

SUPPLEMENTARY MATERIAL

Surface Sediment Samples From Early Age of Seafloor Exploration Can Provide a Late 19th Century Baseline of the Marine Environment

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Tables S1 and S3-S5 can be downloaded as CSV files from the
NHM Data Portal: <https://doi.org/10.5519/0001936>

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Table S1. Planktonic foraminifera species counts of the nine historical samples (see Table 1). IRN (OBD) stands for the internal registration number of the Ocean-Bottom Deposits collection at the Natural History Museum in London. Individuals were identified to the species level by M. Rillo and M. Kucera together.

Historical samples									
Museum number	M.192	M.8780	M.5246	M.408	M.3787	M.4080	M.7487	M.284	M.25
IRN (OBD)	32657	38482	36053	34991	34671	34993	37148	33668	33286
Latitude	-50.02	-40.45	-26.94	-21.25	-19.57	-15.65	-7.59	-0.70	24.33
Longitude	123.07	49.82	111.18	-14.03	64.63	-179.06	61.48	147	-24.47
Species									
<i>Beella digitata</i>	0	0	0	0	2	1	0	0	0
<i>Berggrenia pumilio</i>	0	0	0	0	0	0	0	0	0
<i>Candeina nitida</i>	0	0	0	0	1	0	0	0	0
<i>Globigerina bulloides</i>	175	38	13	4	2	3	8	28	6
<i>Globigerina falconensis</i>	0	4	11	17	2	6	0	12	0
<i>Globigerinella calida</i>	1	1	6	8	11	15	0	12	3
<i>Globigerinella siphonifera</i>	0	0	5	4	29	10	16	14	2
<i>Globigerinita glutinata</i>	5	5	52	18	24	63	77	65	2
<i>Globigerinoides conglobatus</i>	0	0	1	3	12	8	6	2	2
<i>Globigerinoides ruber pink</i>	0	0	0	11	0	0	0	0	0
<i>Globigerinoides ruber white</i>	0	3	73	84	196	131	53	115	68
<i>Globigerinoides tenellus</i>	0	0	0	20	9	19	0	6	0
<i>Globoconella inflata</i>	96	58	10	31	2	0	0	0	35
<i>Globoquadrina conglomerata</i>	0	0	2	0	1	0	0	1	0
<i>Globorotalia crassaformis</i>	0	0	2	2	1	0	0	0	5
<i>Globorotalia hirsuta</i>	0	0	0	1	0	0	0	0	0
<i>Globorotalia menardii</i>	0	0	37	0	1	0	30	1	23
<i>Globorotalia scitula</i>	0	0	0	2	1	0	5	0	0
<i>Globorotalia theyeri</i>	0	0	0	0	0	0	1	0	0
<i>Globorotalia truncatulinoides</i>	14	10	6	12	3	0	1	0	10
<i>Globorotalia tumida</i>	0	0	0	2	0	0	15	2	7
<i>Globorotalia unguolata</i>	0	0	3	2	2	0	4	0	0
<i>Globorotaloides hexagonus</i>	0	0	0	0	1	0	0	0	0
<i>Globoturborotalita rubescens</i>	0	0	0	3	2	4	4	4	0
<i>Neogloboquadrina dutertrei</i>	0	0	34	1	11	4	21	9	7
<i>Neogloboquadrina incompta</i>	8	17	4	1	0	0	33	10	33
<i>Neogloboquadrina pachyderma</i>	19	38	0	0	0	0	0	0	0
<i>Orbulina universa</i>	0	1	1	6	3	4	0	0	1
<i>Pulleniatina obliquiloculata</i>	0	0	2	3	7	0	16	22	5
<i>Sphaeroidinella dehiscens</i>	0	0	0	0	1	0	1	0	2
<i>Trilobatus sacculifer</i>	0	0	17	30	52	32	13	28	46
<i>Turborotalita humilis</i>	0	0	0	0	0	0	1	0	3
<i>Turborotalita quinqueloba</i>	0	2	0	0	0	0	0	0	0
Total count	318	177	279	265	376	300	305	331	260

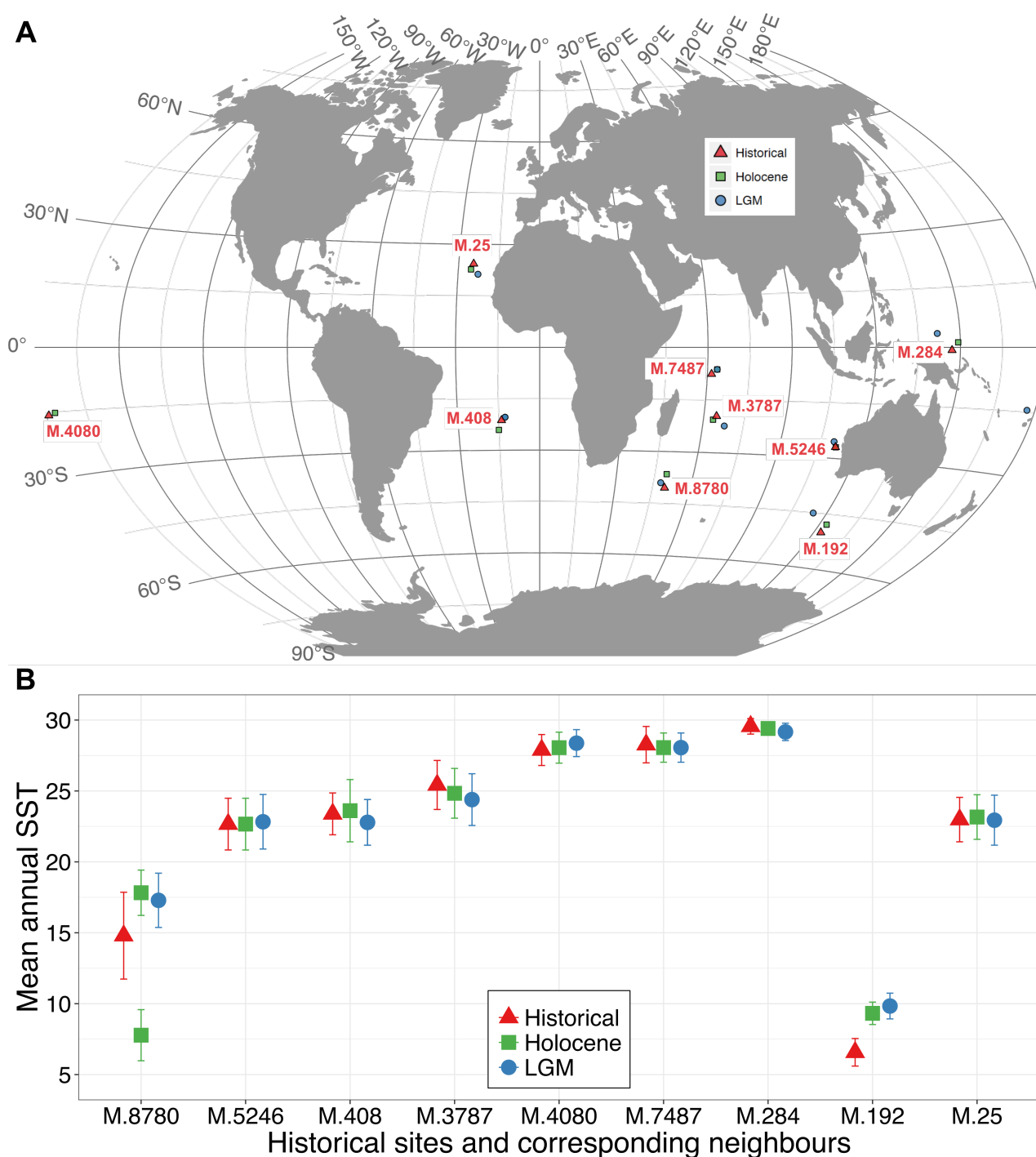


Figure S1. (A) Map of historical sample sites (red triangles) and corresponding neighbouring sites of the Holocene (green squares, ForCenS database) and Last Glacial Maximum (blue dots, LGM, MARGO datasets). Distances between each historical site and its corresponding Holocene and LGM neighbours can be seen in Tables [S3](#), [S4](#), [S5](#). (B) Mean annual sea surface temperature (SST, in degree Celsius) and annual standard deviations (bars) at each sample site (WOA13 data). Note that historical sample M.8780 has two values for the Holocene neighbour. The nearest Holocene neighbour (SST 7.8°C, distance of 374 km) was substituted by the fourth nearest neighbour, which had more similar SST values (17.8°C, distance of 440 km, see map above).

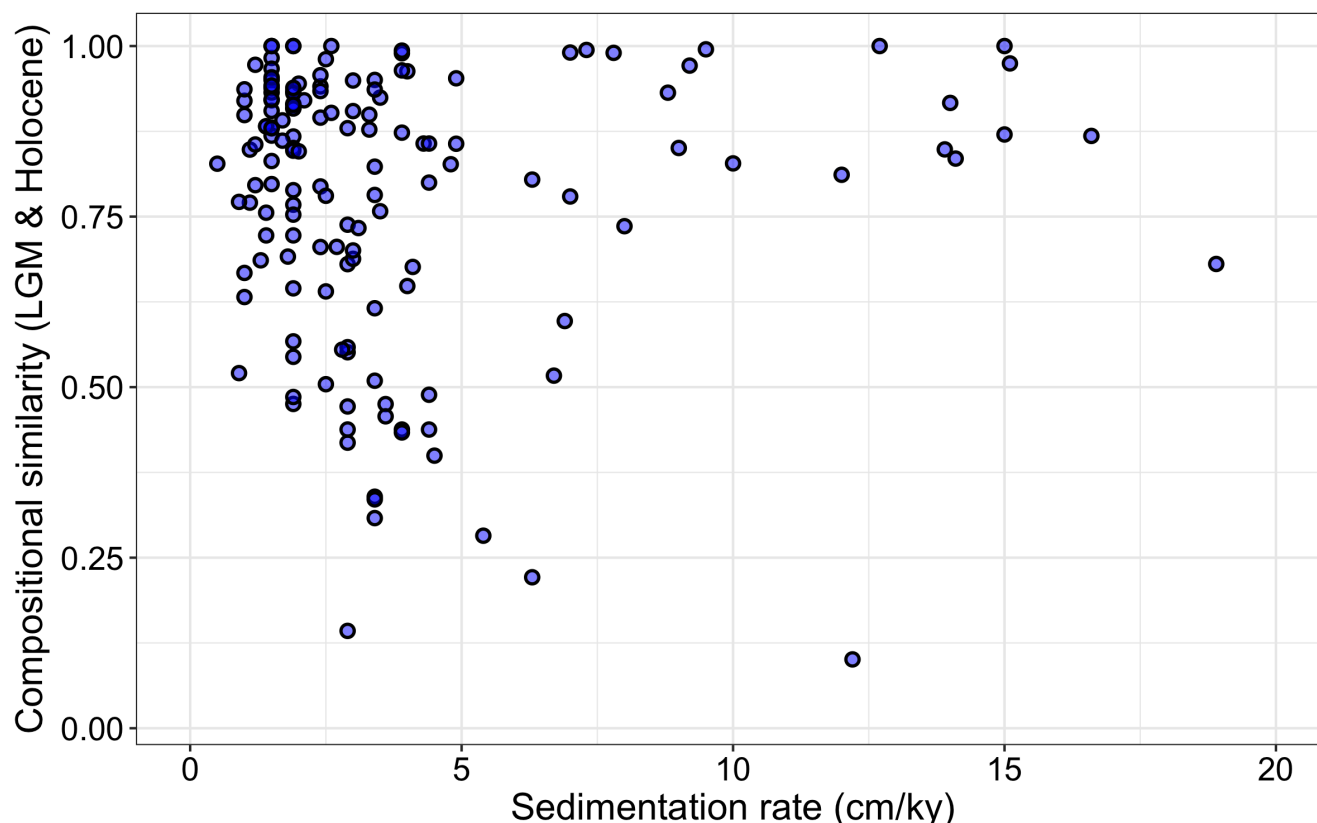


Figure S2. Compositional similarity (Morisita-Horn index) between planktonic foraminifera assemblages in the LGM sample and its neighbouring Holocene sample, plotted against local estimates of open-ocean sedimentation rates (centimetres per thousand of years). Low similarity means a greater temporal turnover in local assemblage composition. In total there are 150 sedimentation rate estimates; six samples with sedimentation rate higher than 20 cm/ky and compositional similarity above 0.75 are not shown.

Table S2. Historical surface sediments collections

Museum	Expedition	Spatial coverage	Period
Natural History Museum in London	<i>Challenger</i> ¹	Atlantic, Antarctic, South Indian, Pacific	1872–76
Muséum National d'histoire Naturelle in Paris	<i>Travailleur, Talisman</i> ²	Atlantic, Mediterranean	1880–83
Museum für Naturkunde in Berlin	German Deep-Sea ^{3,4} (<i>Valdivia</i>)	Atlantic, Antarctic, Indian, Mediterranean	1898–99

¹ <https://www.hmschallenger.net/>

² <https://gallica.bnf.fr/ark:/12148/bpt6k65190274>

³ Keltie, J. S. (1898). The German deep-sea expedition. *Geograph. J.* 12, 494–496, doi: 10.2307/1774523

⁴ Sandeman, G. (1900). The German deep sea expedition on the ship “Valdivia”. *Scott. Geograph. Mag.* 16, 416–418, doi: 10.1080/00369220008733171

Table S3. Relative abundance of planktonic foraminifera species in the historical samples M.192, M.8780 and M.5246, and their corresponding neighbouring samples in the Holocene and Last Glacial Maximum reference datasets. Species not shown had 0% abundance in all samples. Local sedimentation rate is given by the LGM datasets (see Methods) and expressed in centimetres per thousand of years.

Sample	Historical	Holocene	LGM	Historical	Holocene	LGM	Historical	Holocene	LGM
Sample/core number	M.192	CLIMAP.0078	E45-078	M.8780	BUFD_1027	RC14-009	M.5246	MARGO.2820	RC11-145
Latitude	-50.02	-47.77	-45.04	-40.45	-36.50	-39.02	-26.94	-26.97	-25.48
Longitude	123.07	123.10	114.35	49.82	49.57	47.88	111.18	111.33	110.02
Distance (km)	0	250.11	857.04	0	440.25	229.83	0	15.42	199.38
Sedimentation rate (cm/ky)			1.5			3.4			1.4
Species									
<i>Beella digitata</i>	0	0	0	0	0.48	0	0	0	0
<i>Globigerina bulloides</i>	55.03	60.71	51.67	21.47	7.88	25.58	4.66	8.85	1.81
<i>Globigerina falconensis</i>	0	0	0	2.26	15.75	0.66	3.94	0.66	3.32
<i>Globigerinella calida</i>	0.31	0	0	0.56	4.06	0	2.15	0	0.30
<i>Globigerinella siphonifera</i>	0	0	0	0	3.34	0.33	1.79	5.53	1.21
<i>Globigerinita glutinata</i>	1.57	1.53	3.67	2.82	3.58	1.99	18.64	19.25	18.73
<i>Globigerinoides conglobatus</i>	0	0	0	0	0	0	0.36	0.33	0.60
<i>Globigerinoides ruber white</i>	0	0	0	1.69	7.64	1.00	26.16	28.10	16.92
<i>Globigerinoides tenellus</i>	0	0	0	0	0	0	0	5.20	0.30
<i>Globoconella inflata</i>	30.19	20.66	17.33	32.77	35.56	11.63	3.58	6.19	47.73
<i>Globoquadrina conglomerata</i>	0	0	0	0	0	0	0.72	0	0
<i>Globorotalia crassaformis</i>	0	0	0.33	0	0	0	0.72	0	0.60
<i>Globorotalia hirsuta</i>	0	0	0	0	1.43	0.66	0	1.00	0
<i>Globorotalia menardii</i>	0	0	0	0	0	0	13.26	9.85	0.30
<i>Globorotalia scitula</i>	0	0	0.33	0	0.48	0	0	0	0
<i>Globorotalia truncatulinoides</i>	4.40	6.12	1.33	5.65	2.86	1.66	2.15	1.66	1.51
<i>Globorotalia unguolata</i>	0	0	0	0	0	0	1.08	0	0
<i>Globoturborotalita rubescens</i>	0	0	0	0	0	0.33	0	0.33	0
<i>Neogloboquadrina dutertrei</i>	0	0	0	0	1.19	1.00	12.19	3.87	3.93
<i>Neogloboquadrina incompta</i>	2.52	3.32	4.67	9.60	10.02	40.53	1.43	1.00	0.91
<i>Neogloboquadrina pachyderma</i>	5.97	6.63	14.33	21.47	0.24	5.65	0	0	0
<i>Orbulina universa</i>	0	0.51	0.33	0.56	0.72	0.33	0.36	0.66	0.60
<i>Pulleniatina obliquiloculata</i>	0	0	0	0	0	0	0.72	1.66	0
<i>Trilobatus sacculifer</i>	0	0	0	0	0.48	0	6.09	5.86	0
<i>Turborotalita humilis</i>	0	0	0.33	0	0	0	0	0	0
<i>Turborotalita quinqueloba</i>	0	0	5.67	1.13	0.24	8.64	0	0	0

Table S4. Relative abundance of planktonic foraminifera species in the historical samples M.408, M.3787 and M.4080, and their corresponding neighbouring samples in the Holocene and Last Glacial Maximum reference datasets. Species not shown had 0% abundance in all samples. Local sedimentation rate is given by the LGM datasets (see Methods) and expressed in centimetres per thousand of years.

Sample	Historical	Holocene	LGM	Historical	Holocene	LGM	Historical	Holocene	LGM
Sample/core number	M.408	BUFD_0336	GeoB1417-1	M.3787	CLIMAP_0211	V20-175	M.4080	MARGO_1184	RC13-038
Latitude	-21.25	-24.07	-20.37	-19.57	-20.58	-22.30	-15.65	-15.15	-14.52
Longitude	-14.03	-15.12	-12.71	64.63	63.53	68.00	-179.06	-176.49	177.10
Distance (km)	0	332.71	169.48	0	161.12	463.76	0	281.64	431.21
Sedimentation rate (cm/ky)			NA			1.5			1.9
Species									
<i>Beella digitata</i>	0	2.08	0.38	0.53	0	1.82	0.33	0.10	0.61
<i>Candeina nitida</i>	0	0	0.19	0.27	0.27	0.36	0	0	0
<i>Dentigloborotalia anfracta</i>	0	0	0.32	0	0	0	0	0	0
<i>Globigerina bulloides</i>	1.51	1.33	17.75	0.53	2.73	2.55	1.00	0.50	2.66
<i>Globigerina falconensis</i>	6.42	3.60	2.02	0.53	2.19	0.73	2.00	0.70	1.43
<i>Globigerinella adamsi</i>	0	0	0	0	0	0	0	0.10	0
<i>Globigerinella calida</i>	3.02	2.84	0.78	2.93	1.91	5.84	5.00	4.73	3.89
<i>Globigerinella siphonifera</i>	1.51	5.30	2.48	7.71	2.46	1.82	3.33	4.53	4.09
<i>Globigerinita glutinata</i>	6.79	12.88	8.62	6.38	9.29	18.25	21.00	19.32	31.49
<i>Globigerinoides conglobatus</i>	1.13	0.76	0.89	3.19	0.55	1.82	2.67	5.03	2.45
<i>Globigerinoides ruber pink</i>	4.15	1.33	0.81	0	0	0	0	0	0
<i>Globigerinoides ruber white</i>	31.70	40.15	24.42	52.13	56.56	44.16	43.67	38.23	40.90
<i>Globigerinoides tenellus</i>	7.55	4.55	2.50	2.39	0.55	4.38	6.33	4.02	2.86
<i>Globoconella inflata</i>	11.70	2.08	10.20	0.53	0.82	0.36	0	0	0
<i>Globoquadrina conglomerata</i>	0	0	0	0.27	0	0	0	0	0
<i>Globorotalia crassaformis</i>	0.75	0.38	1.82	0.27	0	0.36	0	0	0.41
<i>Globorotalia hirsuta</i>	0.38	0.57	0	0	0	0.73	0	0	0
<i>Globorotalia menardii</i>	0	2.65	0.04	0.27	0.82	0.73	0	0	0.20
<i>Globorotalia scitula</i>	0.75	1.70	1.81	0.27	1.37	1.09	0	0	0.20
<i>Globorotalia truncatulinoides</i>	4.53	5.49	6.34	0.80	1.37	6.57	0	0.20	0
<i>Globorotalia tumida</i>	0.75	0.38	0.02	0	0.82	0	0	0	1.02
<i>Globorotalia unguolata</i>	0.75	0	0	0.53	0	0	0	0	0
<i>Globorotaloides hexagonus</i>	0	0	0	0.27	0	0	0	0.30	0
<i>Globoturborotalita rubescens</i>	1.13	2.08	4.73	0.53	1.64	3.65	1.33	3.82	1.23
<i>Neogloboquadrina duterrei</i>	0.38	0.19	0.89	2.93	2.73	1.82	1.33	0.10	2.25
<i>Neogloboquadrina incompta</i>	0.38	0	3.97	0	0.82	0	0	0	0.41
<i>Neogloboquadrina pachyderma</i>	0	0	0	0	0.27	0	0	0	0
<i>Orbulina universa</i>	2.26	3.22	0.96	0.80	2.73	1.46	1.33	2.41	2.66
<i>Pulleniatina obliquiloculata</i>	1.13	0	0	1.86	0	0.36	0	0	0.61
<i>Sphaeroidinella dehiscens</i>	0	0	0	0.27	0.27	0.36	0	0	0
<i>Tenutella tota</i>	0	0	0.17	0	0	0	0	0	0
<i>Trilobatus sacculifer</i>	11.32	5.30	7.33	13.83	9.56	0	10.67	11.37	0
<i>Turborotalita humilis</i>	0	0	0.35	0	0	0.36	0	0.20	0
<i>Turborotalita quinqueloba</i>	0	0	0.16	0	0	0.36	0	4.33	0.61

Table S5. Relative abundance of planktonic foraminifera species in the historical samples M.7487, M.284 and M.25, and their corresponding neighbouring samples in the Holocene and Last Glacial Maximum reference datasets. Species not shown had 0% abundance in all samples. Local sedimentation rate is given by the LGM datasets (see Methods) and expressed in centimetres per thousand of years.

Sample	Historical	Holocene	LGM	Historical.1	Holocene.1	LGM.1	Historical.2	Holocene.2	LGM.2
Sample/core number	M.7487	BUFD_1236	V29-048	M.284	BUFD_0402	KH92-1-5a	M.25	ATL947 0944	V23-100
Latitude	-7.59	-6.27	-6.27	-0.70	1.27	3.53	24.33	22.70	21.30
Longitude	61.48	63.43	63.43	147.00	149.20	141.86	-24.47	-25.33	-22.68
Distance (km)	0	261.13	260.62	0	328.48	740.79	0	202.35	384.21
Sedimentation rate (cm/ky)			1.0			NA			NA
Species									
<i>Beella digitata</i>	0	0.26	1.11	0	0.11	0	0	0.50	0
<i>Candeina nitida</i>	0	0	0	0	0.22	0.50	0	0	0
<i>Globigerina bulloides</i>	2.62	5.03	3.33	8.46	4.20	5.50	2.31	2.30	9.64
<i>Globigerina falconensis</i>	0	0	0	3.63	0.82	1.50	0	0	1.79
<i>Globigerinella calida</i>	0	1.32	3.33	3.63	2.78	0	1.15	0.20	0.30
<i>Globigerinella siphonifera</i>	5.25	4.76	5.56	4.23	5.94	18.50	0.77	2.90	3.78
<i>Globigerinita glutinata</i>	25.25	6.61	9.63	19.64	17.18	25.50	0.77	2.90	0
<i>Globigerinoides conglobatus</i>	1.97	3.44	4.07	0.60	1.42	0.50	0.77	1.80	0
<i>Globigerinoides ruber</i>	0	0	0	0	0	0	0	0.50	0
<i>Globigerinoides white</i>	17.38	24.07	22.22	34.74	28.57	31.00	26.15	15.18	7.36
<i>Globigerinoides tenellus</i>	0	0.26	0.74	1.81	1.42	1.50	0	0.20	0.50
<i>Globocanella inflata</i>	0	0	0	0	0	0	13.46	16.28	0.30
<i>Globobulimina conglomerata</i>	0	4.76	0.37	0.30	0.87	0	0	0	0
<i>Globorotalia crassaformis</i>	0	0	0.74	0	0.44	0	1.92	1.80	46.42
<i>Globorotalia hirsuta</i>	0	0	0	0	0.11	0	0	0	0
<i>Globorotalia menardii</i>	9.84	14.02	14.44	0.30	2.24	1.75	8.85	13.59	0
<i>Globorotalia scitula</i>	1.64	0.79	1.48	0	0.22	0	0	0.20	0
<i>Globorotalia theyeri</i>	0.33	0	0	0	0	0	0	0	0
<i>Globorotalia truncatulinoides</i>	0.33	0	0	0	0.49	0	3.85	7.89	1.49
<i>Globorotalia tumida</i>	4.92	1.85	1.48	0.60	1.58	1.75	2.69	4.30	0
<i>Globorotalia unguolata</i>	1.31	0	0	0	0	0	0	0	0
<i>Globorotaloides hexagonus</i>	0	3.44	2.22	0	0.11	0	0	0	0
<i>Globoturborotalita rubescens</i>	1.31	0	0.74	1.21	2.29	0.50	0	0	0
<i>Neoglobobulimina dutertrei</i>	6.89	7.94	17.41	2.72	4.74	3.50	2.69	5.69	0
<i>Neoglobobulimina incompta</i>	10.82	0.26	4.44	3.02	0.27	0	12.69	4.80	1.99
<i>Neoglobobulimina pachyderma</i>	0	0	0	0	0.05	0	0	0	5.07
<i>Orbulina universa</i>	0	0.26	1.11	0	0.11	0	0.38	0.20	3.08
<i>Pulleniatina obliquiloculata</i>	5.25	3.17	5.19	6.65	12.21	4.50	1.92	0.70	13.72
<i>Sphaeroidinella dehiscens</i>	0.33	0.79	0.37	0	0.22	0	0.77	0.90	0
<i>Trilobatus sacculifer</i>	4.26	15.87	0	8.46	10.69	3.50	17.69	17.18	3.28
<i>Turborotalita humilis</i>	0.33	0	0	0	0	0	1.15	0	0.99
<i>Turborotalita quinqueloba</i>	0	0	0	0	0	0	0	0	0.30