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3. Data Report: Oxygen and Carbon Isotopes from Site 1146, Northern South China Sea[1]

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INTRODUCTION

Ocean Drilling Program Site 1146 was drilled within a small rift basin on the midcontinental slope of the northern South China Sea. It is located at 19°27.4′N, 116°16.37′E, in 2092 m water depth. This site was drilled to recover records of Asian monsoon variability into the middle Miocene with temporal resolution sufficient for orbital-scale analyses. Here we present oxygen and carbon isotopic measurements of planktonic foraminifers (*Globigerinoides ruber*) and benthic foraminifers (*Uvigerina peregrina* and *Cibicides wuellerstorfi*) as well as a preliminary age model for the top 185 meters composite depth (mcd).

METHODS

To achieve a target sample resolution of ~2 k.y., the Site 1146 splice was sampled every 50 cm from 0 to ~57 mcd, followed by every 20 cm from ~58 to ~83 mcd, every 15 cm from ~84 to ~109 mcd, and every 10 cm from ~110 to ~185 mcd. These 10-cm^3 samples were freeze dried, disaggregated, washed in tap water, sieved at 150 µm, dried, and stored in glass vials.

Planktonic Foraminifers

Two separate size fractions of *G. ruber* (white) were selected (212 to 355 µm and >355 µm) in order to have sufficient material for isotopic analysis with replicates where necessary. Isotopic analyses were

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completed on five to twelve individuals (typically eight) in the 212- to 355-µm size range and three to eight individuals (typically four) in the >355-µm size range, depending on availability. For each sample, foraminifers were placed into the bottom of a reaction vial, broken using a glass pestle, and 30 mL of 5% H_2O_2 was added and allowed to react for 1 hr. Then 60 mL of ethanol was added, the sample was sonified for 30 s, and the solution was drawn off using a micropipette. The sample was then dried overnight at 35°C.

A total of 1936 analyses (including duplicate and triplicate analyses) were conducted on 1170 samples; ~30% of the samples have been replicated at least once. Of the 1936 analyses, 601 were on the 212- to 355-µm size fraction and 1335 on the >355-µm size fraction. A total of 58 samples were measured for both the 212- to 355-µm and >355-µm size fractions. Based on the median difference within these 58 paired analyses, we convert data in the 212- to 355-µm size fraction to values consistent with the >355-µm size fraction by adding 0.44‰ to the $\delta^{13}C$ values (making them heavier) and subtracting 0.16‰ from the $\delta^{18}O$ values (making them lighter). All data reported are relative to the >355-µm size fraction (Table **T1;** Fig. **F1**).

Benthic Foraminifers

Two species of benthic foraminifers were picked in the >150-µm size fraction (*C. wuellerstorfi* and *U. peregrina*) in order to have sufficient material for isotopic analysis with replicates where necessary. Isotopic analyses were completed on one to three individuals depending on availability. For each sample, foraminifers were placed into the bottom of a reaction vial, broken using a glass pestle, and 30 µL 5% H_2O_2 was added and allowed to react for 1 hr. Then 60 µL ethanol was added, the sample was sonified for 30 s, and the solution was drawn off using a micropipette. The sample was then dried overnight at 35°C.

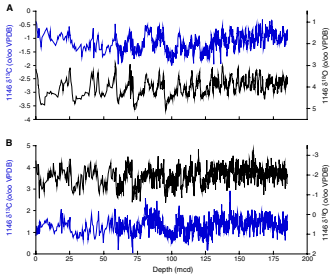
A total of 1224 analyses (including duplicate and triplicate analyses) were conducted on 1045 samples; ~15% of the samples have been replicated at least once. Of the 1224 analyses, 307 were on *C. wuellerstorfi* and 917 on *U. peregrina*. A total of 135 samples were measured for both species. Based on the median difference between these 135 paired analyses, we convert *C. wuellerstorfi* to values consistent with *U. peregrina* by subtracting 0.74‰ from the $\delta^{13}C$ values (making them lighter) and adding 0.64‰ to the $\delta^{18}O$ values (making them heavier). All data reported are relative to *U. peregrina* (Table **T2;** Fig. **F1**).

Isotope Analyses

Samples were run in batches of ~40 on a Finnigan MAT 252 equipped with a carbonate (Kiel) III autosampler that reacts samples in individual reaction vessels at 70°C using H_3PO_4. External reproducibility based on repeated analysis of National Institute of Standards and Technology isotopic reference material NBS-19 (N = 10), Carrara marble (N = 242), and Brown Yule marble (BYM; N = 129) is ±0.02‰ and ±0.06‰ for $\delta^{13}C$ and $\delta^{18}O$, respectively (1 σ). External reproducibility based on replicate analysis of planktonic foraminifer samples is ±0.12‰ and ±0.10‰ for $\delta^{13}C$ and $\delta^{18}O$, respectively (average half-range, N = 32). External reproducibility based on replicate analysis of benthic foraminifer samples is ±0.08‰ and ±0.05‰ for $\delta^{13}C$ and $\delta^{18}O$, respectively (average half-range, N = 26). The Carrara and BYM in-house standards have been cal-

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

F1. Carbon and oxygen isotopic data, p. 5.



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

ibrated to NBS-19 for conversion to the Vienna Peedee belemnite (VPDB) scale. All data reported here are relative to VPDB.

AGE MODEL

A preliminary isotopic age model is presented in Tables T1 and T2. This age model is based on tuning the 41-k.y. (obliquity) component of $\delta^{18}O$ (ice minima) to obliquity maxima and the 23-k.y. (precession) component of $\delta^{18}O$ (ice minima) to precession minima employing the SPECMAP-defined lag of –69° and –78° for obliquity and precession, respectively (Imbrie et al., 1984), and the Laskar (1993) orbital solution.

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Laskar, J., Joutel, F., and Boudin, F., 1993. Orbital, precessional, and insolation quantities for the Earth from –20 Myr to +10 Myr. *Astron. Astrophys.,* 270:522–533.

Figure F1. Carbon and oxygen isotopic data for ODP Site 1146 composite section. Data are reported in per mil (‰) relative to Vienna Peedee belemnite (VPDB). Selected marine isotope stages are labeled. **A.** Benthic $\delta^{18}O$ and $\delta^{13}C$ plotted on the meters composite depth (mcd) scale. **B.** Planktonic $\delta^{18}O$ and $\delta^{13}C$ plotted on the mcd scale. (Continued on next page.)

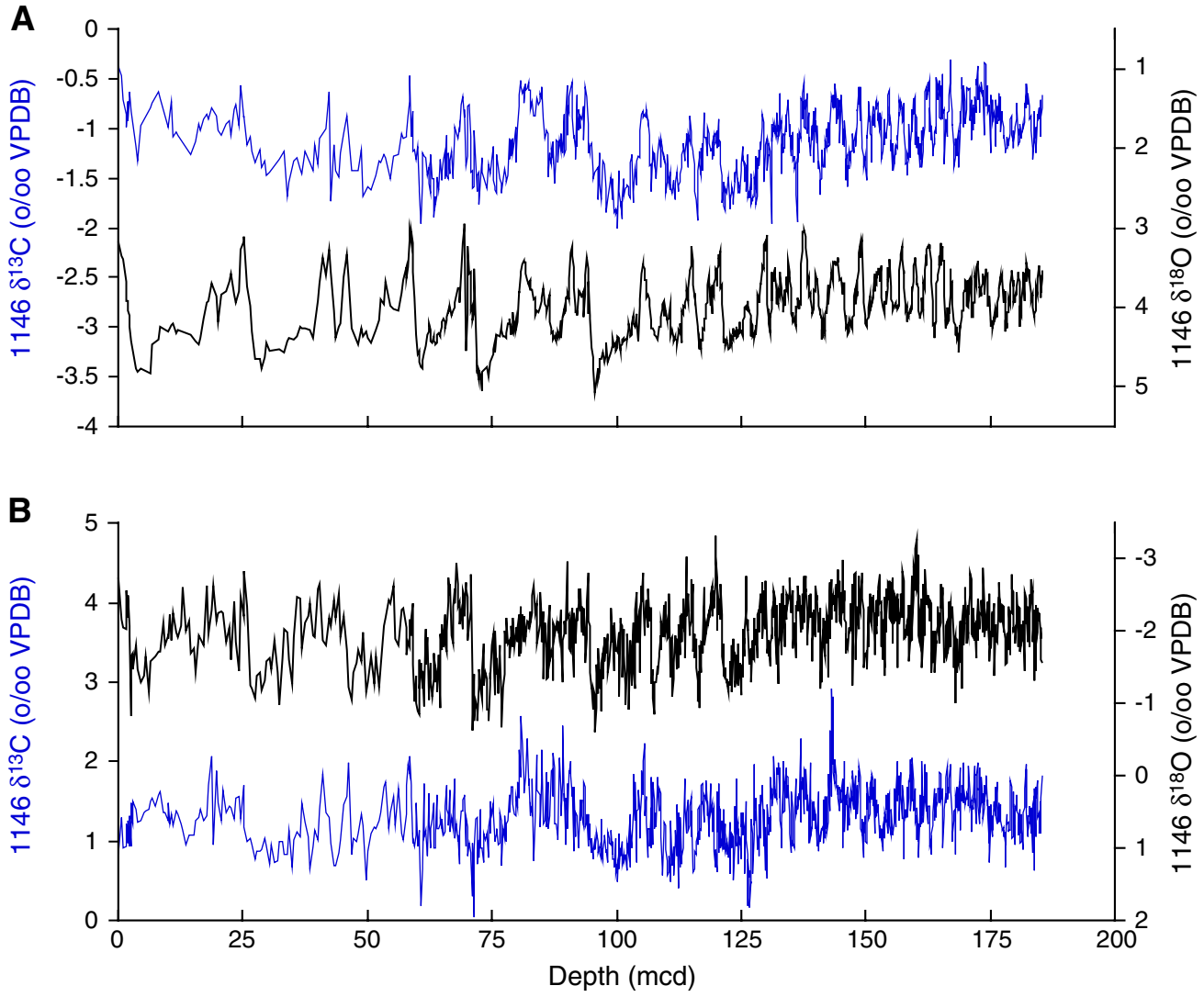

Figure F1 (continued). **C.** Benthic $\delta^{18}O$ and $\delta^{13}C$ plotted as a function of age. **D.** Planktonic $\delta^{18}O$ and $\delta^{13}C$ plotted as a function of age.

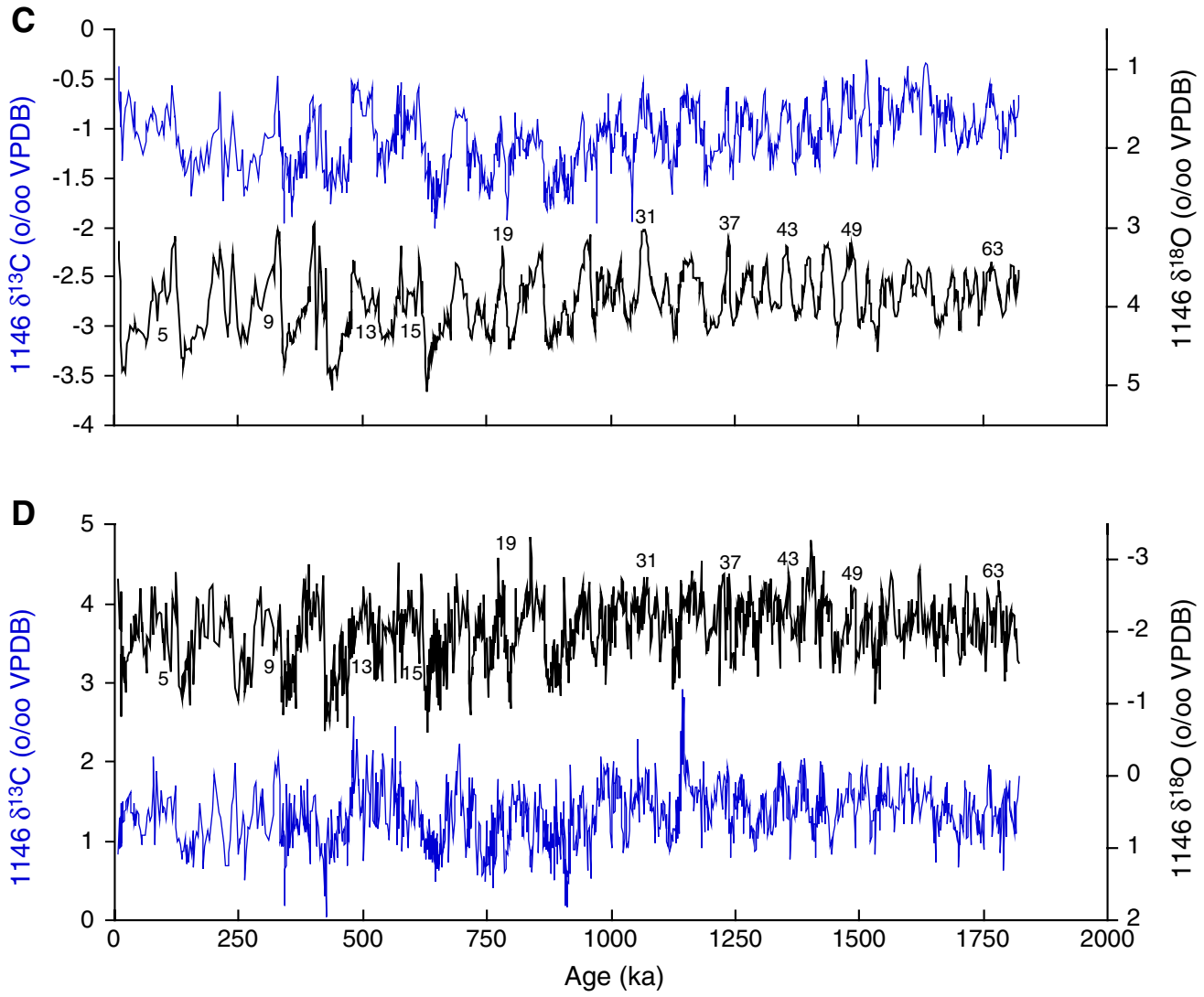

Table T1. Planktonic carbon and oxygen isotope data.

Core, section	Depth in section (cm)	Depth (mbsf)	Depth (mcd)	Age (ka)	$\delta^{13}C$ (‰ VPDB)	$\delta^{18}O$ (‰ VPDB)
184-1146B-						
1H-1	3.50	0.035	0.035	8.08	0.83	–2.74
1H-1	53.50	0.535	0.535	9.16	1.29	–2.16
1H-1	103.50	1.035	1.035	10.24	0.91	–2.06
1H-2	4.50	1.545	1.545	11.35	0.94	–2.02
1H-2	17.00	1.670	1.670	11.62	1.21	–2.56
1H-2	32.00	1.820	1.820	11.94	0.97	–2.20
1H-2	54.50	2.045	2.045	12.43	1.25	–2.49
1H-2	62.00	2.120	2.120	12.59	0.93	–2.08
1H-2	78.00	2.280	2.280	12.94	1.33	–1.95
1H-2	103.50	2.535	2.535	13.49	0.93	–0.83
1H-2	113.00	2.630	2.630	13.70	1.48	–1.49
1H-2	115.00	2.650	2.650	13.74	1.31	–1.65
1H-2	147.00	2.970	2.970	14.44	1.22	–1.70
1H-3	3.50	3.035	3.035	14.58	1.50	–1.47
1H-3	54.50	3.545	3.545	15.68	1.40	–1.80
1H-3	103.50	4.035	4.035	16.74	1.25	–1.48
1H-4	4.50	4.545	4.545	17.85	1.26	–1.30
1H-4	54.50	5.045	5.045	18.93	1.36	–1.39
1H-4	104.50	5.545	5.545	20.01	1.38	–1.64
1H-5	4.50	6.045	6.045	21.20	1.40	–1.17
184-1146C-						
1H-4	103.50	6.535	6.435	22.90	1.51	–1.59
1H-5	4.50	7.045	6.945	25.12	1.53	–1.60
1H-5	53.50	7.535	7.435	27.26	1.43	–1.65
1H-5	103.50	8.035	7.935	29.44	1.58	–1.71
1H-6	4.50	8.545	8.445	31.66	1.63	–1.71
1H-6	53.50	9.035	8.935	33.80	1.35	–2.13
1H-6	103.50	9.535	9.435	35.98	1.36	–1.82
1H-7	4.50	10.045	9.945	38.20	1.26	–1.95
184-1146B-						
2H-2	4.50	8.845	10.095	38.86	1.47	–1.89
184-1146C-						
1H-7	43.50	10.435	10.335	39.90	1.22	–2.24
184-1146B-						
2H-2	53.50	9.335	10.585	40.99	1.34	–1.87
2H-2	103.50	9.835	11.085	43.17	1.19	–2.25
2H-3	3.50	10.335	11.585	45.35	1.38	–1.99
2H-3	53.50	10.835	12.085	47.54	1.34	–1.92
2H-3	103.50	11.335	12.585	49.72	1.22	–2.08
2H-4	3.50	11.835	13.085	51.90	1.14	–2.62
2H-4	53.50	12.335	13.585	54.08	0.96	–2.00
2H-4	103.50	12.835	14.085	56.26	1.08	–2.14
2H-5	3.50	13.335	14.585	58.44	1.07	–1.69
2H-5	53.50	13.835	15.085	60.62	1.07	–1.77
184-1146C-						
2H-4	3.50	15.035	15.635	63.02	1.25	–1.43
2H-4	53.50	15.535	16.135	65.24	1.31	–1.95
2H-4	103.50	16.035	16.635	67.92	1.40	–1.90
2H-5	3.50	16.535	17.135	70.59	1.26	–1.81
2H-5	53.50	17.035	17.635	73.27	1.32	–2.64
2H-5	103.50	17.535	18.135	75.95	1.70	–1.97
2H-6	4.50	18.045	18.645	78.68	2.07	–2.29
2H-6	53.50	18.535	19.135	81.30	0.96	–2.63
2H-6	103.50	19.035	19.635	83.98	1.88	–2.14
2H-7	4.50	19.545	20.145	86.71	1.49	–2.26

Notes: VPDB = Vienna Peedee belemnite. Only a portion of this table appears here. The complete table is available in **ASCII**.

Table T2. Benthic carbon and oxygen isotope data.

Core, section	Depth in section (cm)	Depth (mbsf)	Depth (mcd)	Age (ka)	$\delta^{13}C$ (‰ VPDB)	$\delta^{18}O$ (‰ VPDB)
184-1146B-						
1H-1	4.50	0.045	0.045	8.11	–0.37	3.17
1H-1	53.50	0.535	0.535	9.17	–0.46	3.36
1H-1	103.50	1.035	1.035	10.25	–0.72	3.39
1H-2	4.50	1.545	1.545	11.36	–0.86	3.67
1H-2	17.00	1.670	1.670	11.62	–0.99	3.92
1H-2	34.00	1.840	1.840	11.99	–0.73	3.92
1H-2	54.50	2.045	2.045	12.44	–0.92	4.04
1H-2	62.00	2.120	2.120	12.59	–0.69	4.10
1H-2	78.00	2.280	2.280	12.94	–0.63	4.25
1H-2	115.00	2.650	2.650	13.74	–0.82	4.42
1H-3	54.50	3.545	3.545	15.69	–1.18	4.77
1H-3	103.50	4.035	4.035	16.75	–1.33	4.82
1H-4	4.50	4.545	4.545	17.86	–0.97	4.77
184-1146C-						
1H-4	103.50	6.535	6.435	22.92	–0.80	4.83
1H-5	4.50	7.045	6.945	25.14	–0.74	4.47
1H-5	103.00	8.030	7.930	29.42	–0.63	4.41
1H-6	4.50	8.545	8.445	31.68	–0.69	4.25
184-1146B-						
2H-2	4.50	8.845	10.095	38.88	–0.98	4.31
2H-2	53.50	9.335	10.585	41.02	–0.72	4.23
2H-2	103.50	9.835	11.085	43.20	–1.08	4.21
2H-3	3.50	10.335	11.585	45.38	–1.03	4.33
2H-3	53.50	10.835	12.085	47.56	–1.07	4.28
2H-5	3.50	13.335	14.585	58.46	–1.26	4.36
184-1146C-						
2H-4	3.50	15.035	15.635	63.04	–1.13	4.42
2H-4	53.50	15.535	16.135	65.27	–0.95	4.47
2H-4	103.50	16.035	16.635	67.94	–1.03	4.38
2H-5	3.50	16.535	17.135	70.62	–0.91	4.14
2H-5	53.50	17.035	17.635	73.30	–0.86	3.94
2H-5	103.50	17.535	18.135	75.97	–0.90	3.91
2H-6	4.50	18.045	18.645	78.70	–0.79	3.69
2H-6	103.50	19.035	19.635	84.00	–0.86	3.87
2H-7	4.50	19.545	20.145	86.73	–1.02	4.19
184-1146B-						
3H-2	4.50	18.345	20.645	89.62	–1.06	3.84
3H-2	103.50	19.335	21.635	95.40	–0.96	3.80
3H-3	4.50	19.845	22.145	98.37	–0.92	3.68
3H-3	53.50	20.335	22.635	101.23	–1.07	3.57
3H-3	103.50	20.835	23.135	104.14	–0.80	3.84
3H-4	3.50	21.335	23.635	107.10	–0.76	3.94
3H-4	53.50	21.835	24.135	111.97	–0.97	3.79
3H-4	103.50	22.335	24.635	116.84	–0.57	3.26
3H-5	3.50	22.835	25.135	121.71	–0.88	3.18
184-1146C-						
3H-4	3.50	24.535	25.335	123.00	–0.87	3.10
3H-4	53.50	25.035	25.835	125.92	–1.17	3.73
3H-4	103.50	25.535	26.335	128.85	–1.09	3.98
3H-5	3.50	26.035	26.835	131.78	–1.22	4.30
3H-5	53.50	26.535	27.335	134.71	–1.34	4.66
3H-6	3.50	27.535	28.335	138.06	–1.22	4.64
3H-6	53.50	28.035	28.835	139.67	–1.40	4.77

Notes: VPDB = Vienna Peedee belemnite. Only a portion of this table appears here. The complete table is available in **ASCII**.