5997'N 51°48.1998'W	4955.7[11]	4000–4500[11]	Calcareous nannofossils[12] Cyclostratigraphy[13]; C-isotope stratigraphy[13]	Coordinates, depth: Hole A

[a)] The tie-points used for establishing age models are listed in Supplementary Table 7.

Supplementary Table 2. Nd isotope results for Site 516F

Sample ID[a]	Lab[b]	Site	Hole	Core	Sec.	from (cm)	to (cm)	Depth (mcd)	Age (Ma)[c]	$^{143}Nd/^{144}Nd$	$\varepsilon_{Nd(0)}$[d]	$\varepsilon_{Nd(t)}$[e]	2σ[f]
leachates													
14	K	516	F	83	3	130	132	904.91	56.43	0.5121558	-9.41	**-8.88**	0.15
09	K	516	F	84	3	90	92	914.01	57.24	0.5121517	-9.49	**-8.96**	0.07
11	K	516	F	85	2	21	23	921.32	58.74	0.5121629	-9.27	**-8.72**	0.15
04	K	516	F	86	4	34	35	933.95	59.34	0.5121923	-8.69	**-8.15**	0.07
05	K	516	F	87	4	59	61	943.7	61.76	0.5120942	-10.61	**-10.04**	0.15
24	O	516	F	88	2	92	94	950.53	63.68	0.5120914	-10.66	**-10.07**	0.13
13	K	516	F	89	3	27	29	960.88	64.69	0.5120655	-11.17	**-10.57**	0.15
22	O	516	F	90	3	44	46	970.55	66.35	0.5120697	-11.09	**-10.47**	0.13
10	K	516	F	91	3	120	122	980.81	67.08	0.5121035	-10.43	**-9.81**	0.15
08	K	516	F	92	2	20	22	987.81	67.58	0.5121052	-10.39	**-9.77**	0.15
08b	O	516	F	92	2	20	22	987.81	67.51	0.5121159	-10.18	**-9.56**	0.20
20	O	516	F	93	3	122	124	999.83	68.45	0.5121132	-10.24	**-9.60**	0.13
20b	O	516	F	93	3	122	124	999.83	68.45	0.5121221	-10.06	**-9.43**	0.12
03	K	516	F	94	3	126	128	1009.37	69.14	0.5121107	-10.29	**-9.65**	0.15
15	K	516	F	95	4	18	20	1019.29	70.12	0.5121276	-9.96	**-9.31**	0.15
15b	O	516	F	95	4	18	20	1019.29	70.07	0.5121394	-9.73	**-9.08**	0.20
28	O	516	F	96	2	28	30	1025.39	70.75	0.5121296	-9.92	**-9.26**	0.13
17	K	516	F	97	2	92	94	1032.03	71.45	0.5121532	-9.46	**-8.80**	0.15
17b	O	516	F	97	2	92	94	1032.03	71.40	0.5121423	-9.67	**-9.01**	0.20
07	K	516	F	98	3	110	112	1036.71	71.78	0.5121286	-9.94	**-9.27**	0.15
18	K	516	F	99	1	29	31	1041.9	72.07	0.5121324	-9.86	**-9.20**	0.15
12	K	516	F	100	2	110	112	1046.71	72.50	0.5121225	-10.06	**-9.39**	0.15
Detrital fractions[g]													
335	O	516	F	84	3	74	75	914.10	57.26	0.5121320	-9.87	**-9.35**	0.31
					3	124	125						
336	O	516	F	86	4	24	25	934.10	59.35	0.5122149	-8.25	**-7.71**	0.23
					4	74	75						
333	O	516	F	88	2	25	26	950.11	63.64	0.5120742	-11.00	**-10.42**	0.39
					2	75	76						
334	O	516	F	92	1	128	129	987.63	67.57	0.5120367	-11.73	**-11.13**	0.23
					2	25	26						
332	O	516	F	96	2	25	26	1025.61	70.78	0.5120939	-10.61	**-9.98**	0.23
					2	75	76						

[a] Occurrences of "b" behind sample numbers indicate replicate measurements, averages are plotted.
[b] The "K" stands for the geochemistry facilities of the GEOMAR in Kiel, Germany; "O" stands for the Department of Earth Sciences in Oxford, UK.
[c] The tie-points used for establishing age models are listed in Supplementary Table 6.
[d] Calculated as εNd(0)=
[e] Calculated as εNd(t)= , using a Sm/Nd ratio of 0.124 (ref. 19) and a current value of CHUR of 0.512638 (ref. 34)
[f] 2σ based on Jndi, expressed as ε_{Nd}.
[g] each sample ID represent two samples that were combined to obtain sufficient material.

Supplementary Table 3. Nd isotope results for Hole 525A

Sample ID[a]	Lab[b]	Site	Hole	Core	Sec.	from (cm)	to (cm)	Depth (mbsf)	Age (Ma)[c]	$^{143}Nd/^{144}Nd$	$\varepsilon_{Nd(0)}$[d]	$\varepsilon_{Nd(t)}$[e]	2σ[f]
leachates													
13	K	525	A	31	1	89	91	375.00	55.99	0.5122055	-8.44	**-7.92**	0.31
14	K	525	A	31	4	40	42	379.01	56.13	0.5121828	-8.88	**-8.36**	0.31
12	K	525	A	32	2	40	42	385.51	56.36	0.5121794	-8.95	**-8.42**	0.31
1	K	525	A	32	7	51	53	393.12	56.63	0.5121760	-9.01	**-8.49**	0.31
5	K	525	A	35	2	70	72	404.81	57.05	0.5121955	-8.63	**-8.10**	0.41
4	K	525	A	35	4	129	131	408.40	57.17	0.5122014	-8.52	**-7.99**	0.41
2	K	525	A	37	1	36	38	421.97	59.41	0.5122931	-6.73	**-6.18**	0.54
8	K	525	A	38	3	58	60	434.69	61.82	0.5122163	-8.23	**-7.65**	0.26
11	K	525	A	39	2	47	49	442.58	63.32	0.5121830	-8.88	**-8.29**	0.31
10	K	525	A	39	5	46	48	447.07	64.88	0.5123288	-6.03	**-5.43**	0.31
22	K	525	A	40	2	71	73	452.32	66.08	0.5122363	-7.84	**-7.22**	0.54
6	K	525	A	40	4	36	38	454.97	66.28	0.5122807	-6.97	**-6.36**	0.41
7	K	525	A	41	1	15	17	459.76	66.70	0.5123508	-5.60	**-4.98**	0.41
23	K	525	A	41	4	68	70	464.79	67.19	0.5123205	-6.19	**-5.57**	0.54
3	K	525	A	42	1	109	111	470.20	67.72	0.5123062	-6.47	**-5.85**	0.41
20	K	525	A	42	4	80	82	474.41	68.13	0.5123252	-6.10	**-5.47**	0.54
24	K	525	A	43	1	41	43	479.02	68.55	0.5123169	-6.26	**-5.63**	0.41
19	K	525	A	43	4	55	57	483.66	68.87	0.5122948	-6.69	**-6.06**	0.54

[a–f] Footnotes as for Table 2.

Supplementary Table 4. Nd isotope results for Site 1267

Sample ID[a]	Lab[b]	Site	Hole	Core	Sec.	from (cm)	to (cm)	Depth (CCSF-A)	Age (Ma)[c]	$^{143}Nd/^{144}Nd$	$\varepsilon_{Nd(0)}$[d]	$\varepsilon_{Nd(t)}$[e]	2σ[f]
leachates													
72	K	1267	B	23	4	15	17	232.41	56.08	0.5121009	-10.48	**-9.96**	0.42
94	K	1267	A	23	3	85	87	237.36	56.42	0.5122368	-7.83	**-7.30**	0.42
89	K	1267	B	24	2	88	90	242.34	56.69	0.5121505	-9.51	**-8.99**	0.26
90	K	1267	B	24	5	131	133	247.27	57.01	0.5121974	-8.59	**-8.07**	0.26
75	K	1267	B	25	1	43	45	252.25	57.34	0.5121350	-9.81	**-9.28**	0.42
77	K	1267	B	25	4	89	91	257.21	57.64	0.5121368	-9.78	**-9.24**	0.42
91	K	1267	A	25	4	6	8	262.17	57.94	0.5122271	-8.01	**-7.48**	0.26
70	K	1267	A	26	1	36	38	267.07	58.23	0.5122038	-8.47	**-7.93**	0.41
71	K	1267	A	26	4	86	88	272.07	58.66	0.5121706	-9.12	**-8.57**	0.42
84	K	1267	B	27	5	139	141	277.05	59.19	0.5122532	-7.51	**-6.96**	0.26
121	K	1267	B	28	2	141	143	282.02	59.85	0.5122049	-8.45	**-7.89**	0.42
88	K	1267	B	28	6	37	39	286.98	60.51	0.5121909	-8.72	**-8.16**	0.26
81	K	1267	B	29	3	47	49	291.93	61.16	0.5122020	-8.51	**-7.94**	0.42
82	K	1267	A	29	1	20	22	296.91	61.82	0.5121558	-9.41	**-8.83**	0.26
87	K	1267	A	29	4	66	68	301.87	62.56	0.5121470	-9.58	**-9.00**	0.26
85	K	1267	B	30	7	43	45	306.84	63.45	0.5121989	-8.57	**-7.98**	0.26
74	K	1267	A	30	4	70	72	311.76	64.50	0.5121065	-10.37	**-9.77**	0.41
69	K	1267	B	32	1	125	127	316.61	65.46	0.5121669	-9.19	**-8.58**	0.41
95	K	1267	B	32	3	48	50	318.84	65.79	0.5121637	-9.25	**-8.64**	0.26
80	K	1267	B	32	5	65	67	321.61	66.04	0.5121628	-9.27	**-8.66**	0.26
79	K	1267	A	31	7	121	123	326.65	66.38	0.5121709	-9.11	**-8.50**	0.26
96	K	1267	B	33	4	104	106	331.55	66.72	0.5122319	-7.92	**-7.30**	0.26
93	K	1267	B	34	1	76	78	336.57	67.06	0.5122705	-7.17	**-6.55**	0.26
73	K	1267	B	34	4	122	124	341.53	67.39	0.5121906	-8.73	**-8.10**	0.41
86	K	1267	B	35	1	70	72	346.66	67.74	0.5121759	-9.01	**-8.39**	0.26
92	K	1267	B	35	4	128	130	351.74	68.09	0.5122110	-8.33	**-7.70**	0.26
83	K	1267	B	36	1	2	4	356.93	68.44	0.5121910	-8.72	**-8.09**	0.26
78	K	1267	B	36	4	48	50	361.89	68.78	0.5122140	-8.27	**-7.63**	0.41
76	K	1267	B	36	7	34	36	366.25	69.07	0.5122616	-7.34	**-6.70**	0.41
detrital fractions													
131TD	K	1267	A	23	3	85	87	237.36	56.42	0.5121827	-8.88	**-8.36**	0.18
129TD	K	1267	A	25	4	6	8	262.17	57.94	0.5122021	-8.50	**-7.97**	0.18
128TD	K	1267	B	28	6	37	39	286.98	60.51	0.5122091	-8.37	**-7.81**	0.18
126TD	K	1267	A	30	4	70	72	311.76	64.50	0.5122047	-8.45	**-7.86**	0.18
130TD	K	1267	B	34	1	76	78	336.57	67.06	0.5120998	-10.50	**-9.88**	0.18
127TD	K	1267	B	36	4	48	50	361.89	68.78	0.5120398	-11.67	**-11.03**	0.18

[a–f] Footnotes as for Table 2.

Supplementary Table 5. Nd isotope results for Site 369

Sample ID[a]	Lab[b]	Site	Hole	Core	Sec.	from (cm)	to (cm)	Depth (CCSF-A)	Age (Ma)[c]	$^{143}Nd/^{144}Nd$	$\varepsilon_{Nd(0)}$[d]	$\varepsilon_{Nd(t)}$[e]	2σ[f]
leachates													
98	K	369	A	36	1	49	51	374.99	68.39	0.5119294	-13.82	**-13.19**	0.42
100	K	369	A	36	3	101	103	378.51	70.13	0.5119718	-13.00	**-12.35**	0.42
103	K	369	A	36	5	119	121	381.69	71.64	0.5120641	-11.19	**-10.53**	0.42
101	K	369	A	37	1	97	99	384.97	72.28	0.5119107	-14.19	**-13.52**	0.26
101b	O	369	A	37	1	97	99	384.97	72.28	0.5119545	-13.33	**-12.67**	0.20
105	O	369	A	37	3	78	80	387.78	72.83	0.5118726	-14.93	**-14.26**	0.31
105b	O	369	A	37	3	78	80	387.78	72.83	0.5118352	-15.66	**-14.99**	0.20
detrital fractions													
132TD	K	369	A	36	3	101	103	378.51	70.13	0.5118415	-15.54	**-14.89**	0.18
134TD	K	369	A	37	3	78	80	387.78	72.83	0.5117438	-17.44	**-16.77**	0.18
134TDb	O	369	A	37	3	78	80	387.78	72.83	0.5117683	-16.97	**-16.29**	0.20

[a–f] Footnotes as for Table 2.

Supplementary Table 6. Nd isotope results for Site U1403

Sample ID[a]	Lab[b]	Site	Hole	Core	Sec.	from (cm)	to (cm)	Depth (rCCSF)	Age (Ma)[c]	$^{143}Nd/^{144}Nd$	$\varepsilon_{Nd(0)}$[d]	$\varepsilon_{Nd(t)}$[e]	2σ[f]
leachates													
34	K	1403	A	22	1	118	120	211.17	58.38	0.51220316	-8.48	**-7.94**	0.28
41	K	1403	B	25	3	32	34	214.92	59.27	0.51219441	-8.65	**-8.1**	0.28
39	K	1403	B	25	5	110	112	218.7	60.16	0.5121726	-9.08	**-8.52**	0.28
26	K	1403	A	23	4	130	132	222.04	60.95	0.51211773	-10.15	**-9.58**	0.28
36	K	1403	B	26	3	17	19	225.83	61.85	0.51206354	-11.21	**-10.63**	0.28
38	K	1403	A	25	1	88	90	233.61	63.50	0.51207215	-11.04	**-10.45**	0.28
61	K	1403	A	25	3	14	16	235.87	63.96	0.51214574	-9.6	**-9.01**	0.41
45	K	1403	A	25	6	3	5	240.26	64.84	0.51212113	-10.08	**-9.48**	0.28
29	K	1403	A	26	1	18	20	241.77	65.00	0.51208917	-10.71	**-10.1**	0.41
46	K	1403	A	26	4	8	10	246.17	65.49	0.51209801	-10.53	**-9.93**	0.28
46b	O	1403	A	26	4	8	10	246.17	65.49	0.51209984	-10.5	**-9.89**	0.20
64	K	1403	A	26	4	68	70	246.77	65.71	0.51209701	-10.55	**-9.95**	0.41
47	K	1403	B	28	1	15	16.5	247.16	65.85	0.51211903	-10.12	**-9.51**	0.28
63	K	1403	B	28	1	30	32	247.31	65.90	0.51210475	-10.4	**-9.79**	0.41
48	K	1403	B	28	1	45	46.5	247.46	65.96	0.51214753	-9.57	**-8.96**	0.28
48b	O	1403	B	28	1	45	46.5	247.46	65.96	0.5121445	-9.63	**-9.02**	0.20
68	K	1403	B	28	1	60	62	247.601	66.01	0.51210539	-10.39	**-9.78**	0.41
49	K	1403	B	28	1	75	76.5	247.76	66.05	0.51208094	-10.87	**-10.26**	0.28
30	O	1403	B	28	1	95	96.5	247.96	66.07	0.51214083	-9.7	**-9.09**	0.13
60	K	1403	B	28	1	115	117	248.16	66.09	0.51214344	-9.65	**-9.04**	0.41
65	K	1403	B	28	2	6	8	248.57	66.13	0.51211151	-10.27	**-9.66**	0.41
50	K	1403	B	28	2	46.5	48	248.97	66.17	0.51216274	-9.27	**-8.66**	0.28
50b	O	1403	B	28	2	46.5	48	248.97	66.17	0.51214194	-9.68	**-9.06**	0.20
35	K	1403	A	27	2	30	32	253.95	66.68	0.51211607	-10.18	**-9.56**	0.28
32	K	1403	A	27	3	100	102	256.15	66.90	0.51210387	-10.42	**-9.8**	0.41
51	K	1403	A	27	5	90	92	259.05	67.18	0.51208445	-10.8	**-10.18**	0.28
37	K	1403	B	29	3	130	132	263.28	67.58	0.51209507	-10.59	**-9.97**	0.28
52	K	1403	A	28	4	30	32	267.75	67.92	0.51212524	-10	**-9.37**	0.28
52b	O	1403	A	28	4	30	32	267.75	67.92	0.51213415	-9.83	**-9.2**	0.20
27	K	1403	B	30	2	60	62	271.25	68.33	0.51213766	-9.76	**-9.13**	0.28
67	K	1403	B	31	1	1	3	279.83	69.83	0.51213027	-9.9	**-9.26**	0.41
42	K	1403	B	31	3	100	102	283.82	70.63	0.51217083	-9.11	**-8.46**	0.28
44	K	1403	B	32	1	3	5	290.52	71.97	0.51220812	-8.39	**-7.72**	0.28
44b	O	1403	B	32	1	3	5	290.52	71.97	0.51222027	-8.15	**-7.48**	0.20
62	K	1403	B	32	3	30	32	293.79	72.63	0.51214667	-9.58	**-8.91**	0.41
40	K	1403	B	32	5	40	42	296.59	73.19	0.51220583	-8.43	**-7.75**	0.28
detrital fractions													
54TD	K	1403	B	25	3	32	34	214.92	59.27	0.51211421	-10.22	**-9.67**	0.18
53TD	K	1403	A	25	1	88	90	233.61	63.50	0.51197308	-12.97	**-12.38**	0.18
123TD	K	1403	A	26	1	18	20	241.77	65.00	0.5120373	-11.72	**-11.12**	0.18
56TD	K	1403	A	26	4	8	10	246.17	65.49	0.51200563	-12.34	**-11.73**	0.18
124TD	K	1403	A	28	4	30	32	267.75	67.92	0.51205968	-11.28	**-10.65**	0.18
125TD	K	1403	B	31	1	1	3	279.83	69.83	0.51204884	-11.49	**-10.85**	0.18
55TD	K	1403	B	32	1	3	5	290.52	71.97	0.51211144	-10.27	**-9.61**	0.18

[a–f] Footnotes as for Table 2.

Supplementary Table 7. Tie-points used for the construction of age-models

Site 516 Stratigraphic event[a]	Depth (mcd)	Age (Ma)
base C24n3n	888.10	53.983
base NP10	898.50	55.860
base NP9	913.80	57.210
base C25N	916.72	57.656
base NP8	920.10	58.700
base NP7	929.10	58.970
base NP6	936.60	59.540
base NP5	943.30	61.510
base NP4	946.10	63.250
base NP3	962.10	64.810
base NP2	963.10	65.470
K/Pg boundary	964.11	66.040
base C29r	971.42	66.398
base C31n	1011.15	69.269
base C31r	1032.03	71.449
base C32r	1071.88	74.309

Site 525 Stratigraphic event[a]	Depth (rmcd)	Age (Ma)
base NP10	371.30	55.860
base NP9	409.40	57.210
base NP8	415.90	58.700
base NP7	416.70	58.970
base NP6	423.50	59.540
base NP5	433.00	61.510
base NP4	442.38	63.250
base NP3	446.80	64.810
base NP2	449.30	65.470
K/Pg boundary	451.71	66.040
base C29r	456.69	66.389
base C30n	475.15	68.196
base C30r	476.40	68.369
base C31n	489.35	69.269
base C31r	519.95	71.449
base C32n1n	522.61	71.689
base C32n1r	526.24	71.939
C32n2n, estimate (base C32n2n, age 73.649, below 565 m)	565.00	73.600

Site 1267 Stratigraphic event[a]	Depth (rmcd)	Age (Ma)
astrochronology	232.05	56.042
astrochronology	232.63	56.105
astrochronology	232.85	56.126
astrochronology	233.10	56.147
astrochronology	233.65	56.189
astrochronology	233.88	56.21
astrochronology	235.40	56.315
astrochronology	236.95	56.399
astrochronology	237.43	56.42

astrochronology	237.80	56.441
astrochronology	239.20	56.504
astrochronology	239.55	56.525
astrochronology	240.30	56.567
astrochronology	240.68	56.588
astrochronology	241.05	56.609
astrochronology	241.43	56.630
astrochronology	242.33	56.693
astrochronology	243.05	56.735
astrochronology	243.43	56.756
astrochronology	244.08	56.819
astrochronology	245.08	56.882
astrochronology	245.40	56.903
astrochronology	245.75	56.924
astrochronology	246.85	56.987
astrochronology	247.25	57.008
astrochronology	247.53	57.029
astrochronology	248.40	57.113
astrochronology	249.13	57.176
astrochronology	249.53	57.197
astrochronology	249.83	57.218
astrochronology	251.43	57.302
astrochronology	251.70	57.323
astrochronology	253.46	57.386
astrochronology	253.74	57.407
astrochronology	256.14	57.575
astrochronology	256.49	57.596
astrochronology	257.61	57.659
astrochronology	257.99	57.680
astrochronology	258.34	57.701
astrochronology	259.11	57.743
astrochronology	259.43	57.764
astrochronology	259.80	57.785
astrochronology	260.13	57.806
astrochronology	260.45	57.827
astrochronology	261.35	57.890
astrochronology	261.61	57.911
astrochronology	263.43	58.016
astrochronology	263.88	58.037
astrochronology	264.33	58.058
astrochronology	265.50	58.121
astrochronology	265.83	58.142
astrochronology	266.15	58.163
astrochronology	266.45	58.184
astrochronology	266.75	58.205
base C25r	275.48	58.959
base C26n	277.40	59.237
base C26r	299.90	62.221
base C27n	301.65	62.517
base C27r	307.08	63.494
base C28n	312.53	64.667
base C28r	313.75	64.958
base C29n	317.92	65.688
K/Pg boundary	320.25	66.040

base C29r	326.88	66.389
extrapolated	366.30	69.076

Site 369 Stratigraphic event[a]	Depth (mbsf)	Age (Ma)
extrapolated	372.00	66.916
base C31n	376.00	69.269
base *Micula mura* zone	377.00	69.000
average of two events above	376.50	69.135
base C31r	379.00	71.449
top *Globotruncana gansseri* zone	384.00	71.750
average of two events above	381.50	71.600
top *Eiffellithus eximius* zone	412.00	75.950
Top *Globotruncana elevata* zone	412.00	79.200
average of two events above	412.00	77.575

Site U1403 Stratigraphic event[a]	Depth (rCCSF)	Age (Ma)
base NP 10, FO *Rhomboaster bramlettei*	195.75	55.860
P-E boundary, FO *Rhomboaster* spp.	200.98	55.960
base *Lithoptychius* spp., 1st radiation fasc.	227.00	62.200
base NP3, FO *Chiasmolithus danicus*	239.98	64.810
base NP2, FO *Cruciplacolithus intermedius*	246.12	65.470
K/Pg boundary	247.69	66.040
astrochronology	251.04	66.374
astrochronology	254.96	66.782
astrochronology	259.21	67.192
astrochronology	263.37	67.585
astrochronology	268.68	67.986
astrochronology	271.64	68.383
astrochronology	274.64	68.787
astrochronology	275.00	68.860
extrapolated	300.00	73.870

[a)] "C" followed by a number: magnetochron, "NP" followed by a number: nannoplankton zone[14], LO: Last Occurrence, FO: First occurrence. In case of contradicting ages for stratigraphic events for Site 369, average depths and ages were used as tie-points.

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