4. SITE 588: LORD HOWE RISE, 26°S1

Shipboard Scientific Party²

HOLE 588

Date occupied: 6 December 1982

Date departed: 8 December 1982

Time on hole: 30 hr.

Position: 26°06.7'S; 161°13.6'E

Water depth (sea level; corrected m, echo-sounding): 1533

Water depth (rig floor; corrected m, echo-sounding): 1543

Bottom felt (m, drill pipe): 1548

Penetration (m): 236.00

Number of cores: 26

Total length of cored section (m): 236.00

Total core recovered (m): 220.76

Core recovery (%): 93.5

Oldest sediment cored:

Depth sub-bottom (m): 236.00 Nature: Foraminifer-nannofossil ooze Age: middle Miocene Measured velocity (km/s): 1.617 km/s at 233 m

Basement: Not reached

HOLE 588A

Date occupied: 8 December 1982

Date departed: 8 December 1982

Time on hole: 20 hr.

Position: 26°06.7'S; 161°13.6'E

Kennett, J. P., von der Borch, C. C., et al., *Init. Repts. DSDP*, 90: Washington (U.S. Govt, Printing Office).
 ² James P. Kennett (Co-Chief Scientist), Graduate School of Oceanography, University

of Rhode Island, Narragansett, RI 02882; Christopher C. von der Borch (Co-Chief Scientist), School of Earth Sciences, Flinders University of South Australia, Bedford Park, South Australia 5042; Paul A. Baker, Department of Geology, Duke University, Durham, NC 27708; Charles E. Barton, Graduate School of Oceanography, University of Rhode Island, Narra-gansett, RI 02882 (present address: Bureau of Mineral Resources, Geology, and Geophysics, P.O. Box 378, Canberra, A.C.T., Australia); Anne Boersma, Microclimates, Inc., 404 RRI, Stony Point, NY 10980; Jean-Pierre Caulet, Laboratoire de Géologie, Muséum National d'Histoire Naturelle, 43 Rue Buffon, 75005, Paris, France; Walter C. Dudley, Jr., Natural Sciences Division, College of Arts and Sciences, University of Hawaii at Hilo, Hilo, Hawaii 96720; James V. Gardner, Pacific-Arctic Branch of Marine Geology, U.S. Geological Survey, 345 Middlefield Rd., Menlo Park, CA 94025; D. Graham Jenkins, Department of Earth Sci ences, Open University, Walton Hall, Milton Keynes, MK7 6AA, Buckinghamshire, United Kingdom; William H. Lohman, Marathon Oil Co., Denver Research Center, P.O. Box 269, Littleton, CO 80160; Erlend Martini, Geologisch-Paläontologisches Institut, Johann-Wolfgang-Goethe Universität, Senckenberg-Anlage 32-34, D-6000 Frankfurt am Main, Federal Re-public of Germany; Russell B. Merrill, Deep Sea Drilling Project A031, Scripps Institution of Oceanography, La Jolla, CA 92093 (present address: Ocean Drilling Project, Texas A&M Uni-versity, College Station, TX 77843-3469); Roger Morin, Department of Earth and Planetary Sciences, Massachusetts Institute of Technology, Cambridge, MA 02139 (present address: U.S. Geological Survey, Denver Federal Center, Denver, CO 80225); Cambell S. Nelson, De-partment of Earth Sciences, University of Waikato, Private Bag, Hamilton, New Zealand; Christian Robert, Laboratoire de Géologie Marine, Centre Universitaire de Luminy, Case 901, 13288 Marseille Cedex 09, France; M. S. Srinivasan, Department of Geology, Banaras Hindu University, Varanasi 221 005, India; Rüdiger Stein, Geologisch-Paläontologisches Institut, Universität Kiel, 2300 Kiel, Federal Republic of Germany (present address: Institute of Petro leum and Organic Geochemistry (ICH-5), Kernforschungslage Jülich GmbH, P.O. Box 1913, 5170 Jülich, Federal Republic of Germany); Akira Takeuchi, Department of Earth Sciences, Faculty of Science, Toyama University, Gohuku 3190, Toyama 930, Japan.

Water depth (sea level; corrected m, echo-sounding): 1533 Water depth (rig floor; corrected m, echo-sounding): 1543 Bottom felt (m, drill pipe): 1548 Penetration (m): 344.4 Number of cores: 18 Total length of cored section (m): 108.40 Total core recovered (m): 75.30 Core recovery (%): 69.4

Oldest sediment cored: Depth sub-bottom (m): 344.4 Nature: Foraminifer-nannofossil ooze Age: early Miocene

Basement: Not reached

HOLE 588B

Date occupied: 8 December 1982

Date departed: 10 December 1982

Time on hole: 31 hr.

Position: 26°06.7'S; 161°13.6'E

Water depth (sea level; corrected m, echo-sounding): 1533

Water depth (rig floor; corrected m, echo-sounding): 1543

Bottom felt (m, drill pipe): 1548

Penetration (m): 277.4

Number of cores: 31

Total length of cored section (m): 277.40

Total core recovered (m): 255.87

Core recovery (%): 93 Oldest sediment cored:

Depth sub-bottom (m): 277.4 Nature: Foraminifer-nannofossil ooze Age: middle Miocene

Basement: Not reached

HOLE 588C

Date occupied: 10 December 1982

Date departed: 11 December 1982

Time on hole: 12 hr.

Position: 26°06.7'S; 161°13.6'E

Water depth (sea level; corrected m, echo-sounding): 1533

Water depth (rig floor; corrected m, echo-sounding): 1543

Bottom felt (m, drill pipe): 1548 Penetration (m): 488.1

Number of cores: 19

Total length of cored section (m): 182.40



Figure 1. Regional bathymetry (fathoms) around Site 588, after Mammerickx, et al., 1974. *Glomar Challenger* Leg 90 track shown; heavy portion locates water gun seismic profile illustrated in Figure 2.

Total core recovered (m): 135.61

Core recovery (%): 74.3

Oldest sediment cored:

Depth sub-bottom (m): 488.1 Nature: Siliceous foraminifer-bearing nannofossil chalk and foraminifer-bearing chert Age: middle Miocene

Basement: Not reached

Principal results: Site 588 consists of four holes: Hole 588, which was cored continuously with the HPC from 0 to 236.0 m sub-bottom; Hole 588A, cored continuously with the HPC from 236.0 to 344.4 m; Hole 588B, cored continuously with the HPC from 0 to 277.4 m; and Hole 588C, cored continuously with the rotary drill from 305.7 to 488.1 m BSF.

Site 588 is located at DSDP Site 208, in the warm subtropical water mass at 26° S.

The HPC sequence through carbonate sediments is a record penetration of 315 m, extending from the Quaternary to sediments of late early Miocene age (17 m.y.; Zone NN3 and *Globorotalia miozea* Zone). The overlapping hydraulic piston cores effectively provide 100% recovery of this sequence. Core quality is particularly good in the Miocene, much less so in the Pliocene, and especially poor in the Quaternary, which is soupy. The carbonate fossil sequence is exquisite through the Neogene, but less so in Oligocene sediments. Foraminiferal and calcareous nannofossil zonal sequences are complete, suggesting that there are no hiatuses above the upper Oligocene (NP24). A paleomagnetic polarity stratigraphy has been identified down to the upper part of the Gilbert Chron (about 3.5 m.y.).

Two sedimentary units are distinguished, the upper one divided into three subunits. Subunit IA is a brownish, foraminifer-rich nannofossil ooze in an oxidized and winnowed environment. Subunit IB, comprising most of the sediment column, is a foraminifer-bearing nannofossil ooze. Subunit IC is chalk. There are many thin volcanic ash layers throughout the Miocene sequence; they occur as singlets, doublets, or triplets and exhibit quasi-regular perodicites in some intervals. Most are completely undisturbed by bioturbation, which is unusually limited in this site. Unit II is a light greenish gray, siliceous foraminifer-bearing nannofossil chalk and associated chert of Eocene age.

Iron sulfides are persistent throughout the section and have a close association with volcanic ash layers. The site terminated in middle Eocene silica-rich chalks and cherts.

Textbook examples of microfaults and slickensides occur in three upper lower Miocene cores in a zone where ooze grades downward into chalks. Surfaces are occasionally mineralized by iron sulfide and possibly rhodochrosite.

The uncorrected rate of sedimentation is as follows: early Oligocene-early Miocene, 20.6 m/m.y.; early Miocene, 14.4; middle Miocene-early Pliocene, 17.4, lower Pliocene, 29.5; Quaternary, 12.2.

BACKGROUND AND OBJECTIVES

Site 588 (Fig. 1) was drilled at the same location as Site 208 on the northern part of Lord Howe Rise (26°06'S; 161°13'E) to obtain a high-quality, continuously cored sequence through the upper Paleogene and Neogene. The chosen site overlies a relatively thick sequence of acoustically transparent sediments (Figs. 2 and 3). Previous investigations have demonstrated that the planktonic foraminiferal assemblages at this latitude are made up of both tropical and temperate elements. Site 588 is now located in the warm subtropical water mass which lies between the true tropical water masses to the north and transitional water masses to the south. However, Site 588 experienced 5-10° of northernly movement during the Neogene in association with movements of the Indian Plate (Sclater et al., in press). During the early Miocene, Site 588 was located at about 36°S in the present-day temperate area and within the zone of westerly winds. This northward movement from higher to lower latitudes must have had a major effect upon the ancient biogeography of the planktonic microfossil assemblages.

The section at Site 208 consists of about 430 m of Neogene and 58 m of upper Oligocene foraminiferalnannofossil oozes which make up Unit 1 as defined by the Leg 21 sedimentologists. Unit 1 is underlain by Unit 2, which is made up of Upper Cretaceous to lower middle Eocene siliceous-fossil-bearing nannofossil chalk. Unit 1 is separated from Unit 2 by the regional unconformity. The Site 208 sequence was continuously rotary cored from the Quaternary to the uppermost Miocene, then discontinuously cored to the base of the sequence. Rotary coring produced the usual mechanical disturbance of sediments; in addition, there are many long coring gaps in the section at Site 208.

The plan for Site 588 was to core two separate holes using the HPC in the upper part of the sequence, followed by continuous rotary coring in one hole to the level immediately below the regional unconformity separating the middle Eocene from the upper Oligocene at 488 m sub-bottom depth. Such a sequence would include all of Unit 1 as defined by the Leg 21 shipboard party.



Figure 2. Water gun seismic profile (Glomar Challenger) near Site 588; bandpass filter 40-160 Hz.



Figure 3. Location of Site 588 on Sonne multichannel seismic Profile SO-7-13. Courtesy of S. Hinz, Bundesanstalt für Geowissenschaften und Rohstoffe, FRG.

OPERATIONS

Site 587 to Site 588

Steaming between sites was routine, with ideal Tasman Sea summer weather and a quartering current. The ship covered the 295.6 n. mi. at an average speed of 10.5 knots. Routine underway geophysical data were collected between Sites 587 and 588, as described in the Operations Chapter for Site 587.

Site 588 was designed to reoccupy and utilize the HPC at Site 208, drilled during DSDP Leg 21. Several excellent seismic profiles were available for site selection (*Con*rad 12; Glomar Challenger, Leg 21; Sonne 50-7-12). The combination of simple Neogene stratigraphy, relatively flat topography, and uniformity of condition combined to make it unnecessary to carry out a presite survey. *Glomar Challenger* approached Site 588 from the north and dropped the beacon at 1921 hr., 6 Dec. 1982.

Site 588 (SW-7): Northern Lord Howe Rise

As at Site 587, a special bottom-hole assembly (BHA) was run, compatible with both piston coring and extended core barrel (XCB) rotary coring. The operational plan for Site 588 called for taking duplicate unbroken piston-cored sequences through the Neogene, followed by rotary coring to the base of the Miocene.

The first variable-length (VL) HPC shot was taken with the bit at 1544 m; it recovered a 5.65-m core which established the mud line at 1548 m (Table 1). Piston coring continued easily through calcareous ooze ranging from soupy to stiff for the first 216.8 m. Recovery was consistently nearly 100%, except for Core 588-8, which came up empty. During this interval, 23 9.5-m VLHPC cores were taken. Full stroke on all was achieved using only two shear pins. Cores 588-24 and 588-25 were shot using three shear pins. Overpulls to free the tool after shootoff slowly increased to a maximum of 20,000 lbs.³

At Core 588-26, somewhat more than 100,000 lbs. overpull was applied to free the tool before the driller could stop the draw-works. The piston corer was recovered with its lower core-containing section missing, because the excessive tensile load associated with the overpull had caused a mechanical failure. The hole had to be terminated at this point.

Hole 588A

The bit was pulled to the mud line and Hole 588A was spudded at 0025 hr., 8 December, and washed to the termination point of Hole 588—236.0 BSF. One more 9.5-m VLHPC was deployed. When it experienced full stroke followed by excessive overpull, the bit was washed down over the entire 9.5 m until the tool was washed free.

It was then decided to employ the 5-m VLHPC as far as possible. Overpull was taken to a limit of 20–30,000 lbs. on each core. If the corer could not be freed by pulling at that limit, the bit was washed over the extended section.

A new record depth for piston coring was reached in this manner—315.6 m BSF—and the oldest sediments ever successfully piston cored were recovered (upper lower Miocene). However, as the sediments stiffened, it became impossible to wash the bit over the protruding inner barrel without gouging the extended tool. Therefore, VLHPC work was terminated at Core 588A-15. Surprisingly, full stroking continued throughout the piston-cored sequence, despite the record total depth of penetration.

The XCB was then deployed for Cores 588A-16 to -18. Poor recovery coupled with other symptoms indicated that the XCB was not functioning correctly, and it was decided to terminate Hole 588A and perform the repeat piston core sequence, using the time to modify the XCB system.

Hole 588B

Once again the bit was pulled to the mud line to spud a new hole. The vessel was offset 100 ft. to the north to assure a clean seafloor for a mud line core and Hole 588B was spudded at 2210 hr., 8 December. A good mud line core was shot from 1546 m to be certain that the coring sequence was staggered with respect to Holes 588 and 588A.

Piston coring proceeded smoothly again through calcareous ooze with scattered ash layers. Again full stroke of the 9.5 m VLHPC was routinely achieved with two

Core No.	Date (Dec. 1982)	Time	Depth from drill floor (m) Top Bottom	Depth below seafloor (m) Top Bottom	Length cored (m)	Length recovered (m)	Percentage recovered
Hole 588	8						
	7	0200	1548 0-1553 6	0.0-5.6	5.6	5.65	100
2	7	0250	1553.6-1563.2	5.6-15.2	9.6	9.64	100
3	7	0340	1563.2-1572.8	15.2-24.8	9.6	9.18	95.6
4	7	0420	1572.8-1582.4	24.8-34.4	9.6	9.43	98.2
5	7	0510	1482.4-1592.0	34,4-44.0	9.6	9.11	94.9
7	7	0650	1601.6-1611.2	53.6-63.2	9.6	9.05	94.2
8	7	0730	1611.2-1620.8	63.2-72.8	9.6	0.0	0.0
9	7	0820	1620.8-1630.4	72.8-82.4	9.6	9.48	98.7
10	7	0910	1630.4-1640.0	82.4-92.0	9.6	8.78	91.4
12	7	1000	1640.0-1649.6	92.0-101.6	9.6	9.49	98.8
13	7	1130	1659.2-1668.8	111.2-120.8	9.6	9.49	98.5
14	7	1220	1668.8-1678.4	120.8-130.4	9.6	9.71	100
15	7	1320	1678.4-1688.0	130.4-140.0	9.6	9.44	98
16	7	1415	1688.0-1697.6	140.0-149.6	9.6	5.8	61
18	7	1555	1707.2-1716.8	159.2-168.8	9.6	9.38	98
19	7	1630	1716.8-1726.4	168.8-178.4	9.6	9.64	100 +
20	7	1735	1726.4-1736.0	178.4-188.0	9.6	9.77	100+
21	7	1820	1736.0-1745.6	188.0-197.6	9.6	9.78	100 +
22	7	1930	1745.6-1755.2	197.6-207.2	9.6	9.81	100 +
23	7	2100	1764.8-1774.4	216 8-226 4	9.6	9.66	100+
25	7	2140	1774.4-1785.0	226.4-236.0	9.6	10.04	100 +
			(tool left in hole)			220.76	02.6
Hole 588	A				238.00	220.76	93.5
1	8	0300	1784.0-1793.6	236.0-245.6	9.6	9.76	100+
2	8	0400	1793.6-1798.6	245.6-250.6	5.0	5.16	100 +
3	8	0500	1798.6-1803.6	250.6-255.6	5.0	5.23	100 +
4	8	0550	1803.6-1808.6	255.6-260.6	5.0	4.91	98.2
5	8	0645	1808.6-1813.6	260.6-265.6	5.0	4.39	100+
7	8	0830	1818.6-1823.6	270.6-275.6	5.0	5.19	100+
8	8	0920	1823.6-1828.6	275.6-280.6	5.0	5.27	100 +
9	8	1010	1828.6-1833.6	280.6-285.6	5.0	4.96	99.2
10	8	1115	1833.6-1838.6	285.6-290.6	5.0	5.20	100 +
12	8	1210	1843 6-1848 6	290.6-295.6	5.0	4.22	84.4
13	8	1415	1848.6-1853.6	300.6-305.6	5.0	5.21	100 +
14	8	1500	1853.6-1858.6	305.6-310.6	5.0	3.78	76
15	8	1545	1858.6-1863.6	310.6-315.6	5.0	5.22	100 +
16	8	1720	1863.6-1873.2	315.6-325.2	9.6	0.16	2
18	8	1930	1873.2-1882.8 1882.8-1892.4	334.8-344.4	9.6	2.35	30
					108.40	84.27	77.7
Hole 588	в						
1	8	2250	1547.8-1555.6	0.0-7.8	7.8	7.79	100
2	8	2350	1555.6-1565.2	7.8-17.4	9.6	9.63	100+
4	9	0120	1574.8-1584.4	27.0-36.6	9.6	8.91	92.8
5	9	0200	1584.4-1594.0	36.6-46.2	9.6	9.70	100 +
6	9	0305	1594.0-1603.6	46.2-55.8	9.6	7.92	82.5
7	9	0345	1603.6-1613.2	55.8-65.4	9.6	9.17	95.5
9	9	0520	1622.8-1632.4	75.0-84.6	9.6	9.58	99.7
10	9	0600	1632.4-1642.0	84.6-94.2	9.6	4.04	42.0
11	9	0648	1642.0-1651.6	94.2-103.8	9.6	9.49	98.8
12	9	0740	1651.6-1661.2	103.8-113.4	9.6	9.83	100+
14	9	0920	1670.8-1680.4	123.0-132.6	9.6	9.69	100+
15	9	1000	1680.4-1690.0	132.6-142.2	9.6	9.30	96.8
16	9	1053	1690.0-1699.6	142.2-151.8	9.6	9.14	95.2
17	9	1310	1699.6-1709.2	151.8-161.4	9.6	9.68	100+
18	9	1400	1718.8-1728.4	171.0-180.6	9.6	9.45	98
20	9	1545	1728.4-1738.0	180.6-190.2	9.6	9.80	100 +
21	9	1630	1738.6-1747.6	190.2-199.8	9.6	9.47	99
22	9	1725	1747.6-1757.2	199.8-209.4	9.6	9.30	97
23	9	1815	1757.2-1766.8	209.4-219.0	9.6	9.66	100 +
25	9	2015	1776.4-1781.4	228.6-233.6	5.0	5.15	100 +
26	9	2104	1781.4-1786.4	233.6-238.6	5.0	5.27	100 +
27	9	2205	1786.4-1791.4	238.6-243.6	5.0	5.15	+ 001
28	9	2300	1791.4-1796.4	243.6-248.6	5.0	5.20	100+
30	10	0250	1806.0-1815.6	258.2-267.8	9.6	3.79	39.4
31	10	0415	1815.6-1825.2	267.8-277.4	9.6	5.73	59.6
					277.40	255.87	93.0
lole 5880	С						
1	10	1630	1853.5-1863.1	305.7-315.3	9.6	9.42	98 94
3	10	1830	1872.7-1882.3	324.9-334.5	9.6	8.94	93

 $^{^3}$ The overpull is a measure of the force required to overcome the adhesion and suction which the sediment exerts on the extended section of the piston corer when it is implanted.

Table 1. (Continued).

Core No.	Date		Dept	h from floor m)	Dep	th below afloor (m)	Length	Length	Percentage
No.	1982)	Time	Top	Bottom	Тор	Bottom	(m)	(m)	recovered
Hole 58	8C (Cont	.)							
4	10	1925	1882.3	-1891.9	334.	5-344.1	9.6	8.82	92
5	10	2025	1891.9	-1901.5	344.	1-353.7	9.6	9.02	94
6	10	2130	1901.5	5-1911.1	353.	7-363.3	9.6	9.63	100 +
7	10	2210	1911.1	-1920.7	363.	3-372.9	9.6	5.88	61.2
8	10	2325	1920.7	7-1930.3	373.	9-382.5	9.6	9.43	98.2
9	11	0002	1930.3	-1939.9	382.	5-392.1	9.6	9.62	100 +
10	11	0052	1939.9	-1949.5	392.	1-401.7	9.6	7.42	80.6
11	11	0245	1949.5	5-1959.1	401.	7-411.3	9.6	4.44	46.2
12	11	0355	1959.1	-1968.7	411.	3-420.9	9.6	8.13	84.6
13	11	0455	1968.7	-1978.3	420.	9-430.5	9.6	8.88	92.5
14	11	0550	1978.3	3-1987.9	430.	5-440.1	9.6	7.20	75.0
15	11	0640	1987.9	-1997.5	440.	1-449.7	9.6	6.40	66.6
16	11	0743	1997.5	5-2007.1	449.	7-459.3	9.6	5.32	55.4
17	11	0835	2007.1	-2016.7	459.	3-468.9	9.6	5.60	58.3
18	11	0950	2016.7	-2026.3	468.	9-478.5	9.6	0.62	6.4
19	11	1040	2026.3	-2035.9	478.	5-488.1	9.6	0.85	8.85
							182.40	134.61	73.8

shear pins. The same scenario of increasing overpull requirements was experienced as in the previous hole, this time beginning about 30 m higher. Cores 588B-25 to 588B-28 were taken with the 5-m VLPHC. Piston coring was then terminated.

Again the XCB was deployed, now modified to allow proper venting. Cores were taken on all three deployments but they were not of good quality. Partial collapse and splitting of the plastic core liners occurred on all three attempts. The XCB obviously needed further work and the scientific objective of rotary coring to the Neogene/Paleogene unconformity had not yet been reached, so it was decided to trip the pipe in order to change the bit and BHA for conventional rotary coring.

Hole 588C

The pipe was tripped and a standard BHA with a long-tooth, tungsten carbide insert F93CK bit was assembled and run back to the seafloor. Hole 588C was spudded at 1307 hr., 10 December. The bit was quickly washed to a depth of 305.7 m BSF to provide a slight overlap with the deepest penetration of the piston coring done earlier.

Routine rotary coring then followed, with good core recovery through foraminifer-bearing nannofossil chalk with green ash layers and abundant burrows. The only delay was a 45 min. wait on weather while the vessel took a 400 ft. excursion under the influence of a brief but dramatic line squall bearing 50 m.p.h. winds. At 488.1 m BSF the scientific objective was reached and the hole was terminated. The pipe was tripped and the vessel got under way for Site 589 at 1536 hr., 11 December.

LITHOSTRATIGRAPHY

Site 588 consists of four holes: Hole 588 was cored continuously with the HPC from 0 to 236.0 sub-bottom; Hole 588A was cored continuously with the HPC from 236.0 to 344.4 m; Hole 588B was cored continuously with the HPC from 0 to 277.4 m; and Hole 588C was cored continuously with the rotary drill from 305.7 to 488.1 m sub-bottom. The recovered sequence is divided into two lithostratigraphic units, based upon color and composition (Fig. 4; Table 2).

Subunit IA is a foraminifer-bearing nannofossil ooze to nannofossil-bearing foraminiferal ooze extending from the seafloor to 6.5 or 6.8 m BSF. It is distinguished by its color, which ranges from orange to brown, whereas that of the underlying Subunit IB is white to light gray. Within Subunit IA, a color gradation exists from gray-ish orange (10Y 7/4, 10Y 7/3) and pale yellowish brown (10Y 6/2) in the topmost meter of the sediment column to very pale orange (10Y 8/2) in the remainder of the subunit.

There are several distinct beds within Subunit IA that differ in color, grain size, and composition. The beds are generally separated from each other by sharp contacts. The foraminifers vary in abundance from 5 to 75% and usually form about 25% of the sediment (estimated from smear slides; see Fig. 5). High abundance (75%) was seen only in Sample 588B-1-4, 115-150 cm, which contains the coarsest sediment found at Site 588. Calcareous nannofossils comprise the bulk (25 to 95%) of the remaining sediment. Noncarbonate components in this subunit include traces of quartz, feldspar, heavy minerals, and sponge spicules.

The preliminary interpretation is that Subunit IA is an oxidized and winnowed facies. The sharp color contrast that separates Subunit IA from underlying Subunit IB represents a fundamental change in diagenetic environment as well as in sedimentological environment. Increased current caused winnowing and concentrated the foraminifers. As a result of the coarser grain size, oxidation of organic matter in these sediments was complete within 7 m of the seafloor.

Subunit IB comprises much of the sediment column at Site 588 (6.5 to about 250 m). It is predominantly a foraminifer-bearing nannofossil ooze; rarely, it is a foraminifer-nannofossil ooze or a nannofossil ooze. It is distinguished from underlying Subunit IC by its softness: Subunit IC is a chalk. Subunit IC grades from soft ooze at its top to firm ooze at about 150 to 180 m (Holes 588 and 588B, respectively) to chalk at about 215 to 260 m (Holes 588 and 588B, respectively). Foraminifer abundances typically vary between 5 and 25% in both subunits. Siliceous microfossils are almost entirely absent. The only noncarbonate components that occur in greater than trace amounts are volcanic ash and iron sulfide minerals. The changing abundance of these components is responsible for the overall color changes within Subunits IB and IC. The volcanic ash imparts a green color to the normally white sediment, in shades from very light greenish gray to dark bluish green. The iron sulfide imparts a gray color to the sediment, in shades varying from very light gray to dark gray. Because these components are generally less than 10% in abundance, the light colors prevail.

Sedimentary structures in Subunits IB and IC include bedding and burrowing features. Some beautiful examples of Zoophycos and Chondrites burrows occur throughout this unit, as do a number of circular or ovoid (0.5– 3.0 cm across) burrow sections and mottles. Some flaser-



Figure 4. Lithostratigraphy of Site 588. Recovery in black. HPC = hydraulic piston cored, RC = rotary cored.

like bedding is apparent within Subunit IC (Sections 588C-5-3 and 588C-18-1).

Disseminated volcanic ash or glass is present throughout Subunits IB and IC. Glass occurs as ovoid bubbles and as angular shards in the uppermost parts of the unit (e.g., 588-4-1, 81 cm). In addition, thin (0.5-15 mm thick), light greenish gray laminae, possibly composed of altered volcanic ash, are common below about 160 m sub-bottom to the base of the unit. These layers almost exclusively occur in singlets, doublets, and triplets within about 2 cm of section. Furthermore, the layers occur throughout the section with quasi-regular frequency.

Iron sulfide minerals have been diagenetically formed throughout the unit as a result of mild degrees of microbial sulfate reduction. These minerals occur in blebs, pockets, and burrows. Small, solid tubes (1 to 2 mm in diameter, several cm long) of black iron sulfide fill many of the small burrows. One large (3 to 5 cm) pyrite nodule in Section 588-17-2 containing well-formed pyrite crystals is a burrow fill. A close stratigraphic association ocTable 2. Lithostratigraphy at Site 588.

Lithologic units		Cores ^a	Sub-bottom depth (m)	Description	Age
IA	*	1-2 1B	0.0-6.6 0.0-6.8	Grayish orange to yellowish brown (oxidized), foraminifer-bearing nannofossil ooze	Quaternary
IB		2-24 1A 1B-29B	6.6-226.4 236.0-245.6 6.8-253.0	White to light gray, fora- minifer-bearing nanno- fossil ooze to nannofos- sil ooze	Quaternary to middle Miocene
IC		25 2A-18A 29B-31B 1C-18C	226.4-236.0 245.6-344.4 253.0-277.4 305.7-469.0	White to light gray to light greenish gray, foramini- fer-bearing nannofossil chalk to nannofossil chalk	middle Miocene to late Oligocene
П		18C-19C	469.0-488.1	Light greenish gray, siliceous foraminifer-bearing nannofossil chalk and chert	middle Eocene

a Letters following core number refer to the hole from which core is taken.

curs between iron sulfide and light greenish gray ash(?) layers. In most instances, iron sulfide streaks occur below these layers (but not often above them). This association suggests that the ash(?) layers are a source of iron during diagenesis.

Hole 588A was terminated at about 335 m (Core 588A-18) when the HPC ceased to penetrate, possibly because chert was present. A fist-sized nodule found in Section 588A-18-2 was the only occurrence of chert in Unit I. No chert was found during rotary drilling at an equivalent depth in Hole 588C.

One of the most controversial shipboard sedimentological problems encountered at Site 588 centers on the origin of the microfaults and slickensides observed in Cores 588C-3 through 588C-5. In this interval there are several faults with apparently normal dip-slip offsets of 5 to 10 mm, usually occurring along highly angled surfaces (about 60°). The faces of these surfaces are often slickensided and occasionally mineralized by iron sulfide and possibly rhodochrosite. Two hypotheses for their origin prevail: either the features were produced naturally by tectonism, or the features were produced artificially by drilling. One argument favoring the tectonic origin of these features is the known Neogene tectonism in nearby areas. For example, the Leg 90 water gun seismic profiles illustrate active graben formation extending to Recent times in an area 170 n. mi. north of Site 588. The healed microfaults are also strong evidence for the tectonic origin of most of these features. On the other hand, the interval is quite disturbed by rotary drilling, and a number of cracks are clearly artificial.

Unit II consists of siliceous foraminifer-bearing nannofossil chalks and foraminifer-bearing cherts. This unit was encountered only at the bottom of Hole 588C, and less than one meter of it was recovered. This lithostratigraphic unit is characterized by the presence of siliceous sponge spicules, diatoms, and diagenetic chert. This unit coincides with Unit 2 of DSDP Site 208 (Burns, Andrews, et al., 1973). The color varies from light greenish gray to grayish yellow green. A few burrows occur in samples from Core 588C-19.

PHYSICAL PROPERTIES

Standard DSDP methods (Boyce, 1976; Boyce, 1977) were employed for the measurements of physical properties at Site 588 (see Introduction and Explanatory Notes for specific techniques). The properties measured include sonic velocity, thermal conductivity, and calcium carbonate content. Wet-bulk density, grain density, and porosity were determined by gravimetric analyses, and saturated bulk density was also measured by GRAPE. All of the properties are analyzed and cross-correlated in detail by Morin (this volume).

The values of GRAPE porosity are derived from the GRAPE saturated bulk density results, assuming a grain density of 2.691 g/cm³. This is a reasonable approximation, since the percentage of $CaCO_3$ in the sediments is very high (Fig. 6A). The porosity data are plotted versus depth (points) in Figure 6B, and are subsequently averaged across each meter (solid line). GRAPE porosity for Holes 588 and 588A is compared with that for Holes 588B and 588C in Figure 6C.

Compressional wave velocities demonstrate a sharp increase at the beginning of Hole 588C (Fig. 6D). These data are correlated with those of Figure 6C in an effort to establish a relationship between P-wave velocity and porosity (Fig. 6E). Combining the GRAPE bulk density profile with the sonic velocity values provides a plot of impedance versus depth (Fig. 6F). This latter figure depicts a smooth, gradual increase in impedance through the 488 m of the sediment column.

SEISMIC STRATIGRAPHY

Figure 7 illustrates portion of the shipboard water gun seismic profile collected during the approach to Site 588. Five acoustic units (A, B, C, D, and E) have been identified, analogous to acoustic Units A to E of Willcox et al., 1980. Acoustic units are correlated with the lithology of Site 588, Units I and II.

Acoustic Unit A appears as an acoustically transparent layer at frequencies recorded on the seismic profile. Faint, coherent reflections occur down to 0.1 s⁴ sub-bottom.

Acoustic Unit B (the "chaotic" unit of Willcox et al., 1980) exhibits diffuse, sometimes coherent but generally chaotic reflections. A more reflective zone that occurs between 0.37 and 0.42 s sub-bottom can be traced for some tens of miles to the north on the underway water gun seismic profile.

Acoustic Unit C, comprising high-amplitude, relatively coherent reflectors, is a unit which can be identified throughout the region. The boundary between Unit C and overlying Unit B is relatively sharp. On the Lord Howe Rise, adjacent to and some 160 mi. north of Site 588, the water gun profile shows major graben structures which appear to contain Unit C downfaulted into the grabens.

Acoustic Unit D comprises a high-amplitude, relatively coherent set of reflectors with an appearance similar to that of Unit C. Overlying basement lows (possible graben structures), Unit D is separated from overlying Unit C by a lenticular low-amplitude graben-filling seismic unit (Fig. 7).

Acoustic Unit E is a low-amplitude (relatively transparent) zone overlying acoustic basement, a relationship

⁴ Depths quoted in text as seconds below seafloor have been measured below Site 588.



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Core-Section (level in cm)	Foraminifers	Nannofossils	Radiolarians	Diatoms	Sponge spicules	Silicoflagellates	Fish debris	Quartz	Feldspars	Heavy minerals	Liaht	volcanic glass	Dark	volcanic glass	Glauconite	Clav minerals		Other		Palagonite	Zeolites	Amorahoun	sublidinitie	Fe-Mn	micronodules	Pvrite		Recrystallized	silica	Carbonate	(nusbecilien)	Carbonate	
1-2,83					t	Ш	Ш			Ш	TH	Π	Π	П	III		Π	Ш			П	Π		Ш	Π	t	Π	Π		П	Π	Ш]
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14-1,96							 	t	111	t	ttt	tt	Ħ	11	111	111	Ħ	ttt	tt		Ħ	Ħ	T	III	Ħ	t	Ħ	T	Ш	TT.	Ħ	ttt	1
15-1,74							1111	111	111	HH	t	tt	ttt	Ħ	111	111	Ħ	ttt	T		Ħ	Ħ	T	III	tt	TT	Ħ	П	Ш	T	Ħ	TT	1
16,CC, 8								t	t		t	T	Ш	T	TH		T	Ш	T			Π	T	Ш	Π	Ш	П	Π		T	П	TT	
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12-3, 52								t		t		T			TH	111	T	III	11						Π	t	T	T	\square	T	Π	TT	1
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Dominant lithology, Hole 588A

Figure 5. Smear slide summaries, Holes 588A, B, C.

which is not particularly evident in Figure 7. Similar to the transparent zone between Units C and D, Unit E appears to be a graben-filling unit, showing an onlap relationship with basement. This unit is poorly represented or entirely absent over structural highs, where the highamplitude zones of Units C and D tend to coalesce.

Acoustic basement below Site 588 is inferred to lie at about 0.77 s sub-bottom.

Site 588 was drilled to a total depth of 488.1 m (Hole 588C). The stratigraphic section is divided into two lithologic units.

Unit IA is an oxidized foraminifer-bearing nannofossil ooze of Quaternary age, restricted to the uppermost 6.8 m of section. Unit IB is a light-colored foraminiferbearing nannofossil ooze to nannofossil ooze, ranging in age from Quaternary to middle Miocene. Unit IC is a middle Miocene to upper Oligocene foraminifer-bearing nannofossil chalk to nannofossil chalk. Unit II comprises a siliceous foraminifer-bearing nannofossil chalk and chert.

An interval velocity of 1700 m/s has been determined by averaging shipboard velocimeter mesurements on cores. The stratigraphic column in Figure 7 has been prepared using this velocity value. However, no positive correlation is apparent between acoustic and lithostratigraphic units, with the possible exception of the Eocene/Oligocene boundary. This boundary is obscured by an interval of strong reflections in the vicinity of Site 588, but the left-hand extremity of the profile on Figure 7 shows a reflector which, on extrapolation to the site, may rep-

Trace t <5% rare 5-25% common 25-50% abundant >50% dominant

Dominant lithology: Hole 588B

		Biog	genic	con	npon	ents			N	onbio	gen	ic c	omp	one	nts			A	uthig	enic (comp	oon	en	ts			٦
Core-Section (level in cm)	Foraminifers	Nannofossils	Radiolarians	Diatoms	Sponge	Silicoflagellates	Fish debris	Quartz	Feldspars	Heavy minerals	Light	volcanic glass	volcanic glass	Glauconite	Clay minerals	Other	Palagonite	Zeolites	Amorphous iron oxides	Fe-Mn micronodules	Pyrite	Recrystallized	silica	Carbonate	(unspecified)	Carbonate	rhomos
1-1, 28			Ш	Ш	t	Ш	ШП	Ш				Ш	Ш	TIT		Ш	Ш	Ш	Ш	Ш		П	Щ				П
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Figure 5. (Continued).

Dominant lithology, Hole 588C

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Core-Section (level in cm)	Foraminifers	Nannofossils	Radiolarians	Diatoms	Sponge	sbicnies	Silicoflagellates	Fish debris		Quartz		Feldspars	2	Heavy minerals	Light	volcanic glass	Dark	volcanic glass	Glauconite		Clay minerals		Mica		Palagonite	r	Ceolites	Amorphous	iron oxides	Fe-Mn	micronodules	Pvrite		Recrystallized	silica	Carbonate	(unspecified)	Carbonate	rhombs
1-2.80									t				t	Π	Π	Π			П	Π				Π	Π	Π	Π	Π	Π	Π	Π				Π		П	Π	\square
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2-1,74			111	111	111	Ш	1		1	11		11	t	11	11	1			11	11	11		11	11	11	11	Ш	11	11	11		t		4	Щ	#	Щ	44	1
2-2,60			111	111	111	Ш	11	111	1	11	11	11	t	11	11	1	11		11	44	111	1	11	11	11	11	11	11	11	11	11	t	-	4	44	4	4	11	44
2-6, 53			1111		111	Ш	11	111				11	t	11	11	11	11		1	11	111		11	11	11	44	11	44	Щ	11	11	t		4	Щ.	#	11	44	11
3-1,80			1111		111	Ш	4	111	t		11	11	1	11	t	1	11		11	Щ	11		11	44	11	44	11	11	11	11	1		+	4	Щ	#	Щ	44	11
4-2,60			1111		111	Ш	1	111	1		t	11	t	11		1	11			11				11	++	11	#	#	Щ	#	11		+	11	#	#	Щ	#	Щ.
5-3,96					111-	Ш	44	\downarrow	1	11	11	11	##	11	11	11	11			44	111	-	11	44	++-	4	#	#	#	#		t	+	4	#	#	#	++	#
5-5, 50					+++	111	++-	$\downarrow \downarrow \downarrow$	t	11	11	11	#	11	11	Щ.				11	111	4	-11	11	+++	#	#	#	11	11-			+	4	#	₽	11	₩	#
6-3, 131					+++	111	++-	++++	t			++	₩	++	11	4	++-			44	+++		++	++	++	₩	₩	₩	₩	#			+	4	#	₩	₩	₩	
6-5, 100					+++	Ш	++-	+++-	-		t	₩	₩	++	t	1			++	#			++	++	++	₩	#	₩	#	#			+	++	#	#	₩	₩	++-
7-1,70			++++	+++	+++	Ш	++-				t	++	₩	++	++	#	++-			++	+++	-	++	+	++	₩	₩	₩	₩	++-		H	+	++	4	₩	₩	₩	++-
B-2, 70			-+++		+++		++-	+++-		++	H	₩	₩	++	++		++		++	H	+++		++	₩	₩	₩	₩	₩	₩	₩	++	H	+	+	₩	₩	₩	₩	++-
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12-1,70			++++		111	H	++	+++	H	+++	H	++	+	++	1	H	++	+	++	H	H		++	╫	+	H	H	H	H	H	H	H	+	H	H	H	H	H	H
14-3 60			++++	++++	•	+++	++	+++	╟	++	H	₩	Ĥ	++	+	H		+	++	H	H		++	Ħ	++	Ħ	₩	H	Ħ	Ħ	H		+	H	H	H^{+}	H	Ħ	++-
15-1 70			+++	$\left \right \right $	r H	H	++	+++	H	H	Ħ	Ħ	Ħ	Ħ		H	H	H	++	Ħ	H		++	Ħ	$^{++}$	Ħ	Ħ	H	Ħ	Ħ	H		+	H	Ħ	H	Ħ	Ħ	Ħ
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18-1.50			++++		 	11	++-		H	Ht	Ħ	Ħ	Ħ	Ħ	Ħ	Ħ	H			Ħ	Ħ		++	Ħ	11	Ħ	tt	Ħ	Ħ	Ħ	Ħ		T	H	tt	Ħ	Ħ	Ħ	Ħ
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5-3, 52					111	Ш	1	111		4	t	11	11	11	t	Ц	11		Ш	11	11		44	Щ	11	11	Ш	11	Щ	11	11	t	4	11	11	Ш.	Щ	Ш	Щ.
6-3, 51					111	111	11	Ш				4	11	11			1		11	11	11		11	11	11	#	11	#	11	11	11			4	11	#	11	44	4
6-3, 149			111	1111	111	Ш	11	Ш	t		t	11	11	11		4	Ш.		Ш	Щ	Ш.		11	11	11	Ш	44	11	Щ	11	1			4	Щ	#	Щ	#	#
12-5, 100			111	1111	111	111	11	Ш	4	11		11	t	11		4	11	11	t	11	11		-11	11	11	11	11	11	Щ	11	11	Ш	-	4	11	44	11	44	#
13-2, 50			111		111	111	11	111-	t		11	11	11	11	t	11	11		11	11	11			44	44	#	#	11	44	#	11		+	4	μ.	44	44	44	#
13-2,61			444	444	111	Ш	1	Ш	t		t	11	11	11	t	11	11		11	11	11			Щ	11	11	Ш	Щ.	Щ	11	11		+	11	11	#	Щ	#	щ
13-3, 75					111		1	Ш	1	11		11	t	11	11	11	44		11	11	11		11	11	11	Ш	11	11	11	11	11		-	11	11	#	Щ	#	4
13-6, 29					Ш	Ш		Ш	Ш			11	11	11	ш	Ш	Ш	Ш	Ш	\downarrow			Ш	Ш	11	Ш	Ш	11	Ш	11	Ш.				Ш	11	Ш	Ш	1
14-3, 146			111			111	11	111	t		\square	11	11	11						11	11		11	1	11	11	11	11	11	11	1		1	4	11	#	11	11	11
15-3, 65					t	111			t	11	11	11	11	11	Ц.		11		11	11			11	11	11	11	11	11	11	11	1		1		11	11	11	#	4
16-2, 117			111	111	111	111				11	t	11	11	$\downarrow \downarrow$			11		11	11	11		11	11	11	11	#	11	11	11	1		4	1	11	11	11	#	1
17-3, 47			111		\square	11		111		11	t	11	11	11	t		11		11	11	11		11		11	11	11	11	11	11	11	t	4		11	11	Ш	11	11
19-1, 54						Ш		Ш	Ш		Ш	Ш	t	Ш	11	11	1		Ш	Ш			Ш	Ш	Ш	Ш	Ш	Ш	Ш	Ш	Ш	Ш		Ц	Ш	Ш	Ш	Ш	Ш

Figure 5. (Continued).

resent the onset of chert development in the middle Eocene; this in turn may correlate with the boundary between acoustic Units C and D.

BIOSTRATIGRAPHY

A complete calcareous sequence from the late Oligocene through Recent was recovered from the four holes drilled at Site 588. It is underlain by a siliceous-calcareous sequence of middle Eocene age from which it is separated by a disconformity at approximately 470 m subbottom. The deepest hole, Hole 588C, was terminated at 488.1 m BSF in middle Eocene sediments. The completeness of the sequence, which is far superior to that in Hole 208, drilled on Leg 21, resulted in a very detailed planktonic foraminifer and calcareous nannoplankton zonation, and has provided material for an evaluation of the paleoenvironmental history of warm subtropical waters of the southern hemisphere during the late Oligocene to Recent. The calcareous sediments between 0 and about 470 m contain exclusively foraminifers, calcareous nannoplankton, calcareous dinoflagellates (calcispheres), and at certain levels also ostracodes and pteropods. Below the disconformity at 470 m, down to the terminal depth of 488.1 m, foraminifers and calcareous nannoplankton are associated with diatoms, radiolarians, silicoflagellates, ebridians, and sponge spicules in the middle Eocene.

Preservation of the calcareous fossils is excellent in the upper part of the sequence, and is fairly good for the foraminifers as well in the lower part of the calcareous sequence, where calcareous nannoplankton show considerable calcite overgrowth, especially in the upper Oligocene sediments. Preservation is good again for the calcareous nannoplankton in the middle Eocene, where the sequence contains a considerable amount of siliceous constituents. Calcareous nannoplankton and planktonic foraminiferal zones in the four holes of Site 588 are correlated in Figure 8.

Foraminifers

Planktonic Foraminifers

Zones

The zonal scheme used at Site 588 has been adapted from Kennett (1973) and Srinivasan and Kennett (1981a, b) (Fig. 9). The following changes have been made.

Globorotalia puncticulata Zone: It appears that the zonal marker made a late appearance at Site 588 as compared to the temperate sites of the southwest Pacific where it evolved; its immediate ancestor Globorotalia sphericomiozoa is not present.

Globorotalia plesiotumida Zone: At Site 588 G. conomiozea with a squarer outline in peripheral view made a late appearance within the range of the G. margaritae Zone and so the G. conomiozea Zone of Kennett (1973) and Srinivasan and Kennett (1981a, b) was not used. The G. plesiotumida Zone of the late Miocene is therefore equivalent to the lower part of their G. conomiozea Zone and the entire Globigerina nepenthes Zone.

Globorotalia fohsi s.l. Zone is equivalent to the upper part of the Orbulina suturalis Zone of Kennett (1973) and to the Globorotalia fohsi s.l. Zone and the G. peripheroacuta Zone of Srinivasan and Kennett (1981a, b). The main reason for "lumping" the zones together was the difficulty in consistently identifying the keeled G. fohsi in the upper part of the G. fohsi s.l. Zone at Site 588.

The following zones have been added to the lower part of the sequence in the Oligocene.

Globigerina angulisuturalis Zone: This is a gap zone, with the base defined by the extinction of *Chiloguembelina cubensis* and the top by the first appearance of *Globorotalia kugleri*.

Chiloguembelina cubensis Zone: The top is defined by the extinction of the zonal marker and the base is undefined. The index species G. munda is present in the zone.

Faunas

Globorotalia truncatulinoides Zone: The zone fossil is common, as are Globigerina calida, Globorotalia inflata, G. menardii, G. tumida, and Pulleniatina obliquiloculata.

Globorotalia truncatulinoides-G. tosaensis Zone: The zone is marked by the overlap of the two zonal taxa, which are common in the zone. Other common species include G. inflata and Neogloboquadrina dutertrei.

Globorotalia tosaensis Zone: The zone fossil is abundant. There is evidence at the base of the zone of its evolution from G. crassaformis. Other important species in the zone include *P. obliquiloculata* and *G. menardii; Globigerinoides extremus* and *Dentoglobigerina altispira* became extinct in the lower part of the zone.

Globorotalia inflata Zone: The zone fossil is well represented in the zone, but its entry at the base was probably late compared with its evolutionary appearance further south in the southwest Pacific. Other species present include Globorotalia menardii, G. crassaformis, and Neogloboquadrina dutertrei.

Globorotalia crassaformis Zone: The zone fossil made a late appearance compared with its evolutionary appearance further south; other species present in the zone, included *Globorotalia pliozea*, which became extinct in the lower part of the zone, and *Globigerina nepenthes*.

Globorotalia puncticulata Zone: The zone fossil is rare in the zone and occurred with G. crassaformis, G. tumida, and P. primalis.

Globorotalia margaritae Zone: This zone is well represented with excellent faunas which include the zone fossil. Globorotalia cibaoensis became extinct within the zone and P. primalis made its entry in the lower part of the zone.

Globorotalia plesiotumida Zone: The zone fossil is comparatively rare. This was especially true in the lower part of the zone; other species in the zone include G. miotumida and G. menardii.

Neogloboquadrina continuosa Zone: The zone fossil is fairly rare within the zone and became extinct at the top of the zone; other important species include Candeina nitida, Globigerinatella aequilateralis, and N. nympha, the probable immediate ancestor of N. acostaensis; Globoquadrina dehiscens became extinct within the zone.

Globorotalia mayeri Zone: The zone fossil is fairly rare within the zone, which marks the first appearance of Neogloboquadrina; other species present include G. menardii, G. miotumida, and G. panda.

Globorotalia fohsi s.l. Zone: The zonal markers include G. peripheroacuta and G. fohsi s.l.; the latter form occurs sporadically throughout the zone. Both G. miotumida, G. panda, and G. menardii made their first appearance within the zone, whereas G. miozea became extinct.

Orbulina suturalis Zone: The zone fossil is common within the zone. Also present are *G. peripheroronda* and *G. miozea*.

Praeorbulina glomerosa curva Zone: The zone fossil is common within the zone, in association with G. praescitula, G. miozea, and G. siakensis.

Globorotalia miozea Zone: The zone fossil is common within the zone; other taxa include Globoquadrina dehiscens, Globorotalia praescitula, and G. peripheroronda, which made its initial appearance in the zone.

Catapsydrax dissimilis Zone: The zone fossil is common in the zone and occurs in association with G. semivera and G. siakensis.

Globoquadrina dehiscens Zone: The zone fossil is common within the zone and occurs in association with Globigerinoides primordius, G. altiaperturus, and Globorotalia kugleri.

Globigerinoides primordius Zone: The zone fossil is rare and occurs with Globigerina woodi, Globorotalia



Figure 6. Physical properties, Site 588. A. Carbonate content versus sub-bottom depth for Site 588. B. GRAPE porosity versus sub-bottom depth for Holes 588B and 588C. C. GRAPE porosity versus sub-bottom depth for Holes 588, 588A, 588B and 588C. D. Compressional velocity versus sub-bottom depth for Site 588. E. Porosity versus compressional velocity for Site 588. F. Acoustic impedance versus sub-bottom depth for Site 588.



Figure 6. (Continued).



Figure 7. Comparison of acoustic Units A-E with lithologic Units I-II cored at Site 588; shipboard water gun seismic profile, collected during site approach; depths in meters estimated by assuming a sediment sound velocity of 1700 m/s.

kugleri, and Globoquadrina sp., the possible ancestor of G. dehiscens.

Globigerina angulisuturalis Zone: The zone fossil is common within the zone. The related species Globigerina ciperoensis is very rare. Other species present include G. euapertura, Globorotalia nana, Globorotaloides suteri, and Globorotalia testarugosa.

Chiloguembelina cubensis Zone: The zone fossil is common and occurs with G. munda; G. opima is rare.

Paleobiogeography

The late Oligocene yields a cosmopolitan fauna with an element of the southern cooler-water species such as *Globigerina woodi* and *Globorotalia munda*; the fauna lacks *Globigerina ciperoensis* and there are only a few specimens of *Globorotalia opima*.

The early Miocene was dominated by cooler-water southern taxa such as G. zealandica and G. miozea and marked by the absence of such warm-water forms as Catapsydrax stainforthi, Globigerinatella insueta, and Hastigerinella bermudezi.

The middle Miocene keeled *Globorotalia* fauna is dominated by the *G. miotumida* group and to a much lesser extent by *G. menardii*; the tropical *G. fohsi lobata* and *G. fohsi robusta* are absent. The late Miocene appears to have been cooler, because of the predominance of the southern *G. miotumida* group and the absence of such species as *Pulleniatina primalis*.

There was a marked change in fauna at about the Miocene/Pliocene boundary; G. conomiozea with a squarer outline in peripheral view became extinct and the tropical G. tumida appeared.

The Pliocene-Pleistocene forms were a mixture of warm subtropical-tropical species such as G. tumida, G. menardii, and P. obliquiloculata with a minor coolerwater element represented by G. inflata and Neogloboquadrina pachyderma.

Major Stratigraphic Boundaries

At this site the major boundaries were marked by the following species.

1. Pliocene/Pleistocene boundary: first appearance of *Globorotalia truncatulinoides*.

2. Miocene/Pliocene boundary: Kennett (1973) and Srinivasan and Kennett (1981a, b) placed the boundary at the first appearance of *G. margaritae*, which coincided with the extinction of *G. conomiozea*. In Site 588 we have, instead, observed overlapping ranges of *G. margaritae* and a local morphotype of *G. conomiozea* and have placed the boundary after the extinction of *G. conomio*-



Figure 8. Biostratigraphy for Site 588. No radiolarians were encountered.

	Kennett (1973): warm subtropical zones	Srinivasan and Kennett (1981a, b)	This volume
	Globorotalia tr	uncatulinoides	G. truncatulinoides
Pleistocene	G. truncatulinoides— G. tosaensis	G. truncatulinoides— G. tosaensis	G. truncatulinoides— G. tosaensis
1.1.1	G. tosaensis	G. tosaensis	G. tosaensis
Pliocene	G. inflata	G. inflata	G. inflata
	G. crassaformis	G. crassalormis	G. crassaformis
early	G. puncticulata	G. puncticulata	G. puncticulata
1 1006116	G. margaritae	G. margaritae	G. margaritae
	G. conomiozea	G. conomiozea	
late Miocene	Globigerina	nepenthes	G. plesiotumida
10.00.00.00.00.00.00.00.00.00.00.00.00.0	Globorotalia continuosa	Neogloboquadrina continuosa	N. continuosa
middle	G. mayeri	G. mayeri	G. mayeri
Miocene	Orbuling	G. fohsi s.l.	C labeial
	Orbuina	G. peripheroacuta	G. TONST S.I.
	suturans	O. suturalis	O. suturalis
		Praeorbulina g	lomerosa curva
early	Globigerinoides	G. miozea	G. miozea
Miocene	trilobus	Catapsydra	dissimilis
		Globoquadrin	a dehiscens
		Globigerinoide	s primordius
lato		Globorotal	a kugleri
Oligocene			G. angulisuturalis
engesene -			Chiloguembelina cubensis

Figure 9. Planktonic foraminiferal zones used at Site 588.

zea. This level also coincides with the first appearance of G. tumida.

3. Oligocene/Miocene boundary: first appearance of *Globoquadrina dehiscens* as in Srinivasan and Kennett (1981b, 1983).

Benthic Foraminifers

Benthic foraminifers were examined in aliquots of the fractions less than 63 μ m in core catchers from Holes 588, 588A, and 588C (Table 3). The benthics are well preserved in most core catchers down to the lower Miocene (Section 588A-2 through Sample 588A-18,CC and 588C-8 through 588C-19,CC). Below this point diagenetic alteration of the sediments has removed nearly 50% of the coarse fraction and, in the lower samples, a large percentage of the intermediate size-fraction as well.

From the top of the section down to the middle Miocene, faunas are very similar; they are dominated by species of Oridorsalis, Globocassidulina, Pullenia, and Melonis. Diversity varies from a high of 25 species in the late Pliocene (Sample 588-6,CC) to a low of four species in a rich plankton ooze at the base of the Globorotalia plesiotumida Zone (Sample 588-19,CC). In general, both the diversity of the benthic faunas and the abundance of benthic specimens in the aliquots decrease down the section as the preservation of the carbonates worsens.

In the Pliocene (Samples 588-4 through 588-15,CC) there are three episodes of marked faunal change. In the *G. inflata* Zone (equivalent to the NN15/NN16 boundary in Sample 588-6,CC) there occurs a marked increase

in both diversity and faunal abundance and many species disappear from the faunas. These include Anomalinoides semipunctata, Cibicides lobatulus, Osangularia culter, Karreriella bradyi, Hopkinsina mioindex, and Stilostomella insecta. Two of these species. O. culter and A. semipunctata, are very rare at this site, appear for a short time only in the lower and mid-Pliocene, and then disappear. Both O. culter and A. semipunctata were found at the shallow Site 587, but not at the deeper Site 586. Their presence at the initiation of the glacial Pliocene at Site 588 may represent downward migration of these species and/or increased downslope movement of sediments.

A second episode of increased faunal abundance (Sample 588-8, CC) in the G. crassaformis Zone is accompanied by the unusual appearance of two species, Pullenia quinqueloba and Melonis pompiliodes, which are typical of the faunas at the deeper Site 586, but do not appear in the faunas from the shallow Site 587. The rare appearances of these species, as in Sample 588-8, CC, may indicate upward migration of benthics because of some ecologic change. The proportions of other species in the samples need to be counted to test this idea.

In the top of the *G. margaritae* Zone (Sample 588-10,CC), there is an episode of faunal overturn involving the upward disappearance of several important species: *Ehrenbergina pacifica, Uvigerina spinulosa,* and *Rectuvigerina multistriata,* among others. At the shallower Site 587, *R. multistriata* disappears later, at the beginning of the glacial (= NN15/NN16).

In the Miocene there are also three episodes of marked faunal change: at the base of the *Neogloboquadrina continuosa* Zone, in the *G. fohsi* s.l. Zone, and in the *G. miozea* Zone. Otherwise the Miocene faunas are very consistent. Diversity and faunal abundance are consistent except in those poorly preserved samples lower in the section. Very few new species appear above the base of the middle Miocene.

Toward the base of the N. continuosa Zone (Cores 588-21 through 588-23) there is a second influx of M. pompilioides, P. quinqueloba, and several other species suspected of representing a deeper faunal influence. There is no apparent change in benthic diversity or abundance during this faunal change.

Faunal changes in the G. fohsi s.l. Zone (Samples 588A-2 through 588A-9 and 588C-1 through 588C-9) are difficult to evaluate because carbonate preservation worsens in this zone. Diversity and faunal abundances are generally lower than in overlying samples. The character of faunas alters slightly because *Ehrenbergina* spp., small virgulinids, large nodosarids and *Quinqueloculina* increase in abundance upward. The significance of these forms is not known. In addition, several species disappear from the faunas at this time; these include *Heterolepa trinitatensis, Siphonodosaria modesta, Bulimina tuxpamensis, B. semicostata*, and *Cibicidoides* sp. Upward migration of benthic species is not evident in the material seen so far.

The elimination of typical Eocene–Oligocene benthic species occurs in the base of the *G. miozea* Zone (588A-15 to 588A-16,CC). In these samples both faunal abundance and diversity are highest for the early Miocene. Species which terminate in this zone are *Planulina renzi*, *Sipho*-

nina pulchra, H. hunteri, B. jarvisi, O. mexicana, and Plectofrondicularia sp.

The lowermost Miocene and the Oligocene at Holes 588A and 588C cannot be compared with overlying sediments because of the degree of dissolution in the older samples. In both holes sediments of this age have lost nearly 50% of their coarse fractions, including a large percentage of benthic species. In the Oligocene (588C-9 through 588C-17,CC) the intermediate size-fraction is also largely missing. Glauconite is occasionally present and a large proportion of the fossils are fragmented. Benthic species present include Oridorsalis umbonatus, Globocassidulina subglobosa, C. tuxpamensis, Pullenia coryelli, B. semicostata, and P. quadriloba.

Calcareous Nannoplankton

Core-catcher samples along with enough additional samples to determine zonal boundaries were examined for calcareous nannoplankton. All zonal indicators are present, with the exception of *Helicosphaera ampliaperta*. The upper boundary of the *Helicosphaera ampliaperta* Zone (NN4) is determined instead by the first occurrence of *Discoaster exilis*. Calcareous nannoplankton are abundant and well preserved throughout the upper part of the section.

Hole 588

Pleistocene

The presence of *Emiliania huxleyi* in Sample 588-1-1, 85-86 cm places this sample in the late Pleistocene *Emiliania huxleyi* Zone (NN21). Sample 588-1-2, 85-86 cm is placed in the late Pleistocene *Gephyrocapsa oceanica* Zone (NN20). The presence of *E. ovata* and the absence of *Calcidiscus macintyrei* in Samples 588-1-3, 85-86 cm and 588-1,CC place these samples in the upper subzone of the early Pleistocene *E. ovata* Zone (NN19b). The addition of *C. macintyrei* in Samples 588-2-1, 85-86 cm to 588-3-4, 0-1 cm places these samples in the lower subzone of the *E. ovata* Zone (NN19a).

Pliocene

The last occurrence of *Discoaster brouweri* in Sample 588-4-2, 0-1 cm and the last occurrence of *D. pentaradiatus* in Sample 588-3, CC place Samples 588-3-5, 0-1 cm and 588-4-1, 0-1 cm in the late Pliocene *Discoaster brouweri* Zone (NN18). The presence of *D. brouweri* together with *D. pentaradiatus* in Sample 588-4-2, 0-1 cm places this sample in the late Pliocene *D. pentaradiatus* Zone (NN17).

The last occurrence of *Reticulofenestra pseudoumbilica* in Sample 588-6-6, 0-1 cm places Samples 588-4-3, 0-1 cm to 588-6-5, 0-1 cm in the late Pliocene *Discoaster surculus* Zone (NN16). Samples 588-6-6, 0-1 cm to 588-9-2, 0-1 cm, above the last occurrence of *Amaurolithus tricorniculatus*, are placed in the early Pliocene *Reticulofenestra pseudoumbilica* Zone (NN15). The interval from Sample 588-9-3, 0-1 cm to the first occurrence of *D. asymmetricus* in Sample 588-11-1, 0-1 cm is placed in the early Pliocene *D. asymmetricus* Zone (NN14). The interval from Sample 588-11-2, 0-1 cm to

the first occurrence of *Ceratolithus rugosus* in Sample 588-11-3, 0-1 cm in placed in the early Pliocene *Ceratolithus rugosus* Zone (NN13). The early Pliocene *Amaurolithus tricorniculatus* Zone (NN12) includes Samples 588-11-4, 0-1 cm to 588-12-1, 0-1 cm above the last occurrence of *D. quinqueramus*.

Miocene

The last occurrence of *Discoaster quinqueramus* in Sample 588-12-2, 0-1 cm and the first occurrence of *Amaurolithus primus* in Sample 588-18-3, 0-1 cm places Samples 588-12-2, 0-1 cm to 588-18-3, 0-1 cm in the upper subzone of the late Miocene *Discoaster quinqueramus* Zone (NN11b). The interval from Sample 588-18-4, 0-1 cm to the first occurrence of *D. quinqueramus* in Sample 588-20-7, 0-1 cm is placed in the lower subzone of the late Miocene *D. quinqueramus* Zone (NN11a). Samples 588-20,CC to 588-23-4, 0-1 cm, above the last occurrence of *D. hamatus*, are placed in the late Miocene *D. calcaris* Zone (NN10).

The middle Miocene *D. hamatus* Zone (NN9) includes Samples 588-23-5, 0-1 cm to 588-25-3, 0-1 cm, based upon the occurrence of *D. hamatus*. The interval from Sample 588-25-4, 0-1 cm to the first occurrence of *Catinaster coalitus* in Sample 588-25-6, 0-1 cm is placed in the middle Miocene *Catinaster coalitus* Zone (NN8). Sample 588-25, CC is placed in the middle Miocene *D. kugleri* Zone (NN7). Hole 588 was terminated at a depth of 236.0 m BSF.

Hole 588A

Hole 588A continues downsection from where Hole 588 ended. However, the presence of Catinaster coalitus in Sample 588A-1-1, 0-1 cm suggests a slight stratigraphic overlap between the two holes, because its apparent first occurrence was in Sample 588-25-6, 0-1 cm. The middle Miocene Discoaster kugleri Zone (NN7) is continued from Sample 588A-1-2, 0-1 cm to the first occurrence of Discoaster kugleri in Sample 588A-2-4, 0-1 cm. The interval from Samples 588A-2,CC to 588A-8,CC, above the last occurrence of Sphenolithus heteromorphus in Sample 588A-9-1, 0-1 cm, is placed in the middle Miocene D. exilis Zone (NN6). the interval from Sample 588A-9-1, 0-1 cm to the first occurrence of D. exilis in Sample 588A-12, CC is placed in the middle Miocene Sphenolithus heteromorphus Zone (NN5). The early Miocene Helicosphaera ampliaperta Zone (NN4) includes Samples 588A-13, CC to 588A-15, CC, above the last occurrence of S. belemnos in Sample 588A-16, CC. The interval from Samples 588A-15,CC to 588A-17,CC, above the last occurrence of Triquetrorhabdulus carinatus in Sample 588A-18-1, 0-1 cm, is placed in the early Miocene S. belemnos Zone (NN3). Samples 588A-18-1, 0-1 cm and 588A-18,CC are placed in the early Miocene D. druggii Zone (NN2). Hole 588A was terminated at a depth of 344.4 m BSF.

Hole 588B

Hole 588B duplicates all of Hole 588 and the upper part of Hole 588A; therefore, only the 31 core-catcher samples were examined. The zonal boundaries (NN21/ NN6) encountered in this hole are essentially the same as those of Holes 588 and 588A. Hole 588B was terminated at a depth of 277.4 m BSF.

Hole 588C

Hole 588C stratigraphically overlaps the lower part of Hole 588A and begins with Sample 588C-1,CC in the middle Miocene Sphenolithus heteromorphus Zone (NN5). The interval from Sample 588C-2-1, 0-1 cm, below the first occurrence of Discoaster exilis in Sample 588C-1,CC to 588C-2-5, 0-1 cm above the last occurrence of Sphenolithus belemnos in Sample 588C-2-6, 0-1 cm is placed in the early Miocene Helicosphaera ampliaperta Zone (NN4). The presence of S. belemnos and the absence of Triquetrorhabdulus carinatus in the interval from Sample 588C-2-6, 0-1 cm to 588C-3-6, 0-1 cm places these samples in the early Micene S. belemnos Zone (NN3). The interval from the last occurrence of T. carinatus in Sample 588C-3, CC and the first occurrence of D. druggii in Sample 588C-5-1, 21-22 cm is placed in the early Miocene Discoaster druggii Zone (NN2). Samples 588C-5-2, 0-1 cm to 588C-10,CC, above the late Oligocene in Sample 588C-10-4, 0-1 cm, are placed in the early Miocene Triquetrorhabdulus carinatus Zone (NN1).

The Oligocene/Miocene boundary, taken at the base of nannoplankton Zone NN1 (*T. carinatus* Zone) was encountered at approximately 400 m sub-bottom in Hole 588C. The last occurrences of *Helicosphaera recta*, *Sphenolithus ciperoensis*, and *Zygrhablithus bijugatus* were found in the lower part of Core 588C-10. In 588C-17 S. *distentus* and S. *predistentus* occur together with S. *ciperoensis*, indicating the presence of Zone NP24 (Sphenolithus distentus Zone).

Sphenoliths are not very common in the late Oligocene at this site, but this may be the result of the poor preservation in certain levels. Z. bijugatus, which is known to occur in shallow water, is rather common in the entire late Oligocene. Rare reworked Eocene nannoplankton were found in most late Oligocene samples.

At the top of Core 588C-18, a disconformity was noted between the upper and middle Eocene. The Eocene assemblage, also present in the lowest Core 588C-19, contains, among others, *D. barbadiensis, Reticulofenestra umbilica, Chiasmolithus solitus, Neococcolithus dubius*, and *C. grandis*, indicating a position within nannoplankton Zones NP15 (*Chiphragmalithus alatus* Zone) and NP16 (*D. tani nodifer* Zone). In the late Oligocene, the calcareous nannoplankton is heavily overgrown by secondary calcite, discoasters showing alternating rays fused together and sphenoliths partly fragmented in certain levels. The preservation of calcareous nannoplankton in the middle Eocene is fairly good again, probably because siliceous biogenic constituents, are present.

Diatoms and Silicoflagellates

Diatoms and silicoflagellates were found only in the middle Eocene part of Hole 588C (Cores 588C-18 and 588C-19) and are associated with ebridians and sponge spicules. Diatoms are especially common in Core 588C-19, and include representatives of the genera *Triceratium*,

Actinoptychus, Trochosira, and Thalassiosira among the well-diversified assemblage. Silicoflagellates were encountered in several samples of 588C-19. The assemblage, containing Naviculopsis foliacea and Corbisema spinosa, can be placed in the middle Eocene Naviculopsis foliacea Zone.

Radiolarians

Radiolarians occur only in the middle Eocene part of Hole 588C (Cores 18 and 19).

PALEOMAGNETISM

All well-preserved core sections (i.e., those not fluid or obviously deformed) from Holes 588, 588A, and 588B were measured on the shipboard Digico long-core spinner magnetometer. Apart from the regions of higher intensity (discussed below), the signal was not sufficiently above the noise and contamination levels to give reproducible results in adjacent cores. Long-core measurements were discontinued after this site.

Holes 588, 588A, and 588C were subsampled at two specimens per section (usually), and Hole 588B at one specimen per section. Laboratory NRM measurements have been completed on Holes 588 and 588A (Barton and Bloemendal, this volume). Absolute orientations were attempted on most cores using the Kuster tool, with results as follows: for Hole 588, 21 attempts, 15 successes; for Hole 588A, 8 attempts, all successful; for Hole 588B, 16 attempts, 9 successes and 2 suspect results. This success rate is better than has often been obtained but still needs to be improved.

Intensities of magnetization were generally very low, though noticeably higher than for previous sites on this leg. NRM statistics for the sequence measured are presented in Table 3.

In common with other sites, there is a high-intensity zone $(1 - 15 \mu G)$, at the top of the sequence, but here it is longer, extending to the bottom of Core 588-4. Intensities then become extremely weak (typically 0.05 μ G), with high directional scatter down to Core 588-21 near the mid/late Miocene boundary. Below this, intensities increase monotonically to values of around 15 μ G at the bottom of the section. Prominent intensity spikes were common in the sequence. The most obvious ones in the subsample data are listed in Table 4. There was no general correlation between these "high" intensity spikes and the occurrence of ash layers and iron sulfide nodules. One exception was the prominent ash layer in Core 588-23-2, 145 cm. Iron sulfide nodules removed from various cores had only weak magnetic moments, sometimes barely higher than that of the surrounding sediments. This suggests that pyrrhotite, the only common ferromagnetic iron sulfide, is not a major component.

Table 3. NRM statistics at Site 588.

	Hole 588	Hole 588A
Geometric mean intensity (µG)	0.150	1.552
Scalar mean inclination	$-5.0 \pm 39.7^{\circ}$	$-6.7 \pm 51.6^{\circ}$ s.d.
Axial dipole inclination	- 44.4°	
Mean angle between repeats	4.6°	

Table 4. Prominent magnetization intensity spikes observed in Hole 588.

Core-Section	Depth	Intensity
(level in cm)	(m)	(μG)
2-1, 25	5.85	14.548
2-5, 100	12.60	3.275
4-5, 125	32.05	3.044
5-7, 125	44.65	1.368
9-1, 25	73.05	0.308
9-5, 25	79.05	0.283
11-3, 125	96.25	0.215
11-6, 25	99.75	0.383
12-6, 125	110.35	0.523
13-1, 25	111.45	0.916
13-2, 125	113.95	0.327
14-3, 25	124.05	0.468
14-6, 125	129.55	0.388
19-6, 125	177.55	0.443
21-3, 125	192.25	0.341
23-2, 25	208.95	1.642

Note: Other spikes were apparent in the long-core records.

It was possible to identify a polarity stratigraphy only down to the end of the Gilbert Chron (Fig. 10A). Below this, to the top of the high-intensity zone (around Core 588-22), directions were more scattered and no unambiguous polarity interpretation was possible. It may be possible to improve on this when results from the adjacent HPC become available. Below Core 588-21 it was again possible to identify a polarity stratigraphy (Fig. 10A), but it is not clear how this should be matched to the polarity time scale. The very long normal-polarity interval in Cores 588-24 and -25 would appear to correspond to Chron 9 (8.92 to 10.42 m.y.), but this interpretation conflicts with the foraminifer and nannoplankton zones. The quality of the paleomagnetic record deteriorates markedly in the denser sediments cored with the 5-m HPC in Hole 588A, despite the high intensities. Directional scatter is high and there is a marked negative (normal) bias to inclinations, suggesting viscous overprinting in the present-day field. No polarity interpretation was possible for Hole 588A.

The increase in intensity at the top of the section is presumably due to the reasons discussed in the Introduction. The origin of higher intensities prior to the late Miocene is not clear. Two possibilities are (1) enhanced input of terrigenous material, and (2) inhibition of the reducing conditions which are probably responsible for the falloff in intensity as a function of depth at the top of the section.

SEDIMENTATION RATES

Sedimentation rates were calculated from calcareous nannoplankton zonal boundaries for the four holes drilled at Site 588. Hole 588B (Fig. 11C) duplicated the results from Hole 588. However, since zonal boundaries in Hole 588B were based only on core-catcher samples, sedimentation rates for this particular hole are less reliable than those for the other three holes.

Ages of nannoplankton boundaries used to determine sedimentation rates are the same as those used during Leg 59 (Martini, 1981) with some minor improvements. Middle Eocene sedimentation rates could not be calculated in the calcareous-siliceous sediments, because the section (Cores 588C-17 and 588C-18) was too short and no zonal boundaries were detected.

In the late Oligocene to early Miocene interval (Hole 588C, nannoplankton Zones NN2 top to NN24 top), the sedimentation rate is 20.6 m/m.y. in calcareous sediments, based on four boundary datums (Fig. 12D). The mean sedimentation rate in the early Miocene (Hole 588A, nannoplankton Zones NN2 top to NN7 top), based on six boundary datums, shows a slight decrease to 14.4 m/ m.y., also in calcareous sediments (Fig. 11B). The sedimentation rate in the middle Miocene to early Pliocene interval (Hole 588, nannoplankton Zones NN7 top to NN13 top) is constant at 17.4 m/m.y., based on six datum levels (Fig. 11A). In the late Pliocene (Hole 588, nannoplankton Zones NN13 top to NN18 top) the sedimentation rate increases rather abruptly to 29.5 m/m.y., and drops off to only 12.2 m/m.y. in the Quaternary interval (Hole 588, above nannoplankton Zone NN18 top), both in calcareous sediments. The two latter sedimentation rates are based on eight datum levels (Fig. 11A). The comparatively low sedimentation rate in the Quaternary may be unreliable, and may have resulted from drilling disturbance in the uppermost layers or from winnowing of finer sediments.

SUMMARY AND CONCLUSIONS

Site 588 was drilled at the same location as Site 208 in order to obtain a high-quality, continuously cored sequence through the late Paleogene and Neogene. Previous investigations have demonstrated that the planktonic foraminiferal assemblages at this latitude are made up of both tropical and temperate elements. At the present time, Site 588 is located in the warm subtropical water mass which lies between the true tropical water masses to the north and transitional water masses to the south. However, Site 588 experienced 5-10° of northerly movement during the Neogene in association with movements of the Indian Plate (Sclater et al., in press). During the early Miocene, Site 588 was located at about 36°S in the present-day temperate area and within the zone of westerly winds. This northward movement from higher to lower latitudes must have had a major effect upon the biogeography of the planktonic microfossil assemblages.

Site 588 consists of four holes (Fig. 12): Hole 588, cored continuously with the HPC from 0-236.0 m subbottom; Hole 588A, cored continuously with the HPC from 236.0-344.4 m; Hole 588B, cored continuously with the HPC from 0-277.4 m; and Hole 588C cored continuously with the rotary drill from 305.7-488.1 m subbottom.

The HPC sequence through carbonate sediments is a record penetration of 315 m, extending from the Quaternary to the late early Miocene at 17 m.y. (Zone NN3 or *Globorotalia miozea* Zone). The overlapping hydraulic piston cores effectively provide 100% recovery of this sequence (Fig. 12). There is particularly good core quality in the Miocene, much less so in the Pliocene, and especially poor quality in the Quaternary, which is soupy. The carbonate fossil sequence is exquisite through the



Figure 10. A. Magnetic polarity boundaries for the upper part of Hole 588. B. Polarity zonations at the bottom of Hole 588 and the top of 588A. Shaded zones are normal polarity.

Neogene but less so in the Oligocene. The foraminiferal and calcareous nannofossil zonal sequences are complete (Fig. 12), suggesting that there are no hiatuses above the upper Oligocene (NP24). A paleomagnetic polarity stratigraphy has been identified down to the upper part of the Gilbert Chron (about 3.5 m.y.).

Two sedimentary units are distinguished (Fig. 12), the upper one divided into three subunits. Subunit IA is a foraminifer-bearing nannofossil size to a nannofossil-bearing foraminiferal ooze in an oxidized and winnowed environment. Subunit IB, comprising much of the sediment column at Site 588, is largely a foraminifer-bearing nannofossil ooze, distinguished from Subunit IC by its softness. Subunit IC grades from soft ooze at its top to firm ooze at about 150 to 180 m (Holes 588 and 588B, respectively) to chalk at about 215 to 260 m (Holes 588 and 588B, respectively).

At the bottom of Site 588 (Hole 588C) is Unit II which is separated from overlying Unit IC by the regional unconformity that separates middle or late Eocene from late or middle Oligocene sediments. At Site 588 the unconformity separates sediments of middle Eocene (NP15-16) from late Oligocene (NP24) age.

The middle Eocene sediments consist of siliceous foraminifer-bearing nannofossil chalks and foraminifer-bearing cherts. Less than 1 m of Unit II was recovered before the site was terminated. This lithostratigraphic unit is characterized by the presence of siliceous sponge spicules, diatoms, and diagenetic chert, and coincides with Unit 2 of DSDP Site 208 (Burns, Andrews, et al., 1973).

Textbook examples of microfaults and slickensides occur in three upper lower Miocene cores in a zone where ooze grades into chalks. Surfaces are occasionally mineralized by iron sulfide and possibly rhodochrosite.

There are many thin volcanic ash layers through the Miocene sequence, occurring as singlets, doublets, or triplets and with groups exhibiting quasi-regular perodicities in some intervals. Most are completely undisturbed by bioturbation, which is unusually limited in this site and is an ineffective agent of sediment homogenization. Nevertheless, excellent examples of Zoophycos and Chondrites burrows occur throughout this sequence, as well as relatively sparse larger circular or ovoid (0.5–3.0 cm across) burrow sections and mottles.

Iron sulfides are persistent through the section and have a close association with volcanic ash layers. Drilling terminated in middle Eocene siliceous-rich chalks and cherts.

The uncorrected rates of sedimentation are as follows: lower Oligocene-early Miocene, 20.6 m/m.y.; early Miocene, 14.4; middle Miocene-early Pliocene, 17.4, lower Pliocene, 29.5; Quaternary, 12.2 m/m.y.

In general, the diversity of the benthic faunas and their abundance decrease down the section. Changes in the benthic foraminiferal assemblages provide useful information about changes in intermediate water masses during the Neogene. Elimination of typical Eocene-Oligocene benthic forms occurred in the late early Miocene. During the early late Miocene there was an influx of several species of deeper-water origin. During the Pliocene there was an upward disappearance of several important benthic species and a large number of species disappeared during the late Pliocene, at about 3 m.y.

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Figure 11. Sedimentation rates at Site 588.



Figure 11. (Continued).





ITE	588		HOI	E		CC	RE 1	CORED	INTER	VA	. 0.0-5.6 m		_				
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SITE 58	B HOLE	CORE 3 CORED INTERVAL 15.2-24.8 m		SITE	588	HOLE		CO	RE 4	CORED INTE	RVA	L 24.8-34.4 m	
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SITE 588	3	HOLE	COR	E 5	CORED II	NTERVAL	34,4-44.0 m	SITE	51	38 H	DLE		COR	E 6 COREC	INTER	VAL 44	1.0-53.6 m				
TIME - ROCK UNIT BIOSTRATIGRAPHIC	ZONE	FOSSIL CHARACTER SINE SINE SINE SINE SINE SINE SINE SINE	SECTION	METEHS	GRAPHIC LITHOLOGY	DISTURBANCE SEDIMENYANY STRUCTURES SAMPLES	LITHOLOGIC DESCRIPTION	TIME - ROCK UNIT	BIOSTRATIGRAPHIC	FORAMINIFERS	FOSSIL	ER	SECTION	GRAPHIC LITHOLOGY	DRILLING DISTURBANCE SEDIMENTARY STRUCTURES	SAMPLES		LITHOLOGIC DI	ESCRIPTIO	i.	
late Plicome G. tossensis	NV16 ~ ~ ~	Α.	2 3 4 5 6 7 CC	2			-N6 -N6 -N6 -N6 -N6 -N6 -N6 -N6	late Pilocene	G, initiate NATE NUTE I NUTE				2 3 4 5 6 7 CC	$\frac{1}{1} + \frac{1}{1} + \frac{1}$		• - 5Y - 5Y - 100 - 100	r 8/1 7 7 7 7 7 7 7 7 7 7 7 7 7 7 7 7 7 7 7	FORAMINIFER-B still very wet and I slight deformation SMEAR SLIDE SU Texture: Sand Clay Composition: Foraminifers Cale. nannofossils	EARING N Nigh porosit of most of 0 MMARY: 1,40 3, D D C - D - C C D D	ANNOFOSSI r, specked w ore 6, white 65 5, 40 D C D	L ODZE, soft, th iron sulfide, N9), 5,100 M C D C D C D



166

SITE	588	-	HOL	E	C	ORE	10 CORE	DINTERVA	L 82.4-92.0 m		_	_			SITE	58	88 H	OLE		C	ORE	11 CORED I	NTEF	٩V/
¥	PHIC		FO	ACTER											1.0	PHIC		FO	SIL					Г
TIME - ROC	BIOSTRATIGRA	FORAMINIFERS	NANNOFOSSILS	RADIOLARIANS DIATOMS	SECTION	METERS	GRAPHIC LITHOLOGY	ORILLING DISTURBANCE SEDIMENYARY STRUCTURES SAMPLES		LITHOLOGIC D	ESCRI	PTION			TIME - ROCK	BIOSTRATIGRA	FORAMINIFERS	NANNOFOSSILS	DIATOMS	SECTION	METERS	GRAPHIC LITHOLOGY	DISTURBANCE	SAMPLES
					,	0.5				FORAMINIFER-I white (N9) to very Very light gray to and burrows, Medium gray (N5	IEARII light g yello) lamir	NG NAN pray (NB). wish gray nae of irc	NOFOSS (N8 to 5 n sulfide	IL OOZE, soft, SY 8/1) laminae along the core.		21NN		A		1	0.5			
	G. margaritae	•			2				NB-5Y 8/1	SMEAR SLIDE SI Texture: Sand Silt Cay Composition: Pyrite	2, 1 D C D	RY: 10 1, 130 M C D R	3, 31 M C D	5, 14 M C D						2	uniter from ro			
early Pliocene	NNI3 NNI3		A		3				- N5 N8-5Y 8/1	Foramisiters Calc, nannofossils	D	D	D	D	locane					3	and markense			•
			A		4				N8-5Y 8/1 IW						early P					4	and marked		n.	•
			•		5				- N8-5Y 8/1											5	and a relation			
	G. margaritae NN13	A	A		6				NB-5Y 8/1							aritae				6	-freduce			



167



SITE 588	HOLE	CORE 14 CORED INT	ERVAL 120.8-130.4 m		SITE 58	88 1	IOLE	COR	E 15 CORED	NTERV	VAL 130.4-140.0 m	
TIME - ROCK UNIT BIOSTRATIGRAPHIC ZONE	FOSSIL CHARACTER NUNNOFOSILS BIATOMS DIATOMS DIATOMS	State Craphic Strain State Control Con	S 2000-01-01-01-01-01-01-01-01-01-01-01-01-	LITHOLOGIC DESCRIPTION	TIME - ROCK UNIT BIOSTRATIGRAPHIC	ZONE	HANNOFOSSILS HADIOLARIANS DIATOMS	SECTION	GRAPHIC LITHOLOGY	DISTURBANCE SEDIMENTARY STRUCTURES SAMPLES	LITHOLOGIC DESCRIPTION	
late Mocone G. magerine NN116	A A			NANNOFOSSIL OOZE, soft, white (N9) to very light gray (N8). Very light gray to yellowish gray (N8 to SY 8/1) burrows and laminae. Medium gray (N5) laminae of iron sulfide along the core. Gradual transition to: FORAMINER-BEARING NANNOFOSSIL OOZE, soft, white (N9) to very light gray (N8 to SY 8/1) burrows and laminae. Medium gray (N5) laminae of iron sulfide along the core. *Artificial gap: compaction. SMEAR SLIDE SUMMARY: 2,37 3, 104 5,40 7,9 D D D D Testure: Sand – – – – – Sitt – – – – Cate annofossils – – – – Pyritiers – – – – – Cate, nannofossils – – – – – Sitt – – – – – – – Pyritiers – – – – – – – Sitt – – – – – – – Sitt – – – – – – – Sitt – – – – – – – – Pyritiers – – – – – – – – Sitt – – – – – – – – Sitt – – – – – – – – – Sitt – – – – – – – – – – Sitt – – – – – – – – – – Sitt – – – – – – – – – – – – Pyritiers – – – – – – – – – – – – Sitt – – – – – – – – – – – – – – – – Pyritiers – – – – – – – – – – – – – – – – – – –	Late Miccone G. magaritee G. magaritee G. magaritee	WIIIB > VIII		2 3 4 5 6 7 CC			NANNOFOSSIL OOZE, soft, white (N9) to very ligh (N9). Very light gray to yellowish gray (N8 to 5Y 8/1) be and laminae. NB-5Y 8/1 Medium gray (N5) laminae of iron suifide. -N5 SMEAR SLIDE SUMMARY: 2,30 5,92 1,5 D -N5 Texture Stat -N5 Clay -N5 Clay -N5 Clay -N5 Clay -N5 N8 -N5 Clay -N5 Clay -N5 Clay -N5 Clay -N5 Clay -N5 Clay -N5 N8 -N5 Clay -N5 N8 -N6 N8 -N6 N8	11 gray



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5G 8/1 ash

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SITE 588 HOLE	CORE 20 CORED INTERVAL 178.4-188.0 m	SITE 588 HOLE	CORE 21 CORED INTERVAL 188.0	–197.6 m
TIME - ROCK UNIT BIOSTATIGRAPHIC BIOSTATIGRAPHIC BIOSTATIGRAPHIC BIOSTATIGRAPHIC BIOSTATIGRAPHIC BIOSTATIGRAPHIC	NOLL335		SECTION METERS METERS ADDIHAUSD ADDIHAUSD ADDIANA METERS ADDIANA ADDIA	LITHOLOGIC DESCRIPTION
late Miccene NN10 G. perdenemicide NN11A > > > >	1 T <td>SIL DOZE, white sulfide and light</td> <td>- Void - - - - 0.5 - - - 1 - - -<!--</td--><td>sh(7) much more frequent ah(7) layers giving the sediment a ah(2) bluih white (58 9/1) color; abundant iron suffice. triplet SMEAR SLIDE SUMMARY: 1, 73 2, 4 bluih white (58 9/1) color; abundant iron suffice. 1, 73 2, 4 bluih white (58 9/1) color; abundant iron suffice. ah(7), doublet ah(7), doublet ah(7), subtle ah(7), doublet ah(7), quartet ah(7), quartet, subtle ah(7), quartet, subtle ah(7) subtle</td></td>	SIL DOZE, white sulfide and light	- Void - - - - 0.5 - - - 1 - - - </td <td>sh(7) much more frequent ah(7) layers giving the sediment a ah(2) bluih white (58 9/1) color; abundant iron suffice. triplet SMEAR SLIDE SUMMARY: 1, 73 2, 4 bluih white (58 9/1) color; abundant iron suffice. 1, 73 2, 4 bluih white (58 9/1) color; abundant iron suffice. ah(7), doublet ah(7), doublet ah(7), subtle ah(7), doublet ah(7), quartet ah(7), quartet, subtle ah(7), quartet, subtle ah(7) subtle</td>	sh(7) much more frequent ah(7) layers giving the sediment a ah(2) bluih white (58 9/1) color; abundant iron suffice. triplet SMEAR SLIDE SUMMARY: 1, 73 2, 4 bluih white (58 9/1) color; abundant iron suffice. 1, 73 2, 4 bluih white (58 9/1) color; abundant iron suffice. ah(7), doublet ah(7), doublet ah(7), subtle ah(7), doublet ah(7), quartet ah(7), quartet, subtle ah(7), quartet, subtle ah(7) subtle
M. continuous NN10	Image: starting of the starti	M. Anthrocas MANO	6	ash(?) ash(?) ash(?) ash(?) ash(?) trajet t, ash(?) t, ash(?) by FeS



SITE 588	HOLE	CORE 24 CORED INTER	/AL 216.8-226.4 m	SITE	588	HOLE	cc	ORE 25 CORED	NTERV	AL 226.4-236.0 m	
TIME - ROCK UNIT BIOSTRATIGRAPHIC ZONE	FORAMINIFERS CHARACTER NANNOFORILS RADIOLARIANS DIATOMS	SECTION METERS METERS MILTING DMILLING DMILLING DMILLING SETUREMACE	LITHOLOGIC DESCRIPTION	TIME - ROCK UNIT	BIOSTRATIGRAPHIC ZONE	FOSSIL CHARACT SUDIOLARIANOFOSSILS	SECTION	S GRAPHIC LITHOLOGY	DRILLING DISTURBANCE SEDIMENTARY STRUCTURES	SAMPLES	LITHOLOGIC DESCRIPTION
middle Miccine Gr <i>hob</i> 1.1. G. <i>fobri</i> 1.1.			 SGV 8/1 ah (?) subtle FG 8/1 ah (?) FG 8/1, ah (?) <	middle Miocene	G. fóbú'1.1. NN7 NN8 1 NN8	A A A	1 2 3 4 5 6 7 7 000			-N3 -SGY 8/1, ash(?) -N3 -N3 -N3 -N3 -N3 -N3 -N3 -N3	FORAMINIFER-BEARING NANNOFOSSIL CHALK, firm, homogeneous, Very light gray to very light graenish gray (N3 to SGY 8/1) Light gray (BGY 8/1) Light gray (BGY 8/1) Interes volcanic elements. Dark gray (N3 to N4) Interes volcanic elements. M D - Interes volcanic elements. SMEAR SLIDE SUMMARY: Interes volcanic elements. M D - Texture: Interes volcanic elements. Sand - C Sitt C R Carposition: - - Texture: - - Sitt C R - Carposition: A D - Texture: - - T Volcanic glass - - - Pyrite A D D D Pyrite A T - T Pyrite A D D D Interviniting and the properties of the properities of the


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UNIT UNIT	BIOSTRATIGRI	FORAMINIFERS	NANNOFOSSILS	RADIOLARIANS	DIATOMS	SECTION	METERS	GRAPHIC LITHOLOGY	DRILLING DISTURBANCE SEDIMENTARY STRUCTURES	SAMPLES		LITHOLOGIC DE	SCRIPTION
						,	0.5			•	- N5	FORAMINIFER-BE homogeneous. Very light gray (NE Medium gray (N4 to *Artificial gap due to	EARING NANNOFOSSIL CHALK, firm 8) to very light greenish gray (EGY 8/1) 5 N8) laminae of iron sulfide. 5 drilling.
middle Migoene						2	CONTRACTOR OF			••	- N5 - N5-N6	SMEAR SLIDE SU Texture: Silt Clay Composition: Ouartz Heavy minerals Volcanic glass Foraminifers	MMARY D C D T T C
	nturalis O. suturalis	A				3	and contract			•	- NB	Calc, nannofossils	
	O. R	A	A			cc	-						





SITE	58	8 H	OLE	А	ORE	5.1	12 CORE	DINTE	RVA	AL 295,6-300.6 m	SITE	588	н	OLE	Α		COF	RE	13 CORED	INTER	RVAI	300.6-305.6 m	
TIME - ROCK UNIT	BIOSTRATIGRAPHIC ZONE	FORAMINIFERS	RADIOLARIANS 25	STER SWOLVIG	 METERS		GRAPHIC LITHOLOGY	DRILLING DISTURBANCE	STRUCTURES SAMPLES	LITHOLOGIC DESCRIPTION	TIME - ROCK UNIT	BIOSTRATIGRAPHIC ZONE	FORAMINIFERS	FOR HAR	DIATOMS DIATOMS	R	SECTION	METERS	GRAPHIC LITHOLOGY	DRILLING DISTURBANCE SEDIMENTARY	STRUCTURES SAMPLES		LITHOLOGIC DESCRIPTION
middia Miccene	P. glomerose curva NNS	A	A.		0. 1 2 2 3 4 CC				-	FORAMINIFER-BEARING NANNOFOSSIL CHALK, firm, homogeneous, Very light grav (N8) to very light greenish gray (BGY 8/1), with light greenish gray (SGY 7/1) mottles and very light gray (N8) mottles. SMEAR SLIDE SUMMARY: 1,31,3,52,3,64 D M D State C Clay D Clay D Clay D Clay D Clay D Composition: Guartz - T T BGS 8/1 Foraminifers C R C SGY 7/1 Celc.nennofosils D D D IW N8-5GY 8/1 N8 SGY 8/1 N8	middle Micene	P. glomerosi curva NNA		A .			1 2 3 4 5	0.5 12 10 10 10 10 10 10 10 10 10 10 10 10 10	I I		• • • •	- N7%	ORAMINIFER-BEARING NANNOFOSSIL CHALK, firm, mrv light grav (N8) with a few, very subtle, darker bands; zurrowing is moderate; overall very homogeneous. MEAR SLIDE SUMMARY: 3,56 3,41 M D Composition: Quartz T T Heavy minerals T – Volcanic glass T – Caric, nannofossils A D

SITE 588 HOLE A CORE 14 CORED INTERVAL 305.6-310.6 m	SITE	588 HOLE A (CORE 16 CORED INTERVAL 315.6-32	25.2 m
Unit CHARACCLER CHARACCLER NOLICIAL STRUCTURE STR	GIC DESCRIPTION		Stata GRAPHIC BUTTOLOGY SUBJECT	LITHOLOGIC DESCRIPTION
Void SGY 7/1 Void SGY 7/1 Void	FER-BEARING NANNOFOSSIL CHALK, firm, ray (NB), abundant burrows and iron sulfide, s greener with increasing depth. DE SUMMARY: 1,96 CC D M 17 T - T rati T - T rati T - T	accone NUM A A A A A A A A A A A A A A A A A A A	c <u>+ * *</u> .	FORAMINIFER BEARING NANNOFOSSIL CHALK, very firm, gremith gray (BGY 6/1), homogeneous. SMEAR SLIDE SUMMARY: CC, 8 Composition: Duartz T Feldape T Feldape T Foraminifers C Calc. namofossib D
5GY 8/1 Glauconite Pyrite	- A T - eite		TORE 17 CODED INTERVAL 375.7.2	24.0
E X A Image: Constraint of the second se	s C R SITE	SIGNATION CHARACTER CHARACTER SIGNATION CHARACTER SIGNATION CHARAC	SU GRAPHIC ULITHOLOGY DISTURBENT WAT	LITHOLOGIC DESCRIPTION
GZAAA CC 5G 3/2 glauconite-rich				FORAMINIFER-BEARING NANNOFOSSIL CHALK, very
SITE 588 HOLE A CORE 15 CORED INTERVAL 310.6–315.6 m FOSSIL CHARACTER NO LL 23 CHARACTER NO LL 23 CHARACTER CHARACTER NO LL 23 CHARACTER CHARACTER NO LL 23 CHARACTER CHARACTER NO LL 23 CHARACTER CHARACTER CHARACTER NO LL 23 CHARACTER CHAR	INGIC DESCRIPTION	umila C. daamila >		firm, greenish gay (5CY 6/1), homogeneous, drilling dis- turbance has reduced interval to rubble. SMEAR SLIDE SUMMARY: 2, 45 D Composition: Heavy minerals T Foraminifiers C Calc, namofossib D
FORAMINI	IFER-BEARING NANNOFOSSIL CHALK, firm,	A A NN3		
0.5 T	greenith gray (5GY 7/1), abundant burrowing therwise almost homogeneous.			
1 1 <td>IDE SUMMARY: 1,74 D C C M M M M M M M M M M M M M</td> <td>588 HOLE A CONTRACTOR FORSEL CHARACTER SUBJUNITY STATES AND A CONTRACT AND A CONT</td> <td>CORE 18 CORED INTERVAL 334.8-3</td> <td>LITHOLOGIC DESCRIPTION</td>	IDE SUMMARY: 1,74 D C C M M M M M M M M M M M M M	588 HOLE A CONTRACTOR FORSEL CHARACTER SUBJUNITY STATES AND A CONTRACT AND A CONT	CORE 18 CORED INTERVAL 334.8-3	LITHOLOGIC DESCRIPTION
See of the field of t	arrish Miloone	G. dehitecou C. diatrini/h NN2 > > NN2	2 N8. chert n	FORAMINIFER-BEARING NANNOFOSSIL CHALK, very firm, light greenish gray (5GY 7/1) to greenish gray (5GY 5/1); homogeneous throughout: moderstely deformed. SMEAR SLIDE SUMMARY: 1,70 CC D D Composition: Duarz T – Haavy minerals T – Glauconite T – Glauconite C C Cele. nannofossila A D

SITE 588 HOLE E	CORE 1 CORED INTERVAL	0.0-7.8 m	SITE 588 HOLE B CORE 2 CORED I	INTERVAL 7.8–17.4 m	
TIME - ROCK UNIT EIOSTRATIGRAPHIC ZONE FORAMINIEER MANNOFOSSILLA RADIOLATIANS	ER SUB CARACTER STANAS	LITHOLOGIC DESCRIPTION	LITHE CONTRACTER CHARACTER SOURCE CHARACTER CH	LITHOLOGIC DESCRIPTION	2
G. frumetabliooder MN19 X	$ \begin{array}{c ccccccccccccccccccccccccccccccccccc$	DVR 7/3 FORAMINIFER-BEARING TO FORAMINIFER NANNO- FOSSIL OOZE, very pake brown (10YR 7/3) and subtle variations of color gradations. Soft, with few bioturbation itsuctures apparent. Core appears course: Baction 5, 88 cm to a FORAMINIFER-BEARING NANNOFOSSIL OOZE, white (NP) 87/3 0YR 8/2 10YR 8/2 0YR 7/3 SMEAR SLIDE SUMMARY: 1, 28 2, 10 2, 68 3, 68 4, 67 D D D D Composition: Quartz - T T T T Feddapar T T Forgaminifers A C C C A Cate, nanofosilis A A A A C Sponge spiculis T - T 0YR 8/3 0YR 8/3 OYR 8/3 0YR 8/3 0YR 8/3 0YR 8/3 OYR 8/3 0YR 8/3 0YR 8/3 0YR 8/3 OYR 8/3 0YR 8/3 0YR 8/3 0YR 8/3 0YR 8/3 OYR 8/3 0YR 8/3 0YR 8/3 0YR 8/3 OYR 8/3 0YR 8/3 0YR 8/3 0YR 8/3 OYR 8/3 0YR 8/3 0YR 8/3 0YR 8/3 OYR 8/3 0YR 8/3	Guarmenty Construction 0, functionality 0, functionality 0, functionality 0	SY 8/1 N8 FORAMINIFER-BEARING NA (N0), soft, homogeneous, trac becoming abundant in Section 6 SMEAR SLIDE SUMMARY: 5GY 9/1 N9 Composition: 0uartz T T Voltanic gass T – 5GY 7/1, sab 56 7/1 * N9 SY 9/1 St 9/1	NNOFOSSIL OOZE, white es of iron suffide streaks.

SITE 588	HOLE B	CORE	3 CORED INTERV	/AL 17.4–27.0 m	SITE	588	HO	EB	CC	ORE 4	CORED	INTER	RVA	L 27.0-36.6 m
TIME - ROCK UNIT BIOSTRATIGRAPHIC ZONE	FOSSIL CHARACTER VANNOFOSILS SIADIOLARIANS PLATONOLARIANS CHARACTER SIATIONS PLATONOLARIANS PLAT	SECTION	GRAPHIC LITHOLOGY LITHOLOGY	LITHOLOGIC DESCRIPTION	TIME - ROCK	BIOSTRATIGRAPHIC ZONE	FORAMINIFERS NAMNOFOSSILS	OSSIL RACTER BIATOMS	SECTION	METERS	GRAPHIC LITHOLOGY	DRILLING DISTURBANCE SEDIMENTARY	STRUCTURES SAMPLES	LITHOLOGIC DESCRIPTION
G. trumestulinoldee/G. toteenait MK18		0.5 1 1.0 2 2 3 3 4 4 5 5		Void FORAMINIFER-BEARING NANNOFOSSIL OOZE, white (N9), out, with streaks and burrow molds of iron sufface, iron bands, very pais velow (2.5Y 8/4), Pockets of velocanic ath at Section 5, 75 cm and Section 6, 54 cm. SMEAR SLIDE SUMMARY: 1,70 D 0 Composition: 1,70 Void iron builds 0 NEAR SLIDE SUMMARY: 0 In 70 0 Composition: 1,70 Void iron builds 0 Composition: 0 Void iron builds 0 Composition: 1,70 N7 0 N7 10 N7 10 N6 10 N7 11 N8 11 N8 11 N9 11 11 11 12 11	late Pilocene	G, tosentsá NN16			3 4 5 6	0.5		2		FORAMINIFER-BEARING NANNOFOSSIL ODZE, while INN), soft, iron sulfide laminae and burrow molds scattered throughout. SMEAR SLIDE SUMMARY: 3,78 Void Ornposition: Void Oraminifere C Gale. nannofosils D SY 8/1 - N8

	SITE 588 HOLE B	CORE 5 CORED INTERVA	AL 36,6-46,2 m		TE 58	8	HOLE	B	0	ORE	6 CORED		RVAL	46.2-55.8 m	
	TIME - ROCK UNIT BIOSTRATIGRAPH FORAMINIERE RAMINOFOSSILS NAMINOFOSSILS RADIOLATIANS	FER NOLLIGE SWOLLIGE	LITHOLOGIC DESCRIPTION	TIME - BOCK	UNIT	ZONE	CHAR STISSOLONNAN	ACTER	SECTION	METERS	GRAPHIC LITHOLOGY	DRILLING DISTURBANCE SEDIMENTARY	STRUCTURES SAMPLES		LITHOLOGIC DESCRIPTION
$\begin{array}{c}$	G. influes MN16	3 3 4	FORAMINIFER-BEARING NANNOFOSSIL ODZE, soft, white (N9). Yellowith gray (5Y 8/1) burrows and laminae. Medium gray (N4 to N8) laminae of iron sulfide along the core. 3,20 5,20 D D Texture: Site C – Composition: N5 Calc, namofossite D D SY 8/1 N5 SY 8/1 N5 SY 8/1 N4–N6 Iaminae N5		C influence E	NNIS A	~			0.5 1.0				 N5 N5-N6 N4 5Y 8/1 5Y 8/1 5Y 8/1 N6 N5 N4 5Y 8/1 N6 5Y 8/1 	FORAMINIFER-BEARING NANNOFOSSIL 002E, ad white (N9), Yellowish gray (5Y 8/1) burrows and lamina Medium gray (N4 to N8) laminae of iron sulfide along th con. SMEAR SLIDE SUMMARY: 2, 63 4, 70 D D Texture: 3 It C C Claposition: Heavy minralis T — Foraminifers C C Claic, manofossils D D Sponge spicules — T

SITE 588	HOLE B	CORE 7 CORED INTERVAL 55.8-65.4 m		SITE	588	HOL	EB	cc	ORE 8 CORED	NTERV	VAL 65.4–76.0 m	
TIME - ROCK UNIT BIOSTRATIGRAPHIC	FORAMINIFERS CHARACLES NANNOFORALS RADIOLARIANS PLATOMS	RECTION BELLING BUILT	LITHOLOGIC DESCRIPTION	TIME - ROCK UNIT	BIOSTRATIGRAPHIC ZONE	NANNOFOSSILS	RACTER BIATOMS	SECTION	GRAPHIC LITHOLOGY	DISTURBANCE SEDIMENTARY STRUCTURES	LITHOLOGIC DESCRIPTION	
early Priocene G. crassformis		$ \begin{array}{c} \begin{array}{c} & & & & & & & & & \\ & & & & & & & & \\ & & & & & & & & \\ & & & & & & & & \\ & & & & & & & & \\ & & & & & & & \\ & & & & & & & & \\ & & & & & & & \\ & & & & & & & \\ & & & & & & & \\ & &$	FORAMINIFER-BEARING NANNOFOSSIL OOZE, soft, white (NB). Vellowish pays (BY 8/1) burrows and laminae. Medium pays (N4 to NB) isminae of iron sulfide along the core. SMEAR SLIDE SUMMARY: 2.59 5.125 D M Texture: 3.51 - Sint - - Clay - D Composition: - - Rear inference C R Calc. nanofossilis D D	early Plicene	G. creasaformia NN14 NN15			1 2 3 4 5 6	╃┿┥┿┿┿┿┿┿┿┿┿┿┿┿┿┿┿┿┿┿┿┿┿┿┿┿┿┿┿┿┿┿┿┿┿┿┿		PORAMINIFER-BEARING NANNOFOSSIL QOZE, sol while (N9), Velowich gray (5Y 8/1) burrows and lamina with a writing and (Y4 to N6) laminae of tron subtra along to core. Very light gray to very light greenish gray (N8 to SGY 8/1) laminae. * Artificial gap: compection. IN8, 5Y 8/1 SMEAR SLIDE SUMMARY: 2, 60 4, 108 6, 122 D M M • N6 Sit C C C C Clay • N6 Calay • N5 Foraminifer C C R Cale, namofosils • N5 Foraminifer C C R Cale, namofosils • N5 Foraminifer C C R Cale, namofosils • N5 N5 • N8 Sy 8/1 • N5 Foraminifer C C R Cale, namofosils • N5 Foraminifer C C R Cale, namofosils • N5 Sponge spicules • N5 Sy 8/1 • N6 Sy 8/1 • N8 - SGY 8/1, sub(?) • N8 - SGY 8/1, sub(?)<	It, in he to

SITE	588 9		HOL	E.	B		ORE	9 COREC		T	AL 76.0-85.6 m		
TIME - ROCK UNIT	BIOSTRATIGRAPH	FORAMINIFERS	CHA STISSOLONNAN	RADIOLARIANS 2	SWOLVIG	SECTION	METERS	GRAPHIC	DISTURBANCE SEDIMENTARY	SAMPLES		LITHOLOGIC DESCRIPTION	TIME - ROCK UNIT
							0.				- N6 - 5Y 8/1 - 5Y 8/1 - N5	FORAMINIFER-BEARING NANNOFOSSIL OOZE, soft, white (NB) to vary light gray (NB). Yallowish gray (SY 8/1) burrows and laminae. Medium gray (N4 to N6) laminae of iron suffice. Artificial gap: compaction. SMEAR SLIDE SUMMARY:	
			A				2				5Y 8/1 - 5Y 8/1 - N5 - N5 - N5	1,80,8,103 D M Sand T Sitt C Carposition: D Quartz - Heavy minerals - Foraminiters C Carposition: - Sale: - Pyrite T Foraminiters C Carposition: D	Pilocene
locane	I NN14						3		1,				C minimum
early Pt	NN13		A				4				- 5Y 8/1 - N5 - N5		
			A				5				- 5Y 8/2 - N5 - N6 - 5Y 8/2		
	113		A							-	- 5Y 8/1 - 5Y 8/1		
	G. puncticulata NN12 NN	A	A				7				5Y 8/1 5Y 8/1 N6 5Y 8/1 N8-5Y 8/1 N6-5Y 8/1 N6-5Y 8/1	n	

	PHIC		F	OSS	L					Γ			
UNIT UNIT	BIOSTRATIGRA ZONE	FORAMINIFERS	NANNOFOSSILS	RADIOLARIANS	DIATOMS	SECTION	METERS	GRAPHIC LITHOLOGY	DRILLING DISTURBANCE SEDIMENTARY STRUCTURES	SAMPLES		LITHOLOGIC DI	SCRIPTION
						1	0.5			*	 N6 5Y 8/1 N5 N6 N8-5Y 8/1 	FORAMINIFER-B white (N9) to very burrows and lamin iron sulfide alor (N8–5GY 8/1) lan Artificial gap: com	EARING NANNOFOSSIL OOZE, soft fight gray (NB). Yellowish gray (5Y 87) as, Madium gray, (N4 to N6) laminas of g the core. Very light graenish gray in as in Section 2. paction.
early Pliccene						2	ed to to the tar				 NB=5GY 8/1, ash(?) N5 NB=5GY 8/1, ash(2) 	Composision: Foraminifers Calc. nannofossiis Sponge spicules	1, 116 D C D T
	5. margaritae VN12					3			1		- 5¥ 8/1 → N5		

SITE 58	88	HOLE B		CO	RE	11 COR	ED INTER	VAL	- 95.2-104.8 m		SITI	E 5	88	HOL	Е В		CORE	12 CORE	DINTE	RVA	L 104.8-114.4 m			
TIME - ROCK UNIT BIOSTRATIGRAPHIC	ZONE	FOSSIL CHARACTER SIISOLARIANS RADIOLARIANS RADIOLARIANS	R	SECTION	METERS	GRAPHIC LITHOLOG	A DRILLING DISTURBANCE SEDMENTARY	SAMPLES		LITHOLOGIC DESCRIPTION	TIME - ROCK	BIOSTRATIGRAPHIC	ZONE	FC CHAI	PIATOMS	Included	METERS	GRAPHIC LITHOLOGY	DRILLING DISTURBANCE SEDIMENTARY	STRUCTURES SAMPLES		LITHOLOGIC	DESCRIPTION	
early Pilocone G. romowybe	o. magazine N112			1 1 2 2 3 3 3 3 4 4 4 4 5 5 7 7 7 7 7 7 7 7 7 7 7 7 7 7		사직 직접적 직접 가지에게 하여 여러	נרנר בנרבר בנר מאור בני מי מי די מי מי מוז מוז מוז מו מי		 N4 SY 8/1 SY 8/1 SY 8/1 SY 8/1 SY 8/1 N5 SY 8/1 N8 SY 8/1 N8 SY 8/1 N8 N8 SY 8/1 N8 N8 N8 SY 8/1 N8 N8 N8 N8 N8 SY 8/1 N8 SY 8/1 N8 N8 N8 SY 8/1 N8 N8 SY 8/1 SY 8/1 	FORAMINIFER-BEARING NANNOFOSSIL 002E, sof white (NB) to very light grav (NB). Valionsin grav (NS VA) limitae burros and liminae. Medium grav (NS VA) limitae iron sulfide along the core. Subtle very light graenish gra (NB-5GY 8/1) laminae. *Artificial gap: compaction. SMEAR SLIDE SUMMARY: 2,79 4, 133 D M Composition: Heavy minerals — T Glauconite T T Pyrita T — Foraminiter R C Calc. nannofossib D D	litte Micenne		or. magnituse NN116				0.5 1 1.0 2 3 4 5 6 7				5Y 8/1, N6 5Y 8/1, N6 1 5Y 8/1 5Y 8/1 5Y 8/1 5Y 8/1 5Y 8/1 5Y 8/1 N6 5Y 8/1 N6 5Y 8/1 N6 5Y 8/1 N6 5Y 8/1 N6 5Y 8/1 N6 5Y 8/1 N5 5Y 8/1 SY 8/1	FORAMINIFEP white (N9) to vi- burrows and lan- pyrite. Subtle ve- "Artificial gap: of Site Cary Cary Composition: Heavy minerals Pyrite Foraminifers Calc. nanoofoosil	LBEARING NANNOFOSSIL OQZE, ny light gray (NB). Yellowish gray (SY sinar. Madlum gray (NH to NG) lamin ampaction. SUMMARY: 2,85 5,35 D M C R D D - T - A C - b D C	soft, r 8/1) aur of r evvels.



	DIHIC	Γ	F	OSS	IL	T			T		ľ.		
LIND	BIOSTRATIGRA	FORAMINIFERS	NANNOFOSSILS	RADIOLARIANS	DIATOMS	SECTION	METERS	GRAPHIC LITHOLOGY	DRILLING	SEDIMENTARY	SAMPLES		LITHOLOGIC DESCRIPTION
						1	0.5					N8-5GY 8/1, ath(?)	FORAMINIFER-BEARING NANNOFOSSIL 002E, soft, white (N9) to very light gray (N8). Yellowish gray burrows and laminae (SY 87). Medium gray (N4 to N8) laminae of iron sufficie along the core. * Artificial gap: compaction. SMEAR SLIDE SUMMARY: 2 00
						2						N4 N8-5Y 8/1 N6	Texture: C Site C Clay D Composition: Heavy minerals T Foraminifers C Calc. namofosils D Sponge spicules T
Late Miocene						3							
						4	and some free of			1		- 5Y 8/1	
						5						- 5Y 8/1 - N5 N5 - SY 8/1 - SY 8/1 - SY 8/1 - SY 8/1	
	G, margaritae NM11R	A	A			6 JUO				1		N4 5Y 8/1	

	2	Г	F	oss	IL.	T	I	IU COREI		VA	- 143.2-152.8 m		
TIME - ROCK UNIT	BIOSTRATIGRAPI ZONE	FORAMINIFERS	NANNOFOSSILS	RADIOLARIANS 2	SWOLVIO	SECTION	METERS	GRAPHIC LITHOLOGY	DISTURBANCE DISTURBANCE SEDIMENTARY STRUCTURES	SAMPLES		LITHOLOGIC DE	SCRIPTION
						1	0.5				N9 5Y 8/1 N6 N5 N8-5Y 8/1 N6 N6	FORAMINIFER-B white (N9) to ver burrows and lamin laminae of iron s 130 cm in Section # Artificial gap: com	EARING NANNOFOSSIL OOZE, sof y light gray (N8), with yellowith gra are (5Y 8/1). Medium gray (N4 to N1 uifde along the core. Ring burrow a 5. paction.
						2	or reference inter-				NB-5Y 8/1 NB N6 N5 N5 N8-5Y 8/1	Texture: Silt Clay Composition: Heavy minerals Pyrite Foraminifers Calc. nannofosails Sonore scinules	ммант: 3,40 D C D T T C C D T
late Milocena						3					5Y 8/1	oponge spicoles	
						4	ned method						
						5	1.1.1.1.1.1.1.1.1.1.1.1.1.1.1.1.1.1.1.				- N5 - N5 - N8-5Y 8/1 - N8-5Y 8/1 - N6		
	alesiotumida S					6	and a state of the state				- 5Y 8/1 - N6		
	G.P	A	A			cc	-						



15	000	-	HOI	.E	B	T	I	IS COREL	T	ER	VA	L 172.0-180.6 m			
ç	APHI		CHA	RAC	TER										
UNIT UNIT	BIOSTRATIGR	FORAMINIFERS	NANNOFOSSILS	RADIOLARIANS	DIATOMS	SECTION	METERS	GRAPHIC LITHOLOGY	DRILLING	SEDIMENTARY STRUCTURES	SAMPLES		LITHOLOGIC DE	SCRIPT	ION
						1	0.5		0			- 5Y 8/1 - N8 - N5	FORAMINIFER-8 white (N9) to ver (N8-5Y 8/1) bur N6) laminae of in gray (N8-5GY 8/1 SMEAR SLIDE SL	EARING ry light rows and on suffic 1) lamina	3 NANNOFOSSIL OOZE, soft, gray (N8). Light yellowish gray I Jaminae. Medium gray (N4 to de along the core. Light greenish ee. Y:
						-						N8-5GY 8/1, ash(?) N6	Texture: Silt	1,65 D C	2, 140 M
						2	- tranta					₩ N6 ₩6 ₩ N5	Clay Composition: Quartz Heavy minerals Pyrite Foraminifers Calc nanonfossik	D T T R D	р Т Т С С
						-					•	N8-5GY 8/1, ath(?)			
						3	to other other					N8-5GY 8/1, ash(?) N5 N8-5Y 8/1			
late Miocen						4	the second					- N8-5Y 8/1			
												← N8-5Y 8/1			
						5						N8-5GY 8/1, ash(7)			
												- N6 - N4			
	iotumide					6	to be of the					- NB-5GY 8/1, ash(7)			
	G. pless	A				7	-					- 5G 7/1, ash(7)			

×	VPHIC		F	OSS	TER											
TIME - ROC UNIT	BIOSTRATIGRA	FORAMINIFERS	NANNOFOSSILS	RADIOLARIANS	DIATOMS	SECTION	METERS	GRAPHIC LITHOLOGY	DRILLING DISTURBANCE SEDIMENTARY STRUCTURES	SAMPLES			LITHOLOGIC DE	SCRIP	TION	
						1	0.5				X X	5G 8/1 5G 8/1	FORAMINIFER-B light gray (NB), series of green (50 occurs as pockets, 1 SMEAR SLIDE SI	EARIN firm, at i8/1) a blebs, ar JMMAR	G NAN bundant sh(?) la nd as bu	NOFOSSIL OOZE, we t burrows throughout, minae, occur, iron suifi rrow linings.
							-	7+1+1			-	5Y 8/1		1,71	3, 20	5, 20
						-	1				-	5G 8/1 5G 8/1,	Composition: Heavy minerals	D -	D	T
							1111				-	8/1 5G 8/1, ash(7)	Calc, nannofossits	A	D	D
			ł								=	5Y 8/1 5G 8/1, ash(?)				
						-	1				ŀ	5G 8/1, ash(?)				
									-	ľ	-	5G 8/1, ash(?) 5G 8/1, ash(?)				
						3			F		=	N7 5Y 8/1				
ocene						-			211		-	5G 8/1, ash(?)				
late Mic							1 to to to				=	5G 8/1, ash(?) N7				
						1	1111				=	5G 8/1, ash(?) N6				
							-	~~~ <u>~</u>			1	EX 8/1				
							1.1.1			•		5G 8/1, ash(?)				
						5	1.1.1				-	5Y 8/1				
							1111				=	5G 8/1, ash(?) N6				
											+++++++++++++++++++++++++++++++++++++++	5Y 8/1 5G 8/1, ash(?) 5G 8/1, ash(?) N6				
	unida					6	1				-	5Y 8/1 5G 8/1, ash(?)				
	G. plesiotu NN10					, J						5G 7/1 ash(?)				

SITE 588 HOLE B	CORE 21 CORED	INTERVA	L 190.2–199.8 m	SIT	E 588	H	DLE B	_	CORE	22 CORED	INTERV	AL 199.8-209.4 m	
	NOLLU GRAPHIC LITHOLOGY	DRILLING DISTURBANCE SEDIMENTARY STRUCTURES SAMPLES	LITHOLOGIC DESCRIPTION	TIME - ROCK	BIOSTRATIGRAPHIC	FORAMINIFERS	FOSSIL IARACTEF SWVINETOIDEN SWOLVID	R	SECTION METERS	GRAPHIC LITHOLOGY	DRILLLING DISTURBANCE SEDIMENTARY STRUCTURES	11.1000	LITHOLOGIC DESCRIPTION
Inter Micconfe M. contributede MNI10 Inter Micconfe			5G 8/1, ah(?) FORAMINIFERBEARING NANNOFOSSIL OOZE, very light gray (N8), firm, abundant pyrite and ah(?) lamination. Pyrite also occurs in streaks, blebs, and in burrows. 5G 8/1, ah(?) SMEAR SLIDE SUMMARY: 11 18 2, 64 4, 23 M D M 5G 8/1, ah(?) Composition: 5G 8/1, ah(?) Composition: 5G 8/1, ah(?) Foraminifers 5G 8/1, ah(?) SG 8/1, ah(?) 5G 8/1, ah(?)	lase Moccore	W. contrinuose	0.1MU		7 ~	4 5 6 6 7 7 7 7 7 7 7 7 7 7 7 7 7 7 7 7 7			 5G 8/1, ash(?) 	FORAMINIFER-BEARING NANNOFOSSIL OOZE, very light gray (N8), firm, care straaks, blebs, and burrow fil- ings of pyrits, common green (56 8/1) sh(2) layers. SMEAR SLIDE SUMMARY: 1,70 4,47 D M Composition: Quartz T - Pidiopar T - Pidiopar T - Pidiopar T - Poreminifers C C Calc. nenofossils A A

Lo	-	HOLL				1E 2	3 CORE	DINTE	RVA	L 209.4-219.0 m			SI	TE	588	H	IOLE	B		ORI	E 24	CORED
APHIC		FO	ACTER	1									×		PHIC	0	FO	SSIL				
TIME - ROC UNIT BIOSTRATIGR	FORAMINIFERS	NANNOFOSSILS	DIATOMS		SECTION	METERS	GRAPHIC LITHOLOGY	DISTURBANCE	STRUCTURES SAMPLES		LITHOLOGIC D	SCRIPTION	TIME - ROC	UNIT	BIOSTRATIGRI	FORAMINIFERS	NANNOFOSSILS	RADIOLARIANS DIATOMS	COTTON	NCI ION	METERS	GRAPHIC LITHOLOGY
late Mocene A. continuose	M48				22 22 33 33 44 4					 5G 7/1, ash(?) N6 5G 6/1, ash(?) N7 5Y 8/1 5G 8/1, ash(?) 	NANNOFOSSIL d soft, homogeneou laminae. Green (E throughout: SMEAR SLIDE SL Composition: Feldger Volcanic glass Pyrita Foraminifers Calc. nannofossib	DOZE, very light gray (NB), relatively A, rare iron suffide streaks, blobs, and GG 7/1) volcanic ash(?) layers scattered MMARY: 1,70 G,70 D M T T T - C R C D A		midde Mocene	G, mayeri NNG		~					┠┙┫┝┙╒┥╡┿┺┿┿┿┿┿┿┿┿┿┿┿┿┿┿┿┿┿┿┿┿┿┿┿┿┿┿┿┿┿┿┿┿┿┿┿



SITE	588	HOLE B	CORE	25 CORE	D INTERVA	228.6-233.6 m			SITE	588	HOL	EВ	CO	RE 2	6 CORED I	NTERVAL	233.6-238.6 m	
TIME - ROCK UNIT	BIOSTRATIGRAPHIC ZONE	FORAMINIFERS NANNOFOSSILS RADIOLARIANS BIATOMS DIATOMS	SECTION	GRAPHIC LITHOLOGY	DRILLING DISTURIANCE SEDIMENTARY STRUCTURES SAMPLES		LITHOLOGIC	DESCRIPTION	TIME - ROCK UNIT	BIOSTRATIGRAPHIC ZONE	FORAMINIFERS NANNOFOSSILS	RACTER SILLING	SECTION	METERS	GRAPHIC LITHOLOGY	DISTURBANCE SEDIMENTARY STRUCTURES SAMPLES		LITHOLOGIC DESCRIPTION
middle Miocene	G. mayeri NNB		2 3 4 CCC -			 N7, ash(2) 5G 7/1, ash(2) 5G 8/1, ash(2) 5GY 7/1, ash(2) 	FORAMINIFER light gray (N8), (5G 7/1) soh(?) is SMEAR SLIDE 1 Composition: Volcanit glass Pyrite Foraminifers Gate. mannofossil	BEARING NANNOFOSSIL OOZE, very very firm, homogeneous with rare green aminae. SUMMARY: 1,90 D T T C da A	middle Mosene	G, muyeri NNB			1 2 3 4	0.5			- N7	FORAMINIFER BEARING NANNOFOSSIL OOZE, very light grav (NB), very firm, extremely homogeneous. SMEAR SLIDE SUMMARY: 1, 70 D Composition: Volcanic gias T Foraminifers C Cate, manofosgis D Sponge spicules T

SITE	588	H	OLE B	1	co	RE 2	7 CORED	INTERVAL	238.6–243.6 m	SITE 5	88	HOLE	в	CORE	28 CORED INT	TERVAL 243.6-248.6 m	
TIME - ROCK UNIT	BIOSTRATIGRAPHIC ZONE	FORAMINIFERS	HADIOLARIANS	DIATOMS	SECTION	METERS	GRAPHIC LITHOLOGY	DRILLING DISTURBANCE SEDMENTARY STRUCTURES SAMPLES	LITHOLOGIC DESCRIPTION	TIME - ROCK UNIT BIOSTRATIGRAPHIC	ZONE	CHAR STISSOLOWNAN	SIL ACTER SWOLVIG	SECTION	GRAPHIC LITHOLOGY UNITING	ATT	LITHOLOGIC DESCRIPTION
middle Miccene	G, foht s.i. NYZ	~	A		1 2 3 4 CC	0.5			FORAMINIFER-BEARING NANNOFOSSIL OOZE, very firm ooze, very light grav (NB), homogeneous throughout, a few iron sulfide blebs. SNEAR SLIDE SUMMARY: 170 Oomposition: Poramie/fers C Calc. nannofossils D 5G 7/1, ash(?) N5, ash(?) with iron sulfide N7, subtle	middle Moxene	NN7 ×	A		0.5 1 1.0 2 3 4 CC		*	FORAMINIFER-BEARING NANNOFOSSIL OOZE, very light gray (N8); softar than overlying three or four cores; very homogeneous; minor pyrite. SMEAR SLIDE SUMMARY: 1, 80 0 Composition: Foraminifers Cale, nannofossib D





0	000	-	non	10	D		nc .	UNED	INTE	nv.	AL	207.0-277.4m
×	APHIC		F	OSS	TER							
TIME - ROC UNIT	BIOSTRATIGR	FORAMINIFERS	NANNOFOSSILS	RADIOLARIANS	DIATOMS	SECTION	METERS	GRAPHIC LITHOLOGY	DISTURBANCE	STRUCTURES	SAMPLES	LITHOLOGIC DESCRIPTION
middle Miccene	G. Abdu' k.I. Nob) 2 3 4 CCC	0.5					FORAMINIFER SEARING NANNOFOSSIL CHALK, very light gray (N8), almost homogeneous throughout. SMEAR SLIDE SUMMARY: 2, 60 4, 59 M D Composition: Foraminiters A C Cale, nannofossils A D N7% SY 7/1, darker sh(7) layer N7% N8 N9

11.	588	_	HOI	_E	С	-	CO	RE	1 CORED	INT	ER	VA	L 305.7-315.3 m				
	PHIC		F	OSS	TER												
UNIT UNIT	BIOSTRATIGRA	FORAMINIFERS	NANNOFOSSILS	RADIOLARIANS	DIATOMS		SECTION	METERS	GRAPHIC LITHOLOGY	DRILLING	SEDIMENTARY	SAMPLES		LITHOLOGIC D	ESCRI	PTION	
							1	0.5					- 5GY 7/1 - 5GY 7/1 - 5GY 7/1	FORAMINIFER-N gray (5GY 8/1 to light gray (N8) bur burrows and lar Possible Chondrite *Gap due to drilling	IANNO 5GY 7, rows an ninae. s along	FOSSIL /1). Gree d lamina Zoophy the core.	CHALK, light greenish nish gray (5GY 7/1) and e. Medium gray (N4–N6) cos-like burrows (N4).
							2	and the state of t					- N4 - N6 - N4 - 5GY 7/1	Texture: Sand Silt Clay Composition: Quartz Feidspar Mica Heavy minerals	2,80 D T C D T - T	3,75 T C D - -	6,68 T A A T T T
niddle Miocene							3	and contrast			,		- 5GY 7/1 N5 5GY 7/1 N5 - N5	Volcanit: glass Pyrite Foraminifers Cale, nannofossils		R A A	T A A
							4	the second s					- N8 - N8 - N5 - N5 - N8 - N5				
							5	and a selection of the second			1		5GY 7/1 5GY 7/1 5GY 7/1 -5GY 7/1 -N5				
	Nomerosa curva						6				11 3		5GY 7/1 5GY 7/1 5GY 7/1 5GY 7/1 5GY 7/1				
	P.9 NN						7				1		NB				

	PHIC		CH	OS	SIL				Π	1						
TIME - ROCK UNIT	BIOSTRATIGRA	FORAMINIFEKS	NANNOFOSSILS	RADIOLARIANS	DIATOMS	SECTION	METERS	GRAPHIC LITHOLOGY	DRILLING	STRUCTURES	SAMPLES		LITHOLOGIC D	ESCRI	IPTION	
						1	0.5						FORAMINIFER-N. gray (SGY 8/1 to SGY 6/1) and ligh laminae. Medium and <i>Chondritas</i> bur (1) SGY 7/1 levels. SMEAR SLIDE SU	ANNO 5GY t greet gray (rows a	FOSSIL 7/1). C nish gray N4–N8) along the RY:	CHALK, light greenid Greenish gray (5GY 7/1 (5GY 8/1) burrows and laminae. Zoophycos-lik core.
						2	A CONTRACTOR OF THE		* * * * * * * * * * *	1	:	ר <u>ר</u>	Texture: Sand Silt Clay Composition: Heavy minerals Pyrite Foraminifers		R A A T T A	0
Miocene						3	The second second			terrer an anner	•		Calc, nannofossils	A	A	A
early						4	to the test later.			-	•	ן ר י				
						5	and the set of a set				•					
	G. miozen NN2					6			****			1 1 1				

SITE 588 HOLE C	CORE 3 CORED INTERVAL 324	l,9—334.5 m	SITE 588 HOLE O	C CORE 4 CORED INTERV	AL 334.5-344.1 m
TIME - ROCK NUIT BIOSTRATHOR PORAMAREES NAMOFOSSILS NAMOFOSSILS NAMOFOSSILS	R RECTION RECTION RECTION RECTION RECTION RECTION RECTION RECTION RECTION RECTION RECTION RECTION RECTION	LITHOLOGIC DESCRIPTION		FER NOLLUS SUBJUCTION	LITHOLOGIC DESCRIPTION
early Miscens C. ditamilia NM2 >		FORAMINIFER-NANNOFOSSIL CHALK, light greaning gray (5GY 8/1 to 5GY 7/11 becomes grayich yallow grean (5GY 7/2) in Sections 3 and 4, then greenish gray (5GY 7/1 to 5GY 6/11) borrows and laminae. Medium gray (N4 to N6) laminae. Zoophytopolike and Chandrides burrows along the core. Microfractures associated with N5 laminae are present in Sections 4, 5, and 6. (115GY 7/1) * Gap due to drilling. * Grap due to drilling. * BMEAR SLIDE SUMMARY: 1, 80 Texture: * Band R Sitt A Composition: Chartz T Meavy minerais T Volcanic glass T Foraminifers A Cate. nannofossilk A	anty Miccree anty Miccree C distribution C distributit C distribution C distribution C distribut		FORAMINIFERNANNOFOSSIL CHALK, light greenish gay (5GY 7/1) to greenish gay (5GY 6/1), Greenish gay (5GY 6/1) and light greenish gay (5GY 6/1) burrows and Laminae. 2009/ycosilis and Chondrite burrows Medum gay (NA-N6) taminae of iron sulfide. Micro tractures in Section 8. (1) SGY 7/1 (1) SMEAR SLIDE SUMMARY: 2,60 6,30 D M Texture: Sit — A Clay — A Composition: Feldigar T — Heavy minerals T T Volcanic glass — T Pyrite R R (1) Foruminiters A C Cate. nannofosilis A D (1) (1) (1) (1) (1) (1) (1) (1)

SITE	588	HOLE C	COR	E 5	CORED INTER	VA	L 344.1–353.7 m	SITE	588	н	DLE	С	CO	RE 6 CORE	DINTERV	VAL	353,7-363.3 m	
TIME - ROCK UNIT	BIOSTRATIGRAPHIC ZONE	FOSSIL CHARACTER SILVINOLOURIN SILVINOLOURIN DIATOMS	SECTION	METERS	GRAPHIC LITHOLOGY DNUTUBA	SAMPLES	LITHOLOGIC DESCRIPTION	TIME - ROCK UNIT	BIOSTRATIGRAPHIC ZONE	FORAMINIFERS	FOSSIL ARACT SWEINERDOIDER	SWOLDIG	SECTION	GRAPHIC LITHOLOGY	DRILLING DISTURBANCE SEDIMENTARY STRUCTURES	SAMPLES		LITHOLOGIC DESCRIPTION
early Miceane	G. dehistens NN1 N12		2 2 3 3 4 5 6 6				N7% FORAMINIFER BEARING NANNOFOSSIL CHALK, firm, very light gray. (NB): great deal of drilling disturbance. Berection and sites/mides currace at Section 1, 95 cm. Chonor/thes burrows. Fracturing 1, 95 cm. Chonor/thes burrows. File N7% Beding SMEAR SLIDE SUMMARY: Deding N8 0 N7 Feldspar N8 0 Big. opal - N8 0 SGY 5/1, vokanic sediment, it. green clasts in darker matrix Flaer beds and microfractures N7 SGY 5/1, burrow SGY 5/1, burrow SGY 7/1 Burrowed surface	sen'ty Miccone	G, dahkeani NNT				1 2 3 4 5 6 7				5GY 8/1 5GY 8/1 5GY 8/1 5GY 8/1 5GY 8/1 5GY 8/1 5GY 6/1 5GG 4/1, distinct, ash 5GY 6/1 5GG 4/1, distinct, ash, q 5G 8/1, glass-rich 5GY 7/1 5GY 7/1 5GY 7/1 5GY 7/1 5GY 7/1	NANNOFOSSIL CHALK, very firm, light greenish gray (BGY 8/1 or 5G 8/1), abundant burrowing many fire flexks of ion sufficie throughout; numerous abi(?) layers sufficient for the section 3. SMEAR SLIDE SUMMARY: 3.131 8, 5 3, 51 3, 147 Texture: Silt A - Composition: Care - A - Composition: Care - T C T Votanic glass - T A C Gare - C A Foraminifers R R - R Calc: nanofossila D D - A ext ash(?) lass-rich



G. deh NN1

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Š	RAP	\$2	CHAR	SACT S	ER	z	\$2							×	APHIC		CHA	RAC	TER		
UNIT UNIT	BIOSTRATIC	FORAMINIFE	NANNOFOSSI	RADIOLARIA	DIATOMS	SECTIO	METE	LITHOLOGY	DISTURBANC DISTURBANC SEDIMENTAR STBILICTURE	SAMPLES		LITHOLOGIC DESCRIPTION		TIME - ROC UNIT	IOSTRATIGR ZONE	ORAMINIFERS	ANNOFOSSILS	ADIOLARIANS	IAT DMS	SECTION	METERS
						1	0.5		44	•	N7	FORAMINIFER-BEARING NANNOFOSSIL CHALK, firm, very light gray (NB), abundant burrows — m Zoophycos; very slight greenish hue throughout (glas SMEAR SLIDE SUMMARY: 1,107 Composition: D Volcanic glass T Foraminifers C	ery 1ny 57].		8		z	æ		100	0. 1 1./
						2	-14141414141414		-	•	5G 7/1	Calc. nannofosilli D									2
						3					- 56 ¥ 7/1			i Oligoorne							3
late Oligocene						4					5Y 8/1			late							
						5					KB, iron sulfide ten bands				G. kugleri 4N1					ŧ	5
	ordius					6					NB				- 2	A	A			0	C
	G, prim	~	A			7	11 11 11 11														



1	PHIC	1	F	OSSI	L	Τ			
	BIOSTRATIGRA	FORAMINIFERS	NANNOFOSSILS	RADIOLARIANS	DIATOMS	SECTION	METERS	GRAPHIC LITHOLOGY DBUILLINU DBUILLIN	LITHOLOGIC DESCRIPTION
	NP25		A			ä			FORAMINIFER-BEARING NANNOFOSSIL CHALK, light graenish gray (5GY 7/1), no bedding, moderate burrowing, some iron sulfide.
late Oligocene						2			- w
G Freedow	G. Kugleri NP25	A	A			3			



ITE	588		HOI	LE	C	CC	DRE	13 CORED	INT	ER	VAL	420.9-430.5 m					_	
	PHIC		F	OSS	TER													
UNIT UNIT	BIOSTRATIGRA	FORAMINIFERS	NANNOFOSSILS	RADIOLARIAMS	DIATOMS	SECTION	METERS	GRAPHIC LITHOLOGY	DRILLING	SEDIMENTARY	SAMPLES		LITHOLOGIC D	ESCRIP	TION			
						1	0.5				•	- 5GY 7/1	FORAMINIFER-B homogeneous, ligt grav (5GY 7/1, 5/ Zoophycos-like bu Medium grav (N4-	EARING at green GY 6/1, arrows a N6) bur	3 NA iish gra 5G 5/ ind Chu rows an	NNOF y (5G' 2) burn ondrite d lamin	OSSIL Y 8/1), ows and s along tate.	CHALK, Greenish d laminae. the core.
													SMEAR SLIDE SU	MMAR)	2 50	2 61	3 75	6.29
						\vdash	-		1					D	M	M	M.	M
							1			1		N5-N6	Texture: Silt	-	-	-	A	с
							1.4			1		5GY 6/1	Clay	-	-	-	A	D
						2	-	1	1	-		5GY 7/1 N5	Composition: Quartz		т	т	-	-
										3		- 5GY 6/1	Feldspar	-	2	т	2	-
							127			_			Volcanic glass	<u>.</u>	т	T	2	2
							- 5	1	4	1	4	- 5GY 7/1	Pyrite	*	С	R	R	-
						-	-		1	1	- 1		Foraminifers	C	A	C	C	C
							-		11	-1	1		Sponge spicules	2	<u> </u>	R	-	-
						~	1											
				1		3	1.3				1	N5						
cene										*****		- 5GY 7/1						
Oligo							-		1	1		- N4						
ate C							1 5	11,1,1		1	1	- ^m						
~							- 5	11111		-		5GY 7/1						
							1.1			13		ND						
						4				1	•							
							1			1								
										11								
		1		13						1		1000						
						H		-		1		- 1W - 5GY 8/1						
										1								
										=		5GY 6/1-7/1						
							3			1								
						5	1.3			1	•							
							1.52			11		- NE						
										5								
							1.3			1								
						F				1		5G 5/2						
				E.			1 8			=		5G 5/2						
	2						1.2					eeb.						
	ura						1.13			2								
	lisur					6				N		- 5GY 7/1						
	25		1				1.88	1		-		- 5GY 7/1						
	S. P					-	-											
		1	10	_		LC	-									_		



SI	EE	88 1	IOLE C	<u>.</u>	COR	E 1	5 CORE	DINTERV	AL 440.1-449.7 m		SI	TE I	588	HOI	EC	C	ORE	16 CORED	INTER	/AL 449.7-459.3 m	
TIME - BOCK	BIOSTRATIGRAPHIC	ZONE	FOSSIL HARACTO HARACTO BUAYOMO	R	SECTION	ME LENS	GRAPHIC LITHOLOGY	DRILLING DISTURBANCE SEDIMENTARY		LITHOLOGIC DESCRIPTION	TIME - ROCK	UNIT	BIOSTRATIGRAPHIC ZONE	FORAMINIFERS	OSSIL RACTER BIATOMS	SECTION	METERS	GRAPHIC LITHOLOGY	DRILLING DISTURBANCE SEDIMENTARY STRUCTURES	SAMPLES	LITHOLOGIC DESCRIPTION
	G. amerikisturalik	MP25			1 0 1 1. 2 2 3 3 4				- 5G 5/2 - 5G 6/1-N8 - 5G 6/1-N8 - 5G 6/2-5G 6/1 - 5G 5/2-N6 - 5G 5/2-N6 - 5G 76/1-N8 - N6 - 5G 5/2-N6 - 5G 5/2-N6 - 5G 5/2-N6 - 5G 76/1 - N6 - 5G 76/1 - N6 - 5G 76/1 - N6	FORAMINIFER BEARING NANNOFOSSIL CHALK, light grenish gray (5QY 271). Grenish gray (5QY 611, 5G 671, 5G 572) and medium gray (N4-N6) burrows and laminae. Zoophycosilike burrows and Choordrifes along the ore. SMEAR SLIDE SUMMARY: 170 3, 86 0 M Texture: Sit C – Clay D – Clay D – Clay D – Clay D – Clay D – Clay B – Clay		late Otigocene	G. angulaurturalis NP25	A A		2 3 4 CC	0.5				FORAMINIFER-BEARING NANNOFOSSIL CHALK, light greenish grav (5GY 7/1), Greenish grav (5GY 6/1, 5G 5/2), gravish vellow green (5GY 7/2) and medium grav (N4 to N8) burrows and laminae. Zoophycosilike burrows and Chondrites are present along the core. SMEAR SLIDE SUMMARY: 1, 57 2, 117 Texture: 0 M Texture: 0 M Texture: 0 M Texture: 0 J Clay D Composition: 0 J Count T Feldpair – T Peldpair – R Poraminifers C Calc. nannofossils D Sponge spicules T –

×	APHIC	1	F	OSS	TER									
UNIT - RU	BIOSTRATIGR	FORAMINIFERS	NANNOFOSSILS	RADIOLARIANS	DIATOMS	SECTION	METERS	GRAPHIC LITHOLOGY	DISTURBANCE SEDIMENTARV STRUCTURES	SAMPLES		LITHOLOGIC DE	SCRIP	TION
	NP25		A			1	0.5		-++-		- 5GY 6/1 - 5G 5/2 - 5GY 6/1-5G 5/2 - 5G 5/2 - 6GY 7/2	FORAMINIFER-Bi greenish gray (5G 5/2), grayish yello (N4 to N6) burrow and <i>Chondrites</i> are	EARIN Y 7/1) w gree vs and l present	G NANNOFOSSIL CHALK, light Greenish gray (5GY 6/1, 5G n (5GY 7/2) and medium gray aminae. Zoophycos-like burrows along the core.
	NP24						1.0		4 11		- 5G 5/2	SMEAR SLIDE SU	MMAR 3, 65 D	Y: 3,47 M
ta Oligocene			A			2			4	•		Silt Clay Composition: Feldspar Heavy minerals Volcanic glass Pyrite Foraminifers Calc. nannofossils Silicoflagellates	A A TT CDT	С. Т. Т. Т. С. С.
2						3	the state of the s				+ 5GY 6/1, N6 + N6 + 5GY 7/2			
	C. cubenais NP24	4	A			4	Intel tart				N6 5G 5/2			

SITE	588	. 1	HOL	E	C	C	ORE	18 CORED	INTER	VAL	468.9–478.5 m
×	VPHIC		FOSSIL							Π	
TIME - ROC UNIT	BIOSTRATIGRA	FORAMINIFERS	NANNOFOSSILS	RADIOLARIANS	DIATOMS	SECTION	METERS	GRAPHIC LITHOLOGY	DRILLING DISTURBANCE SEDIMENTARY STRUCTURES	SAMPLES	LITHOLOGIC DESCRIPTION
late Oligocene	NP15/16 NP24		C			1	0.5		A A A		FORAMINIFER-BEARING NANNOFOSSIL CHALK, very firm, compacted burrows, greenish-gray (SG 7/1), flase- bedded in part and FORAMINIFER-BEARING CHERT, greenish gray (SG 7/1).

SITE 588 HOLE C CORE 19 CORED INTERVAL 478.5-488.1 m

VPHIC		CHA	OSS	IL	1					Π	
UNIT UNIT BIOSTRATIGRA	FORAMINIFERS	NANNOFOSSILS	RADIOLARIANS	DIATOMS	Skicoflagellates	SECTION	METERS	GRAPHIC LITHOLOGY	DRILLING DISTURBANCE SEDIMENTARY	SAMPLES	LITHOLOGIC DESCRIPTION
Middle Eocene N. follocos Zone		c c c		<	F	1	0.5			•	FORAMINIFER-BEARING NANNOFOSSIL CHALK, gray- ish yellow green (SGY 7/2) from the top to 30 cm, then light greenish gray (SGY 7/1). Yellowish gray (SY 6/2) and grayish yellow green (SGY 7/2) burrows.
											SMEAR SLIDE SUMMARY: 1,54 D Sand R Sit C Composition: Heavy minerals T Foraminifers C Calc, namofosis D

SITE 588 (HOLE 588)









SITE 588 (HOLE 588)



	10-3	10-4	10-5	10-6	10,CC	11-1	11-2	11-3	11-4	11-5	11-6	11-7
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— 0 cm	6-1	6-2	6-3	6-4	7-1	7-2	7-3	7-4	8-1	8-2	8-3	8-4
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			Area Ministration	N	La yand all da							
			A Contract of the		1 × 1			15	ちょう			P
-	and the second second		an A Manufacture	and the second second second						1.25 M	and a stand	A CANANA AND
—75 -		ALL ALL		6,CC	1 4 4 1 4 4 4 4 4 4 4 4 4 4 4 4 4 4 4 4	· F · · · · · · · · · · · · · · · · · ·	19 C. S.	7,CC		and the second second	the second	
-		12/12	A.C.I.						A CALLER AND	A.L.		8,00
										and a start		
-						-			A A SACA			
-			1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 1									
- - 150		A CARL	the second			A.	ary.		and the second			







SITE 588 (HOLE 588B)

□ cm	1-1	1-2	1-3	1-4	1-5	1-6	1,CC	2-1	2-2	2-3	2-4	2-5
ŀ	散		CHER S	17	2		N.			See.	A MAR	-
F				12	11	1-1	R.		-	1-11		
F		T	12				1				1	
F		19			and a		14		1			
-25		1		10	and the second		1.22	100			and the	
F					Carlor A			C. A.	-	*		
-	2	and a	E STATE		and the second					de-	THE.	
[Sec.	(and		and the second			Part I	1			
50		and a	1		and the second s			Dalen				
		and the	- Ja	() Fart					a Dec			
Ļ		5							And And		P	
-	44	1									1-	
-		2.72									21	
-75	and and a	-	13/24	1								
-	a start	and a	4 4		and the second							2.40
-	and the second		1.3									
F		and an		-				1.				
-										A - 2.	1.5.	
-100								1995 - 1905 - 19				
F			•									
F	and the second		Astra.	1 al								
Ē	Star Par	The second									12.5	
		and the second s										
[125									11. 11.	C. C. C.		
	100		V								and a	1
		1	1									
Ļ			1 Alexandre	4				1 -		196		
L_150	a series	and P	lie.	N. A				. inter			1	. 25







-0 cm	7-6	7,CC	8-1	8-2	8-3	8-4	8-5	8-6	8-7	8,CC	9-1	9-2
				14	-		2		-		1	Print and
Γ	1	· · ·		in the	1 Lin	15	1.2		17.24	1-	1	i to
F	1 50	1.	1.1	Ser.	Part I	1.14	111	2	1.1.2		(m)	1.4.
L	1 3	1	1.1			1000	124	1. 15	1.1		200	1
E .	1- 3	1-	F State			1	1.10	5	1.00		*	appent 1
F	1.1.1		1-1-5	and the		2.2.4	1.12	1	11.14	and the		- All
25	in me		1	1 - 1	1.0	P. P. P.	S. R.		1.1	100	300	1
25		2 ·	1	1 60	11 3	1. 1	1.3	1. A.	1.50	10.00	- 4	1
-	1.1		1.		120	and the	1.1.1	2	1253		2.00	Car St
L	1.00		- Contract	12 7	100	1	1.1	1 T	T. A		1.5	1 -
	1.18		1. 2	1.1	20. 43	1	1	2.1				2 14
F	41.4			1 3		1.5	14.				C. N	C.
-	1		1 -	1. 1	5132		168	10			Sec. 1	18
	1.949		1.3	125	6-11-1	1.	1.00				102.0	1.
-50	111		1 7	1.2			1.5				1	A str
F	1.2.25		12.14	1	1-0	1.10	150	1			1.1	1
	1.		12	11		1.00	1.51	- A			1 de	S.P.
Γ	32		1 7	1.00	a re		1.7	1.1			130.34	100
\vdash	1. 1		131	12.3	1.1.1	-	1.54	e m			17.33	10
L	1. 1.		1.11	11		1	101	1				18 9
				11.0		1	110	. 3			1 2 2 4 2	100
-75	10		12 12		2	1	1. 1	1				1
F	F. Sale		2.1	10.0	12.0		12	1			1	199
			1	8 -			1	1 .			E.	har .
F	" water		1			P	12.5				14 J. T.	14
+			(1	B. S.	r	1.0	1.18	1. 1			and the second	₹
			1. 1	Dec. 1	S . 3	1 1	+1				- Aler	311
Γ				1				1.				1.4
-100	111			18 64	1.1	122	8				- sint	199
L	T		Tille	13.00		L.	1.0	1.1				
	NS		D. D.	12.5	1414	1 124	148	E.			17	1
F	1. 2			125	1.1.1	19	1	3			100	See of
F	1. at		1	19.5			1 0				E. Sai	
			1.	13	£	1. 5	di.	12 1			the the	6.7
F	Sec. 1			1 1	20	4-1	11				G.F.C	The Red
-125	and the second		STAN	1220		1	trees	10-2			Enclaster.	No C
	12		1000	27.5		- 1	1	A			1 2 AV	
Г			N ST	1. A			10.1				123/45	*
F	G ,			A.		1.4.19	1 34				The Land	
L	N 197		Sect	A. 14	126	Sec. 3		100 m			1.1	
	8.2.8		1	1 cont	11 2	1. 5		and the second			ARE	
F	19 19 19		4	is set		ties =		Etter,			AL	
L_150			A	Sec. 9	1 - can	111		1.5			-	- A

— 0 cr	n 9-3	9-4	9-5	9-6	9-7	9,CC	10-1	10-2	10-3	10,CC	11-1	11-2
F			(The second	1	4				1 2 2 2	•	(Spar	
ŀ						an alter	in s	7	5 4		a star	A.2.
F	Nan			- R		A		1		No.	CA.	1
F				- line		1 minut	19	1	Pin I	1	and the second	5-
-25		+	三 月三	734	2-1		Sch		A.S.		E.	
4	12.2	in the	Adama -				20	1	1-2-3-1	1	ET.	
F		1	19 8.	1	1				1		12	K
F		1.14	Section.	-	Landers		1)-17	1.1	2.17.2		A. C.	ALC: N
F		1.24	-1	1 -			12 64		in il			1
-50	and and a	1		- 1-			2. 33	译行	F			1
L		1.1.1		0.33			52	1.00	E.			11
L	Contras.		14	2.1			• 7	21			行作	
	1	he sa	14 12	-			-	Fare	1. 14		(2.47)	1.004
	2		200	6.5							1 2 M	
75	2-4		1						12		il.	1
-/5	e there is	200	1				N.	1.8			(Geo)	1. 1. 1.
[4.	1		11			-	191			5	
Γ		1		-			1				1.	Kar in
F	1	12 19	1-1-1-1				1				1	rin
F	18	1111	1				1	11			100	
-100	W.S.	1					114	-				14
F	1			6			1.1	and the			11.50	bert
F		1	1.0	41 IL							1.	
F		12 2		10			75	1-5			S.	
				1999			and a second					-24
-125		1					1					1
				and the second			N N				1	St.
		1					-	1999 - 1999 1999 - 1999 1999 - 1999			0.4	1
				1924								and the second
-	1. 4	1. A.		the second							130	a laste
-150 L		14.13	ale series	and a second			in a	in the			and and	1 1

0 cm	11-3	11-4	11-5	11-6	11-7	11,CC	12-1	12-2	12-3	12-4	12-5	12-6
	and the	1220	Licial	100	9	and a	5	1993		65465B	THE R	
- 1	1. 1.	12)	(A)	E.C.	1	200		1 Ball	- 11	A the g	16.2	ALCRUCH
-	12.78	2. 1	1.1.1				1			17	1.00	1 5 1
	- 19:0	a h	100 - 2	the second second	1999	1200	P.S.	A.S.	1 2 4			14.3
-	1 - bet	F 14		1	5	4	1947	5.35		P		The second
-	1 19 0		1	and the second	1 21	Dere al	AN		1 1	20-1	1	WILL D
	1	4.2 L			1 march	and and	1-1	12	1	2.59	C.S.S.	
25	1.4	1 7	1.1					N.S.N.	111 21	16 8	14-5	
-	1 - Barris	111	100		1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 1			4.11) 4.12			1:23	in the second
	17.3		E F	11				344		1	1	1.1
F	-	P	1	1 mar			1.1			1-1-1		
+	5.7	. 1	Sec					-3 (*)	1.000	1.1.2	国本	825
				1			Colors.	Constant's	Alterne ?	11 3		A AN
Γ	The set	at here		1 4 5			Ser.	AF C.	h	-	1 the	
-50	14	Et a		1.1			- 1K2	AL.	And the second	3.4	11 - 1	- 3A
L		1. 21	1.00				Ser 4	and the	and the second	- 7 E	1.	· the s
T I				14			Case of	1.5	1000	FIE	1	2.26
F	1 .			- 1				and a		140		1
L	3.8	Sec. 20	1	1					198	1.	1	11 -1
Γ	CTP3	11	3.				a mar	10	6-	1 mp and	1	1
-	1. 1	1		2.0			N. S.			1. 1. 5	F	i for the
L_75	144.0	1 and	4				12.54		1	121	died.	1.5
 	\$	Sec. 1	N-	1.0-2			150.00		4 4 1	Da A	1997 - 19	1. 308 A
F	134		· · · ·	153			1.1.1		13 82	10 103	his fat	112
L	1.1 1		-	1.20			-1-1	100	1111	Nº S	3.2	in f
	1.2	1418	-1.44	1.54			Saint .		1.21	1.12	They al	£ _ 3
F	2 to and	1.	2. 1.3	300					1. 2.	1. 1	6 · · ·	2 × 24
L	1 2	5.33	1.1	-			25 mg	1818月	1. 20			12
	1. 1.	E T	1	6.93				11.54	181 8	111	Prove Car	For all
-100	1.23	Same?	TUL C					17 The	12.23	1	1 14	門馬
L	it.	March 1	and the	1.1			in the	4.4	1. 1	1.1.1	1 4- 19-1 1	1 - It
	The second	19 1	in a star	and the second				1.30	A CONTRACT	and the	- 200	Nº P
F	-	The s					1999	128-1	B That E.	1.1.1.3	*	1 1
F	194	No.		19.15			19 14 - 2% -	and the	2	1 1		1-1-1
		100		No tes			1 100	and the			19.7	100
	1.2.4	1	1 des	1 Cas				C. C. S.			The second	仁昌發
-125	-	1.3.3	Same	14			Ed of S			1-56-11	[-, 0]	1000
00-05405	· 100	Sec. Sec. 1	21-514	18 200			S. S. S.	· ·	1		1 19	15
-	1117		N. Carl	1					1 50 kg	1 the first	- 10	
-	- to 14	1		and the second			and the	R.	1231	10-5	6 72	
	ant	- Port	and annia	in C			in the	Section 1		Contraction of the		1
F	123			10 3			and y	的现在	100	Pront in	1 (A 1	
-		all the	and the	S-1			•	Prove 1		1	South 1	
150	a 11	137	New 1	The start			5	and the second	an s.	e and	A CORE STATE	- AC

	12-7	12,CC	13-1	13-2	13-3	13-4	13-5	13-6	13-7	13,CC	14-1	14-2
F	Te			File	1 4 H	141	Par .	1 1 3	1.4		M	The second
L			17	(月二)	N.Y.Y	4		1.2		A Starborn	P	14
L	Tag	The second	136		all's sheet	- 24			1000	-	A.A.	
	Lange -	7		-	- 3		1		and the	K.	1. Salar	A AL
Γ	E LARA		MyL.	$r_{T,\gamma}$	10				and the second	No.	D.A.	
-25	The second		1. 42		N.		1.50		her		32	4.4
F		S. SPALK	A.	and an	1911		1.17				1.4	6.44
-	12		12	1	14	1 P	The second				1	
-	1.000		1 10		Pro	12	1.1	- 14			1 miles	1
-	No.		E.A.		142		1. AP	12			and the	1 6
-50	10.3			- Tope	ALC B		(CON)	100			633	
			100			See	120	1			152	1
						. 4		15.2			177	
Γ			S 1-	1.3	1.2 1	11	in mit				34	1. 24
F				18	$= \int_{-\infty}^{+\infty} dr dr$	1 12	S	1.14			13.7	he f
Γ				2:0	1000		6.1	- Sig			2	
-75			and the second	-		1	2	1			1	1 1
F				$\mathcal{U}_{i} = \mathcal{T}_{i}$	ant.	1		RY			1	
-				-	1.	31	1 -	1.23				1-1-
F			in per		18	114	1 × 2 1 × 1	1			HE TH	考虑
L			1	1	A	5.1	No.				19.5	12.3
_100				R. S.	10 to		12				17	1000
100			1		- All a	1		1			1 is	1 8
F				123	1. 360	11	121	The second			E.A.	
F				1				A. 1			1.54	1. 3
F					124	6.3	1	2-1			1	12
-			1	and a star	12.1		4	1				E.
-125			2		1	4	247	19 8			- 4-1 (+)	1 4
F			1.4		The second	1	1	1.1.1			18 3	10
L				and the							2	100
L			12 V		1		Politia					1. 15-
[Fin .		1				Alexan	
F				Elect	一本	TAX.	-				151	Prove State
L-150			Comments and the	a h	100 million - 1	Contraction of the	the second	12 K 6 4 9				1

-0 cm-	14-3	14-4	14-5	14-6	14-7	14,CC	15-1	15-2	15-3	15-4	15-5	15-6
		Chil	10	T '	1/2			- 3	-	1-		
F 1	3.4	1	1 4 -	1.1.1	12.		-011			1.1.1		1. 10
- 1	Mr.	1		1.1	1.5	1	1.	Rain		-		25 Y
L 1	1	D A P		19123					121		1.1	16
		Nº .	18.00	1.1.2	1. 25%	in the second second	· ·		2-	19 1		
-		100	R. C.	and.	6 2 4	-	T.S. C.		¢	1975		Performante
-25	A.	122 13	30	134			12		1.52			A
	45.	1215		1-1			1	1.1	能 表 1	Ti.	1 31	
		1964		17-2	1.						12	and the second s
	~	Sala	1	No.	1-3		1. 1.	1	Anna A	1 13-	1.40	A STATE
- 1		19.3.9	1	1.1.2	1. 7. 2		1 ton	1 14	30	1	2.2.5	1.4
	51	Sile	A in	*			19 P.	4			1.3	1
	1	KN S	1. 2.	3 1	1		1.1.2	1.			1	-3
-50	A.	25.8	1.1	1	1		1 6	200	1:	1.1	1	
-	22.1	1 STAL	VES	a tidare			de la	and -	1.2	1214		
L	1	0	1.1	A. A.S.			1.12	23.	1.20	12.5		
	¥.	1.00	15				12.4	12 1	and a		1.1	
F	1. 1.	10.00	1.1	1 million			1	· · ·	12	Rug 1	1.14	
F	12.1	1 35	-	6.5.4				1	141.5	1 mart	and the	1000
-75	A)		Phane 1				1 11	*	1 3	100		P : *
[⁷⁵	164		國的	しん川			Nº 4	1.00	1	14	1	
F	S. Ce	1. 9		Lor in			1	0.46	123	No. 1	1 1 1	1
F	The W	Pil		1 1 1			1	1	40 7	- Art St	1.12829 A.T.	1.
	1966	1	243	1.			1 3	1.1	14	1.1	1.1	
Γ	X	3.3		1 Sec.			14		612	- The	123	8
-	14	100	1.00	18			de :	1	11		12 .	5
-100	121	1.1	the state	1			1		1. 1	a = a + b	15 1	100-20
		13.	×.	6.4			1.5	1.	132-1		1-1	1
F	15	3	2 Cont	1.5			1		1.2	Service The	11	·
F	1	2.91	1.	Let.			212	and a	10.10	1000	E Ser	1.3
L	1	- 5		1. 35.				(Suma	1000		125	1.33
	1	2.5	C. Frid	子学			1	11	1. Alasta		1. 10	1
F		22.1		200			15-2-1	375	2 3		C. marrie	1-25
-125	67.73	1	the state	. he -				1 2 3 1	1	1	1.17	Sec.
L	Mar	the state		12.33			- 2	44	Se i	11	1	1
	Q.s.	d Be	~	transfer 1				1. 1. 4.3	1.5			1
F	1		1	6.1.14			and the		10.20		1.25	100
F	1.	8		Sec. 1				53		Sec. 1	1.1	1.19
	in the	1.		1 - 27			100	here and	1.74		+	621
Γ	15	A.	103	1					5	1. Proj	12	1
L-150	-	Terra	1 Asta	1.111			share Providence		Real Property lies		SHOT	CONTRACTOR OF

0 cm 15-7	15,CC	16-1	16-2	16-3	16-4	16-5	16-6	16,CC	17-1	17-2	17-3
- 1	• T.			- 31	A		1		1		
-	1		1		15-11		and the second		7		
-			-R.	-	1		4	100 M			1
+			Renter	Fill	19154		100				1.1
-25		with the		81.3	Ant			in	E.		tra
-			and a	-	1.			1-		NER J	1
-		e.		191	Les		10		1.1		1
-			14.	1		12				100 - 10 - 10 10 - 10 - 10 10 - 10	1
-		1 44	17 14 J	Pre .	1.71					1	1.
-50							a series		- Starter &	and a second	12 miles
		10	1	1 3 4	han		100		- the		(and
-		and a	1		S.	1			and the second	(*** ***) (**	Sec. 1
-		1.2.1		Sill	15-		1 33				
-			1-11-3 	1	1.	R M	44		and the second se	4 5	1
-75			NA.		1	Fred	1		1. 1	and the second	1.11
		and and	1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 1	1			至南		1	· · · ·	
-		*	4	and the	1.50	n al	A				
-			1111 - 1	390						100	1 h
-			1.15	1 Carl	5.0		h -		T. Martin		i je
-100		1	1.1. A	here	12		£ . :		1	and the	
-			(ja)	1.5	e a	32	h e		1. 1. 1. 1. 1		picks T
-		4		14		1	4-			1 1.47	144
-		1.1	1.	12	- 1944 - 22				- 79	14 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1	
-			大学社		a production of	15			:41	A VILLE	
-125		1. 1	der.	1.3.4	Liteo pi	1			- 14		10 miles
-		10-24	Provide State	1		ц ' ;			· · ·	1	1 and
L					and		10-1-1-		1 4 10 -	Ell' 2-1	in the
-		化品	1 the second	-	1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1		2.2			100 A	-
L			Eler of	-	1 dila				i -		1 to 1
_150				Salatas	and the	Survey of			100	1 . 75	

-0 cm	17-4	17-5	17-6	17-7	17,CC	18-1	18-2	18-3	18-4	18-5	18-6	18,CC
-		4						Ale and a second				
L	1		e	なって不可			1-1				- 1-1	
					a star		1 5			1.1		
Γ		· · ·				1 AM	3.74.		11	100		
F	-			1		1 des			the state			10 7
-25	1.1.1		44.7 12	12		14		2 . 1	2 . M		100	K
-	2.2					A LAN	1	A.F			1	
F	125					A			i ji	1		
Ļ	1		A CONTRACT	生活で加			i ka	564	11	-		
L	Times.					R. 5	1					
	and		AL TO	1. 6.1		一百		4 - 4				
- 50	in			and of		1					2 - 2	
F	1-1-2		1			$\langle \cdot, F \rangle$	1. 3	1	1	244		
F	大王							a market		and a second		
F	42/20		1			1	10 14			100		
F	and and	. F				e Bringe		- 14°			4	
-75		12	States			• •	14 to 1	. î	22.27			
	1	1 3	A STAN				1-2.			1	1	
Γ	April	the second					1					
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	1 - 6		13			ha			1			
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-0 cm	20-5	20-6	20-7	20,CC	21-1	21-2	21-3	21-4	21-5	21-6	21-7	21,CC
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SITE 588 (HOLE 588C)





SITE 588 (HOLE 588C)





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SITE 588 (HOLE 588C)

