

18. DATA REPORT: OXYGEN ISOTOPIC RECORD OF THE LAST 0.8 M.Y. AT THE BLAKE RIDGE, SITE 994C¹

Tadamichi Oba,² Akiko Shikama,² and Hisatake Okada³

INTRODUCTION

The purpose of this study is to establish the oxygen isotopic stratigraphy of the last 0.8 m.y. at Hole 994C, drilled during Ocean Drilling Program (ODP) Leg 164. Hole 994C (31°47.1'N, 75°32.8'W) is on the Blake Ridge off the coast of the southeast United States, at a water depth of 2799 m. The sediments from Hole 994C consist of light pale brown calcareous nannofossil clay containing relatively abundant and well-preserved foraminifers. Because the sediment on the Blake Ridge is composed of contourites derived from north by the Western Boundary Undercurrent beneath the Gulf Stream, the oxygen isotopic record is expected to be a mixture of the indigenous and reworked components. However, normal oxygen isotopic curves since the last 20 k.y. have already been reported from the Blake Ridge (Keigwin and Jones, 1989; Haskell et al., 1991). The oxygen isotopic data obtained through this study is also correlatable to the standard oxygen isotopic stratigraphy, although some abnormality exists in certain intervals.

METHODS

Samples for the oxygen isotopic analysis were collected from the top 42 mbsf of Hole 994C at 10-cm intervals using a 2-cm³ plastic tube. The samples were desegregated in an ultrasonic bath and washed through a 63- μ m sieve. More than 25 specimens of *Globigerinoides sacculifer* and *Globigerinoides ruber* larger than 250 μ m size (mostly between 250 and 425 μ m for *G. sacculifer* and between 250 and 355 μ m for *G. ruber*) were hand picked for the isotopic analyses. The foraminiferal samples were reacted with 100% H₃PO₄ at 60.0°C, and the oxygen isotopic ratio of the evolved gas was measured with a Finnigan MAT 251 mass spectrometer. The isotopic values are expressed in per million differences from the Pee Dee belemnite (PDB) standard. The precision of the oxygen isotopic measurement is better than $\pm 0.04\%$.

RESULTS

The oxygen isotopic record from Hole 994C is shown in Tables 1 and 2 and Figure 1. The $\delta^{18}\text{O}$ values of both species, *G. sacculifer* and *G. ruber*, mostly fluctuate between +0.5‰ and -1.7‰ (Fig. 1). This range is nearly same as, or slightly smaller than, those of previous reports (Keigwin and Jones, 1989; Haskell et al., 1991). The mean $\delta^{18}\text{O}$ value of *G. ruber* is about 0.2‰ lighter than that of *G. sacculifer*, because the former species lives in slightly shallower water depths than the latter species (Hemleben et al., 1989, fig. 10.6). In Figure 1, the average $\delta^{18}\text{O}$ values between *G. sacculifer* and *G. ruber* are connect-

ed with a solid line, except at a few levels where $\delta^{18}\text{O}$ values of only one species were measured. When the $\delta^{18}\text{O}$ curve of Hole 994C is compared with that of ODP Site 659, which is located in the eastern equatorial Atlantic, each of the oxygen isotopic peaks from Stage 1 to Stage 21 can be tentatively correlated between the two sites (Fig. 1). On the other hand, biostratigraphic events in Hole 994C are found between 8.05 and 9.05 mbsf for the first appearance of *Emiliania huxleyi* at 0.26 Ma and between 19.0 and 20.0 mbsf for the last occurrence of *Pseudoemiliania lacunosa* at 0.46 Ma. The paleomagnetic Brunhes/Matuyama boundary is determined to be at 37.8 mbsf in Hole 994C. These events are consistent with the $\delta^{18}\text{O}$ correlation between Hole 994C and Site 659 as shown in Figure 1. The correlation indicates that sedimentation rates at Hole 994C varied through time. For example, the sedimentation was very slow and/or temporarily ceased during oxygen isotopic Stages 5₁-5₄, 6, 13-15, and 20, whereas the rate was high in Stages 1-2, 10-11, 12-13, and 15-16. Furthermore, it is very difficult to find out any relationship between the sedimentation rate and glacial-interglacial climatic change (Fig. 1). Such a high variation in sedimentation rates is most likely due to the mixture of reworked foraminifer specimens transported by the contour current. Nevertheless, the oxygen isotopic curve contains all the stages from Stages 1 to 21, and coccolith events, as well as the Brunhes/Matuyama boundary, are also consistent with the oxygen isotopic stratigraphy. This suggests that the pelagic sediments from Hole 994C, including at least these two species, continuously accumulated during each time period without redeposition of old sediments, which can be used to construct a valid chronostratigraphy for this area.

ACKNOWLEDGMENTS

We thank R. Tiedemann, GEOMAR, Germany, for providing us with the oxygen isotope data of ODP Site 659. We are also grateful to R. Matsumoto, Tokyo University, Japan for helping us to obtain additional samples.

REFERENCES

- Haskell, B.J., Johnson, T.C., and Showers, W.J., 1991. Fluctuations in deep western North Atlantic circulation on the Blake Outer Ridge during the last deglaciation. *Paleoceanography*, 6:21-31.
Hemleben, C., Spindler, M., and Anderson, O.R., 1989. *Modern Planktonic Foraminifera*: Berlin (Springer-Verlag).
Keigwin, L.D., and Jones, G.A., 1989. Glacial-Holocene stratigraphy, chronology, and paleoceanographic observations on some North Atlantic sediment drifts. *Deep-Sea Res.*, 36:845-867.
Tiedemann, R., Sarnthein, M., and Shackleton, N.J., 1994. Astronomic timescale for the Pliocene Atlantic $\delta^{18}\text{O}$ and dust flux records of Ocean Drilling Program Site 659. *Paleoceanography*, 9:619-638.

¹Paull, C.K., Matsumoto, R., Wallace, P.J., and Dillon, W.P. (Eds.), 2000. *Proc. ODP, Sci. Results*, 164: College Station, TX (Ocean Drilling Program).

²Graduate School of Environmental Earth Science, Hokkaido University, N10 W5, Kita-ku, Sapporo 060-0810, Japan. Correspondence author: Oba-tad@ees.hokudai.ac.jp

³Graduate School of Science, Hokkaido University, N10 W8, Kita-ku, Sapporo 060-0810, Japan.

Date of initial receipt: 23 April 1998

Date of acceptance: 10 March 1999

Ms 164SR-230

Table 1. Oxygen isotopic values measured for the upper 42 mbsf sequence in Hole 994C for *G. ruber*.

Depth (mbsf)	<i>G. ruber</i> ¹⁸ O vs. PDB	Depth (mbsf)	<i>G. ruber</i> ¹⁸ O vs. PDB
0.14	-1.11	18.38	-1.79
0.54	-0.95	20.21	-1.32
0.85	-1.20	20.77	-0.91
0.94	-3.12	21.23	-0.85
1.05	-0.94	21.74	-0.65
1.35	-0.96	21.89	-0.08
1.54	-0.50	22.15	-0.12
1.75	-0.31	22.53	-0.31
1.94	-0.46	22.71	-0.68
2.15	0.11	23.01	0.06
2.35	-0.40	23.45	-0.83
2.55	-0.57	23.85	-0.80
2.85	-0.56	24.25	-0.70
3.14	-0.73	24.65	-1.13
3.55	-0.60	24.85	-1.53
3.65	-0.80	25.05	-0.64
3.94	-0.54	25.25	-1.04
4.14	-0.35	25.45	-1.10
4.22	-1.68	25.65	-0.29
4.55	-0.82	25.85	-0.21
4.65	-1.62	26.25	0.40
4.74	-0.68	26.55	0.07
5.04	-0.78	26.65	-0.15
5.14	-0.38	26.75	-0.43
5.23	-0.32	26.85	0.32
5.43	-0.32	27.05	-0.48
5.63	-1.98	27.35	-0.47
5.82	-0.70	27.65	-0.61
6.12	-0.66	28.05	-1.18
6.41	-0.33	28.35	-1.44
6.61	-0.76	28.75	-1.18
7.00	-0.26	29.75	-1.01
7.10	-0.39	30.15	-0.89
7.39	0.03	30.59	-0.78
7.59	-0.49	30.79	-0.53
7.78	-0.40	31.15	-0.93
7.98	-0.65	31.65	-0.97
8.17	0.16	32.05	-1.07
8.37	-0.42	32.35	-0.96
8.66	-0.79	32.65	-0.67
9.06	-0.81	32.94	-0.95
9.35	-0.82	33.13	-1.09
9.65	-1.21	33.33	-1.34
9.84	-1.48	33.72	-0.75
9.94	-1.45	34.72	0.28
10.04	-0.70	35.07	-0.19
10.16	-0.06	36.14	0.39
10.43	-0.16	36.43	0.04
10.85	-0.03	36.63	-0.29
10.92	-0.05	37.02	0.02
11.24	-0.52	37.21	-0.68
11.31	-0.48	37.63	-0.53
11.70	-1.24	38.57	-1.05
11.90	-1.30	39.15	-0.70
12.10	-1.20	39.35	-0.50
12.29	-0.99	39.64	-0.49
13.47	0.04	39.83	-2.18
13.94	-0.50	40.03	-1.42
14.14	-0.57	40.22	-1.60
14.35	0.10	40.41	-1.45
14.73	-1.35	40.71	-2.24
15.11	-0.77	40.80	-1.50
15.81	-1.26	41.02	-1.04
16.44	-0.84	41.29	-0.78
16.85	-1.19	41.77	-0.87
17.20	-0.65	42.16	-0.63
17.56	-1.26		

Table 2. Oxygen isotopic values measured for the upper 42 mbsf sequence in Hole 994C for *G. sacculifer*.

Depth (mbsf)	<i>G. sacculifer</i> ¹⁸ O vs. PDB	Depth (mbsf)	<i>G. sacculifer</i> ¹⁸ O vs. PDB
0.14	-1.32	20.77	-0.24
0.54	-1.08	21.23	-0.59
0.85	-0.77	21.74	-0.46
0.94	-0.87	21.89	-0.03
1.05	-0.67	22.53	-0.21
1.35	-0.01	22.81	-0.33
1.54	-0.72	23.01	0.03
2.15	-0.04	23.45	-0.66
2.55	0.06	23.85	-0.67
4.14	-0.07	24.25	-0.90
4.22	-0.36	24.45	-0.89
4.55	-1.01	24.65	-1.26
4.65	-1.46	24.85	-1.38
4.74	-0.44	25.05	-0.78
5.04	-0.38	25.45	-0.52
5.14	-0.19	25.65	-0.21
5.23	0.05	25.85	-0.14
5.43	-0.13	26.25	0.64
5.63	-1.01	26.55	0.28
5.82	-0.46	26.65	0.22
6.12	-1.39	26.85	0.35
6.21	-1.05	27.05	0.11
6.41	-0.27	27.35	0.06
6.61	-0.94	27.65	0.13
7.00	-0.54	27.95	-0.98
7.10	-0.58	28.05	-1.00
7.39	0.29	28.35	-0.73
7.59	0.18	29.15	-0.77
7.78	-0.68	30.15	-0.57
7.98	-0.28	30.59	-0.25
8.17	0.21	30.79	-0.76
8.37	-0.05	32.05	-0.54
8.66	-0.89	32.35	-0.44
9.06	-0.74	32.65	-0.62
9.35	-0.88	32.94	-0.67
9.65	-0.99	33.13	-0.94
9.84	-1.20	33.33	-1.16
9.94	-0.75	33.72	-0.99
10.04	-0.14	36.63	-0.17
10.43	0.20	37.02	0.18
10.92	-0.05	37.21	-0.33
11.31	-0.45	37.63	-0.49
11.70	-0.93	37.99	-0.88
11.90	-1.42	38.18	-0.35
12.10	-1.08	38.89	0
12.29	-1.00	39.15	-0.70
12.78	-0.64	39.35	-0.38
13.27	-0.56	39.64	-0.81
13.47	0.10	39.83	-1.24
13.94	-0.60	40.03	-1.12
14.14	-0.19	40.22	-1.63
14.35	-0.19	40.41	-1.29
14.73	-0.93	40.71	-0.86
15.81	-0.85	40.80	-0.85
17.20	-0.42	41.02	-0.79
19.24	-0.56	41.29	-0.96
19.70	-0.98	41.77	-0.98
20.36	-0.41	42.16	-0.78

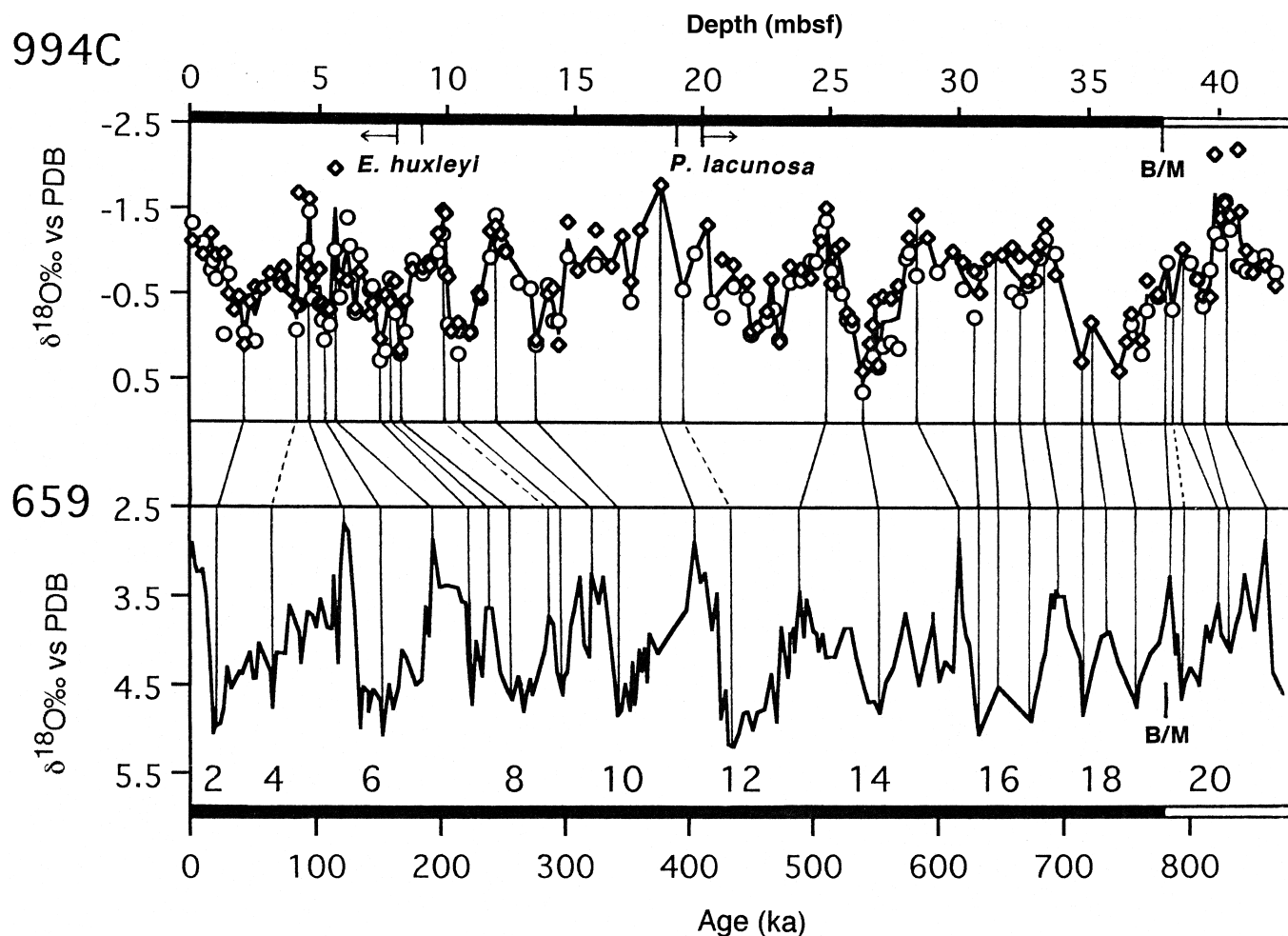


Figure 1. Oxygen isotopic curve from Hole 994C and the tentative correlation with the isotopic stratigraphy in Hole 659 (Tiedemann et al., 1994). The solid line of Hole 994C is connected to the mean $\delta^{18}\text{O}$ values of *G. sacculifer* (open circle) and *G. ruber* (open diamond), except in two short intervals (17.56–20.36 mbsf and 34.72–36.43 mbsf) where only one type of data were measurable because of the paucity of the taxa involved. The first appearance of *Emiliania huxleyi*, last occurrence of *Pseudoemiliania lacunosa*, and the Brunhes/Matuyama boundary (B/M) are also shown here. The numbers in the lower part of the figure indicate oxygen isotopic stages. The dashed line correlating between the records of Hole 994C and Hole 659 indicates less reliable correlation.