Wefer, G., Berger, W.H., and Richter, C. (Eds.)
Proceedings of the Ocean Drilling Program, Scientific Results Volume 175

2. Data Report: Carbonate and Organic Carbon Contents of Sediments from Site 1087, Southern Cape Basin[1]

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INTRODUCTION

Site 1087 is located on the continental rise of southwest Africa at a water depth of 1371 m in the southern part of the Cape Basin. The site is part of the suite of Africa margin locations drilled during Leg 175 to reconstruct the onset and evolution of the elevated biological productivity associated with the Benguela Current upwelling system. Measurements of the amounts of inorganic and organic carbon that have accumulated in sediment under this major coastal upwelling regime are essential to this reconstruction, and these were routinely done for the first 12 sites occupied during Leg 175. However, determinations of calcium carbonate and organic carbon concentrations in sediments from Site 1087 had to be deferred to postcruise analysis because the *JOIDES Resolution* (JR) entered Cape Town 1 day after completing this site.

Sediment samples were collected at intervals of three per core from Hole 1087A and the lower part of Hole 1087C to provide a survey of the histories of post-Eocene accumulation of calcium carbonate and organic carbon at this site. The samples were freeze-dried on the ship in preparation for subsequent shore-based analysis. Concentrations of calcium carbonate and organic carbon in the sediment samples were measured at the University of Michigan after the cruise. Organic matter atomic C/N ratios were employed to infer the origin of the organic matter contained within the sediments and to explore some of the factors affecting its preservation and accumulation.

[1]Meyers, P.A., and Robinson, R.S., 2001. Data report: Carbonate and organic carbon contents of sediments from Site 1087, Southern Cape Basin. *In* Wefer, G., Berger, W.H., and Richter, C. (Eds.), *Proc. ODP, Sci. Results,* 175, 1–11 [Online]. Available from World Wide Web: <http://www-odp.tamu.edu/publications/175_SR/VOLUME/CHAPTERS/SR175_02.PDF> [Cited YYYY-MM-DD]
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Initial receipt: 15 June 1999
Acceptance: 3 August 2000
Web publication: 19 January 2001
Ms 175SR-211

METHODS

Freeze-dried samples were analyzed for calcium carbonate using the carbonate bomb technique of Müller and Gastner (1971). The carbonate bomb procedure differs from the coulometrics procedure (Engleman et al., 1985) used on board the JR to determine carbonate carbon concentrations but yields comparable results (P. Meyers, unpubl. data). Weighed samples were reacted with 3N HCl, and the volume of CO_2 released from each sample was measured and compared to the volumes released from known amounts of pure $CaCO_3$ to determine the percentage in the sample. The carbonate-free residue remaining after acid treatment was collected, rinsed, and dried for use in CHNS determinations.

Amounts of organic carbon and nitrogen in the carbonate-free residues were directly measured with a Carlo Erba 1108 CHNS analyzer. This procedure involves heating the sample at 1020°C and measuring the combustion products by gas chromatography (Verardo et al., 1990). Known amounts of sulfanilamide ($C_6H_8N_2O_2S$) are used to calibrate the instrument and to calculate the quantities of C, N, and S released from each sample. Total organic carbon (TOC) concentrations were calculated on a whole-sediment basis, adjusting for the carbonate concentrations determined from the bomb technique. C/N ratios were calculated on an atomic basis.

Meyers and Silliman (1996) compared the direct determination procedure of the TOC concentration of carbonate-free sediment samples used here with the by-difference analysis that is routinely used on board the JR and that was employed to measure TOC concentrations in sediments from the other 12 Leg 175 sites (Wefer, Berger, Richter, et al., 1998). The direct procedure is more reliable at TOC concentrations of <0.1 wt%, but agreement between the two procedures is good above this value.

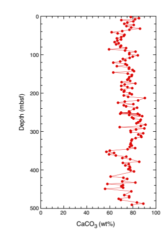
RESULTS

Concentrations of $CaCO_3$ in Site 1087 sediments range between 91.0 and 55.9 wt% (Table T1). Sediments at this site are divided into two lithostratigraphic units (Shipboard Scientific Party, 1998) that contain nearly the same amounts of carbonate. Unit I, an upper middle Miocene–Pleistocene nannofossil-foraminifer ooze, averages 76 wt% $CaCO_3$. Unit II is an interrupted upper Eocene–middle Miocene foraminifer-rich nannofossil ooze that averages 73 wt% $CaCO_3$. Marked variations in concentrations occur within each unit (Fig. F1) and reflect varying combinations of changes in delivery of calcareous material, dilution by noncalcareous components, and carbonate dissolution fueled by oxidation of organic matter. The variations in Unit I mimic similar oscillations in carbonate concentrations that exist in Miocene–Pleistocene sediments from other Leg 175 sites under the Benguela Current (Wefer, Berger, Richter, et al., 1998).

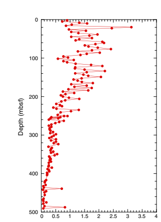
TOC concentrations of the samples of Site 1087 sediments vary between 3.13 and 0.06 wt% (Table T1). Concentrations in sediments shallower than 240 mbsf are larger and more variable than in deeper sediments (Fig. F2). This sediment depth corresponds to the latest Miocene (Shipboard Scientific Party, 1998), which has been identified as the time when the Benguela Current upwelling system began to develop (Siesser, 1980; Meyers et al., 1983; Berger et al., 1998). Maximum TOC

T1. $CaCO_3$, TOC, TN, and TS percentages in sediment samples, p. 9.

F1. $CaCO_3$ concentrations, p. 5.



F2. TOC concentrations, p. 6.

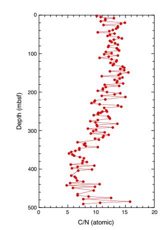


concentrations appear between 80 and 60 mbsf, which is equivalent to about 2 Ma and therefore much like similar maxima observed at Deep Sea Drilling Project Sites 362 and 532 on the Walvis Ridge (Siesser, 1980; Meyers et al., 1983) and at other Leg 175 sites farther north in the Cape Basin than Site 1087 (Berger et al., 1998). These maxima suggest that upwelling once induced greater biological productivity than recent times. However, Pliocene–Pleistocene sediments at Site 1087 are not nearly as rich in organic carbon as those closer to the Walvis Ridge (Wefer, Berger, Richter, et al., 1998), indicating that upwelling in the southern Cape Basin has never created similarly elevated levels of productivity as at the more northerly locations.

Variations in TOC concentrations in the upper 240 m of sediment are typically ~1% (Fig. F2). Similar, but more strongly expressed, variations in TOC concentrations are present in Pliocene–Pleistocene sediments at Leg 175 Sites 1082, 1084, and 1085 (Wefer, Berger, Richter, et al., 1998). These variations resemble the cyclic variations in TOC concentrations in sediments at Sites 362 and 532 on the Walvis Ridge that Diester-Haass et al. (1992) interpret to represent glacial-interglacial changes in the intensity and locus of the Benguela Current.

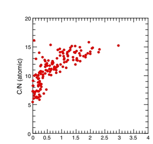
Organic C/N values were calculated for sediment samples from Site 1087 using TOC and total nitrogen concentrations (Table T1). The C/N values vary from 15.8 to 5.4 (Fig. F3). Most of these atomic ratios are intermediate between unaltered algal organic matter (5–8) and fresh land-plant material (25–35) (Emerson and Hedges, 1988; Meyers, 1994). Many of the low C/N values occur in sediment that is poor in organic carbon; these values may be biased by the tendency of clay minerals to absorb ammonium ions generated during the degradation of organic matter (Müller, 1977). Because of their setting off shore of a coastal desert, it is likely that these sediments contain mostly marine-derived organic matter. However, the initiation of the Namib Desert and consequent paucity of land-derived organic matter is linked to the onset of coastal upwelling in the late Miocene (van Zinderen Bakker, 1984). The elevated C/N values of organic carbon–lean Eocene–Oligocene sediments near the base of the core (Fig. F3) may record contributions of land-derived organic matter from a less arid and consequently more vegetated continental paleoenvironment.

F3. Atomic TOC/TN values, p. 7.



C/N values are higher in sediments richer in TOC than in those lean in TOC (Fig. F4). Many of the values are higher than in fresh algal organic matter and indicate that selective loss of nitrogen-rich proteinaceous matter and consequent elevation of the elemental ratios occurred during sedimentation of marine organic matter. Similar evidence of early diagenetic alteration of C/N values is commonly seen under areas of elevated marine productivity such as upwelling systems (Meyers, 1997). The existence of the diagenetically elevated C/N values is evidence that organic matter preservation was enhanced during accumulation of the Pliocene–Pleistocene sediments at Site 1087, presumably because of the presence of a strongly developed oxygen minimum zone along the continental margin of the Cape Basin.

F4. C/N ratios and TOC concentrations, p. 8.



ACKNOWLEDGMENTS

Jennifer Dalton assisted in the $CaCO_3$ and CHNS analyses. This study was supported by a United States Science Support Program grant provided to PAM.

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Figure F1. Concentrations of calcium carbonate in sediments from Holes 1087A and 1087C.

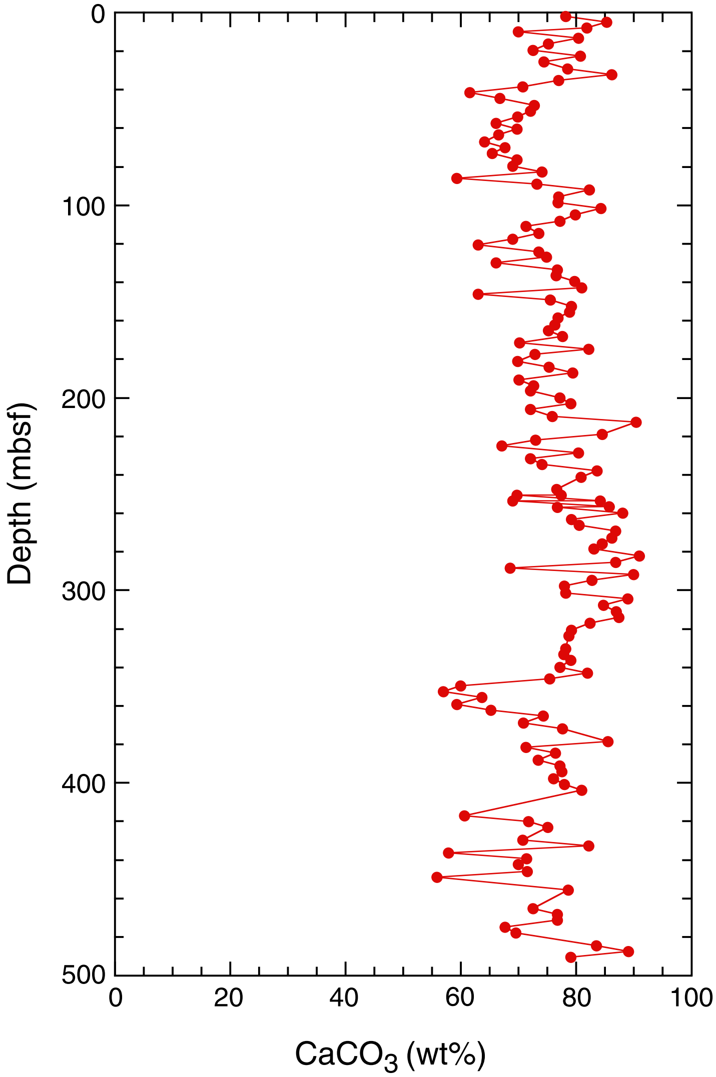

Figure F2. Concentrations of total organic carbon in sediments from Holes 1087A and 1087C.

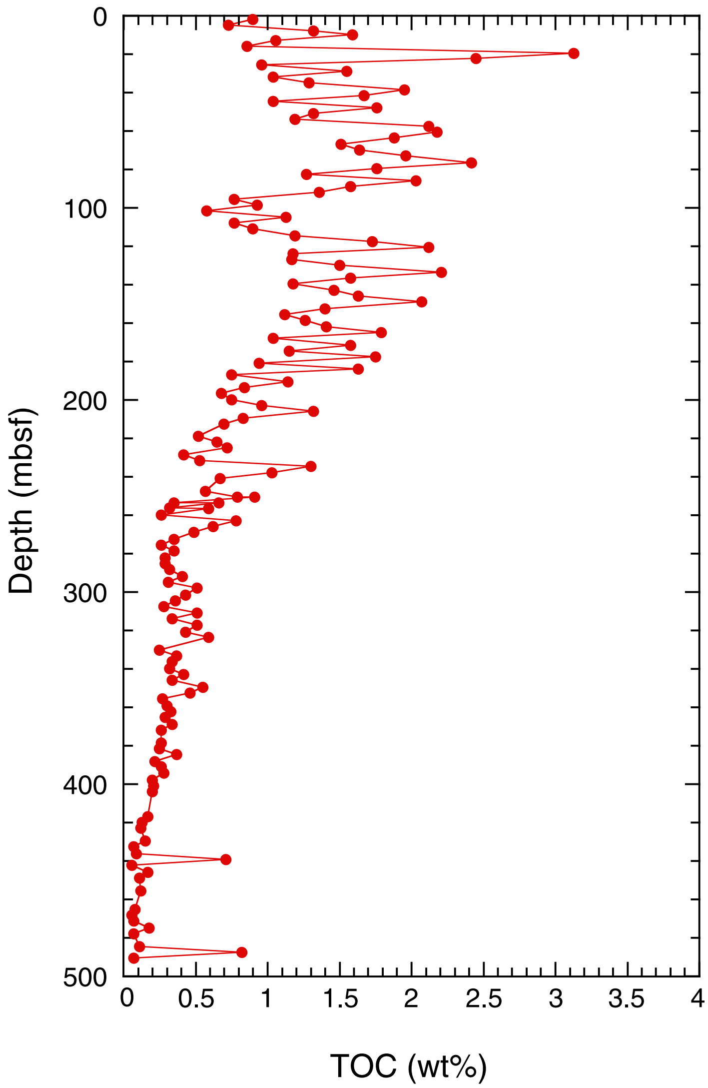

Figure F3. Atomic TOC/TN values for sediments from Holes 1087A and 1087C.

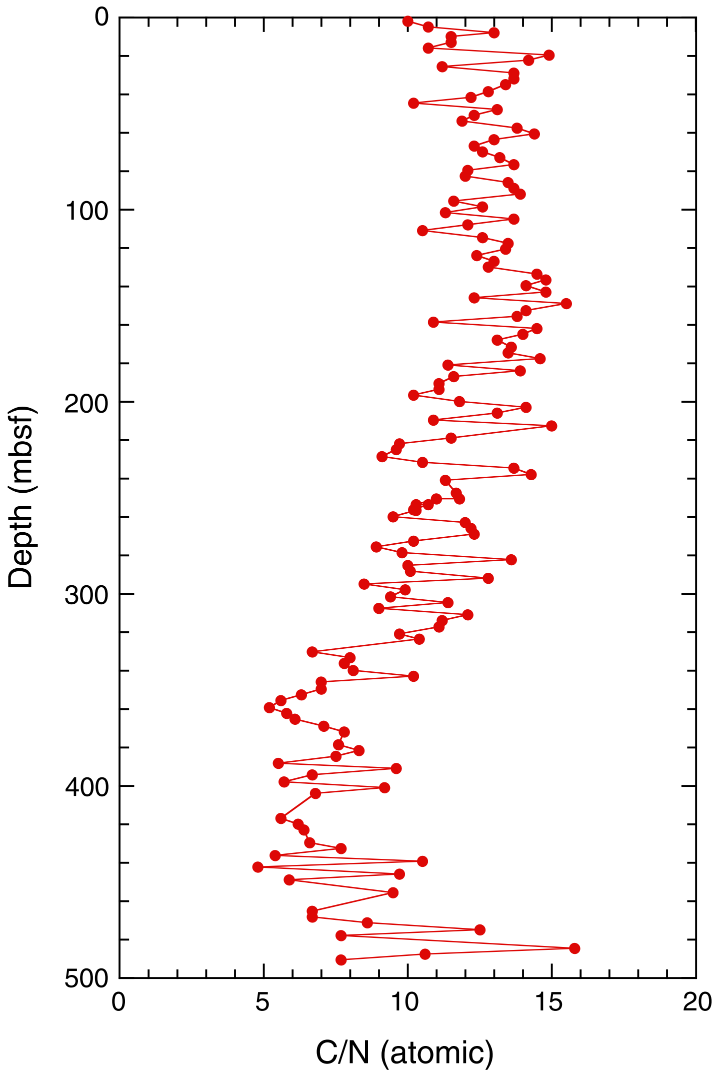

Figure F4. Comparison of organic matter C/N ratios and total organic carbon concentrations of sediments from Holes 1087A and 1087C. Note that the correspondence between increases in both parameters indicates that preferential preservation of organic carbon during sediment settling and early burial is important to enhancing the concentrations of marine organic matter in sediments under the Benguela Current.

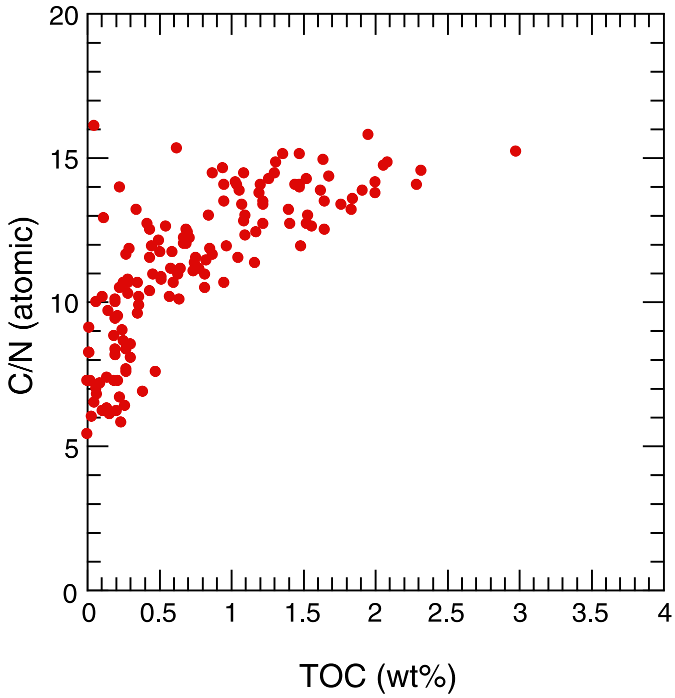

Table T1. Percentages of calcium carbonate, total organic carbon, total nitrogen, and total sulfur in sediment samples, Holes 1087A and 1087C. (**See table notes.** Continued on next two pages.)

Core, section, interval (cm)	Depth (mbsf)	$CaCO_3$ (wt%)	TOC (wt%)	TN (wt%)	C/N (atomic)	TS (wt%)
Unit 1: Pleistocene to upper middle Miocene foraminifer-nannofossil ooze						
175-1087A-						
1H-2, 46-47	1.96	78.2	0.90	0.11	10.0	0.06
1H-4, 46-47	4.96	85.4	0.73	0.08	10.7	0.20
1H-6, 46-47	7.96	81.9	1.32	0.12	13.0	0.17
2H-2, 46-47	10.16	70.0	1.59	0.16	11.5	0.35
2H-4, 46-47	13.16	80.5	1.06	0.11	11.5	0.15
2H-6, 46-47	16.16	75.3	0.86	0.09	10.7	0.16
3H-2, 46-47	19.66	72.6	3.13	0.25	14.9	0.50
3H-4, 46-47	22.56	80.8	2.45	0.20	14.2	0.34
3H-6, 46-47	25.56	74.5	0.96	0.10	11.2	0.17
4H-2, 46-47	29.16	78.6	1.55	0.13	13.7	
4H-4, 46-47	32.16	86.3	1.04	0.09	13.7	
4H-6, 46-47	35.16	77.0	1.29	0.11	13.4	
5H-2, 46-47	38.66	70.8	1.95	0.18	12.8	0.40
5H-4, 46-47	41.66	61.6	1.67	0.16	12.2	0.61
5H-6, 46-47	44.66	66.8	1.04	0.12	10.2	0.36
6H-2, 46-47	48.16	72.8	1.76	0.16	13.1	0.34
6H-4, 46-47	51.16	72.2	1.32	0.13	12.3	
6H-6, 46-47	54.16	69.9	1.19	0.12	11.9	0.33
7H-2, 46-47	57.66	66.2	2.12	0.18	13.8	
7H-4, 46-47	60.66	69.8	2.18	0.18	14.4	0.83
7H-6, 46-47	63.66	66.6	1.88	0.17	13.0	0.43
8H-2, 46-47	67.16	64.1	1.51	0.14	12.3	0.50
8H-4, 46-47	70.16	67.7	1.64	0.15	12.6	0.49
8H-6, 46-47	73.16	65.5	1.96	0.17	13.2	0.56
9H-2, 46-47	76.66	69.8	2.42	0.21	13.7	0.76
9H-4, 46-47	79.66	69.1	1.76	0.17	12.1	0.44
9H-6, 46-47	82.66	74.1	1.27	0.12	12.0	0.38
10H-2, 46-47	86.16	59.4	2.03	0.18	13.5	0.79
10H-4, 46-47	89.16	73.3	1.58	0.13	13.7	
10H-6, 46-47	92.16	82.4	1.36	0.11	13.9	0.34
11H-2, 46-47	95.66	77.1	0.77	0.08	11.6	
11H-4, 46-47	98.66	76.9	0.93	0.09	12.6	0.42
11H-6, 46-47	101.66	84.4	0.58	0.06	11.3	
12H-2, 46-47	105.16	79.9	1.13	0.10	13.7	0.39
12H-4, 46-47	108.16	77.3	0.77	0.07	12.1	0.31
12H-6, 46-47	111.16	71.3	0.90	0.10	10.5	0.40
13H-2, 46-47	114.66	73.6	1.19	0.11	12.6	0.47
13H-4, 46-47	117.66	69.0	1.73	0.15	13.5	0.37
13H-6, 46-47	120.66	63.0	2.12	0.18	13.4	0.74
14H-2, 46-47	124.16	73.6	1.18	0.11	12.4	0.45
14H-4, 46-47	127.16	74.9	1.17	0.10	13.0	
14H-6, 46-47	130.16	66.1	1.50	0.14	12.8	
15H-2, 46-47	133.66	76.8	2.21	0.18	14.5	0.75
15H-4, 46-47	136.66	76.6	1.58	0.12	14.8	
15H-6, 46-47	139.66	79.8	1.18	0.10	14.1	0.41
16H-2, 46-47	143.16	81.0	1.46	0.11	14.8	0.53
16H-4, 46-47	146.16	63.0	1.63	0.16	12.3	0.50
16H-6, 46-47	149.16	75.6	2.07	0.16	15.5	0.67
17H-2, 46-47	152.66	79.3	1.40	0.12	14.1	0.48
17H-4, 46-47	155.66	78.9	1.12	0.09	13.8	0.28
17H-6, 46-47	158.66	76.9	1.26	0.13	10.9	0.32
18H-2, 46-47	162.16	76.4	1.41	0.11	14.5	0.43
18H-4, 46-47	165.16	75.3	1.79	0.15	14.0	0.48
18H-6, 46-47	168.16	77.7	1.04	0.09	13.1	0.35
19H-2, 46-47	171.66	70.3	1.58	0.14	13.6	
19H-4, 46-47	174.66	82.3	1.15	0.10	13.5	0.25
19H-6, 46-47	177.66	72.9	1.75	0.14	14.6	0.52
20H-2, 46-47	181.16	69.9	0.94	0.10	11.4	
20H-4, 46-47	184.16	75.4	1.63	0.14	13.9	0.32
20H-6, 46-47	187.16	79.5	0.75	0.08	11.6	0.18
21H-2, 46-47	190.66	70.1	1.14	0.12	11.1	0.38
21H-4, 46-47	193.66	72.7	0.84	0.09	11.1	0.20
21H-6, 46-47	196.66	72.2	0.68	0.08	10.2	0.24

Table T1 (continued).

Core, section, interval (cm)	Depth (mbsf)	$CaCO_3$ (wt%)	TOC (wt%)	TN (wt%)	C/N (atomic)	TS (wt%)
22H-2, 46-47	200.16	77.3	0.75	0.07	11.8	0.30
22H-4, 46-47	203.16	79.2	0.96	0.08	14.1	0.45
22H-6, 46-47	206.16	72.2	1.32	0.12	13.1	0.40
23H-2, 46-47	209.66	75.9	0.83	0.09	10.9	0.21
23H-4, 46-47	212.66	90.5	0.70	0.05	15.0	0.18
24H-2, 46-47	219.16	84.6	0.52	0.05	11.5	
24H-4, 46-47	222.16	73.0	0.65	0.08	9.7	0.18
24H-6, 46-47	225.16	67.2	0.72	0.09	9.6	0.32
25H-2, 46-47	228.66	80.5	0.42	0.05	9.1	0.16
25H-4, 46-47	231.66	72.2	0.53	0.06	10.5	0.17
25H-6, 46-47	234.66	74.2	1.30	0.11	13.7	0.31
26H-2, 46-47	238.16	83.7	1.03	0.08	14.3	0.27
26H-4, 46-47	241.16	80.9	0.67	0.07	11.3	0.18
27H-2, 46-47	247.66	76.7	0.57	0.06	11.7	
175-1087C-						
28X-2, 46-47	250.56	77.5	0.79	0.08	11.8	0.26
175-1087A-						
27H-4, 46-47	250.66	69.8	0.91	0.10	11.0	
175-1087C-						
28X-4, 46-47	253.56	84.3	0.35	0.04	10.3	0.08
175-1087A-						
27H-6, 46-47	253.66	69.1	0.66	0.07	10.7	0.13
175-1087C-						
28X-6, 46-47	256.56	85.8	0.32	0.04	10.2	
29X-2, 46-47	256.86	76.8	0.59	0.07	10.3	0.27
29X-4, 46-47	259.86	88.2	0.26	0.03	9.5	
30X-2, 46-47	263.16	79.3	0.78	0.08	12.0	0.14
30X-4, 46-47	266.16	80.6	0.62	0.06	12.2	
30X-6, 46-47	269.16	86.9	0.49	0.05	12.3	0.09
31X-2, 46-47	272.76	86.2	0.35	0.04	10.2	
31X-4, 46-47	275.76	84.6	0.26	0.03	8.9	0.08
31X-6, 46-47	278.76	83.2	0.35	0.04	9.8	0.11
32X-2, 46-47	282.36	91.0	0.29	0.02	13.6	0.06
32X-4, 46-47	285.36	86.9	0.29	0.03	10.0	0.09
32X-6, 46-47	288.36	68.6	0.32	0.04	10.1	0.10
33X-2, 46-47	291.96	90.0	0.41	0.04	12.8	0.11
33X-4, 46-47	294.96	82.8	0.31	0.04	8.5	0.09
33X-6, 46-47	297.96	78.0	0.51	0.06	9.9	
34X-2, 46-47	301.66	78.2	0.43	0.05	9.4	0.22
34X-4, 46-47	304.66	89.0	0.36	0.04	11.4	
34X-6, 46-47	307.66	84.8	0.28	0.04	9.0	
35X-2, 46-47	311.21	87.0	0.51	0.05	12.1	0.11
35X-4, 46-47	314.21	87.5	0.34	0.04	11.2	0.08
35X-6, 46-47	317.21	82.5	0.51	0.05	11.1	0.10
36X-2, 46-47	320.86	79.3	0.43	0.05	9.7	0.14
36X-4, 46-47	323.86	78.8	0.59	0.07	10.4	0.13
37X-2, 46-47	330.46	78.3	0.25	0.04	6.7	0.06
37X-4, 46-47	333.46	77.9	0.37	0.05	8.0	
37X-6, 46-47	336.46	79.1	0.34	0.05	7.8	
38X-2, 46-47	340.16	77.2	0.32	0.05	8.1	0.19
38X-4, 46-47	343.16	82.1	0.42	0.05	10.2	
38X-6, 46-47	346.16	75.5	0.34	0.06	7.0	0.17
39X-2, 46-47	349.76	60.1	0.55	0.09	7.0	0.27
39X-4, 46-47	352.76	57.1	0.46	0.09	6.3	0.06
39X-6, 46-47	355.76	63.7	0.27	0.06	5.6	0.31
40X-2, 46-47	359.36	59.4	0.30	0.07	5.2	
40X-4, 46-47	362.36	65.2	0.33	0.07	5.8	0.18
40X-6, 46-47	365.36	74.4	0.29	0.06	6.1	0.09
41X-2, 46-47	369.06	70.9	0.34	0.06	7.1	0.22
41X-4, 46-47	372.06	77.7	0.26	0.04	7.8	0.09
42X-2, 46-47	378.66	85.6	0.26	0.04	7.6	0.05
42X-4, 46-47	381.66	71.4	0.25	0.04	8.3	0.07
42X-6, 46-47	384.66	76.5	0.37	0.06	7.5	
43X-2, 46-47	388.26	73.5	0.22	0.05	5.5	0.08
43X-4, 46-47	391.26	77.2	0.26	0.03	9.6	0.04
43X-6, 46-47	394.26	77.6	0.28	0.05	6.7	0.05
44X-2, 46-47	397.96	76.2	0.20	0.04	5.7	0.10

Table T1 (continued).

Core, section, interval (cm)	Depth (mbsf)	$CaCO_3$ (wt%)	TOC (wt%)	TN (wt%)	C/N (atomic)	TS (wt%)
44X-4, 46-47	400.96	78.1	0.21	0.03	9.2	0.13
44X-6, 46-47	403.96	81.1	0.20	0.03	6.8	0.05
46X-2, 46-47	417.16	60.7	0.17	0.04	5.6	1.09
46X-4, 46-47	420.16	71.8	0.13	0.03	6.2	0.56
46X-6, 46-47	423.16	75.1	0.12	0.02	6.4	
Unit II: Lower Miocene-upper Eocene foraminifer-rich nannofossil ooze						
175-1087C-						
47X-4, 46-47	429.76	70.8	0.15	0.03	6.6	0.04
47X-6, 46-47	432.76	82.3	0.07	0.01	7.7	0.00
48X-2, 46-47	436.46	57.9	0.09	0.02	5.4	0.00
48X-4, 46-47	439.46	71.5	0.71	0.08	10.5	0.39
48X-6, 46-47	442.46	70.0	0.06	0.02	4.8	0.00
49X-2, 46-47	446.06	71.6	0.17	0.02	9.7	0.01
49X-4, 46-47	449.06	55.9	0.11	0.02	5.9	0.00
50X-2, 46-47	455.76	78.7	0.12	0.02	9.5	0.01
51X-2, 46-47	465.36	72.6	0.08	0.01	6.7	1.64
51X-4, 46-47	468.36	76.8	0.06	0.01	6.7	1.25
51X-6, 46-47	471.36	76.8	0.07	0.01	8.6	0.01
52X-2, 46-47	475.06	67.7	0.18	0.02	12.5	0.01
52X-4, 46-47	478.06	69.6	0.07	0.01	7.7	
53X-2, 46-47	484.66	83.6	0.11	0.01	15.8	
53X-4, 46-47	487.66	89.1	0.82	0.09	10.6	0.03
53X-6, 46-47	490.66	79.2	0.07	0.01	7.7	1.82

Notes: TOC = total organic carbon; TN = total nitrogen; TS = total sulfur. C/N values are calculated from TOC and TN concentrations and are given as atom/atom ratios.