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4. Data Report: Stable Isotopes from Site 1143[1]

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INTRODUCTION

Site 1143 is located at 9°21.72′N, 113°17.11′E, at a water depth of 2772 m within a basin on the southern continental margin of the South China Sea. Three holes were cored at the site and combined into a composite (spliced) stratigraphic section that documents complete recovery for the upper 190.85 meters composite depth, the interval of advanced piston coring (Wang, Prell, Blum, et al., 2000; Wang et al., 2001). The early Pliocene to Holocene sediment sequence provided abundant and well-preserved calcareous microfossils and offered an excellent opportunity to establish foraminiferal stable isotope records. Here, we present benthic and planktonic $\delta^{18}O$ and $\delta^{13}C$ records that cover the last 5 m.y. These data sets will provide an important basis for upcoming studies to generate an orbitally tuned oxygen isotope stratigraphy and examine long- and short-term changes in deep and surface water mass signatures (temperature, salinity, and nutrients) with an average sample spacing of ~2.9 k.y. for the benthic and ~2.6 k.y. for the planktonic records.

METHODS

Samples were oven-dried at 60°C and sieve washed. Well-preserved specimens were chosen from the coarse-fraction (>154 µm) residues and cleaned with ethanol (≥99.7%) in an ultrasonic bath. They were dried again in an oven at 60°C and reacted with orthophosphoric acid in an automatic carbonate device (Kiel III) at 70°C to generate CO_2. The escaping CO_2 was then transferred to a Finnigan MAT252 mass spectrometer at the Laboratory of Marine Geology in Tongji University,

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People's Republic of China, for measurement of stable isotopes. Benthic foraminifers *Cibicidoides wuellerstorfi* (diameter = 300–900 µm, 1–3 specimens) or *Uvigerina* spp. (length = 400–900 µm, 1–3 specimens), and planktonic foraminifers *Globigerinoides ruber* (diameter = 300–360 µm, 5–7 specimens) or *Globigerinoides obliquus* (diameter = 200–340 µm, 3–7 specimens) were analyzed. A total of 1896 planktonic samples (Table T1) and 1717 benthic samples (Table T2) were analyzed. Because of isotopic differences between species and according to the adjustment factors proposed by Shackleton et al. (1995), a constant 0.64‰ was added to each $\delta^{18}O$ value of *C. wuellerstorfi* and a constant 0.9‰ was added to each $\delta^{13}C$ value of *Uvigerina* in order to merge the values of the two. No adjustment factors were used for *G. ruber* and *G. obliquus*, as both species display similar isotope values according to the work of Lourens et al. (1996). Precision was regularly checked with the Chinese national carbonate standard GBW04405. Conversion to the international Peedee belemnite (PDB) scale was performed using NBS19 and NBS18 standards: $\delta^{13}C$ = 0.57‰ PDB, $\delta^{18}O$ = –8.49‰ PDB); the standard deviation = 0.07‰ for $\delta^{18}O$ and 0.04‰ for $\delta^{13}C$ during the year 2000.

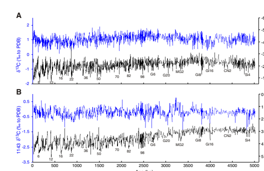
T1. Planktonic oxygen and carbon isotope data, p. 7.

T2. Benthic oxygen and carbon isotope data, p. 8.

RESULTS

Oxygen and carbon isotope ratios were measured on benthic and planktonic foraminifers from a 190-m Pliocene–Pleistocene section of Site 1143 (Fig. F1, F2) at a sampling interval of ~10 cm (Tables T1, T2). This sample spacing corresponds to a temporal resolution of ~2.6 k.y. Based on biostratigraphic events and the comparison of the benthic $\delta^{18}O$ curve with that of a newly compiled 6-m.y. $\delta^{18}O$ curve by Shackleton (Shackleton, unpubl. data at **delphi.esc.cam.ac.uk/coredata/v677846.html**), a total of 191 oxygen marine isotope stages were identified for the last ~5 m.y. (190.77 m) (Tian et al., 2002).

F1. Stable isotope record vs. age, p. 5.



Three major intervals are distinguished in the $\delta^{18}O$ records, as suggested by changing trends in both planktonic and benthic $\delta^{18}O$ curves (Figs. F1, F2): (1) the last 0.9 m.y. shows 100-k.y. cycles and relatively stronger amplitude fluctuations, (2) the interval 3.3–0.9 Ma is characterized by a steplike increase in $\delta^{18}O$ values that is separated by three terraces, and (3) the period 5–3.3 Ma is marked by relatively low amplitude variation and a constant trend. In the second interval, the terrace at 3.1–2.5 Ma has the steepest trend. In the planktonic foraminiferal $\delta^{18}O$ record, the 3.3 to 0.9 Ma interval also shows three terraces. However, the earliest terrace at 3.3–2.5 Ma has a more constant trend than in the benthic record. The record indicates several paleoceanographic events: (1) a general cooling trend; (2) a decline of South China Sea deepwater temperature at 3.1–2.5 Ma, reflecting the increase in Northern Hemisphere glaciation; (3) two increases in surface water temperature at 4.8–4.5 and 4.4–3.5 Ma in the southern part of the South China Sea; and (4) a warm deepwater period at 5–3.3 Ma.

F2. Stable isotope record vs. depth, p. 6.

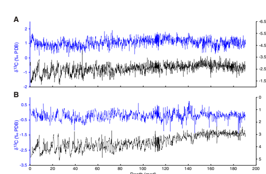


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Figure F1. Stable isotope record from ODP Site 1143 vs. age. Selected marine isotope stages are labeled. PDB = Peedee belemnite. **A.** Planktonic δ^{18}O and δ^{13}C. **B.** Benthic δ^{18}O and δ^{13}C.

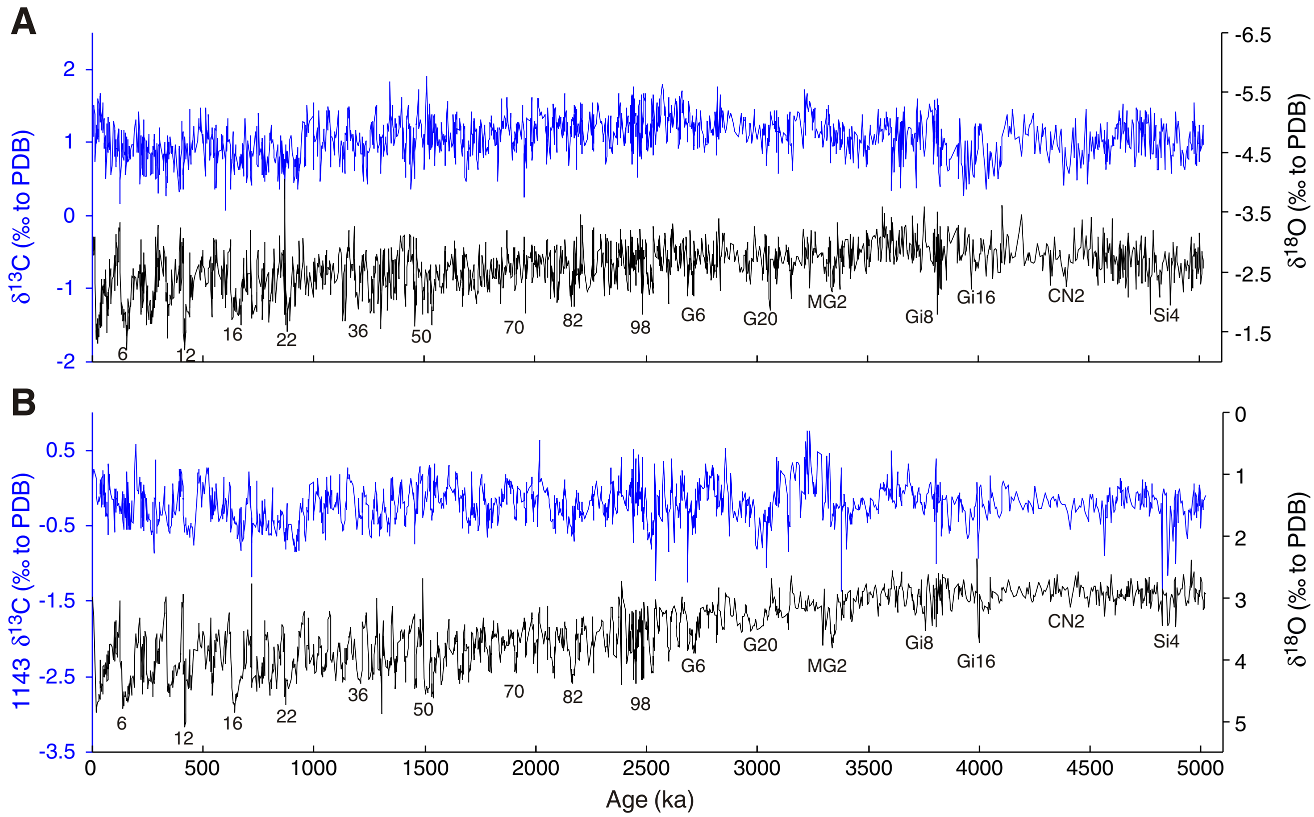

Figure F2. Stable isotope record from ODP Site 1143 vs. depth. PDB = Peedee belemnite. **A.** Planktonic $\delta^{18}O$ and $\delta^{13}C$. **B.** Benthic $\delta^{18}O$ and $\delta^{13}C$.

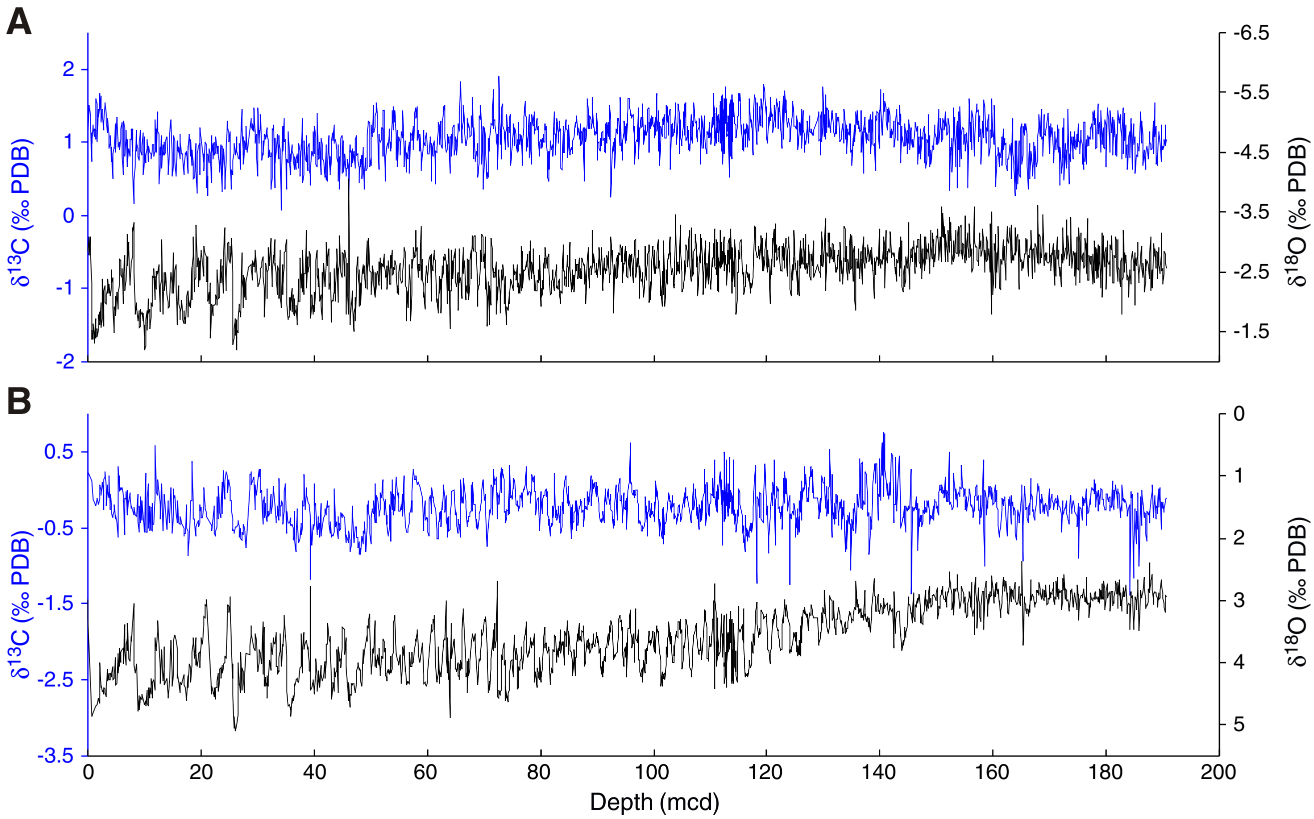

Table T1. Oxygen and carbon isotope data for planktonic foraminifers, Site 1143.

Core, section, interval (cm)	Depth (mbsf)	Depth (mcd)	Age (ka)	Species	δ^{13}C (‰)	δ^{18}O (‰)
184-1143A-						
16H-3, 110–112	140	146.56	3394.12	*G. ruber*	1.146	–2.93
16H-3, 120–122	140.1	146.66	3395.60	*G. ruber*	1.219	–2.904
16H-3, 130–132	140.2	146.76	3402.73	*G. ruber*	0.700	–3.036
16H-3, 140–142	140.3	146.86	3409.87	*G. ruber*	1.084	–3.036
16H-4, 0–2	140.4	146.96	3417.00	*G. ruber*	0.852	–2.683
16H-4, 10–12	140.5	147.06	3418.88	*G. ruber*	0.986	–2.625
16H-4, 20–22	140.6	147.16	3420.76	*G. ruber*	1.186	–2.553
16H-4, 30–32	140.7	147.26	3422.63	*G. ruber*	0.779	–3.145
16H-4, 40–42	140.8	147.36	3424.51	*G. ruber*	0.980	–2.696
16H-4, 50–52	140.9	147.46	3426.39	*G. ruber*	1.083	–2.396
16H-4, 60–62	141	147.56	3428.27	*G. ruber*	1.045	–2.891
16H-4, 70–72	141.1	147.66	3430.14	*G. ruber*	1.129	–2.729
16H-4, 80–82	141.2	147.76	3432.02	*G. ruber*	1.223	–2.6
16H-4, 90–92	141.3	147.86	3433.90	*G. ruber*	0.722	–3.101
16H-4, 100–102	141.4	147.96	3443.45	*G. ruber*	1.143	–2.509
16H-4, 110–112	141.5	148.06	3453.00	*G. ruber*	1.089	–2.689
16H-4, 120–122	141.6	148.16	3457.35	*G. ruber*	0.652	–3.09
16H-4, 130–132	141.7	148.26	3461.69	*G. ruber*	0.763	–2.723
16H-4, 140–142	141.8	148.36	3466.04	*G. ruber*	1.051	–2.898
16H-5, 0–2	141.9	148.46	3470.38	*G. ruber*	0.989	–2.831
16H-5, 10–12	142	148.56	3474.73	*G. ruber*	1.390	–2.905
16H-5, 20–22	142.1	148.66	3480.98	*G. ruber*	0.811	–2.98
16H-5, 30–32	142.2	148.76	3489.12	*G. ruber*	1.091	–2.582
16H-5, 40–42	142.3	148.86	3494.20	*G. ruber*	0.672	–2.476
16H-5, 50–52	142.4	148.96	3496.20	*G. ruber*	0.902	–3.19
16H-5, 60–62	142.5	149.06	3498.20	*G. ruber*	0.707	–2.926
16H-5, 70–72	142.6	149.16	3500.20	*G. ruber*	0.899	–2.716
18H-4, 30–32	159.6	167.12	4078.23	*G. obliquus*	0.752	–2.897
18H-4, 40–42	159.7	167.22	4085.15	*G. obliquus*	1.001	–2.88
18H-4, 50–52	159.8	167.32	4092.08	*G. obliquus*	0.499	–2.492
18H-4, 60–62	159.9	167.42	4099.00	*G. obliquus*	0.854	–2.49
18H-4, 70–72	160	167.52	4100.40	*G. ruber*	0.960	–2.978
18H-4, 80–82	160.1	167.62	4101.80	*G. obliquus*	0.672	–2.918
18H-4, 100–102	160.3	167.82	4104.60	*G. obliquus*	0.759	–2.653
18H-4, 110–112	160.4	167.92	4106.00	*G. obliquus*	1.079	–3.615
18H-4, 120–122	160.5	168.02	4119.50	*G. obliquus*	1.199	–2.623
18H-4, 130–132	160.6	168.12	4133.00	*G. obliquus*	1.385	–3.125
18H-4, 140–142	160.7	168.22	4137.23	*G. obliquus*	1.080	–3.081
18H-5, 0–2	160.81	168.33	4141.87	*G. obliquus*	1.229	–2.658
18H-5, 10–12	160.91	168.43	4146.10	*G. obliquus*	1.116	–2.824
18H-5, 20–22	161.01	168.53	4156.05	*G. ruber*	1.450	–2.736
18H-5, 30–32	161.11	168.63	4166.00	*G. obliquus*	1.044	–2.752
18H-5, 40–42	161.21	168.73	4181.85	*G. ruber*	1.078	–3.153
18H-5, 50–52	161.31	168.83	4197.70	*G. obliquus*	0.803	–3.46
18H-5, 60–62	161.41	168.93	4210.17	*G. obliquus*	1.378	–2.614
18H-5, 70–72	161.51	169.03	4214.74	*G. obliquus*	1.110	–2.6705
18H-5, 80–82	161.61	169.13	4219.30	*G. obliquus*	1.115	–2.734
18H-5, 90–92	161.71	169.23	4223.87	*G. obliquus*	1.096	–2.822
18H-5, 100–102	161.81	169.33	4228.43	*G. obliquus*	1.152	–2.693
18H-5, 110–112	161.91	169.43	4233.00	*G. obliquus*	1.234	–2.823
18H-5, 120–122	162.01	169.53	4237.76	*G. obliquus*	1.260	–2.676
18H-5, 140–142	162.21	169.73	4247.29	*G. obliquus*	1.396	–2.651
18H-6, 0–2	162.33	169.85	4253.00	*G. obliquus*	0.851	–2.677
18H-6, 10–12	162.43	169.95	4269.31	*G. obliquus*	1.217	–2.988
18H-6, 20–22	162.53	170.05	4280.29	*G. obliquus*	0.842	–2.76
18H-6, 30–32	162.63	170.15	4289.00	*G. obliquus*	1.252	–2.79
18H-6, 40–42	162.73	170.25	4294.29	*G. obliquus*	1.070	–2.529
18H-6, 50–52	162.83	170.35	4299.57	*G. obliquus*	1.178	–2.829
18H-6, 60–62	162.93	170.45	4304.86	*G. obliquus*	1.207	–2.791
18H-6, 70–72	163.03	170.55	4310.14	*G. obliquus*	0.895	–2.985
18H-6, 80–82	163.13	170.65	4315.43	*G. obliquus*	0.808	–2.934
18H-6, 90–92	163.23	170.75	4320.36	*G. obliquus*	0.720	–2.75

Notes: *G. ruber* = *Globigerinoides ruber*, *G. obliquus* = *Globigerinoides obliquus*. Only a portion of this table appears here. The complete table is available in **ASCII.**

Table T2. Oxygen and carbon isotope data for benthic foraminifers, Site 1143.

Core, section, interval (cm)	Depth (mbsf)	Depth (mcd)	Age (ka)	Species	$\delta^{13}C$ (‰) (raw)	$\delta^{13}C$ (‰) (adjustment factor)*	$\delta^{18}O$ (‰) (raw)	$\delta^{18}O$ (‰) (adjustment factor)*	$\delta^{13}C$ (‰) (final)	$\delta^{18}O$ (‰) (final)
184-1143A-										
16H-3, 100–102	139.9	146.46	3392.64	*C. wuellerstorfi*	–0.085	0.00	2.467	0.64	–0.085	3.107
16H-3, 110–112	140	146.56	3394.12	*C. wuellerstorfi*	–0.26	0.00	2.409	0.64	–0.26	3.049
16H-3, 120–122	140.1	146.66	3395.60	*C. wuellerstorfi*	–0.18	0.00	2.312	0.64	–0.18	2.952
16H-3, 130–132	140.2	146.76	3402.73	*C. wuellerstorfi*	–0.807	0.00	2.400	0.64	–0.807	3.040
16H-3, 140–142	140.3	146.86	3409.87	*C. wuellerstorfi*	–0.251	0.00	2.288	0.64	–0.251	2.928
16H-4, 0–2	140.4	146.96	3417.00	*C. wuellerstorfi*	–0.481	0.00	2.248	0.64	–0.481	2.888
16H-4, 10–12	140.5	147.06	3418.88	*C. wuellerstorfi*	–0.326	0.00	2.453	0.64	–0.326	3.093
16H-4, 20–22	140.6	147.16	3420.76	*C. wuellerstorfi*	–0.425	0.00	2.713	0.64	–0.425	3.353
16H-4, 30–32	140.7	147.26	3422.63	*C. wuellerstorfi*	–0.394	0.00	2.495	0.64	–0.394	3.135
16H-4, 40–42	140.8	147.36	3424.51	*C. wuellerstorfi*	–0.336	0.00	2.677	0.64	–0.336	3.317
16H-4, 50–52	140.9	147.46	3426.39	*C. wuellerstorfi*	–0.491	0.00	2.720	0.64	–0.491	3.360
16H-4, 60–62	141	147.56	3428.27	*C. wuellerstorfi*	–0.412	0.00	2.742	0.64	–0.412	3.382
16H-4, 70–72	141.1	147.66	3430.14	*C. wuellerstorfi*	–0.263	0.00	2.606	0.64	–0.263	3.246
16H-4, 80–82	141.2	147.76	3432.02	*C. wuellerstorfi*	–0.316	0.00	2.534	0.64	–0.316	3.174
16H-4, 90–92	141.3	147.86	3433.90	*C. wuellerstorfi*	–0.137	0.00	2.360	0.64	–0.137	3.000
16H-4, 100–102	141.4	147.96	3443.45	*C. wuellerstorfi*	–0.271	0.00	2.427	0.64	–0.271	3.067
16H-4, 110–112	141.5	148.06	3453.00	*C. wuellerstorfi*	–0.299	0.00	2.189	0.64	–0.299	2.829
16H-4, 120–122	141.6	148.16	3457.35	*C. wuellerstorfi*	–0.226	0.00	2.405	0.64	–0.226	3.045
16H-4, 130–132	141.7	148.26	3461.69	*C. wuellerstorfi*	–0.299	0.00	2.527	0.64	–0.299	3.167
16H-4, 140–142	141.8	148.36	3466.04	*C. wuellerstorfi*	–0.141	0.00	2.352	0.64	–0.141	2.992
16H-5, 0–2	141.9	148.46	3470.38	*C. wuellerstorfi*	–0.222	0.00	2.486	0.64	–0.222	3.126
16H-5, 10–12	142	148.56	3474.73	*C. wuellerstorfi*	–0.138	0.00	2.255	0.64	–0.138	2.895
16H-5, 20–22	142.1	148.66	3480.98	*C. wuellerstorfi*	–0.143	0.00	2.253	0.64	–0.143	2.893
16H-5, 30–32	142.2	148.76	3489.12	*C. wuellerstorfi*	–0.306	0.00	2.139	0.64	–0.306	2.779
16H-5, 40–42	142.3	148.86	3494.20	*C. wuellerstorfi*	–0.458	0.00	2.397	0.64	–0.458	3.037
16H-5, 50–52	142.4	148.96	3496.20	*C. wuellerstorfi*	–0.331	0.00	2.311	0.64	–0.331	2.951
16H-5, 60–62	142.5	149.06	3498.20	*C. wuellerstorfi*	–0.331	0.00	2.464	0.64	–0.331	3.104
16H-5, 70–72	142.6	149.16	3500.20	*C. wuellerstorfi*	–0.384	0.00	2.430	0.64	–0.384	3.070
18H-4, 30–32	159.6	167.12	4078.23	*C. wuellerstorfi*	–0.26	0.00	2.302	0.64	–0.26	2.942
18H-4, 40–42	159.7	167.22	4085.15	*C. wuellerstorfi*	–0.357	0.00	2.314	0.64	–0.357	2.954
18H-4, 50–52	159.8	167.32	4092.08	*C. wuellerstorfi*	–0.399	0.00	2.460	0.64	–0.399	3.100
18H-4, 60–62	159.9	167.42	4099.00	*C. wuellerstorfi*	–0.353	0.00	2.383	0.64	–0.353	3.023
18H-4, 70–72	160	167.52	4100.40	*C. wuellerstorfi*	–0.302	0.00	2.417	0.64	–0.302	3.057
18H-4, 80–82	160.1	167.62	4101.80	*C. wuellerstorfi*	–0.193	0.00	2.389	0.64	–0.193	3.029
18H-4, 90–92	160.2	167.72	4103.20	*C. wuellerstorfi*	–0.174	0.00	2.201	0.64	–0.174	2.841
18H-4, 100–102	160.3	167.82	4104.60	*C. wuellerstorfi*	0.028	0.00	2.240	0.64	0.028	2.880
18H-4, 110–112	160.4	167.92	4106.00	*C. wuellerstorfi*	0.086	0.00	2.185	0.64	0.086	2.825
18H-4, 120–122	160.5	168.02	4119.50	*C. wuellerstorfi*	–0.018	0.00	2.285	0.64	–0.018	2.925
18H-4, 130–132	160.6	168.12	4133.00	*C. wuellerstorfi*	0.045	0.00	2.071	0.64	0.045	2.711
18H-4, 140–142	160.7	168.22	4137.23	*C. wuellerstorfi*	–0.309	0.00	2.163	0.64	–0.309	2.803
18H-5, 0–2	160.81	168.33	4141.87	*C. wuellerstorfi*	–0.185	0.00	2.251	0.64	–0.185	2.891
18H-5, 10–12	160.91	168.43	4146.10	*C. wuellerstorfi*	–0.124	0.00	2.240	0.64	–0.124	2.880
18H-5, 20–22	161.01	168.53	4156.05	*C. wuellerstorfi*	–0.171	0.00	2.342	0.64	–0.171	2.982
18H-5, 30–32	161.11	168.63	4166.00	*C. wuellerstorfi*	–0.051	0.00	2.314	0.64	–0.051	2.954
18H-5, 40–42	161.21	168.73	4181.85	*C. wuellerstorfi*	–0.167	0.00	2.183	0.64	–0.167	2.823
18H-5, 50–52	161.31	168.83	4197.70	*C. wuellerstorfi*	–0.29	0.00	2.326	0.64	–0.29	2.966
18H-5, 60–62	161.41	168.93	4210.17	*C. wuellerstorfi*	–0.199	0.00	2.356	0.64	–0.199	2.996
18H-5, 70–72	161.51	169.03	4214.74	*C. wuellerstorfi*	–0.203	0.00	2.192	0.64	–0.203	2.832
18H-5, 80–82	161.61	169.13	4219.30	*C. wuellerstorfi*	–0.322	0.00	2.291	0.64	–0.322	2.931
18H-5, 90–92	161.71	169.23	4223.87	*C. wuellerstorfi*	–0.175	0.00	2.307	0.64	–0.175	2.947
18H-5, 100–102	161.81	169.33	4228.43	*C. wuellerstorfi*	–0.188	0.00	2.113	0.64	–0.188	2.753
18H-5, 110–112	161.91	169.43	4233.00	*C. wuellerstorfi*	–0.217	0.00	2.367	0.64	–0.217	3.007
18H-5, 120–122	162.01	169.53	4237.76	*C. wuellerstorfi*	–0.26	0.00	2.435	0.64	–0.26	3.075
18H-5, 130–132	162.11	169.63	4242.52	*C. wuellerstorfi*	–0.348	0.00	2.410	0.64	–0.348	3.050
18H-5, 140–142	162.21	169.73	4247.29	*C. wuellerstorfi*	–0.217	0.00	2.314	0.64	–0.217	2.954
18H-6, 0–2	162.33	169.85	4253.00	*C. wuellerstorfi*	0.020	0.00	2.353	0.64	0.020	2.993
18H-6, 10–12	162.43	169.95	4269.31	*C. wuellerstorfi*	–0.271	0.00	2.105	0.64	–0.271	2.745
18H-6, 20–22	162.53	170.05	4280.29	*C. wuellerstorfi*	–0.271	0.00	2.208	0.64	–0.271	2.848
18H-6, 30–32	162.63	170.15	4289.00	*C. wuellerstorfi*	–0.205	0.00	2.314	0.64	–0.205	2.954
18H-6, 40–42	162.73	170.25	4294.29	*C. wuellerstorfi*	–0.128	0.00	2.244	0.64	–0.128	2.884
18H-6, 50–52	162.83	170.35	4299.57	*C. wuellerstorfi*	–0.056	0.00	2.263	0.64	–0.056	2.903
18H-6, 60–62	162.93	170.45	4304.86	*C. wuellerstorfi*	–0.138	0.00	2.224	0.64	–0.138	2.864

Notes: *C. wuellerstorfi* = *Cibicidoides wuellerstorfi, U. peregrina* = *Uvigerina peregrina.* $\delta^{13}C$ and $\delta^{18}O$ given in reference to Peedee belemnite standard. * = adjustment factor as per Shackleton et al. (1995). Only a portion of this table appears here. The complete table is available in **ASCII.**