7. SITE 591: LORD HOWE RISE, 31°S¹

Shipboard Scientific Party²

HOLE 591

Date occupied: 19 December 1982 Date departed: 20 December 1982 Time on hole: 38 hr. Position: 31°35.06'S; 164°26.92'E Water depth (sea level; corrected m, echo-sounding): 2131 Water depth (rig floor; corrected m, echo-sounding): 2141 Bottom felt (m, drill pipe): 2142.2

Penetration (m): 283.1

Number of cores: 31

Total length of cored section (m): 283.1

Total core recovered (m): 278.21

Core recovery (%): 98.3

Oldest sediment cored: Depth sub-bottom (m): 283.1 Nature: Nannofossil ooze Age: Early late Miocene

Basement: Not reached

HOLE 591A

Date occupied: 20 December 1982

Date departed: 22 December 1982

Time on hole: 37 hr.

Position: 31°35.06'S; 164°26.92'E

Water depth (sea level; corrected m, echo-sounding): 2131

Water depth (rig floor; corrected m, echo-sounding): 2141 Bottom felt (m, drill pipe): 2142.9 Penetration (m): 284.6 Number of cores: 30 Total length of cored section (m): 284.6 Total core recovered (m): 233.15 Core recovery (%): 81.9 Oldest sediment cored: Depth sub-bottom (m): 284.6 Nature: Nannofossil ooze Age: Early late Miocene

Age: Early late Miocene Measured velocity (km/s): 1.656 km/s at 249 m Shear strength: 145 g/cm² at 248 m; greater than 250 g/cm² below

Basement: Not reached

HOLE 591B

Date occupied: 23 December 1982

Date departed: 24 December 1982

Time on hole: 31 hr.

Position: 31°35.06'S; 164°26.92'E

Water depth (sea level; corrected m, echo-sounding): 2131

Water depth (rig floor; corrected m, echo-sounding): 2141

Bottom felt (m, drill pipe): 2141.5

Penetration (m): 500.4

Number of cores: 24

Total length of cored section (m): 229.8

Total core recovered (m): 130.86

Core recovery (%): 56.9

Oldest sediment cored: Depth sub-bottom (m): 500.4 Nature: Foraminifer-bearing nannofossil chalk Age: Latest early Miocene Measured velocity (km/s): 2.218 km/s at 495 m Shear strength: 222 g/cm² at 294 m; greater values below

Basement: Not reached

Principal results: Site 591 consists of three holes. Hole 591 was cored continuously with the hydraulic piston corer (HPC) from 0-283.1 m sub-bottom; Hole 591A was cored continuously with the HPC from 0-246.5 m and rotary cored with the extended core barrel (XCB) from 246.5-284.6 m; and Hole 591B was cored continuously using conventional rotary coring from 270.6-500.4 m sub-bottom. Cores recovered with the first HPC are relatively undisturbed; those using the second HPC are slightly more disturbed because of rough sea conditions. The cores recovered using conventional rotary coring exhibit mixed quality: quite disturbed in the upper part of the section, although recovery was high; moderate recovery in the middle part of the sequence; and good quality cores with moderate to low recovery rates in the lowest part of the sequence. The extended core barrel did not function successfully at this site.

The sequence is made up of one lithostratigraphic unit represented mostly by foraminifer-bearing nannofossil ooze or foramin-

Kennett, J. P., von der Borch, C. C., et al., *Init. Repts. DSDP*, 90: Washington (U.S. Govt, Printing Office).
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ifer-rich nannofossil ooze. Site 591 is a continuous sequence from the late early Miocene (17 m.y. ago) to the Quaternary. The HPC part of the sequence is from early late Miocene (11 m.y. ago) to the Quaternary. The biostratigraphy is complete with no apparent hiatuses. A paleomagnetic polarity stratigraphy has been identified down to the late Gilbert Chron (about 3.5 m.y. ago).

The sequence is divided into three subunits based on changes in color and the relative abundance of foraminifers and calcareous nannofossils, and on the degree of lithification. The sedimentary sequence is similar to that at Site 590, but there are even more spectacular sedimentation rates within the early Pliocene: 131 m/m.y. These high rates are due to the high productivity of calcareous biogenic material occurring in the late Neogene at three sites in this area (590, 591, and 206). It is possible that the particularly high biogenic productivity in this area is related to the poorly known Subtropical Divergence that crosses the Tasman Sea at the latitude of these sites. Rates are much lower at the sites drilled to the north of Lord Howe Rise (Site 588) and to the south (Site 592). We have dismissed the possibility that the high sedimentation rates in the Pliocene are due to secondary reworking of material from elsewhere. This is because of the isolated location of Site 591, near the crest of a spur of Lord Howe Rise, and because clearly reworked material is absent from the section.

Diagenetic alteration of the microfossil sequence took place in younger sediments than at Site 590, because Site 591 has higher sedimentation rates. Foraminiferal recrystallization is already well advanced in the lower middle Miocene sediments, and calcareous nannofossils exhibit signs of overgrowths in lower Pliocene sediments. The higher rates of sedimentation at Site 591 have allowed finer stratigraphic resolution than at Site 590. A number of evolutionary sequences within the planktonic foraminifers are clearly exhibited in this expanded sequence.

Site 591 provides excellent opportunities for high-resolution microfossil and stable isotopic work in the upper Miocene through Quaternary section, which is well preserved. Radiolarians, diatoms, and silicoflagellates are persistently but rarely present throughout the entire section.

Benthic foraminifers are well represented in the late Miocene to Quaternary. Site 591 is intermediate in vertical depth profile (2131 m) between Sites 590 and 206. Benthic faunas typical of upwelling zones appear in the middle Miocene. Important faunal differences exist between Sites 591 and 590, reflecting different paleoceanographic histories at these different water depths. The paleoceanographic changes include both upward and downward migrations of some forms of benthic foraminifers.

Site 591 exhibits a valuable tephrochronology, based on many volcanic ash layers and inferred altered ash layers. There is an important Quaternary peak in activity, low activity in the Pliocene and late Miocene, high activity in the early late Miocene to late early Miocene. The mid-Neogene peak may extend through the middle Miocene, but core recovery was poor in this interval.

BACKGROUND AND OBJECTIVES

Site 591 lies near the crest of a southern spur of the eastern part of the Lord Howe Rise (Fig. 1). The spur extends outward into the New Caledonia Basin and is surrounded by turbidite fill to the east and south. The western edge of the spur is, in its northern part, separated from the main part of the Lord Howe Rise by a valley that slopes southward, leading toward a ponded turbidite sequence which slopes toward the level of the New Caledonia Basin. Thus the crest of the spur on which Site 591 is located is isolated from any influences of sediment transportation from the main part of the Lord Howe Rise. The seismic profile (Fig. 2) exhibits a relatively simple transparent layer about 520 m thick above a distinct reflector which is considered to represent the regional unconformity associated with the Eocene/ Oligocene boundary.



Figure 1. Regional bathymetry (fathoms) around Site 591, after Mammerickx et al. (1974). *Glomar Challenger* Leg 90 track shown; heavy portion locates water gun seismic profile illustrated in Fig. 2.

Site 591 was selected to provide a Neogene-late Paleogene stratigraphic succession at water depths intermediate (about 2200 m) between Sites 590 (1299 m) and 206 (3196 m). A site at this intermediate depth is required to study changes in the vertical water mass structure of the southwest Pacific Ocean during the Neogene. These three sites, in combination, will provide an opportunity to carry out detailed studies of changes in the intermediate water masses between 1000 and 3000 m water depth. Site 591 is located midway between Sites 590 and 206, providing a compact suite of sites.

Determining the vertical temperature gradient of past oceans represents a problem that has not been studied in detail. Keigwin et al. (1979) examined the thermal structure of the Pacific Ocean for the early Pliocene, using sediment cores from water depths between 1000 and 4500 m and oxygen isotopic analyses of benthic foraminifers. This study demonstrated an approximate 1% difference in δ^{18} O between cores taken at 1000 m and those from 3000 m, representing a 3°C vertical temperature difference through the intermediate water masses. A major goal of Site 591, as with the other sites in the depth traverse, was to provide a continuous sequence of high stratigraphic resolution through the Neogene, which would allow us to compare and contrast the $\delta^{18}O$ and temperature gradients between selected intervals of time (see Kennett, this volume). For instance, we were interested in determining whether any changes occurred in the character of the vertical temperature gradient during the middle Miocene paleoceanographic event, when considerable ice accumulated on east Antarctica (Shackleton and Kennett, 1975; Kennett, 1978; Woodruff et al., 1981); during the terminal Miocene event, when a distinct shift in $\delta^{13}C$ occurred in the deep-sea sediment record 6.2 m.y. ago (Loutit and Kennett, 1979; Vincent et al., 1980; Hag et al., 1980), perhaps related to a major change in oceanic turnover rates (Bender and Keigwin, 1979); and during the late Pliocene, about 3 m.y. ago, when Northern Hemisphere ice sheets began to form (Shackleton and Opdyke, 1977).



Figure 2. Water gun seismic profile (Glomar Challenger) near Site 591; bandpass filter 50-160 Hz.

Changes in δ^{13} C were also to be examined through the Neogene at the different water depths offered by the sites in this traverse. It has been determined that differences in δ^{13} C values represent valuable fingerprints of bottom waters.

The vertical depth traverse also was intended to provide a valuable opportunity to examine changes in benthic foraminiferal assemblages within the intermediate water masses during the Neogene. Benthic foraminifers are particularly valuable tracers of change in bottomwater characteristics through time (Douglas and Woodruff, 1981). They either migrate, evolve, or become extinct in response to bottom-water changes. The cores in the southwest Pacific depth traverse were expected to allow foraminiferal changes to be evaluated within a framework of paleodepths. This, in turn, should provide valuable data on the evolution of the intermediate water mass and allow comparisons with the stable isotopic data.

Site 591 is located at 2130 m, above the foraminiferal lysocline, and calcareous microfossil preservation was expected to be of high quality. Like Site 590, this site is located in waters transitional between the warm sub-tropical and temperate water masses and is of potential importance in correlating stratigraphic sequences of these areas. Because Site 590 was marked by very high sedimentation rates in the middle Miocene and younger sequences, high overburden pressure created much recrystallization of the microfossils in the middle and early Miocene. This has a potentially detrimental effect upon stable isotopic values. It was hoped that the calcareous microfossils through the early Neogene sequence at Site 591 would be less recrystallized and thus more useful for analyses of stable isotopes.

The final location of SW-6 (Site 591) changed during Leg 90. Originally SW-6 was to be located at a similar depth about 1° of latitude further north on the slope of the Lord Howe Rise. The original position was located on an Australian Bureau of Mineral Resources seismic profile which is of poor resolution but was the best available in the region. During the breakdown of the shipboard positioning computer, a useful survey conducted near Site 206 with the excellent water gun profiling system of the *Glomar Challenger* provided high-resolution data of the upper part of the sediment column. It was discovered that areas between about 1900 m and 2900 m on the slope of the rise exhibit heavily slumped topography. This seems also to be the case in the original area proposed for Site SW-6 drilling. A new area favorable for SW-6 objectives was discovered on the spur of the Lord Howe Rise, in unslumped terrain, exhibiting apparently uncomplicated stratigraphy and with a sediment thickness of 520 m down to the inferred regional unconformity separating the Eocene and Oligocene.

The drilling plans at Site 591 were to take two hydraulic piston cores and to rotary core (XCB) continuously through the Neogene sequence to the upper Oligocene sequence.

OPERATIONS

Site 591 (new SW-6): Downslope of Central Lord Howe Rise

The ship was positioned over the beacon with some difficulty because wind, current, and swell were all present from different directions. A combination variable length (VL) HPC-XCB bottom-hole assembly (BHA) was made up and run to the seafloor. Hole 591 was spudded at 1150 hr., 19 December, with a mud line core which verified the water depth as 2142 m (Table 1).

Piston coring proceeded using the 9.5-m VLHPC with only two shear pins. A nearly perfect series of cores was taken to a total depth of 283.1 m BSF in gradually stiffening carbonate ooze. Favorable conditions of vessel motion, repeated full stroke of the piston corer, and excellent core quality made this an exceptionally well preserved cored sequence which was marked by greater than

Table 1. Coring Summary, Site 591.

	Date		Depth from drill floor	Depth below seafloor	Length	Length	
no.	(Dec. 1982)	Time	(m) Top Bottom	(m) Top Bottom	(m)	recovered (m)	recovered
Hole 591							
1	19	1215	2142.2-2145.6	0.0-3.4	3.4	3.38	99 +
2	19	1318	2145.6-2155.2	3.4-13.0	9.6	9.72	100 +
4	19	1503	2164.8-2174.4	22.6-32.2	9.6	9.47	99+
5	19	1605	2174.4-2184.0	32.2-41.8	9.6	8.82	92
6	19	1705	2184.0-2193.6	41.8-51.4	9.6	9.57	100
8	19	1805	2193.6-2203.2	51.4-61.0	9.6	9,12	93
9	19	1950	2212.8-2222.4	70.6-80.2	9.6	9.44	100 +
10	19	2055	2222.4-2232.0	80.2-89.8	9.6	9.65	100 +
11	19	2150	2232.0-2241.6	89.8-99.4	9.6	9.16	95
13	19	2350	2251.2-2260.5	109.0-118.3	9.3	9.19	98.8
14	20	0050	2260.5-2269.8	118.3-127.6	9.3	9.67	100 +
15	20	0200	2269.8-2279.1	127.6-136.9	9.3	9.64	100 +
16	20	0300	2279.1-2288.4	136.9-146.2	9.3	9.63	100 +
18	20	0450	2297.7-2307.0	155.5-164.8	9.3	9.29	100 +
19	20	0600	2307.0-2316.5	164.8-174.3	9.5	9.55	100 +
20	20	0700	2316.5-2326.0	174.3-183.8	9.5	9.59	100 +
21	20	0740	2326.0-2335.5	183.8-193.3	9.5	9.47	99.7
23	20	0940	2344.9-2354.3	202.7-212.1	9.4	9.50	100 +
24	20	1035	2354.3-2363.7	212.1-221.5	9.4	8.63	91.8
25	20	1145	2363.7-2373.3	221.5-231.1	9.6	9.73	100 +
26	20	1245	23/3.3-2382.9	231.1-240.7	9.6	8.76	100 +
28	20	1445	2392.5-2402.0	250.3-259.8	9.5	9.11	95
29	20	1615	2402.0-2411.5	259.8-269.3	9.5	8.93	94
30	20	1730	2411.5-2416.5	269.3-274.3	5.0	4.40	88
31	20	1900	2410.3-2423.3	274.3-283.1		8.76	- 99
					283.10	278.21	98.3
Hole 591A						121221	122
1	20	2052	2140.9-2150.1	0.0-9.2	9.2	9.16	100
3	20	2300	2159.7-2169.3	18.8-28.4	9.6	6.40	66.6
4	20	2340	2169.3-2178.9	28.4-38.0	9.6	8.30	86.4
5	21	0055	2178.9-2188.5	38.0-47.6	9.6	8.67	90.3
7	21	0200	2188.3-2198.1 2198.1-2207.7	47.0-57.2	9.6	9.28	87.9
8	21	0350	2207.7-2217.3	66.8-76.4	9.6	7.92	82.5
9	21	0445	2217.3-2226.9	76.4-86.0	9.6	7.34	76.4
10	21	0540	2226.9-2236.5	86.0-95.6	9.6	6.92	72.0
12	21	0745	2236.3-2246.1	105.2-114.5	9.6	8.61	92.5
13	21	0840	2255.4-2264.7	114.5-123.8	9.3	8.55	91.9
14	21	0940	2264.7-2274.0	123.8-133.1	9.3	9.20	95.8
15	21	1040	2274.0-2283.3	133.1-142.4	9.3	9.39	100+
17	21	1240	2292.6-2301.9	151.7-161.0	9.3	9.24	99
18	21	1340	2301.9-2311.4	161.0-170.5	9.5	8.86	93
19	21	1440	2311.4-2320.9	170.5-180.0	9.5	8.79	92
20	21	1540	2320.9-2330.4	180.0-189.5	9.5	8.27	87
22	21	1745	2339.8-2349.2	198.9-208.3	9.4	9.48	100 +
23	21	1900	2349.2-2358.6	208.3-217.7	9.4	9.25	98
24	21	2030	2358.6-2368.2	217.7-227.3	9.6	8.29	86
25	21	2130	2308.2-2377.8	236.9-246.5	9.6	8.18	87 6
27	22	0100	3387.4-2396.9	246.5-256.0	9.5	7.31	76.9
28	22	0445	2396.9-2406.4	256.0-265.5	9.5	0.0	0.0
29	22	0545	2406.4-2415.9	265.5-275.0	9.5	0.0	0.0
30	22	0045	2413.9-2423.3	275.0-284.0	9.0	4.15	43
					284.6	233.15	81.9
Hole 591B	22	0400	2411 6 2424 1	370 6 300 3	0.6	1.0	30.4
2	23	0645	2411.5-2421.1	280.2-280.2	9.6	9.48	98.7
3	23	0730	2430.7-2440.3	289.8-299.4	9.6	7.42	77.2
4	23	0820	2440.3-2449.7	299.4-308.8	9.4	7.08	73.7
5	23	0905	2449.7-2459.1	308.8-318.2	9.4	5.00	52.0
7	23	1045	2468.5-2478.1	327.6-337.2	9.6	9.00	93.7
8	23	1130	2478.1-2487.7	337.2-346.8	9.6	2.17	22.6
9	23	1235	2487.7-2497.3	346.8-356.4	9.6	2.69	28.0
10	23	1335	249/.3-2506.9	350.4-366.0	9.6	4.31	44.9
12	23	1535	2516.5-2526.1	375.6-385.2	9.6	2.51	26.1
13	23	1620	2526.1-2535.7	385.2-394.8	9.6	3.24	33.7
14	23	1740	2535.7-2545.3	394.8-404.4	9.6	2.21	23.0
15	23	1840	2545.3-2554.9	404.4-414.0	9.6	4.11	42.8
17	23	2040	2564.5-2574.1	423.6-433.2	9.6	5.06	52.7
18	23	2140	2574.1-2583.7	433.2-442.8	9.6	8.70	90.6
19	23	2240	2583.7-2593.3	442.8-452.4	9.6	7.86	81.9
20	23	2340	2593.3-2602.9	452.4-462.0	9.6	7.74	80.6
22	24	0145	2612.5-2612.5	471.6-481.2	9.6	7.98	83.1
23	24	0245	2622.1-2631.7	481.2-490.8	9.6	9.71	100+
24	24	0345	2631.7-2641.3	490.8-500.4	9.6	6.24	65.0
					229.80	130.86	56.9

98% recovery. The hole was terminated despite continued full stroke when excessive pullout loads endangered the coring tool.

Hole 591A

The bit was pulled to the mud line and the vessel was offset 100 ft. in preparation for a repeat piston core sequence. The new hole was spudded at 2012 hr., 20 December. Cores were staggered to overlap those from Hole 591. Rougher weather resulted in poorer core quality and recovery in the repeat piston core sequence. Again full stroke was achieved on all cores.

Piston coring was stopped at 246.5 m BSF to avoid excess overpull. The XCB was then deployed a total of six times. Each of the six attempts resulted in a severely shattered liner which created much difficulty in removing the liners and/or cores from the core barrels.

Additional problems were encountered when several of the XCB core barrels did not land at their proper latch-in point above the bit. Each seemed to become stuck at a position 70–80 m above its normal landing point and required repeated jarring by the wireline to become free. No immediate cause for or solution to this phenomenon could be found.

Both these problems led to the termination of Hole 591A, and the pipe was tripped to allow us to change over to the standard rotary system and inspect the BHA. Subsequent inspection of all BHA components including disassembly and servicing of the bumper subs failed, however, to reveal why the barrels had become stuck.

During the pipe trip the vessel was subjected to a severe combination of wind, swell, and current. In an attempt to hold the roll to a minimum for safety of personnel on the rig floor while pulling out of the hole, the vessel was allowed to wander about 3 mi. from the beacon. When we returned to the beacon the adverse conditions made positioning exceedingly difficult unless the ship's heading was such that the rolls made running in the hole unsafe. After the ship spend 7 hr. seeking optimum positioning while waiting on the weather, the wind abated enough to allow the vessel to position in automatic with a safe level of vessel motion.

Hole 591B

A short-hook-up BHA, spaced out for standard rotary drilling, was run back to the seafloor and the bit was washed to 270.6 m BSF to begin rotary coring. After the wash barrel was retrieved, 24 rotary cores were taken to a depth of 500.4 m BSF (Table 1). At this point fossils were too badly preserved to be valuable for analyses so the hole was terminated.

Core quality was mediocre and recovery was below average, largely because of unfavorable sea conditions and vessel motion. The pipe was tripped, the rig secured for sea, and the ship was underway for second-priority Site SW-3 at 0950 hr., 24 December 1982.

LITHOSTRATIGRAPHY

The sedimentary sequence recovered at Site 591 is a calcareous biogenic facies that constitutes a single lithostratigraphic unit. The basic color of the sediment is light gray, with greenish gray interbeds. The main biogenic components are calcareous nannofossils and foraminifers (Fig. 3). Biosiliceous components are occasionally present in trace amounts, and increase slightly in abundance below Core 591-27 and throughout Hole 591B. Siliceous components consist mainly of fragments of radiolarians, diatoms, and sponge spicules, and silicoflagellates appear in Cores 591-21 and 591A-23.

Nonbiogenic components comprise a very small proportion of the sediment. Quartz, feldspars, mica, possible heavy minerals, and micritic carbonate are generally present. Micritic carbonate significantly increases below Core 591B-18. Trace quantities of clear volcanic glass occur throughout the sequence. Ash layers are present in Cores 591-2, 591-5, 591-10 and possibly 591-13, and in 591A-1 and possibly 591A-2 (Fig. 4). Pockets of volcanic glass also occur in Core 591A-25. Zeolites are present in trace amounts in Cores 591-2 and 591-4. Palagonite is also present in Cores 591-31 and 591A-3. Light greenish gray laminae are common and often associated with underlying gray laminae of iron sulfides. These laminae (Fig. 4) may represent alteration products of devitrified volcanic glass. These paired color bands occur more frequently above 80 m BSF (Cores 591-1 to 591-9 and 591A-1 to 591A-8), as well as in Hole 591B below Core 591B-3 (Fig. 4). Authigenic iron sulfides occur within burrows and foraminifer tests, and as finely dispersed gray pockets, halos, and laminae throughout the sequence. Pyrite nodules are present in Hole 591B.

The sequence at Site 591 is divided into three subunits based on color, on the relative abundance of foraminifers and calcareous nannofossils, and on the degree of lithification (Fig. 5).

Subunit IA extends from the seafloor to 0.62 m subbottom in Hole 591 and to 0.50 m in Hole 591A. This subunit is late Quaternary in age. The sediment is yellowish gray to pale yellowish brown and consists of a foraminifer-bearing nannofossil ooze. Subunit IA corresponds to the zone of oxidation.

Subunit IB extends from the base of the oxidized layer to 289.8 m sub-bottom (Quaternary to upper Miocene). The sediments, light gray in color, range from a foraminifer-bearing nannofossil ooze to a nannofossil ooze. Greenish gray levels are frequent in this subunit and contain slightly more foraminifers (5 to 10%) than light gray oozes.

Subunit IC extends from 289.8 m sub-bottom to the bottom of Hole 591B (500.4 m sub-bottom). This subunit is late Miocene to early Miocene in age. The sediments, very light gray to light greenish gray, range from a foraminifer-bearing nannofossil chalk to a nannofossil chalk.

Bioturbation in Hole 591 is important in Cores 591-7 and 591-8, and Cores 591-9 to 591-31 are slightly to moderately bioturbated. The entire sequence in Hole 591A is slightly to moderately bioturbated, with the exception of Core 591A-13, which is extremely bioturbated. Sediments in Hole 591B are moderately bioturbated in Cores 591B-4 and 591B-5, as well as in 591B-15 to 591B-24. Many burrows—gray, light greenish gray, and grayish yellow green—are present. Examples of Planolites-like burrows are apparent in the three holes. Zoophycos-like burrows are common below Core 591B-3. Flaser-type structures appear below Core 591B-16. Microfractures are present in Cores 591B-5 to 591B-7 and in 591B-12.

The sediment becomes more indurated with depth. Sediment above 290 m sub-bottom is an ooze and becomes progressively stiffer with depth, especially below 155 m (soft to stiff). Sediment below 290 m (Core 591B-3) is chalk, with clear recrystallization below 300 m (Core 591B-4). Sediment becomes very hard and recrystallization is widespread below 443 m (591B-19).

The first section of Cores 591-1 to 591-12 is generally soupy or very disturbed. Sections 1 to 3 of Cores 591-12 to 591-24 are slightly to very disturbed. Cores 591-24 to 591-31 are undisturbed. All cores in Hole 591A are soupy or disturbed in the first section. Cores 591A-5 to 591A-9 are moderately to very disturbed in Sections 1 to 4, and Cores 591A-9 to 591A-13 and 591A-18 to 591A-30 are slightly to very disturbed in Sections 1 and 2. Cores 591B-1, 591B-2 and 591B-8 to 591B-13 are very disturbed and consist of biscuits of sediment surrounded by a slurry of soft ooze introduced during the coring process.

PHYSICAL PROPERTIES

Combining Holes 591A and 591B yields a continuously cored section with good recovery, nearly 500 m long, from which numerous physical properties were obtained. Gravimetric, sonic velocity, and shear strength measurements were systematically performed at small intervals along the HPC cores and most sections were run through the continuous GRAPE scanning apparatus (see Introduction for specific techniques). Grain densities were determined by standard gravimetric analyses and the results are shown in Figure 6A. Below a depth of 300 m, the data were obtained from solid chunk samples rather than from sediment-filled cylinders (Boyce, 1976). The grain densities are quite uniform at this level and are consistent with calcareous sediments (CaCO₃ grain density = 2.71 g/cm^3). The carbonate content of these sediments is quite high (Fig. 6B). At shallower depths, however, the grain density varies erratically. It appears that the chunk method used with lithified samples is more accurate and reliable than the cylinder technique which is employed for soft, easily deformable sediments.

The GRAPE porosity data are plotted versus depth in Figure 7A, where the GRAPE wet-bulk densities have been converted to porosities by assuming an average grain density of 2.691 g/cm³. The results are averaged across each meter of depth, and these mean values are depicted by a solid line. The porosity profile of Hole 591 coincides well with that of the adjacent Holes 591A and 591B (Fig. 7B).

All of the acoustic velocity and shear strength measurements were made on split cores, parallel to bedding. The P-wave velocity results are plotted versus depth in Figure 7C. This information, when combined with the GRAPE porosity profile, yields a relationship between compressional velocity and porosity (Fig. 7D). A sharp increase in this property is observed as the sediment porosity approaches 53%.

Similarly, shear strength is plotted versus depth in Figure 7E, where a sudden rise in its magnitude is seen to occur at approximately 250 m. At a depth of 290 m, lith-

Trace	t
<5% rare	100
5-25% common	
25-50% abundant	
>50% dominant	

Dominant lithology, Hole 591

		Bio	genic	com	npone	nts			1	Nor	nbiog	genic	com	pone	nts			A	ut	hige	enic	cor	npo	one	nts	ģ.		
Core-Section (level in cm)	Foraminifers	Nannofossils	Radiolarians	Diatoms	Sponge spicules	Silicoflagellates	Fish debris	Quartz	Foldenore	relaspars	Heavy minerals	Light volcanic glass	Dark volcanic glass	Glauconite	Clay minerals	Other	Palagonite	Zeolites	Amorphous	iron oxides	Fe-Mn micronodules	Durito	Pyrite	Recrystallized	Carbonate	(unspecified)	Carbonate	rhombs
1-1,25			H	t	t	Ш	Ш			Π		Ш				HII	Ш	Щ		П	Ш	t	Ш	П	Ш	П	Ш	Ŧ
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Figure 3. Smear slide summary, Site 591.

Trace t <5% rare 5-25% common

25-50% abundant >50% dominant

Minor lithology, Hole 591

		Biog	genic	com	pone	nts			N	onbi	oge	enic	cor	npo	ne	nts			4	Auth	nige	enic	c	omp	oor	nen	ts		
Core-Section (level in cm)	Foraminifers	Nannofossils	Radiolarians	Diatoms	Sponge spicules	Silicoflagellates	Fish debris	Quartz	Feldspars	Heavy minerals		Light volcanic glass	Dark Volcanio alaco		Glauconite	Clay minerals	Other	Palagonite	Zeolites	Amornhous	iron oxides	Fe-Mn	micronoguies	Pyrite	Bacruetallized	silica	Carbonate (unspecified)	Carbonate	rhombs
2-2, 45							Ш	t	t	t	T		III		TT		t		t	Ш	Π		T	t		Π			Π
2-2,56															Ш		t						Ш						Ш
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5-3, 126	- 44						1111	t	111	t		44	111-	44	11	t	++++	1111	+++	111	11	111	111		Щ	11		11	Ш
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23-3, 75	t			1111		t		t	t		11	111	111				1111	Ш	111	Ш	11	111	1		#	11	t	111	Ш
24-3, 80	t		t			444	1111	1111	111		t	111	111	1	11	111	t	1111	111	Ш	11	111	11	111	#		τ	111	Ш
25-3,80			τ	C			1111	1111	t	t	11.	111	111	++	11	1111	1111		+++	###	++-	111	11.	111	#			+	Ш
26-3, 72	-+++		τ	τ	T			1111	t	++++	1t	111	+++-	11	11-	1111	++++	1111	+++	##	++-	111	H		#	++-		+++	++
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Figure 3. (Continued).

ification prevents further testing as the shear strength progresses beyond the range of the Wykeham-Farrance vane device. These data depict the same behavior as that described by the acoustic velocity results of Figure 7D. The shear strength increases dramatically as a declining porosity approaches 53% (Fig. 7F).

A relationship between acoustic impedance and depth can be established by combining the compressional velocity results with the GRAPE wet-bulk density profile (Fig. 7G). A more detailed presentation and analysis of the physical properties results for Site 591 is reported by Morin (this volume).

SEISMIC STRATIGRAPHY

Figure 8 illustrates a portion of the shipboard water gun seismic profile collected during the approach to Site 591. Five acoustic units have been identified (A-E), equivalent to the regional acoustic units of Willcox et al.,

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

Minor lithology, Hole 591A

		Bio	genic	con	npone	ents				N	lor	bio	ge	nic	co	mp	on	en	ts						A	uth	ig	eni	c	con	np	on	en	ts		
Core-Section (level in cm)	Foraminifers	Nannofossils	Radiolarians	Diatoms	Sponge spicules	Silicoflagellates	Fish debris		QUARTZ	Feldsnars	0.000.00	Heavy minerals	Light	volcanic glass	Dark	volcanic glass	Glauconite		Clay minerals		Other		Palagonite	:	Zeolites	Amorphous	iron oxides	Fe-Mn	micronodules	Durito	rynte	Recrystallized	silica	Carbonate	(unspecified)	Carbonate rhombs
1-1, 29				Ш	t	Ш	Ш	\prod	\square	t	Π	t		Π	Π		П	Π	Ш		П	П		П	Π		Π	Π	П	Π	П	Π	П	\square	Ш	Ш
1-1, 61				1111	t	++++	++++	t	111	t	1	t			μ.		++-	11			++	Ш	11	#	44	Ш	#	Щ	#	11	11	44	Щ	111	Ш	++++
1-3,61					++++	++++	++++		11	t	H			4	#		++	11			++	₩	#	₩	#	₩	++	#	#	11	#	#	#	#	Ш	+++
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Figure 3. (Continued).

1980. These are correlated in part with the lithology of the site (lithostratigraphic Subunits IA, IB, and IC).

The five acoustic units are identical to those described in the Seismic Stratigraphy section for Site 590, with the exception that Unit E at Site 591 may represent acoustic basement, and not the graben-filling low-amplitude unit described earlier. Some obvious erosion has occurred immediately to the northwest of the site, with uppermost reflectors below the reflected wave form showing evidence of truncation. However the actual site locality, at a slightly shallower water depth, appears to overlie a relatively complete stratigraphic sequence.

Site 591 was drilled to a total depth of 500.4 m, through acoustic Unit A into acoustic Unit B. The sedimentary section comprises three lithostratigraphic subunits (IA, IB, and IC), ranging in age from Quaternary to latest early Miocene. Subunit IA is too thin to be shown on Figure 8. Lithologies range from foraminiferbearing nannofossil ooze or nannofossil ooze to foraminifer-bearing nannofossil chalk, with the ooze/chalk boundary occurring at a sub-bottom depth of approximately 290 m.

The most significant observation from the data outlined above is the gradation from ooze to chalk, which occurs within the upper Miocene. This occurs approximately 40 m above the selected upper boundary of acoustic Unit B, assuming an interval velocity of 2000 m/s averaged from shipboard velocimeter measurements. The greater amplitudes observed near the top of acoustic Unit B are considered to be due at least in part to variations in the degree of induration of sediments observed within lithostratigraphic Unit IC.

BIOSTRATIGRAPHY

Site 591 was drilled with the objective of recovering a deep-water Neogene section that could be combined with those from Sites 590 (1299 m) and 206 (3196 m) to form a depth traverse through the three major bottom-water types in this area of the Tasman Sea. The planktonic biostratigraphies and faunas were expected to be very similar to those at Site 590, which is located only about 100 km to the west.

Three holes were cored at Site 591. Hole 591 contains 31 cores and includes sediments of Quaternary through late Miocene age. Hole 591A repeated the section at Hole 591. Hole 591B overlapped in part with the upper Miocene section at Hole 591, then recovered Miocene sediment down to the uppermost lower Miocene. The nannoplankton and planktonic foraminiferal zones are shown in Figure 9.

The planktonic foraminiferal faunas at Site 591 are well preserved through the Pliocene and upper Miocene; below that point preservation deteriorates rapidly and by the lower middle Miocene most forms are recrystallized. In the few lower Miocene cores, many species are barely recognizable because of recrystallization and cementation. The faunas are identical to those from nearby Site 590; however, three biostratigraphic zones not recognized at Site 590 were recovered at Site 591. These are the lower Pliocene *Globorotalia sphericomiozea* Zone, the *Orbulina suturalis* Zone, and the *Praeorbulina glomerosa curva* Zone of the early middle Miocene. The identification of these zones is attributed to the very high sedimentation rates at Site 591.

Calcareous nannoplankton were very abundant and were preserved throughout the section; however, their preservation was, in general, worse than at Site 590. Overgrowths occur in the Pliocene, and the Miocene discoasters are difficult to recognize. As with the foraminifers, preservation deteriorated rapidly toward the bottom of the hole. The biostratigraphy of the section was the same as at Site 590. Benthic foraminiferal faunas are well preserved from the Quaternary through the upper Miocene, but below that faunas are impoverished; in the middle Miocene, recrystallization of the individuals increases and by the lower Miocene few if any forms could be recognized because of recrystallization and cementation. The benthic faunas contain many of the same species found at site 590; however, an indigenous element was recognized.

Radiolarians, diatoms, and silicoflagellates were found in most cores throughout the section; they were rare to common down to the lower middle Miocene.

Planktonic Foraminifers

Zones

The following zones were identified at Site 591; the zonal boundary markers are shown below:

Globorotalia truncatulinoides Zone

L. A. Globorotalia tosaensis

Globorotalia truncatulinoides-G. tosaensis Zone I. A. G. truncatulinoides

Globorotalia tosaensis Zone

I. A. G. tosaensis

Globorotalia inflata Zone

I. A. G. inflata

Globorotalia crassaformis Zone I. A. G. crassaformis

Globorotalia puncticulata Zone

I. A. G. puncticulata Globorotalia sphericomiozea Zone

L. A. G. conomiozea Globorotalia conomiozea Zone

I. A. G. conomiozea

Globigerina nepenthes Zone L. A. Neogloboquadrina continuosa

Neogloboquadrina continuosa Zone L. A. Globorotalia mayeri

Globorotalia mayeri Zone

L. A. G. peripheroacuta

Globorotalia fohsi s.l. Zone I. A. G. peripheroacuta

Orbulina suturalis Zone

I. A. O. suturalis

Praeorbulina glomerosa curva Zone

I. A. P. glomerosa

Globorotalia miozea Zone

Faunas

The preservation of the abundant planktonic foraminiferal faunas was good down to the early late Miocene *N. continuosa* Zone, but in this zone and sporadically down through the middle Miocene into the lower Miocene the preservation deteriorated; this poor preservation is especially true for the lowermost middle Miocene and down into the lower Miocene.

As expected, the species content of the zones was almost identical to those at Site 590.

Benthic Foraminifers

Benthic foraminifers were examined from all core catchers from Holes 591 and 591B. Benthic faunas are well preserved in the Quaternary, Pliocene, and upper



Figure 4. A. Horizons and histograms of distinct, megascopic volcanic ash layers (thick lines) and possibly devitrified ash layers (thin or broken lines) of Holes 591 and 591A are shown. Thickness of each layer is more than 1.0 cm and is typically several centimeters. Single, very thin laminae less than 1 mm thick are omitted. B. A compiled histogram showing the frequency of ash layers at Site 591, with careful correlation between Holes 591 and 591A. Because of relatively poor recovery in Hole 591B, a normalization is also shown as "ash-layer density" (m⁻¹), which is the averaged number of ash layers in every 10-m interval (Holes 591 and 591A) or in every core (Hole 591B).



Figure 4. (Continued).

Miocene sediments; however, faunas are impoverished, and the preservation of several taxa deteriorates below the upper Miocene. Recrystallization was first noticed in the mid-middle Miocene; by the lower Miocene few if any individuals could be recognized because of the cementation of the carbonates. Benthic faunas at Site 591 contain many of the same species found at the shallower Site 590, but did reveal an indigenous element consisting of several miliolid species, *Favocassidulina fava*, *Uvigerina pygmaea*, *Angulogerina angulosa*, and *Epistominella exigua*. The species that occurred very rarely at Site 591, including *Bolivinopsis*



Figure 5. Lithostratigraphy of Site 591 (recovery in black).

praelonga, Pleurostomella alternans, Rectuvigerina multistriata, and Cibicidoides rugosus, to name only a few, were those which were common and typical of the shallower Site 590.

Because of the poor preservation, little could be derived from the lower to mid-middle Miocene faunas at Site 591 (591B-16 to 591B-24,CC). Species resistant to dissolution are the same as found at the other sites. *Ci*- bicidoides tuxpamensis does not range above the Globorotalia fohsi s.l. Zone as it does at other sites. The first increase in the size of faunas that is not attributable to the vagaries of preservation occurs in 591B-12,CC, in the Globorotalia mayeri Zone. The six new entrants appearing at this time are all also found in abundance in the Pliocene at Site 590, but are most typical and abundant at sites underlying upwellings.



Figure 6. Grain density (A) and carbonate content (B) versus sub-bottom depth for Site 591.

At the base of the *Neogloboquadrina continuosa* Zone (591B-8,CC; 591-30 to 591-31,CC), large numbers of miliolid fragments and two species, *Pyrgo murrhina* and *Quinqueloculina seminulina*, occur for the first time. Faunas through the remainder of the Miocene are dominated by the miliolids and, in the *Globigerina nepenthes* Zone, by *Uvigerina hispido-costata*. This type of miliolid-uvigerinid fauna, including also *Melonis pompilioides* and several taxa more typical of Site 590, disappears at the top of the Miocene, but reappears in this area during the *Globorotalia tosaensis* Zone and continues into the Quaternary.

At the top of the Miocene (*Globorotalia conomiozea* Zone, 591-22, CC through 591-21) preservation deteriorates and the depleted benthic faunas contain only the most dissolution-resistant species and some miliolid fragments.

Lower Pliocene faunas (591-20,CC to 591-14) are well preserved and diverse; typical taxa include Oridorsalis umbonatus, Heterolepa kullenbergi, P. murrhina, and Bulimina alazanensis. The transition to the glacial fauna (G. crassaformis/G. inflata) shows a change in coarsefraction content. Species changes include only the reintroduction of species already present in the Miocene at this site and variations in abundances of species common in the Pliocene. The miliolids decrease markedly in number through this interval.

The most obvious change in faunal content of the Pliocene occurs in the *G. tosaensis* Zone (591-10 to 591-9,CC) and in the *G. tosaensis-G. truncatulinoides* overlap interval (591-8 to 591-5,CC), when faunas again resemble those of the upper Miocene and include, as well, several species typical of shallower sites, such as *Anamalinoides globulosa*, *Cibicidoides pseudoungerianus*, *Cassidulina laevigata*, and *Pullenia quadriloba*.

Whereas most of the appearances/disappearances throughout this section are not considered to have been evolutionary events, it is interesting that the first appearance of *Uvigerina peregrina* occurs later at Site 591 (in the *G. puncticulata* Zone) than it did at the shallow Site 590, where it first occurs in the upper Miocene. This suggests that a form not generally associated in the Quaternary or Pliocene with intermediate waters first appeared at these shallower depths. The descent of uvigerinids from upper bathyal to deeper areas occurred several times during the history of the group.



Figure 7. A. GRAPE porosity versus sub-bottom depth for Hole 591A. B. GRAPE porosity versus sub-bottom depth for Holes 591, 591A, and 591B. C. Compressional velocity versus sub-bottom depth for Site 591. D. Porosity versus compressional velocity for Hole 591A. E. Shear strength versus sub-bottom depth for Hole 591A. F. Porosity versus shear strength for Hole 591A. G. Acoustic impedance versus sub-bottom depth for Hole 591A.



Figure 7. (Continued).

Calcareous Nannoplankton

Core-catcher samples along with sufficient additional samples to determine zonal boundaries accurately were examined for calcareous nannoplankton. All of the 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 throughout the section at Site 591. Preservation is good in the Quaternary and Pliocene. In the Miocene, preservation deteriorates from moderate to poor, and in particular most of the discoasters are heavily overgrown.

Hole 591

Thirty-one cores were recovered from Hole 591, providing a complete nannoplankton zonation from late Quaternary to late Miocene.

Quaternary

Samples 591-1,CC to 591-2-3, 3-4 cm are placed in the late Pleistocene *Gephyrocapsa oceanica* Zone (NN20). Sample 591-2-5, 3-4 cm contains *Emiliania ovata* and is placed in the upper subzone of the early Pleistocene *Emiliania ovata* Zone (NN19b). The presence of *E. ovata* together with *Calcidiscus macintyrei* in Samples 591-5-5, 3-4 cm to 591-6,CC places these samples in the lower subzone of the *E. ovata* Zone (NN19a).

Pliocene

The presence of *Discoaster brouweri* in Samples 591-7-1, 3-4 cm to 591-8-1, 3-4 cm places these samples in the late Pliocene *Discoaster brouweri* Zone (NN18). The late Pliocene *D. pentaradiatus* Zone (NN17) is represented only by Sample 591-8-3, 3-4 cm, based on the last occurrence of *Discoaster pentaradiatus*. The late Pliocene *D. surculus* Zone (NN16) is located by the last oc-



Figure 7. (Continued).

currence of *D. surculus* in Samples 591-8-5, 3-4 cm to 591-12-3, 3-4 cm, above the last occurrence of *Reticulo-fenestra pseudoumbilica*.

Samples 591-12-5, 3-4 cm to 591-16,CC above the last occurrence of *Amaurolithus tricorniculatus*, are placed in the early Pliocene *Reticulofenestra pseudoumbilica* Zone (NN15). The co-occurrence of *D. asymmetricus* and *A. tricorniculatus* in Samples 591-17-1, 21-22 cm to 591-20,CC places these samples in the early Pliocene *Discoaster asymmetricus* Zone (NN14). The first occurrence of *Ceratolithus rugosus* in Sample 591-21-5, 3-4 cm places this sample and the overlying Sample 591-21-1, 3-4 cm in the early Pliocene *Ceratolithus rugosus* Zone (NN13).

Miocene

Samples 591-24-3, 3-4 cm, the last occurrence of *D*. quinqueramus, to 591-28-3, 3-4 cm, the first occurrence

of *A. primus*, are placed in the upepr subzone of the late Miocene *D. quinqueramus* Zone (NN11b). Samples 591-28-5, 3-4 cm to 591-31,CC, the deepest core at Hole 591, are placed in the lower subzone of the *Discoaster quinqueramus* Zone (NN11a).

Hole 591A

Only the 31 core-catcher samples from the hole were examined, because this hole duplicated the zonation of Hole 591.

Hole 591B

Miocene

The first occurrence of *D. quinqueramus* in Sample 591B-4,CC places Samples 591B-1,CC to 591-4,CC in the lower subzone of the late Miocene *Discoaster quinqueramus* Zone (NN11a). The interval from Samples



Figure 8. Comparison of acoustic units A-E with lithostratigraphic Subunits IA (not shown), IB, and IC cored at Site 591; shipboard water gun seismic profile, collected during site approach; depths in meters estimated by assuming a sediment sound velocity of 2000 m/s.

591B-5-1, 3-4 cm to 591B-9-2, 4-5 cm, above the last occurrence of D. hamatus in Sample 591B-9, CC, is placed in the late Miocene D. calcaris Zone (NN10). The range of D. hamatus in Samples 591B-9, CC to 591B-11-1, 4-5 cm places these samples in the middle Miocene D. hamatus Zone (NN9). Sample 591B-11, CC is placed in the middle Miocene Catinaster coalitus Zone (NN8). The interval from Samples 591B-12-1, 3-4 cm to 591B-12,CC, the first occurrence of D. kugleri, is placed in the middle Miocene D. kugleri Zone (NN7). The interval from Samples 591B-13-1, 3-4 cm to 591B-18-5, 3-4 cm, above the last occurrence of Sphenolithus heteromorphus in Sample 591B-18,CC, is placed in the middle Miocene D. exilis Zone (NN6). The presence of S. heteromorphus together with D. exilis in Samples 591B-18,CC to 591B-23,CC places these samples in the middle Miocene Sphenolithus heteromorphus Zone (NN5). Sample 591B-24,CC possibly belongs in the early Miocene Helicosphaera ampliaperta Zone (NN4).

Diatoms and Silicoflagellates

Diatoms and silicoflagellates occur in fair numbers throughout most of the section, but the occurrences are heavily masked by vast numbers of foraminifers and calcareous nannoplankton. Fragments of diatoms and silicoflagellates were noted in several routine smear slides from the late Pliocene down to the middle Miocene. The residue of an acid-treated sample (591B-5,CC) of late Miocene age (nannoplankton Zone NN10) included representatives of the diatom genera *Hemidiscus*, *Thalassiosira*, and *Coscinodiscus*. The silicoflagellate assemblage of this particular sample is dominated by members of the *Dictyocha fibula* group (forms with horizontal apical bar) and *Distephanus polyactis*. Present also are *D. crux*, *D. speculum*, and *Mesocena circulus*. They are associated with sponge spicules and endoskeletal dinoflagellates.

Radiolarians

Fragments of radiolarians were found in smear slides from various levels, indicating the presence of this fossil group throughout most of the drilled section. In the residue of the acid-treated Sample 591B-5,CC radiolarians are rather common, but were not investigated in detail.

PALEOMAGNETISM

Preliminary NRM results were generally similar to those from previous sites. Sedimentation rates are somewhat higher than in nearby Site 590 and there was no evidence of a viscous component of magnetization. A magnetic polarity stratigraphy can be traced down to the end of the Gilbert Chron which is reproduced in the Hole 591A.

Hole 591 was subsampled at three specimens per section, Hole 591A at two specimens per section, and rota-



Figure 9. Correlation between calcareous nannoplankton and foraminifer zones in Hole 591, 591A, and 591B (radiolarians, though present in small numbers, were not investigated).

ry-drilled Hole 591B at one specimen per section. Apparent success rates with the Kuster orientation tool were 55 and 58% for Holes 591 and 591A. Laboratory NRM measurements have been completed on three specimens per section for the upper three cores from Holes 591 and 591A, and one specimen per section for the remaining cores from these two holes. The mean hole statistics are:

	Hole 591	Hole 591A
Geometric mean intensity (µG)	0.066	0.059
Scalar mean inclination $(\pm 1 \text{ s.d.})$	$-9.1 \pm 43.7^{\circ}$	$-7.2 \pm 44.0^{\circ}$
Axial dipole inclination	- 5	0.9
Mean angle between repeats	6.1°	6.7°

The ubiquitous and surficial high-intensity zone (1 to $10 \ \mu$ G) is almost completely confined to the first core in each hole. From about 5–20 m sub-bottom depth intensities are typically 0.1 μ G and thereafter remain consistently low (typically a few $\times 10^{-2} \ \mu$ G). There is a general trend toward lower intensity with increasing depth. High-intensity spikes noted in Hole 591 are listed in Table 2.

The quality of the paleomagnetic record deteriorates increasingly as a function of depth and cannot be interpreted in terms of polarities with any confidence below about 110 m sub-bottom depth (the upper part of the Gilbert Chron, about 3.5 m.y. ago). The polarity stratigraphy for Hole 591 (Fig. 10) is duplicated in the adjacent HPC Hole 591A.

To assess the magnetic stability of these sediments, partial AF demagnetization tests were run on seven specimens from Hole 591 (Table 3). More strongly magnetized specimens where chosen deliberately, because the weaker ones rapidly became immeasurable when demagnetized. The upper sediments which preserve a polarity record give stable directions in fields up to at least 400 Oe (40 mT) and median destructive fields in the range 215 to 310 Oe (21.5 to 31 mT). Lower in the section median destructive fields ranged from 120 to 155 Oe, and directional stability was poorer-consistent directions were observed up to peak AF's of about 200 Oe. There was no evidence for a soft viscous component in any of the specimens, which agrees with the fact that the mean inclination for the section does not have a significant negative bias. Without a more extensive study it is not possible to establish the scale of any chemical overprinting:

Table 2. High-intensity spikes at Site 591.

Sample	Depth (m)	Intensity
(lever in ein)	(uii)	(LC)
591-1-2, 80	2.30	7.419
591A-4-5, 40	34.80	2.371
591-8-1, 80	61.80	0.586
591-12-6, 75	107.65	0.597
591A-12-6, 40	113.10	0.248
591A-15-3, 40	136.50	0.234
591-16-4, 75	142.15	0.210
591-16-5, 75	143.65	0.273
591A-19-2, 40	172.40	0.369
591-20-3, 75	178.05	0.187
591A-20-1, 40	180.40	0.896
591A-24-3, 40	221.10	0.122
591-28-4, 75	255.55	0.168
591-28-5, 75	257.05	0.170

Chron	Age (m.y.)	Britania (Con Iev	oundary e-Section, el in cm)	Sub-bottom depth (m)	Sediment (m/r	ation rate n.y.)
Brunhes			3-3, 25	16.25	22.3 to 22.9	
	0.73 Jaramillo		3-3, 75	16.75		
atuyama	1.66		6-3, 75 6-4, 75	45.55 47.05	27.6 to 29.6	27.9 to 28.4
×	Olduvai		6-5, 75 6-6, 75	48.55 50.05		
	2.47		8-3, 80 8-5, 80	64.80 67.80		
Gauss					29.3 to 34.1	
Ŧ	3.40		11-4, 75 11-5, 75	95.05 96.55		ļ
Gilber						

Figure 10. Magnetic polarity stratigraphy for the upper part of Hole 591.

Table 3. Summary of partial AF demagnetization results for Hole 591.

Core-Section (level in cm)	Depth (m)	J ₀ (μG) ^a	MDF (Oe)	AF stability range (Oe)	Inclination variation
1-1, 25	0.25	5.395	255	0-400	±5°
2-2, 125	6.15	1.544	310	0-400	± 5°
3-1, 125	14.25	0.364	215	0-500	±6°
3-4, 75	18.25	0.191	120	{ 0-200 0-500	±14° ±24°
12-6, 75	107.65	0.424	120	0-150	±13°
20-3, 75	178.05	0.179	155	0-300	±6°
28-5, 75	257.05	0.165	135	0-500	±25°

Note: The range of demagnetizing field for a given range of inclination variation is shown in the last two columns.

a Initial NRM intensity.

the present indication is that the remanence is essentially single-component and sufficiently stable to preserve a record of polarity reversals. Since measurements on the very weakly magnetized material are reproducible, the scatter in the data cannot be attributed predominantly to instrumental noise.

SEDIMENTATION RATES

Sedimentation rates (Fig. 11) are based on calcareous nannoplankton boundaries and their absolute ages, as indicated in the Introduction. For better comparison, intervals taken for calculating the sedimentation rates are the same as for the previous sites.





Figure 11. Sedimentation rates and datum levels in Holes 591 and 591B.

In the middle Miocene (Hole 591B, NN4 top to NN7 top), the sedimentation rate is based on four datum levels and is 26.9 m/m.y. for indurated calcareous sediments with minor siliceous constituents (Fig. 11B).

In the late middle Miocene to early Pliocene interval (Hole 591B, NN7 top, to Hole 591, NN13 top), the sedimentation rate is 23.2 m/m.y. and similar to that of the middle Miocene (Fig. 11A, B). This rate is based on seven datum levels.

Then a remarkable increase in the sedimentation rate occurs in the late early to late Pliocene, similar to that of Site 590. The sedimentation rate of calcareous sediments (foraminifer-bearing nannofossil ooze) for the entire interval between NN13 top and NN18 top in Hole 591 is 61.8 m/m.y., and is based on six datum levels. The strongest increase is found during deposition of Zones NN14 and NN15 (between 4.1 and 3.5 m.y. ago), where it increases to 131.3 m/m.y. In the late Pliocene (Hole 591, NN15 top to NN18 top), the sedimentation rate slows to 33.5 m/m.y. (Fig. 11A).

In the Quaternary (Hole 591, above NN18 top) the sedimentation rate drops further to a value of 27.1 m/m.y., which, however, is well above the 17.2 m/m.y. at Site 590.

SUMMARY AND CONCLUSIONS

Site 591 lies near the crest of a southern spur of the eastern part of the Lord Howe Rise at 31°35.06'S, 164°26.92'E and at a water depth of 2131 m. The spur extends outward into the New Caledonia Basin and is surrounded by turbidite fill to the east and south. The western edge of the spur is, in its norther part, separated from the main part of Lord Howe Rise by a valley that slopes southward, leading toward a ponded turbidite sequence which slopes toward the level of New Caledonia Basin. Thus the crest of the spur on which Site 591 is located is largely isolated from any influences of sediment transportation from the main part of Lord Howe Rise. The seismic profile exhibits a relatively simple transparent layer about 520 m thick above a distinct reflector which is considered to represent the regional unconformity associated with the Eocene/Oligocene boundary.

Site 591 was selected to provide a Neogene-late Paleogene stratigraphic succession at water depths intermediate (about 2200 m) between Site 590 (1299 m) and Site 206 (3196 m). A site at this intermediate depth was required to study changes in the vertical water mass structure of the southwest Pacific Ocean during the Neogene. These three sites, in combination, will provide an opportunity to carry out detailed studies of changes in the intermediate water masses between 1000 and 3000 m water depth. Site 591 is located midway between Sites 590 and 206, providing a compact suite of sites. Northward movement of the Indo-Australian Plate has carried Site 591 about 4-5° of latitude from about 35°S in the early Miocene to its present-day position near 31°30'S. Thus the Neogene sedimentary history at this site has been related in part to its northward movement away from the temperate region and the zone of westerly winds.

Site 591 consists of three holes: Hole 591 was continuously cored with the HPC from 0-283.1 m sub-bottom; Hole 591A was continuously cored with the HPC from 0-246.5 m and rotary cored with the XCB from 246.5-284.6 m; and Hole 591B was continuously cored using conventional rotary coring from 270.6-500.4 m sub-bottom. Cores recovered with the first HPC are relatively undisturbed; those using the second HPC are slightly more disturbed because of rough sea conditions. The cores recovered using conventional rotary coring exhibit mixed quality; quite disturbed in the upper part of the section although recovery was high; moderate recovery in the middle part of the sequence; and good quality cores with moderarte to low recovery rates in the lowest part of the sequence. The extended core barrel did not function successfully at this site.

The sequence is made up of one lithostratigraphic unit represented mostly by foraminifer-bearing nannofossil ooze or foraminifer-rich nannofossil ooze. Site 591 is a continuous sequence from the late early Miocene (17 m.y.) to the Quaternary. The HPC part of the sequence is complete from early late Miocene (11 m.y.) to the Quaternary. The biostratigraphy is complete with no apparent hiatuses. A paleomagnetic polarity stratigraphy has been identified down to the late Gilbert Chron (about 3.5 m.y.). Like Site 590, this site exhibits high sedimentation rates (uncorrected) ranging from 23 m/m.y. to 131 m/m.y.

Biosiliceous components are occasionally present in trace amounts, and exhibit slightly higher abundances in the early Miocene to early late Miocene. Siliceous components consist mainly of fragments of radiolarians, diatoms, and sponge spicules, and silicoflagellates appear in the latest Miocene (Cores 591-21 and 591A-23).

Nonbiogenic components comprise only a very small proportion of the sediment. Micritic carbonate significantly increases near the bottom of the section in the early and early middle Miocene. In the middle middle Miocene, trace quantities of clear volcanic glass occur throughout the sequence. Ash layers are present at certain intervals as well as very common light greenish gray laminae which possibly represent devitrified layers of volcanic ash. These laminae are commonly associated with underlying gray laminae of iron sulfides.

The sequence at Site 591 is divided into three subunits based on color, on the relative abundance of foraminifers and calcareous nannofossils and on the degree of lithification (Fig. 12).

Subunit IA extends from the seafloor to 0.62 m subbottom in Hole 591 and to 0.50 m in Hole 591A. This subunit is late(?) Quaternary in age. The sediment is yellowish gray to pale yellowish brown and consists of a foraminifer-bearing nannofossil ooze. Subunit IA corresponds to the zone of oxidation which was found in all of our sites.

Subunit IB extends from the base of the oxidized layer to 289.8 m sub-bottom (Quaternary to upper Miocene). The sediments, light gray in color, range from a foraminifer-bearing nannofossil ooze to a nannofossil ooze. Frequent greenish gray levels occur within this subunit, which contain slightly more foraminifers than the dominant light gray oozes.

Subunit IC extends from 289.8 m sub-bottom to the bottom of Hole 591B (500.4 m sub-bottom). This subunit is upper Miocene to lower Miocene in age. The sediments, very light gray to light greenish gray, range from a foraminifer-bearing nannofossil chalk to a nannofossil chalk. Clear recrystallization occurs below 300 m. Sediment becomes very hard and recrystallization is widespread below 452 m (earliest middle Miocene).

Diagenetic alteration of the microfossil sequence appears at Site 591 in younger sediments than at Site 590, because of the higher sedimentation rates at Site 591. Foraminifer recrystallization is already well advanced by the early middle Miocene, and calcareous nannofossils exhibit signs of overgrowths by the early Pliocene. The higher rates of sedimentation at Site 591 have allowed finer stratigraphic resolution than at Site 590. The planktonic faunas are identical to those from nearby Site 590; however, three biostratigraphic zones not recognized at Site 590 were recovered at Site 591. These are the early Pliocene Globorotalia sphericomiozea Zone, the Orbulina suturalis Zone of the early middle Miocene, and the Praeorbulina glomerosa curva Zone of the early Miocene. The presence of these relatively thin zones is attributed to very high sedimentation rates at Site 591.

Radiolarians, diatoms, and silicoflagellates were present but uncommon in most cores throughout the section. They are common in the coarse fractions of sediments younger than early middle Miocene. The greater water depth of Site 591 somehow favors the preservation of some of the siliceous biogenic fraction compared with the nearby, shallower-water Site 590, which has almost no siliceous biogenic components. A number of evolutionary sequences within the planktonic foraminifers are clearly exhibited in this expanded sequence which, in general, provides excellent opportunities for high-resolution microfossil and stable isotopic work, particularly in the well-preserved upper Miocene through Quaternary section.

Site 591 is intermediate in its vertical depth profile (2131 m) between Sites 590 and 206; thus the benthic foraminifers are of considerable interest. Benthic fora-



 4 5 6



Figure 12. Summary lithology, biostratigraphy, and mass accumulation rates at Site 591 (recovery in black).

500 L

Sub-bottom depth (m)

miniferal faunas are well preserved from the Quaternary through the late Miocene; earlier than that, faunas are impoverished; in the middle Miocene, recrystallization of the individuals increases and by the early Miocene few, if any, forms could be recognized because of the recrystallization and cementation. The benthic faunas contain many of the same species found at Site 590; however, some important differences reflect distinct paleoceanographic histories at these different water depths. The paleoceanographic changes include both upward and downward migration of some benthic foraminifers. Assemblages typical of upwelling zones appear in the middle Miocene.

Site 591 exhibits a valuable tephrochronology based on many layers and laminae which are inferred to be altered volcanic ash layers. These are compiled in Figure 4 for each of the three holes. Figure 4B shows a compilation for all Site 591 holes and also provides average ash layer densities per unit of core. These data clearly show that there have been a number of episodes of volcanic explosivity separated by more quiescent intervals. Intervals of more active volcanism are as follows: 17–14 m.y., latest early Miocene to middle Miocene; 10.5–9 m.y., early late Miocene; 5.4–4 m.y., latest Miocene to early Pliocene; 1.8–0.5 m.y., early to middle Quaternary.

Middle Miocene volcanic explosivity may be more extensive, but this is difficult to determine because of poor core recovery throughout this interval. The episodes of increased explosive volcanicity are separated by periods of relative quiescence, which include much of the Pliocene and late Miocene. This history is similar to that compiled by Kennett et al. (1977) for the southwest Pacific region and is also similar to the trends exhibited in a global compilation.

Paleoenvironmental History of Site 591

The Neogene sediments at Site 591 were deposited in a paleoenvironmental setting similar to that of nearby Site 590. Both of these sites exhibit similar stratigraphic records and paleoenvironmental histories. However, the greater water depth of Site 591 and its location upon an isolated spur of Lord Howe Rise have created a number of important paleoceanographic differences, especially in the intermediate waters.

During the late early to middle Miocene, the site was located about 4 to 5° of latitude further south than its present-day position near 31°35'S. This would have placed it within the zone of westerly winds and in temperate latitudes, a reconstruction which is supported by the distinctly temperate planktonic foraminifer assemblages in the early Neogene. Foraminifer-bearing nannofossil oozes were laid down during this time interval as well as in the early late Miocene. During the early middle to early late Miocene, siliceous biogenic materials were preserved in the sequence, although they are fairly uncommon. At other times they are much less common. Their increased abundance during the interval must reflect decreased dissolution. Sedimentation rates were moderately high during the late early to middle Miocene, with values of between 23 and 27 m/m.y.

Explosive volcanicity seems to have been quite intense in the source region between 17 and 14 m.y. ago, judging from the large number of volcanic ash layers. This episode of increased volcanicity may have continued through the middle Miocene, but poor core recovery prevented comparable analysis.

During the late middle Miocene, a number of new benthic foraminiferal species appeared, heralding important changes in bottom waters at this site. These changes occurred later than the well-known earlier middle Miocene changes known from other areas (Woodruff et al., 1981) that have been linked to bottom-water changes that took place during the accumulation of the east Antarctic ice sheet.

During the early late Miocene, the mode of sedimentation changed to more pure nannofossil oozes, which lasted until the mid-early Pliocene. Rates of sedimentation remained much the same at about 23 m/m.y.

The benthic foraminifer assemblages show important changes in the early late Miocene when miliolids become more important. they showed further change during the latest Miocene, when the assemblage became dominated by dissolution-resistant forms. This low-diversity assemblage heralds further important changes in the character of the bottom waters; it is associated with increased global glaciation. This represents the time of the Messinian "salinity crisis" of the Mediterranean Basin. The latest Miocene planktonic foraminiferal assemblages at Site 591 are typically cool, as they are also at Site 590. More foraminifer-rich sediments were laid down during a number of brief intervals during the latest Miocene, perhaps reflecting greater winnowing activity of bottom currents.

In this region the late Miocene is bracketed near the beginning and end with episodes of increased explosive volcanicity. These occur at about 10.5 to 9 and 5.4 to 4 m.y. ago, respectively. These episodes are separated by an especially quiescent period.

The beginning of the Pliocene is marked by a return of warmer-water planktonic foraminiferal assemblages. By the middle early Pliocene, sediment deposition again changed from rather pure nannofossil ooze to foraminifer-bearing nannofossil oozes. At the same time, there occurred a remarkable increase in sedimentation rates to 131 m/m.y. during the interval between 4 and 3.5 m.y. This increase almost certainly is created by an important increase in biogenic productivity. Explosive volcanic activity seem to have been relatively quiet during this interval, although the extremely high biogenic sedimentation rates may have masked any such activity.

During the late Pliocene, sedimentation rates decreased markedly to a still high rate of 33 m/m.y. This does not seem to coincide with any distinct change in the lithofacies. Explosive volcanism remained quiescent. As at all other sites, the benthic foraminiferal assemblages at Site 591 changed during the late Pliocene, when forms were reintroduced that had occurred through the Miocene. The earliest of these events were associated with global climatic changes about 3 m.y. ago related to major global climate cooling. Further and more important changes occurred later in the late Pliocene, probably in response to the initiation of Northern Hemisphere ice-sheet formation.

By the Quaternary, rates of sedimentation had further decreased to 27 m/m.y. Explosive volcanic activity was further renewed at this site in the Quaternary, as in many other circum-Pacific area.

As at other sites cored during Leg 90, the youngest sediments form an oxidized veneer at and close to the ocean floor.

The sedimentation rates calculated for Site 591 are mostly rather normal for carbonate biogenic oozes in shallow waters. The Pliocene rates of 131 m/m.y. are, however, extremely high and unexpected. High rates (57 m/m.y.) also mark the Pliocene of Site 590. We consider that these high rates are due to high productivity of calcareous biogenic material, a phenomenon now known in the late Neogene at three sites in this area (590, 591, and 206). It is possible that increased biogenic productivity is related to the poorly known Subtropical Divergence that crosses the Tasman Sea at the latitude of these three sites. Rates are much lower at the sites drilled to the north of Lord Howe Rise (Site 588) and to the south (Site 592). However, high rates have also been repeated for the Pliocene (early Pliocene, 40 m/m.y.; late Pliocene, 51 m/m.y.) of Site 289 on the Ontong-Java Plateau (Andrews, Packham, et al., 1975). We have now dismissed the possibility that the high sedimentation rates in the Pliocene are due to secondary reworking of material from elsewhere. This is due to the isolated location of Site 591 near the crest of a spur of Lord Howe Rise and to an absence of any clearly reworked material in the section.

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Date of Acceptance: 1 December 1983

SITE	591	-	HO	LE	-	100	DRE	1 COREC	INTERVAL	0.0-3.4 m			
TIME - ROCK UNIT	BIOSTRATIGRAPHI ZONE	FORAMINIFERS	NANNOFOSSILS	RADIOLARIANS 200	SWOLVIO	SECTION	METERS	GRAPHIC LITHOLOGY	DRILLING DISTURBANCE SEDIMENTARY STRUCTURES SAMPLES		LITHOLOGIC D	ESCRIP	TION
						ĩ	0.5			5Y 8/1	FORAMINIFER 1 (5Y 8/1, top 62 burrow mottles - spotted by iron sul SMEAR SLIDE SU Texture: Sand	MANNC cm) and of mod fides of MMAR 1, 25 D C	POSSIL OOZE, vellowish gray I very light gray (N8), soft, with erate yellow green (SGY 7/4) light gray (N8–N7). Y: 2,110 D
Quatemen	G. truncatulinoides NN20/21					2			*	NR	Silt Clay Composition: Quartz Heavy minerals Clay Pyrite Foraminifers Calc. nannofossils Diatoms Sponge spicules	C D R R R T A D T T	A D T T T A D T

SITE	591	-	HOI	LE			DRE	2 COREC	D INTER	T	3.4–13.0 m	_	_		
¥	APHI	1	CHA	RA	CTER										
UNIT UNIT	BIOSTRATIGRI	FORAMINIFERS	NANNOFOSSILS	RADIOLARIANS	DIATOMS	SECTION	METERS	GRAPHIC LITHOLOGY	DRILLING DISTURBANCE SEDIMENTARY STBUCTURES	SAMPLES	LITHOLOGIC	DESCRIP	TION		
	NN20		~			1	0.5			*	FORAMINIFEF light gray (N8) gray (5GV 8/1) (5GY 8/1) and 1 Ash layer (fota Section 2, clear, Light gray (N7) occur in the low Section 2, clear, SMEAR SLIDE: SMEAR SLIDE: N7 Texture: Sand Sit Clay Composition: Quartz Mice Heavy minerals Clay Volcanic glass Pyrite Zaolite Carbonets umpo Expensioners	BEARIN to white cons and ght (N7) s y 25 cm light gray y 25 cm r bart of r D T C D T T T T T T T T T T C C C	G NAN (N9), double greenish the core Y: 2,45 M T T R D T T T R C T T T C	NOFOS soft, with colored kness) a grav (ti (Section C A R T 	ISIL OOZE, ver tith light greenis bands of greenis t about 55 cm i hickness. SGY 8/1) Jamini ns 5, 6). 4, 120 D T T T T T T T T C
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TIME - ROCK UNIT BIOSTRATIGRAPHIC ZONE FORAMINIFENS	BADIOLARIANS BIATOMS DIATOMS	SECTION	GRAPHIC	A DRILLING DISTURBANCE SEDIMENTARY STRUCTURES SAMPLES	LITHOLOGIC DESCRIPTION	TIME - ROCK UNIT	BIOSTRATIGRAPHIC ZONE	FC CHAF	PLADIOLARIANS PS	R	METERS	GRAPHIC LITHOLOGY	DRILLING DISTURBANCE SEDIMENTARY STRUCTURES		LITHOLOGIC DESCRIPTION
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TIME ROCH UNIT BIOSTRATIGRA	ZONE	FORAMINIFERS	NANNOFOSSILS	RADIOLARIANS	DIATOMS	SECTION	METERS	GRAPHIC LITHOLOGY	DISTURBANCE DISTURBANCE SEDIMENTARY STRINCTURES	SAMPLES		LITHOLOGIC DE	SCRIP	TION				TIME - ROC	BIOSTRATIGRA
Outlinnary	touncatulinoldex/G. rosemate V19					2 3 4 5 5	0.5				5GY 8/1 N8 5GY 8/1 N8 5GY 8/1 N9 5GY 7/2–8/1 N8 5GY 7/2 N8	FORAMINIFER-BI dominantly very li green (5GY 7/2), s Two-tone colored 1 ish gray (5G 8/1) a Volcanic ash layer greenish gray (5GY SMEAR SLIDE SU Texture: Sand Sit Clay Composition: Clay Composition: Clay Mica Heavy minerala Clay Volcanic glass Pyrite Foraminifers Cate: nannofossils	EARIN Bands core e comme at the 6/2). MMMARR 2,00 D T T T T C D	G NAN Y (N8) i d light g bottom Y: R R T T T T T C D	NOFO: ray (No per vigeout) of Sec 3, 14 C C A R T T C C A	SSIL O tiv gray 7) and 1 ction 3, 4 4,46 M T T T T T T C D	OZE, pre- ish yellow inght green- clear dark 6,60 D T C D T T T T T C D	Quatemary	tiviariti foremente
	G. trunc NN19	A	A			cc					5GY 8/1								

ITE	591	1.0	HOL	.E		CC	DRE 6 COR	ED IN	TER	VA	L 41.8-51.4 m				
	APHI	- 9	F	RAC	TER										
UNIT	BIOSTRATIGR	FORAMINIFERS	NANNOFOSSILS	RADIOLARIANS	DIATOMS	SECTION	GRAPHIC LITHOLOG	DRILLING	SEDIMENTARY SEDIMENTARY STRUCTURES	SAMPLES		LITHOLOGIC OF	ESCRIP	TION	
					-	1		PH PFH			NS	FORAMINIFER-B color: alternation and light greenish laminae, both ligh and specks of iron t	EARING of pres gray (ter and sulfides	3 NAN dominar 5GY 7 darker, of dark	NOFOSSIL OOZE, soft it very light gray (N8) /2-8/1) with numerous and with band, streaks gray (N4-6).
												SMEAR SLIDE SU	3, 70	Y: 5,54 M	5, 122 D
							17	- i	-	1		Texture:	~		
- 1							1 + + + +	-		1	56Y 7/2	Sand	T	R	T
							1 1	-			7	Clay	D	D	0
- 1						2	17					Composition:		-	
							+++++++++++++++++++++++++++++++++++++++				NB	Quartz	-	Ţ	- T
- 1							77	1				Heavy minerals	÷.		T
- 1							77	1				Clay	т	-	-
- 1								1			L 5GY 7/2	Volcanic glass	τ	-	÷
- 1							1		1.1			Pyrite	÷	-	T
1								1			ND	Carbonate Unspec.	-	c	8
							1-1-1				na	Calc, nannofossils	Ď	D	D
- 1							1-1-1-1-		1.1						
- 1						3									
							1-1-1		1.1						
							1-1-1		1.3		-				
.						11		-	11		5GY 8/1				
						\vdash		-	+ -		- IW				
						11	1	-			NB				
3						11	11	-			r.				
- 1						11					5GY 8/1				
							17	-			NIG				
- 1						11		-	11		- 110				
								-			5GY 7/2-8/1				
							171++	-		1					
- 1								-							
- 1						H		-	\vdash	1	N8				
						11		-			1428				
								-							
								-							
						5	-	<u>-</u>							
- 1						-	1744	-							
- 1						1.1	17	-	-		Concert Manufact				
- 1							17-1-	-	-	*	5GY 8/1				
- 1							177-1-	-		1					
				1				-							
	1515						171-1-								
	Nes						171-1-	-	2.22	1	N8				
	to						171-1-		1		1 mar 10 million				
	S/S					6	THAT								
	ovicte								-	1					
	dine						1-++								
	catu														
	Sunna B						1 ++++++++	-	m						
	NN.					1	774-5-1-	-		1					
						Ľ		-	5.	1					
		1.4	1.1			CC	++, +, -	- 1	1	L					

SITE SOT HOLE	COR	E	7 CORED	INTE	ERV	AL 51.4-61.0 m	SITE	59	n	HOL	E	_	COR	RE	8 CORED	INTER	IVAL	_ 61.0-70.6 m	
TIME - ROCK UNIT BIOSTRATIGRAPHIC BIOSTRATIGRAPHIC FONAMINIFERS NANUCFOSSILLS RADIOLARIANS	SECTION SECTION	METERS	GRAPHIC LITHOLOGY	DRILLING DISTURBANCE SERVICENTARY	SEDIMENTARY STRUCTURES	LITHOLOGIC DESCRIPTION	TIME - ROCK UNIT	BIOSTRATIGRAPHIC	ZONE	NANNOFOSSILS H	RADIOLARIANS BAD		SECTION	METERS	GRAPHIC LITHOLOGY	DISTURBANCE DISTURBANCE SEDIMENTARY STRUCTURES	SAMPLES		LITHOLOGIC DESCRIPTION
Cuternary Cuternary Nulla Nulla Nulla Viewents	3 3 4 5 6 7 7					SGY 8/1 FORAMINIFER-BEARING NANNOFOSSIL ODZE, soft, predominantly verv light grav (NS), but partially greenish grav (SGY 7/2-8/1) where bioturbation is present. Modulated viscol and drunks). N8-9 SMEAR SLIDE SUMMARY: 2.50 2, 108 5, 89 6, 50 0 M M D SGY 8/1-7/2 Omega T Grav T GY 8/1-7/2 Outrit Grav T GY 8/1-7/2 Outrit Grav T SGY 8/1-7/2 Outrat Grav T Grav T Grav T Foraminifies C C C Grav T SGY 7/2 N8	Quaternery	G. truncturiholder/G. tossenti	NNIB NNIB NNIZ I NNIB	A A A			2 3 4 5 6 7 CC					N9 5GY 8/1 - N8-9 5GY 7/2-8/1 N8-9 - 5GY 7/2-8/1 - IW N8 - SGY 7/2-8/1 - N8 - N8	FORAMINIFER-BEARING NANNOFOSSIL QOZE, soft: color alternation of very light gay (NB-NB) and greening gay (SGY 22-SCY 87); with borrow motiles and pyritized specks. Double colored laminae common. SMEAR SLIDE SUMMARY: D D D D SMEAR SLIDE SUMMARY: D D SMEAR SLIDE SUMMARY: D D Smart R R R Clay D Domosition: D Duartz T Clay T Day T Private T Calc. nanofossilis D Domosition: D Duartz T Calc. nanofossilis D Sponge spicules - T T Foraminifers C C C Calc. nanofossilis D Sponge spicules - T -

591		HOI	E		CC	RE	9 CORED	INTE	RVA	70.6–80.2 m
PHIC		CHA	OSS	L						
BIOSTRATIGRA	FORAMINIFERS	NANNOFOSSILS	RADIOLARIANS	DIATOMS	SECTION	METERS	GRAPHIC LITHOLOGY	DISTURBANCE	STRUCTURES SAMPLES	LITHOLOGIC DESCRIPTION
					1	0.5	+ + + + + + + + + + + + + + + + + + +	000		FORAMINIFER-BEARING NANNOFOSSIL OOZE, very light gray (NB) to light greenish gray (5GY 8/1), soft, with burrow mottles (vellowish gray (5Y 8/1)) and several laminae of two-tone color of light greenish gray (5G 8/1) and light gray (N7). Pyritized specks common. SMEAR SLIDE SUMMARY: 2, 50 5, 80 6, 20
					Н	-	+			D D M Texture:
										Sand R R R Silt C C R Clay D D D
					2	on Lon			ł	Gungoalium Guartz — T — Mica T — T Heavy minerals — T T Clay T T —
ensis					H	-				Volcanic glass T T T Pyrite T B B
i. tosi						1	+			Carbonate untpec. — T — Foraminifers C C C
runcatulinoides/C	4				3	decela				Calc. nannofossils D D D
6.5					Н	1		-		
					4	tradite			-	
					L			-	-	
					5	and more		2.0	5	
						al unit			-	
						i i i i i				
sis					6					
tosaeri 116					-	-	귀소소소			
SZ		A			1 cc	-	<u> </u>			
	G. touvesteise G. truvestulinoides/G. toearole BIOSTRATIGE RAPHIC E NVTE	C. rowerski C. rowerski C. rowerski C. rowerski BIOSTRATICA AMIC BIOSTRATICA AMIC BIOSTRATICA AMIC C.	C. transmits C. tr	C. Troneental C. Troneental BIOSTATICancentia Election 0.0012 0.0122 0.0012 0.0012 <td>A A</td> <td></td> <td></td> <td>BOTH PROCESSIE CORE 9 CORE 9 CORE 9 FOSSIL CHARACTER RIVERSIGE FOSSIL CHARACTER RIVERSIGE GRAPHIC UINOLOGY 05 TT 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1</td> <td>BOT FOLE CORE 9 CORE DINE FOOSSIL FOOSSIL GRAPHIC DISSOURCE DISSOURCE CHARACTER NOL23 GRAPHIC DISSOURCE DISSOURCE NOL23 BULCORE BULCORE GRAPHIC DISSOURCE INOUC BULCORE BULCORE GRAPHIC DISSOURCE INOUC BULCORE BULCORE BULCORE DISSOURCE INOUC BULCORE BULCORE INFERENCE DISSOURCE INOUC BULCORE BULCORE INFERENCE DISSOURCE INOUC INFERENCE BULCORE INFERENCE DISSOURCE INOUC INFERENCE INFERENCE INFERENCE INFERENCE INFERENCE INFERENCE INFERENCE INFERENCE INFERENCE</td> <td>ODI HOLE CORE 9 2</td>	A A			BOTH PROCESSIE CORE 9 CORE 9 CORE 9 FOSSIL CHARACTER RIVERSIGE FOSSIL CHARACTER RIVERSIGE GRAPHIC UINOLOGY 05 TT 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1	BOT FOLE CORE 9 CORE DINE FOOSSIL FOOSSIL GRAPHIC DISSOURCE DISSOURCE CHARACTER NOL23 GRAPHIC DISSOURCE DISSOURCE NOL23 BULCORE BULCORE GRAPHIC DISSOURCE INOUC BULCORE BULCORE GRAPHIC DISSOURCE INOUC BULCORE BULCORE BULCORE DISSOURCE INOUC BULCORE BULCORE INFERENCE DISSOURCE INOUC BULCORE BULCORE INFERENCE DISSOURCE INOUC INFERENCE BULCORE INFERENCE DISSOURCE INOUC INFERENCE INFERENCE INFERENCE INFERENCE INFERENCE INFERENCE INFERENCE INFERENCE INFERENCE	ODI HOLE CORE 9 2

	2		F	055	IL.				TT	T					
š	HdV		CHA	RAC	TE	R									
UNIT	BIOSTRATIGR	FORAMINIFERS	NANNOFOSSILS	RADIOLARIANS	DIATOMS		SECTION	GRAPHIC LITHOLOGY	DRILLING	SEDIMENTARY STRUCTURES	SAMPLES		LITHOLOGIC DE	SCRI	PTION
Lare Plocens	entik						1 2 3 4 5 6		00 -0			- P - P - P - P - P - P - P - P	FORAMINIFER-B greenish gray (SG) soft, with swirts, gravish purple (SP) are only identifial SMEAR SLIDE SU Composition: Quartz Feldspar Volcanic glass Pyrita Foraminifers Cale: nannofossils Sponge spiculas	EARIII Y 8/14 streak 4/2) ble b T - R - C D T T	NG NANNOFOSSIL OOZE, ligh 1 to light gravity green (5G 871) s, and halos of various shades of of iron suffice, <i>Handlette</i> burrow urrows but mottles are common IRY: 5 3, 70 D T T T C D -
	5. tosse NN16						7								



SITE	591	H	DLE		co	DRE	13	CORED	INTER	RVA	L 109.0-118.3 m		_		-	SITE	591	_	HO
×	APHIC	Cł	FOSSI	L TER												×	CHIC		CH
TIME - ROC UNIT	BIOSTRATIGR/	FORAMINIFERS	RADIOLARIANS	DIATOMS	SECTION	METERS	GR LITP	APHIC IOLOGY	DISTURBANCE	STRUCTURES SAMPLES		LITHOLOGIC D	ESCRI	PTION		TIME - ROCI	BIOSTRATIGRA	FORAMINIFERS	a manufacture
					1	0.5			:		NS	FORAMINIFER-B light gray (N8), s thin laminae (< 2 grayish yellow gra- occur scattered th apparent with dep occur at Section 6. SMEAR SLIDE SL	EARIN mm) of mm) of rougho th. Pol 50 and	VG NANNOFOSSIL OOZE, very stiff, Common blebs, straaks, and of iron sulfide. Burrow mottles of 7/2/j and interbads of same color out. Burrow mottles become more suble ash layers (< 1 mm thick) 162 cm.					
					2	ter data data data data data data data dat			1		J 5GY 7/2 N8 5GY 7/2 N8	Composition: Feidspar Mica Heavy minerals Volcanic glass Foraminifers Calc. nannofossils Sponge spicules	3,70 D T T C D T	р 6,51 D T T T C D T					
Dene					3	indent tree					- 5GY 7/2 - 5GY 7/2	64 2 1.2 0 2142623				late Pliocene	G. inflata	A	
late Plice					4						5GY 7/2 N8 5GY 7/2								
					5														
	rfiata 15				6	at a state of a			111		-5GY 7/2 10G 8/2 ash? 10G 8/2 ash? 5GY 7/2 N8								
	G. MN	A			7 CC		+++++				- 5GY 7/2					early Pliocene	rassaformis tr	2	

1.5	0	<u> </u>	101	- E		T	I	IN CONED	T		VA	110.0-129.0	m			
2	APHI	1	CHA	RAC	TER											
UNIT UNIT	BIOSTRATIGRI	FORAMINIFERS	NANNOFOSSILS	RADIOLARIANS	DIATOMS	SECTION	METERS	GRAPHIC LITHOLOGY	DISTURBANCE	SEDIMENTARY STRUCTURES	SAMPLES		LITHOLOGIC D	ESCRIP	TION	
						1	0.5		þó			5GY 8/2 5GY 8/2 5GY 8/2	FORAMINIFER-BI light gray (NB), so of iron sulfide. L yellow green (5GY are conspicuous ar yellowish green (10	EARING ift, with aminae 8/2) oc nd a fe IGY 7/2	S NANI streaks and in cur the w plane) lamina	NOFOSSIL OOZE, very s and laminae (< 2 mm) iterbeds of light gravish oughout. Burrow mottle blites occur. A few pale e.
							E			ť			SMEAR SLIDE SU	MMAR	F 10	5 109
						F	1	다고고				5GY 8/2	Composition:	9,02 D	D, 19	5, 105 M
						2	and the			1		≺5GY 8/2	Quartz Feldspar Heavy minerals Foraminifers Calc. nanoofossils	т - с	T T C D	T T C D
							100					-5GY 8/2 - P 5GY 8/2	Radiolarians Sponge spicules	Ŧ	T T	Ŧ
8						H	-	·			1	- iw				
late Plicce							- Han			12		- 5GY 8/2				
	inflate	A				3	100					-5GY 8/2 -5GY 8/2				
	6						1					-5GY 8/2 5GY 8/2				
						H				1		5GY 8/2				
							1					-5GY 8/2				
						4	- I I I				•	- P - 10GY 7/2 1 10GY 8/2 - 5GY 8/2				
							1					le personal				
							1111				•	5GY 8/2 10YR 7/2 5GY 8/2				
						5	-					- 5GY 8/2				
							a la a					- 5GY 8/2 - 5GY 8/2				
						+	-					— Р				
							. True			11		- NB + 5GY 8/2				
						6	1.1.1					-10GY 7/2				
cente	sis															
terly Plic	assarform 5					7				a.		-1 5GY 7/2				
-	G. cr					cc	-	친구수								

SITE I	591	HOLE		C	DRE	15 COR	ED INTERV	L 127.6-136.9 m		SIT	E 59	n	HOLE		COR	E	16 CORED INTERVAL	- 136.9-146.2 m	
TIME - ROCK UNIT	ZONE	FORAMINIFERS	ACTER DIATOMS	SECTION	METERS	GRAPHIC LITHOLOG	DRILLING DISTURDANCE SEDIMENTARY SEDIMENTARY SAMOLES		LITHOLOGIC DESCRIPTION	TIME - ROCK	BIOSTRATIGRAPHIC	FORAMINIFERS	FOS CHAR	SIL ACTER SWOLVIO	SECTION	METERS	GRAPHIC LITHOLOGY UNTLING DISTURNATION DISTURNATION		LITHOLOGIC DESCRIPTION
early Pfocome	G. crassiformus NN15			1 2 3 4 5 6 7 7 000	0.5			N8 5GY 7/2 N8 5GY 7/2 N8 5GY 7/2 N8 5GY 7/2 N8 5GY 7/2 5GY 7/2 5	FORAMINIFER BEARING NANNOFOSSIL OOZE, very light gray (N8) with interbeds and burrow myths of grayih visito graen (502 772), soft, with streaks and blobs of iron sufficiences and throughout. SMEAR SLIDE SUMMARY: 4, 38 0 Composition Ray minerals T Somo Ray minerals Cate, nanotosis D Cate, nanotosis D Cate, nanotosis D Cate, nanotosis D Cate, nanotosis Sponge spicules T	and a growth and a growth a gr	G. crastifornit	W15			2 3 4 5 6 7 7			N8 + 5GY 7/2 5GY 7/2 N8 5GY 7/2 N8 5GY 7/2 N8 5GY 7/2 N8 5GY 7/2 1 5GY 7/2 N8 5GY 7/2 N8	PORAMINIFER BEARING NANNOFOSSIL OOZE, very ight pay (NW) with mottles of grayph yellow grain (5GV burrow outlines of medium light gray (NH) scattered throughout: Sections 1 and 2 budy disturbed by coring. SMEAR SLIDE SUMMARY: 5.92 Composition: D Havy minerals T Foraminifers C Gaic, namoforalis D Sponge solcules T

SITE 591 HOL	E	CORE	17 CORED	INTERVAL	148.2155.5 m	SITE	591	H	DLE		COF	E 18 CORE	DINTE	RVAL 155.5-164.8 m	
TIME - ROCK UNIT BIOSTRATIGRAPHIC ZONE FORAMINIFERS	RACITER DIATOMS	SECTION METERS	GRAPHIC LITHOLOGY	DRILLING DISTURBANCE SEDIMENTARY STRUCTURES SAMPLES	LITHOLOGIC DESCRIPTION	TIME - ROCK UNIT	BIOSTRATIGRAPHIC ZONE	FORAMINIFERS	FOSSIL ARACT SWEINETOIDER	DIATOMS	SECTION	GRAPHIC LITHOLOGY	DRILLING DISTURBANCE SEDIMENTARY	ALMALLISES	LITHOLOGIC DESCRIPTION
Multy Pilocene Multy Pilocene Multy Pilocene Multa		2 1 2 3 4 7 CC	┨╕╡┩╕┥┥╡╡╡╡╡╡╡╡╡╡╡╡╡╡╡╡╡╡╡╡╡╡╡╡╡╡╡╡╡╡╡╡╡		FORAMINIFER-BEARING NANNOFOSSIL OOZE, very igen (SGV 72). Ken sulfide straker, medium dark grav (N4) common, H ₂ S odor released when split. Yellowish grav interted at Section 4, 25–83 cm. SMEAR SLIDE SUMMARY: 6, 30 D Composition: Feldpain: Foraminifers: 0 Calc. nannofossile: D 	astry Pilocena	G, puncticulata MN14	A .		7	2 3 4 5 6			S SGY 7/2 S SGY 7/2 N8 + 5GY 7/2 S SGY 7/2 S S SGY 7/2 S S S S S S S S S S S S S	AANOFOSSIL OOZE, very light gray (N8), soft, with reaks and laminae of medium dark gray (N4) ion suffide roogbour. Mottles and thin (<2 mm) laminae of grayish ellow green (550 7/2) caminae occur in Section 5. MEAR SLIDE SUMMARY: 4, 74 organision: Ioleanic glass T yrite T adialariant T ponge spicules T

SITE 591	HOLE	CORE 19 CORED INTERVAL	164.8–174.3 m	SITE 591 HOLE	CORE 20 CORED INTERVAL	174.3–183.8 m
TIME - ROCK UNIT BIOSTRATIGRAPHIC ZONE	FOSSIL CHARACTER SUOLANIANNA RADIOLANIANS PLATONS PLATONS CHARACTER SHIJINNIAN SHIJINAN SHIJIN	SECTION METERS METERS METERS METERS METERS METERS METERS METERS METERS METERS	LITHOLOGIC DESCRIPTION	FOSSIL CHARACTER JUNU SILVEN S	SECTION RECTION METERS MALERS MALERS SERVICE	LITHOLOGIC DESCRIPTION
estiy Pliceana G. puncticulata NN14	A A	$\begin{array}{c} 3\\ 3\\ 3\\ 4\\ 4\\ 7\\ \\ \\ \\ \\ \\ \\ \\ \\ \\ \\ \\ \\ \\ \\ \\$	NB ANNOFOSSIL OOZE, very light gray (NB), soft, with sulfides common throughout. Mottles and zones of gray in yellow green (SGY 7/2) sattered throughout. Dark vol- canic glass in Insoluble residue at Section 5, 147 cm. SGY 7/2 C Graposition: Feddoar T Poreminifers T OCIC. namofossils D Radiolarians T Sponge spicoles T -N4 N8 + 5GY 7/2 N8 N8 N8 with montles of SGY 7/2 N8 N8 N8 with montles SGY 7/2 N8 N8 N8 vith montles M8 vith montles	Lite Miccree Late Miccree arty Pilotone arty Pilotone Annual		NANNOFOSSIL OOZE, very light gray (NB), soft, with tranks, spots, and thin laminae of light gravity. (IV) ion subtrade common throughout. Burrow motifs of light gravity. (BG VB1) associated throughout. Subtraction of the second s

TE	591	_	HOI	.E	-	cc	RE	21 COREC	INT	TERVA	183,8-193,3 m			
2	PHIC		CHA	RAC	TER									
UNIT UNIT	BIOSTRATIGRA ZONE	FORAMINIFERS	NANNOF0581L8	RADIOLARIANS	DIATOMS	SECTION	METERS	GRAPHIC LITHOLOGY	DISTURBANCE	SEDIMENTARY STRUCTURES SAMPLES		LITHOLOGIC DE	SCRIPT	ION
	EINN 3		A			1	0.5					NANNOFOSSIL O to moderately defo Light greenish gray scattered.	OZE, w rmed by (5GY	ery light grey (N8), soft, slightly y drilling. 8/1) and light gray (N7) mottles Y:
							3		11				3, 80 D	6, 125 D
						2	1.111.12					Texture: Sand Silt Clay Composition:	T T D	R R D
												Quartz Mica Heavy minerals Volcanic glass Pyrite	т - т -	
early Pliocene						3						Carbonate unspec. Foraminifers Calc. nannofossils Diatoms Radiolarians Sponge spicules Silicoflagellates	R D T T	Т В D Т Т Т Т
	G. puncticulata					4			-					
	NN13		^			5								
	Mericomiozea 112					6				-				
	G.S	A	A			co	-							

TIME - ROCK UNIT	PHIC		FOSSIL														
	BIOSTRATIGRA	FORAMINIFERS	NANNOFOSSILS	RADIOLARIANS	DIATOMS	SECTION	METERS	GRAPHIC LITHOLOGY	DRILLING DISTURBANCE SEDIMENYARY STRUCTURES SAMPLES		LITHOLOGIC DESCRIPTION						
early Pilocene	G, sphericonilorea					3	0.5				FORAMINIFER-BEARING NANNOFOSSIL QOZE, both server light gray (NB), upper half, light gravelish grav (SG 8/1), lower; with mottles of vellowish grav (SY 8/1) and upter grave (NB - NZ). SMEAR SLIED SUMMARY: 0 0 0 0						
cene						5	In dradie			•							
late Mich	conomiozes V12					6	offeren										

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SITE 591	1 HOLE	CORE 23 CORED INT	ERVAL 202.7-212.1 m		SITE	591	HC	LE	(CORE	24 CORED	NTERV	AL 212.1-221.5 m		
TIME - ROCK UNIT BIOSTRATIGRAPHIC	FOSSIL CHARACTER NANNOFORMAN RADIOLARIANS RADIOLARIANS RADIOLARIANS	NOLUSIA SHAT GRAPHIC SHAT LITHOLOGY SHATTING	SECTION AND A	LITHOLOGIC DESCRIPTION	TIME - ROCK UNIT	BIOSTRATIGRAPHIC ZONE	FORAMINIFERS	FOSSIL	ER SWOLVIN	METERS	GRAPHIC LITHOLOGY	DISTURDANCE SEDIMENTARY STRUCTURES		LITHOLOGIC DESCRIPTION	
tate Milocene G. conomicose	NN12 >>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>			FORAMINIFER BEARING NANNOFOSSIL OOZE, very light gray (NB), toft, with burrow motiles of light gray (NG-N7) and yellowish gray (SGY 8/1-SGY 7/2). Accessory pyrite of medium gray (N4). Moderately bioturbed. SMEAR SLIDE SUMMARY: 3,65 5,66 6,00 Testure: 3,05 5,66 0,00 Testure: 3,05 7,66 0,00 Testure: 3,05 7,66 0,00 Testure: 3,05 7,67 0,00 Testure: 3,05 7,00 Testure: 3,05 7,00 Testure: 4,00 Test	Late Miccree	G. heperifies Minib Minib				4 5 6 0.0			IW Light greenish gray (SGY 8/1) biorurtration	NANNOFOSSIL OOZE, very light gray (N8), soft, with mottles of pale olive (10Y 6/2) and light gray (N7) in color. SMEAR SLIDE SUMMARY: 2,70 6,60 D D Texture: Sand T T Sitt R R Clay D D Composition: Cuartz T T Feldspar – T Mica T T Meany minerals T – Foraminifers R R Cole, nanorosulis D D Diatoms T T Sponge spicules – T	
	DHIC		F	OSSI	L	Τ				Π	Τ				
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UNIT	BIOSTRATIGRAF	FORAMINIFERS	NANNOFOSSILS	RADIOLARIANS	DIATOMS	SECTION	METERS	LIT	APHIC HOLOGY	DISTURBANCE SEDIMENTARY	STRUCTURES SAMPLES		LITHOLOGIC DE	SCRIPT	TON
						1	0.5	+++++			****	NB	FORAMINIFER-B light gray (N8) to burrow mottles of light gray (N5 to (N4).	EARING light gro yellowi N7), and	G NANNOFOSSIL OOZE, very senish gray (SGY 8/1), soft, with sh gray (SY 7/2) and medium to d with iron sulfides of dark gray
								7-1-	<u></u>		1		mixed by bioturus	intern.	
					1	+	-		1-1-	11	3	5GY 8/1	SMEAR SLIDE SU	MMAR	Y:
								Et.	±		3	<u>1</u> 20		3, 60 D	0, 80 D
							-	41.	+++	11			Texture:	1020	2
								+L.	+_+	1			Sand	R	T B
						2	1	tru	±_+_				Clay	D	D
							14	THE	+_+			NB	Composition:	5252	
							1.2	TH	+_+-			I Was	Quartz	Ť	T
								TL		11	11		Heavy minerals	-	Ť
								TH		1 1			Volcanic glass	т	8
							1.8	+++		11	1.		Pyrite	T	Ţ
- 1	1		- 1	1	1	1	1.5				2		Carbonate Unspec.	c	c
			- 1				1.7	1-1-		11			Calc. nannofossils	D	D
2			- 1			3		174		11			Radiolarians	т	-
ocer							1.2	TH		11					
MIC							1.1	TL		11					
t i							1.1	TH		11					
1820							-	T+.	+++-	11					
									- <u>-</u>	11		_			
								TH	1-1-	11	1				
							-	11	1 <u>4</u> 1-	11		5GY 8/1			
			1			4		T.	+ +	1					
						1		正告	1 × 1-	11	1	0.84			
							1	TH				NB			
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								TH-	+++-	1					
							-	11	1,1-	1					
				1				Th.	+ +	1					
								1	+,+	1		.			
							1.5	LF		1					
						5		LT	11-			5GY 8/1-10Y 6/2			
								1	1.1						
							1 3	1TH	1-1-	1		N			
							1.3	1-1-	+++	1					
						1	-	1-1-	1,1-	1					
								1-1-	1.1-	1		-			
								1-1-	+++	1					
							11 -	+	+ +	1		NB			
						1	1	1-1-	+,+	1					
						0		1		11	1.	6			
							-	Th	1,1	1					
	8							11	·	1					
	(Jacob						1	11-	++	11					
	11B					1		1	++	11	1				
						7	1 3	114	·	- 1					
	S NN						-		and the second second						

2	2		nu	FOS	2511	-	T	T	RE 26	CORED	INTER	VAL	231.1240.7 m			
TIME - ROCK UNIT BIOSTRATICRAPH	ZONE	FORAMINIFERS	NANNOFOSSILS 2	ARADIOLARIANS	ACT	DIATOMS	CELTINA	MOLIDIO	METERS	GRAPHIC ITHOLOGY	DRILLING DISTURBANCE SEDIMENTARY STRUCTURES	SAMPLES		LITHOLOGIC DE	SCRIP	TION
Ize Miccine Ize Miccine Niccine Ni	8	A						22		┙┽┝┿┿┿┿┿┶┶┶┶┿┿┿┿┿┿┿┿┿┿┿┿┿┿┿┿┙┙┙┙┙┙┙┙┙┙┙┙		-	ΤW	NANNOFOSSIL C mottles of gravith bioturbated. SMEAR SLIDE SL Texture: Sand Clay Composition: Quartz Faidopar Heavy minarals Pyrite Carbonate unspec Foramiolifes Carbonate unspec Foramiolifes Sponge spicules	DOZE, yellov 2,51 D T T T T T T T T T T	very light gay (N8), soft, wit green (5GY 7/2); almost total RY: 5 5,40 T R D T T T T T T T T T T T T T T T T T

SITE 5	HOLE	CORE 27 C	CORED INTERVAL	240.7–250.3 m	SITE	591	HOLE		CORE	28 CORE	D INTERV	AL 250.3-259.8 m	
TIME - ROCK UNIT BIOSTRATIORAPHIC	FOSSIL CHARACTER NANNOFOSILLS RADIOLARINANS PLATOMS	NOILUU SEAU LITHOL	DRILLING DISTURCE VISTORIANCE VISTORIANCE STRUCTURIS STRUCTURIS	LITHOLOGIC DESCRIPTION	TIME - ROCK UNIT	BIOSTRATIGRAPHIC ZONE	PORAMINIFERS NANNOFOSSILS RADIOLARIANS	SIL CTER SWOLVIO	SECTION METERS	GRAPHIC LITHOLOGY	DRILLING DISTURBANCE SEDIMENTARY STRUCTURES	STANA STAN	LITHOLOGIC DESCRIPTION
late Milocene	NATIB			NANNOFOSSIL OOZE, very light gray (N8) and partly light graenish gray (ISOY 8/1), loft, almost totally bio varbed.	Late Miccene	At contrinuose NN11A NN11B NN11B		-	1 0.5 1 1.0 2 3 3 4 5 5 6 5			• •	NANNOFOSSIL OOZE, very light greenish grav (5GY 8/1), ioft, almost totally bioturbated. SMEAR SLIDE SUMMARY: 2, 80 6, 80 D Texture: Sind — T Sitt R T Clay D D Composition: Quartz T T Mica — T Heavy minerals T – Carbonate unspec T T Foreminifers T R Clef, nanofossils D D Diatoms T T Radiolarians T T

ITE	591		HOI	E		CC	RE	29 COREC	INTE	RVAL	259.8-269.3 m
	PHIC		F	OSS	TER				\prod		
UNIT	BIOSTRATIGRA ZONE	FORAMINIFERS	NANNOFOSSILS	RADIOLARIANS	DIATOMS	SECTION	METERS	GRAPHIC LITHOLOGY	DRILLING DISTURBANCE SEDIMENTARY	SAMPLES	LITHOLOGIC DESCRIPTION
						1	0.5				NANNOFOSSIL OOZE, very light gray (NB), soft, al totally bioturbased, with burrow mottles (rim of light [N7] and core of grayish yellow green [5GY 7/2]). SMEAR SLIDE SUMMARY: 2,80 6,80 D Texture: Sand T Sand T T
						2					Sitt T H Carposition: Quartz T – Mica T T Heavy minerals – T Corbonate umpec. – T Foraminifers T R Calc. namofossis D D Distoms T –
						3	the sector s				Hadiolarians I T Sponge spicules T T
late Miocene						4	territered trees				
						5					
	N. continuosa NN11A					6					

×	VPHIC		F	OSSI	L								
TIME - ROC UNIT	BIOSTRATIGR/ ZONE	FORAMINIFERS	NANNOFOSSILS	RADIOLARIANS	DIATOMS	SECTION	METERS	GRAPHIC LITHOLOGY	DRILLING	SEDIMENTARY	SAMPLES	LITHOLOGIC	DESCRIPTION
late Miccene	N. continuote NN11A					1	0.5				•	NANNOFOSSI mottles and fa 7/2). Streeks SMEAR SLID Composition: Foraminifers Calc, nannofos Diatoms Sponge spicule	L OOZE, very light gray (N8), stiff, wid nt interbeds of grayish yeliow green (5G) of medium dark gray (N4) iron sulfide SUMMARY: 2,63 D R B B R T

SILE	591	-	HOL	E	_	-	ço	RE	31	CORED	IN	TER	VAL	274,3-283,1 m		
×	DIHA		F	RAC	TER											
TIME - ROC	BIOSTRATIGRA	FORAMINIFERS	NANNOFOSSILS	RADIOLARIANS	DIATOMS		SECTION	METERS	GR. LITH	APHIC OLOGY	DRILLING	SEDIMENTARY STRUCTURES	SAMPLES		LITHOLOGIC DE	SCRIPTION
late Miccene	Landrinuose 11A						1 2 3 4 5 6	0.5						5GY 7/2 Diffusion band +5GY 7/2 N8 + 5GY 7/2 intermixed 5GY 7/2 -5GY 7/2	NANNOFOSSIL O geneoux, with stret fide common throi green (SGY 7/2) ra SMEAR SLIDE SU Composition: Quartz Feldspar Palagonite Foraminifers Cale. nanofossils Badiolarirans Sponge spicules	OZE, very light gray (NB), soft, homo- ks of medium dark gray (N4) inn sui- globur. Faint mottles of grayish yellow re to common. MMARY: 3,71 D T T T T T T T T T T
	2 Z	A	A				CC		11	1 <u>1</u>		["				
_			1.00			_				and the second			-			

Duttemary	TIME - ROCK	SITE
G. ronnostulinoides	BIOSTRATIGRAPHIC	59
Andrei Ei	FORAMINIFERS	1
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	FOSSI ARAC SNEILENOIDE	LE /
	L TER SWOLVIG	
		- 24
44 66	SECTION	COR
	METERS	E
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	THOL	C
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	DRILLING) IN
1	SEDIMENTARY	TER
* *	SAMPLES	VAL
1 10YR N8 N7 N8 N7 N8 N7 N8 N8 N8 N7 SGY N8 N8 N8 N8 N8 N8 N8 N8 N8 N8 N8 N8 N8		0.0-
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FOR ywlich with 4/21 1NG (2 m FOR grav Secti Secti Soci Com Grav Secti Com Com Com Com Com Com Com Com Com Com	LIT	
AMINIFI with bro Sequence R). Control NANNO AMINIFI (N7) and V bioturnon thre (N7) and V bioturnon thre (GGY 7. (N6) in of Swith per per values of the second per values of	HOLOGI	
R-BEA wn (10) sed interest act with a set with FOSSIL FOSSIL States of dark is set of dark is set of dark set of dark is set o	C DESC	
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Outimany	UNIT UNIT	TE
6. runcestunoniset NN19	ZONE	591
	FORAMINIFERS	HC
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	L	A
3	SECTION	
0.5	METERS	ORE
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	STRUCTURES	ERV
ז רודז ד.ו. לרוו דודו		10
N8 N8 + 5GY 7/2 ash? N8 N7 N8 N7 N8 SGY 7/2 with faintly darker hous N8 SG 8/1 ash? SG 8/1 ash? SG 8/1 ash? SG 8/1 ash?	9,216,6 m	0.2 19.9 m
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AANNOFOS Ind light graen on sulfide ight graenial reen (5GY : SMEAR SLI Composition Duartz feldspar feavy miner /original /o /o /o /o /o /o /o /o /o /o	LITHOLOG	
SIL OOZ y (N7), is through gray (55 C C C C C C C C C C C C C C C C C C C	3IC DESC	
E, alterr oft, strau, 8/1), S mottles i, 37 5, MARY: - T - C - C	RIPTIC	
ations c sks of m weral t 867 5, M T T T T T D	N	
f very li in zon nes af g M — — — C C C C C		
loht gray		
v (N8) v (N4) sh(?), veillow		



SITE	591		HO	.E	A	CO	RE	5 CORED	IN	TER	VA	38.0-47.6 m
	HIC		F	oss	IL				Γ			
TIME - ROCK UNIT	BIOSTRATIGRAP	FORAMINIFERS	NANNOFOSSILS	RADIOLARIANS	DIATOMS	SECTION	METERS	GRAPHIC LITHOLOGY	DRILLING	SEDIMENTARY STRUCTURES	SAMPLES	LITHOLOGIC DESCRIPTION
						1	0.5		0000000			NANNOFOSSIL OOZE, very light gray (N8) alternating with FORAMINIFER-BEARING NANNOFOSSIL OOZE, grayish vellow green (5GY 7/2), soft, mottied, common streaks of iron sufficied or modum dark gray (N4) and several doublets of altered ash(7) of light greenish gray (5G 8/1) and medium dark gray (N4). Two pockets of forams and prvite at Section 5, 32 cm and Section 6, 57 and 85 cm. Chemical diffusion bands common.
						2	other of the					SMEAR SLIDE SUMMARY: 5,7 5,122 D D Composition: Feldspar — T Volcanic glass T T Forsminifers R C Cate. nannofossila D D
smary						3	artice from a					
Oun						4	real conficer b					← 5G 8/1 N4 ash? ← 5G 8/1 N4 ash?
	nais					5	and the set of a set			0		 SG 8/1 ash? SG 8/1 ash? Pocket of forams + pyrite SG 8/1 N4 ash? N8 SGY 7/2
	G. truncatulinoides/G. tosaer NN19		A			6						N8 -N4 - 5GY 7/2 N8 - Pocket of forams + pyrite SGY 7/2 N8

	PHIC		CH	OSS	TER					Τ	
TIME - ROCI	BIOSTRATIGRA	FORAMINIFERS	NANNOFOSSILS	RADIOLARIANS	DIATOMS	SECTION	METERS	GRAPHIC LITHOLOGY	DISTURBANCE SEDIMENTARY	STRUCTURES SAMPLES	LITHOLOGIC DESCRIPTION
						3	0.5				FORAMINIFER-BEARING NANNOFOSSIL OOZE, alte nating very light gav, (NB) and gravith veltow green (56 7/2), soft, with streaks of medium dark grav (N4) iron su fide, and doublets of alternd ath(7) light greeninis gr (56 8/1) and (N4). Pockets of forams and pyrite in Se tions 5 and 6. SMEAR SLIDE SUMMARY:
						2	eretterenteren				4, 13 5, 96 D D D Composition: Feldapar T T Volcanic glass T T Pyrita T T Forominifer C C Calc: namofossils D D
Quaternary						3	territrend erre			-	- N4 5G 8/1 ath?
2						4	annef march an e				ич 5GY 7/2 N8 5GY 7/2 N8
	/G. tosemsis					5	and a reference				G B/1 N4 ash? G S/1 N4 ash? Pocket of forams + pyrite G SG 8/1 N4 ash?
	G. truncatulinoides. NN18	A	A			6	T			-	→ 5G 8/1 N4 ash?

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UNIT UNIT	BIOSTRATIGRAP	FORAMINIFERS	NANNOFOSSILS	RADIOLARIANS	SWOLVIO	SECTION	METERS	GRAPHIC LITHOLOGY	DISTURBANCE SEDIMENTARY	STRUCTURES	C D	LITHOLOGIC DESCRIPTION
						1	0.5					FORAMINIFER-BEARING NANNOFOSSIL ODZE, very light gray (N8) alternating with gravish yetlow green (5G 7/2), Several thin laminae and common streaks of medium dark gray (N4) iron sulfide.
						2	and contractions					
late Pliocene						3	triftent to t			11.11.1	N8 N4 5GY 7/2 N8 N8 N8	
						4					N8 + 5GY 7/2 N8 N8 N8 5GY 7/2 N8 15GY 7/2	
	G. tossentsis NN16	A	A			5	A DEPENDENCE			-	• N4 • N8 • N8 + N4 • intermixed • 5GY 7/2	

	HIC		F	OSS	IL		Τ		TT	Τ			
TIME - ROCK UNIT	BIOSTRATIGRAF	FORAMINIFERS	NANNOFOSSILS	RADIOLARIANS	DIATOMS	SECTION	METERS	GRAPHIC LITHOLOGY	DISTURBANCE SEDIMENTARY	STRUCTURES SAMPLES		LITHOLOGIC DI	ESCRIPTION
							0.5				NB	NANNOFOSSIL (yellow green (5G) of medium dark ; tion occurs in Sec occur in Section 4.	DOZE, very light gray (N4) and grayish 7/2) with common streaks and laminae gray (N4) iron sulfide. A pyrite concre- tion 3 and pockas of forams and pyrite Entire sequence is mottled.
aux						;				1 11	5GY 7/2 5GY 7/2 + N4	SMEAR SLIDE SL Composition: Feldspar Heavy minerals Pyrite Foraminiters	лмаару: 3,71 D T T T R
late Plioc						3				* *	P N8	Cale, nannofosails	D
						4				-	Pockets of forams and 5GY 7/2 with hues of 5G and N4 N8 with mottles of 5GY 7/2	pyrite	
	G. tocsensis NN16	A	A			5	0						

SITE 591 HOLE A CORE 10 CORED INTERVAL 86.0-95.6 m

SITE 591	HOLE A	CORE 11 CORED INTERVA	L 95.6-105.2 m	SITE 591 HOLE A	CORE 12 CORED INTERVA	AL 105.2-114.5 m
TIME - ROCK UNIT BIOSTRATIGRAPHIC ZONE	FORAMINIF ERS CHARACTER NANNOFOSSILS HADIOLARIANS DIATOMS DIATOMS	Stataawa Stataawa Stataawa Sharawa Sha	LITHOLOGIC DESCRIPTION	TIME - ROCK UNIT BIOSTRATIGRAPHIC FORMINIES MANUOFOSIELS ADDISON	R SPACE SPAC	LITHOLOGIC DESCRIPTION
Late Plicenne G. inifere NN16	A .	$\begin{array}{c} 1 & 1 & 1 & 1 & 1 \\ 0 & 1 & 1 & 1 & 1 \\ 1 & 1 & 1 & 1 & 1 \\ 1 & 1 &$	NB FORAMINIFER-BEARING NANNOFOSSIL DOZE, very light gray, (NB) with zones of intermixed maximum dark gray (NA) and grayidy very (SY 7/2), Strekks of NA common. Faint huse of SGY 7/2, Strekks of NA common. Faint huse of SGY 7/2 common. Mentles of SGY 7/2 common. Thin laminae of NA occur SMEAR SLIDE SUMMARY: 4, 72 Composition: Volcanic glass Yolcanic glass T Foraminifiera C Camposition: Volcanic glass Yolcanic glass T Soonge spicules T Soonge spicules T Sory 7/2 Soonge spicules NB with bands of NA and 5GY Yi Paint hues of 5GY	Late Pliceere NIS >		NANNOFOSSIL OOZE, very light gray (NB), soft to firm, homogeneous except for common streaks of medium dark gray (NA) from suffice, thin bands of NA, grayinin yellow green (50° 7/2) and high greening gray (58 A). Large <i>Planolizes</i> like matties of SQY 7/2 commonly occur below Section 4. Biotratistic is common and distinctive. SMEAR SLIDE SUMMARY: CC Composition: Feldpage T Pyrite T Foraminifers R Cate, nannofossile D 50Y 7/2 N8 with N4 streaks 50Y 7/2 N8 with N4 streaks 50Y 7/2 N8 to N4 50Y 7/2 N8 to N4 N4 N4 N4 N4

SITE 591	HOLE A	CORE 13 CORED INTERVA	L 114.5–123.8 m	SITE 591	OLE A	CORE	14 CORED IN	TERVA	L 123.8–133.1 m
TIME – ROCK UNIT BIOSTRATIGRAPHIC ZONE	FORAMINIFERS CHAUNOFOSSILS NANNOFOSSILS RADIOLARIANS PLATOMS	SECTION BECTION BUILTING CONTRACTOR CONTRACO	LITHOLOGIC DESCRIPTION	TIME - ROCK UNIT BIOSTRATIGRAPHIC ZONE FORAMINIFENS	FOSSIL HARACTER BIATOMS	SECTION	GRAPHIC LITHOLOGY	SEDIMENTARY SEDIMENTARY STRUCTURES SAMPLES	LITHOLOGIC DESCRIPTION
late Pilcoene Nitsa Nits		2	FORAMINIFER BEARING NANNOFOSSIL OOZE, predominantly vary light gray (NB), firm, homogeneous. N8 Specks, streaks, and thin bands of iron sulfides (dark to light gray (NA-NO)) and mottles of burrows (grayish valion grane). Total bioturbation. SMEAR SLIDE SUMMARY: 4,80 0 Soft 7/2 Clay 5GY 7/2 Clay N8 Mice Totalbioturbation: Oursit Sand T SGY 7/2 Clay SGY 8/1 Foraminifier SGY 8/1 N8 N8 Mice SGY 8/1 N8	early Plooere G. craaafornu. NNUS >	~	1 0.5- 1 1.0- 2 - 			PORAMINIFER-BEARING NANNOFOSSIL OOZE, very light gray (N8), firm, totally bioturbased. SMEAR SLIDE SUMMARY: 3,80 3,110 D M Texture: Sand T R Sit C R Clay D D Composition: Mice T - Heavy minerals, - T Poreminifers C C Calc. nannofoxmit D D Radiotarians T - Sponge spicules T T - 5GY 8/1

4	
4	
4	

SITE 591 HOLE A CORE 15 CORED INTERVAL 133.1-142.4 m	SITE 591 HOLE A CORE 16 CORED INTERVAL 142.4–151.7 m
VIDUATION Second Control of Control o	LITHOLOGIC DESCRIPTION
Source Source<	NANOFOSSIL DOZE, vrv løht gry (NB), forn, uteliv bouldvald Andrifte like notitis av suproved bouldvald Andrift

ITE	591		HO	LE	A		OR	E 17	CORED	INT	TER	VAL	151.7-161.0 m	
	PHIC		CH	OSS	IL									
TIME - ROCH	BIOSTRATIGRA ZONE	FORAMINIFERS	NANNOFOSSILS	RADIOLARIANS	DIATOMS	INCLASE	AUTO DATA	METERS	GRAPHIC LITHOLOGY	DRILLING	SEDIMENTARY STRUCTURES	SAMPLES		LITHOLOGIC DESCRIPTION
							1	5 1 1 1 1 1 1		ł				NANNOFOSSIL OOZE, very light gray (NB), firm, homo- geneous except for pyritized rims of trace fossils. SMEAR SLIDE SUMMARY: 3, 75 D Texture: Sand T
						12	2							Sit T Ciay D Composition: Quartz T Mice T Volcanic glass T Vortanic glass T Pyrite T Foraminifiers R Cale, nanofossiis D Radiolarians T
aarty Pliocene							3			The second s			NB	
						4	•						5GY 8/1	
	crassaformis V14												NB	
	GZ	A	A			c	c	P						

5 14		CHA	ARAC	CTER		1.1				
BIOSTRATIGR	ZONE	NANNOFOSSILS	RADIOLARIANS	DIATOMS	SECTION	METERS	GRAPHIC LITHOLOGY	DISTURBANCE DISTURBANCE SEDIMENTARY STRIMITIONS	SAMPLES	LITHOLOGIC DESCRIPTION
artly Pliceme BLD		NAN	RAD	DIA	1 2 3 4 5 6	0.5				NANNOFOSSIL OOZE, very light gray (NB), soft, homo geneous. Grayish yellow green (5GY 7/2) colored mottles common (total bioturbation) SMEAR SLIDE SUMMARY: <u>9,80</u> 5,52 <u>0</u> M Texture: Sand T T Silt R R Clay D D Composition: Oueriz - T Feldippe T T Meas T T Volcanic glass T T Prite T - Foraminiters R R Calc. namofossils D D Distorm Sponge spicules T -

SITE 591 HOLE A	CORE 19 CORED INTERVAL 170,5-180	0.0 m	SITE 591 HOLE A CORE 20 CORED INTERVAL 180.0-189.5 m
	SECTION BECTON CUT	LITHOLOGIC DESCRIPTION	LITHOLOGIC DESCRIPTION
early Pliccens Mil 1 	1 1 1 1 0.5 1 1 1 1 1 1 1 1<	NANNOFOSSIL OOZE, very light gray (NB), firm, homo- genoux. Gravish yellow green (EGY 7/2) colored mottles with light gray (NB-N7) rims are common. SMEAR SLIDE SUMMARY: 3,80 D Texture: Sand T Sit R Composition: Flagar T Heavy mimerals Teraminifers R Composition: Sponge spicules T	Image: Second
	CC Void		

SITE	591	HC	LE A		COF	RE	21 CORI	ED IN	TERVA	L 189.5–198.9 m	SITE	591	HO	DLE /	Ą	COF	RE 2	2 CORED	NTER	VAL 198.9-208.3 m	
TIME - ROCK UNIT	BIOSTRATIGRAPHIC ZONE	FORAMINIFERS	FOSSIL ARACTEE SWOIJUIDIGU	1	SECTION	METERS	GRAPHIC LITHOLOGY	DRILLING	DISTURBANCE SEDIMENTARY STRUCTURES SAMPLES	LITHOLOGIC DESCRIPTION	TIME - ROCK UNIT	BIOSTRATIGRAPHIC ZONE	FORAMINIFERS	FOSSIL	ER	SECTION	METERS	GRAPHIC LITHOLOGY	DISTURBANCE SEDIMENTARY STRUCTURES	SAMPLES	LITHOLOGIC DESCRIPTION
late Miccree	G. construitoree NN13			7	2 2 2 2 3 3 3 3 4 4 4 6 6 6 6 6 6 6 6 7 7 7 7 7 7 7 7 7					NANNOFOSSIL OOZE: way light gray (NB), firm, homo- geneous with spacks, strasks, and mottles of medium gray (NB) and Light gravitation). SMEAR SLIDE SUMMARY: B D Texture: Sand T Sitt B Clay D Composition: Outriz T Feldspar T Heavy minerais T Volcanic glas T Cate, nannofossila D Sponge spicules T	lat Micene	G. concenticare NN12				1 2 3 4 5 6 7 CC			torococococococococo ma ima ima ima ima ima ima ima ima ima	• 5GY 8/1	NANNOFOSSIL OOZE, very light gray (NB), firm, biotur- bated and homogeneous pyritization of margin of large <i>Plano/iter-like burrows</i> (medium light to light gray [NB- N7]). SMEAR SLIDE SUMMARY: 3,80 Composition: Mice Carbonate unopec. T Foraminifers Calco.nannofosilis D Distoms T

SITE	591	HOLE	A	- 3	CORE	23	CORE	DINT	ERVA	AL 208.3-217.7 m	SITE	591	HO	LE A		COF	RE 2	4 CORED I	TERV	AL 217.7-227	.3 m
ROCK T	NE	FO CHAR	ACTER	_	ION		GRAPHIC	CE	s		ROCK	IGRAPHIC	CH	ARACI	TER	NOI	ERS	GRAPHIC	CE RV S		
TIME -	201	NANNOFOS	BIATOMS		METI		LITHOLOGY	DRILLING	SEDIMENTA STRUCTURE SAMPLES		TIME -	BIOSTRAT	NAMOFOS	RADIOLARI	DIATOMS	SECT	METI	LITHOLOGY	DISTURBAN SEDIMENTA STRUCTURE	BAMPLES	LI INCOMO DESCRIPTION
late Mocene versetiere	12- 12-				1 0.3 1 1.0 2 2 3 3 4 5 5 6					NANNOFOSSIL OOZE, very lipht gray (N8), firm, very homogeneous except for superposed trace fossils of giant <i>Plandilesis</i> (inclume to light gray [N6–N7]). SMEAR SLIDE SUMMARY: 2,75 Texture: 3,15 Composition: 9rite T Composition: 9rite T Catconaus unspec. T Foraminifers T Catc. namedoalin D Silicoffagellates T	ALE MOONE	G, nagenthal NN11B				1 3 4 5 6 cc			00000000	N9 5GY 8/1 N8 5GY 8/1 N8 5GY 8/1 N8 Void	NANNOFOSSIL OOZE, predominantly, very light gray (NB) and partly light gray (5GY 8/1), firm but very disturbed by coring. SMEAR SLIDE SUMMARY: 3,80 Texture: Sand T Sit T Day D Composition: Mice T Volcanic glas T Carbonate unspec. T Carbonate unspec. T Cate. nanofossils D Radiolarigns T
C	ź /	A			c	-	主主	1		Void											

SITE 591	HOLE A	CORE 25 CORED INTERVA	L 227.5-236.9 m	SITE 591 HOLE A CORE 26 CORED INTERVAL 236.9-246.5 m
TIME - ROCK UNIT BIOSTRATIGRAPHIC ZONE	FOSSIL CHARACTER NANNOFORILS RADIOLA RIANS PLANNA PLANNA CHARACTER RADIOLA RADIOLINI RAD	CLICON BEACTORY CLICK CL	LITHOLOGIC DESCRIPTION	VICTOR CHARACTER CHARACTER VOOL UNIT UNIT UNIT UNIT UNIT UNIT UNIT UNIT
Late Milocene G. repeer/her NVT1B	A A	3	N8 NANNOFOSSIL 002E, very light gray (N8) to light gravity (N4-N7) is non-motivation. Specks of iron-sulfides of medium to light gravity (N4-N7) and mottles, or bands of gravity vellow green (BGY 7/2) to light gravity (SGY 8/1) is a common. SGY 8/1 Occasionally, small pockets including volcanic glass occur (gravith olive [10Y 4/2]) at about 30 cm in Section 3. SMEAR SLIDE SUMMARY: 3, 28, 3, 20, motive (10Y 4/2)) at about 30 cm in Section 3. SGY 8/1 Occasionally, small pockets including volcanic glass occur (gravith olive (10Y 4/2)) at about 30 cm in Section 3. SGY 8/1 Outrat SGY 8/1 Outration (10) (10) (10) (10) (10) (10) (10) (10)	Name Name <th< td=""></th<>



PHIC		CHA	OSS	TER				
TIME - ROC UNIT BIOSTRATIGRJ	ZONE	NANNOFOSSILS	RADIOLARIANS	DIATOMS	SECTION	METERS	GRAPHIC LITHOLOGY UNITING STURILS STUR	LITHOLOGIC DESCRIPTION
late Miccene continuoza M11A	N11A				1	0.5		NANNOFOSSIL OOZE, very light gray (N8) with streak of medium dark gray (N4) iron sulfide and grayish yellow green (5GY 7/2) throughout. Core totally wrecked by the coring procedure and splitting thus a detailed description is impossible.

59	1	HOI	LE	В	CC	DRE	1 COREL	INTERVAL	270.6–280,2 m
PHIC		CHA	RAC	TER					
BIOSTRATIGRA	FORAMINIFERS	NANNOFOSSILS	RADIOLARIANS	DIATOMS	SECTION	METERS	GRAPHIC LITHOLOGY	DRILLING DISTURBANCE SEDIMENTARY STRUCTURES SAMPLES	LITHOLOGIC DESCRIPTION
continuosa 111A					2	0.5			NANNOFOSSIL OOZE, very light gray (N8), firm, homo- genized by rotary coring, streaks of medium dark gray (N4) and blobs of gravish vellow green (5GY 7/2) scat- tered throughout. SMEAR SLIDE SUMMARY: 2,69 D Composition: Volcanic glass T Portainites T Foraminiters R Calc. nanofostilis D Diatoms T Radiolarians T
	N. continuosa BIOSTRATIGRAPHIC BI NN11A ZONE BI	W. contrinuous BIOSTRATTICAAPHIC ST NILLA PORAMNETES	N. contributions BIOSTAT/IGAAPHIC ST NINTIA FORMANIES 2006 9	201 3100F 2006 BIOSTIATIGARPHIC NN11A FORMANUE NANNOFOSILIA NANNOFOSILIA	B01 HOLLE B07 F03 F03 F03 F03 F03 F03 UH4Y012 F03 F03 S13 S13 S13 S14 S13 S13 S14 S14 S14 <td>B91 HOLE 8 CC CHARACTER NOLLSS B131/WWW804V B142/B142/B142/B142/B142/B142/B142/B142/</td> <td>591 HOLE B CORE 591 HOLE B CORE CHARACTER NOCULAR NOCULAR NOCULAR SHOTANWAWA SNOC NOCULAR NOCULAR NOCULAR SNOC NOCULAR NOCULAR NOCULAR SNOC NOCULAR NOCULAR NOCULAR SNOC NOCULAR NOCULAR NOCULAR NOCULAR NOCULAR NOCULAR NOCULAR NOCULAR</td> <td>501 HOLE B CORE 1 CORE VIACOUNT FOSSIL CHARACTER NO S S GRAPHIC VIACOUNT S S S S S GRAPHIC VIACOUNT S S S S S GRAPHIC VIACOUNT S S S S S S S VIACOUNT S S S S S S S VIACOUNT S S S S S S S S <t< td=""><td>501 HOLE CORE CORE CORED CORED INTERVAL F0051L F0051L GRAPHIC INTERVAL INTERVAL INTERVAL F0051L CHARACTER NOLL INTERVAL INTERVAL INTERVAL INTERVAL INTERVAL INTERVAL INTERVAL INTERVAL INTERVAL</td></t<></td>	B91 HOLE 8 CC CHARACTER NOLLSS B131/WWW804V B142/B142/B142/B142/B142/B142/B142/B142/	591 HOLE B CORE 591 HOLE B CORE CHARACTER NOCULAR NOCULAR NOCULAR SHOTANWAWA SNOC NOCULAR NOCULAR NOCULAR SNOC NOCULAR NOCULAR NOCULAR SNOC NOCULAR NOCULAR NOCULAR SNOC NOCULAR NOCULAR NOCULAR NOCULAR NOCULAR NOCULAR NOCULAR NOCULAR	501 HOLE B CORE 1 CORE VIACOUNT FOSSIL CHARACTER NO S S GRAPHIC VIACOUNT S S S S S GRAPHIC VIACOUNT S S S S S GRAPHIC VIACOUNT S S S S S S S VIACOUNT S S S S S S S VIACOUNT S S S S S S S S <t< td=""><td>501 HOLE CORE CORE CORED CORED INTERVAL F0051L F0051L GRAPHIC INTERVAL INTERVAL INTERVAL F0051L CHARACTER NOLL INTERVAL INTERVAL INTERVAL INTERVAL INTERVAL INTERVAL INTERVAL INTERVAL INTERVAL</td></t<>	501 HOLE CORE CORE CORED CORED INTERVAL F0051L F0051L GRAPHIC INTERVAL INTERVAL INTERVAL F0051L CHARACTER NOLL INTERVAL INTERVAL INTERVAL INTERVAL INTERVAL INTERVAL INTERVAL INTERVAL INTERVAL

	PH		F	OSS	IL	T			Γ		Γ	
UNIT	BIOSTRATIGRAP	FORAMINIFERS	NANNOFOSSILS	RADIOLARIANS	DIATOMS	SECTION	METERS	GRAPHIC LITHOLOGY	DISTURBANCE	SEDIMENTARY STRUCTURES	SAMPLES	LITHOLOGIC DESCRIPTION
late Mioseree	1010					1 2 3 4 5 6	0.5			and a state		NANNOFOSSIL OOZE, very light gray (N8), firm, homo- geneous with a few streaks of medium dark gray (N4) iron sulfide. Swere drilling disturbance below Section 3. Small nodule of CHERT, light gray (N7) at Section 5, 145 cm – working hait. SMEAR SLIDE SUMMARY1 3, 61 0 Compatition: Paragonite T Paragonite T Poraminifern R Calc, nanofositis D Radiolarians T

SIT	E 281	HOLE	s co	RE 3	CORED INTERVAL	L 289.8–299.4 m	SIT	E 5	591	HOL	E B	C	ORE	4 CORED I	NTERVA	AL 299.4-308.8 m	
TIME - ROCK	BIOSTRATIGRAPHIC ZONE	FORAMINIFERS	SECTION	METERS	GRAPHIC GRAPHIC UNTUNNUS UNTUNN GRAPHIC UNTUNN GRAPHIC	LITHOLOGIC DESCRIPTION	TIME - ROCK	BIOSTRATIGRAPHIC	ZONE	CHAP STISSOLONNAN	ACTER SWOIDING	SECTION	METERS	GRAPHIC LITHOLOGY	DEFILITION SEDIMENTARY STRUCTURES SAMPLES		LITHOLOGIC DESCRIPTION
tin Missesse	A. continuota NN11A.		2 3 4 5 CC	0.5		NANNOFOSSIL CHALK, very light grav (NB) with blets of medium dark grav (N4) iron sulfides. Core is broken into "biscuis" and "drilling soup" throughout. Nanno fosis show overgrowths. SMEAR SLIDE SUMMARY: 2,85 D Composition: Volcanic glas Calc. nannofosills Dictores T Radiolariane T Sponge spicules T Silicoflagelfates	Late Miscene	A. continuose	ANIIA D	A			0.5 1 1.0 1.0 1.0 1.0 1.0 1.0 1.0 1.0 1.0 1			SG 8/1 SG 8/1	NANNOFDSSIL CHALK, very light gray (N8), with common streaks, poda, and diffusion bands of medium dark gray (N4) iron sulfide. Attend ath(7) of light graenish gray (56 87) ools is common in very faint bends, Often a band of N4 is beneath the 56 8/J. Burrows are very common and include Zoophycos and Planolites. SMEAR SLIDE SUMMARY: 3, 82 D Composition: Volanic glass T Foraminifers R Calc. nanofossilis D Distorm T Radiolarians T Silcoffagellates T

APHIC		CH	FOSS	IL							
BIOSTRATIGRJ ZONE	FORAMINIFERS	NANNOFOSSILS	RADIOLARIANS	DIATOMS	SECTION	METERS	GRAPHIC LITHOLOGY	DRILLING DISTURBANCE SEDIMENTARY	SAMPLES	LITHOLOGIC	DESCRIPTION
La te Miccene La Miccene Navio Niccene		A			1	0.5				ENTIRE CORE ED BY GROUN FORAMINIFER Ight gay (N8) in Section common, typical SMEAR SLIDE SMEAR SLIDE Composition: Pyrite Carbonate unspection Carbonate unspection Carbonate unspection Carbonate unspection Carbonate unspection Sponge spicules Sponge spicules Solution	BROKEN INTO BISCUITS SURROUND -UP SEDIMENT. BEARING NANNOFOSSIL CHALK, very grading to light greenidh gray (5GY 8/1) isolutbation very evident with Azophy- se common at thin bands. Microfault 3, ly medium dark gray (N4). SUMMARY: 2, 85 T c. A C b A T T T

ALE	29	<u> </u>	HOI	LE OSS	B		DRE (CORED	INT	ER	VAI	318.2-327.6 m
×	APHI		CH/	RA	TER	_						
UNIT UNIT	BIOSTRATIGR	FORAMINIFERS	NANNOFOSSILS	RADIOLARIANS	DIATOMS	SECTION	METERS	GRAPHIC LITHOLOGY	DRILLING DISTURBANCE	SEDIMENTARY	SAMPLES	LITHOLOGIC DESCRIPTION
late Micene						2	0.5			* **		FORAMINIFER BEARING NANNOFOSSIL CHALK, ven light grav (NB), firm, with lots of light greenish grav [OS 871] and medium dark grav (N4) bands of pyrite and icor suffides. Microflaufts with about 15 mm sepatation (norma dip-alig) are common. Biosurbation very, evident with Zoophycop and Plano lifetilike common to abundant. SMEAR SLIDE SUMMARY: 2, 112 0 Composition: Foraminifers Cale, nannofosilis Diatoms T Radiolarians T
						4	and and and a set					
	. continuosa N10					5				XXX XX		

	PHIC		F	OSS	TER					Γ			
UNIT	BIOSTRATIGRA	FORAMINIFERS	NANNOFOSSILS	RADIOLARIANS	DIATOMS	SECTION	METERS	GRAPHIC LITHOLOGY	DISTURBANCE DISTURBANCE SEDIMENTARY	SAMPLES		LITHOLOGIC DESCRIPTION	
						1	0.5-				← 5G ash?	FORAMINIFER-BEARING NAN light grav (NS), firm with lots o 8/11 thin laminae and paired or light grav (N7). Light greenish grav bands comp possibly altered from ash.	NOFOSSIL CHALK, very f light greenish gray (5G olor band of 5G 8/1 and losed of parallel laminae,
						T					← 5G 8/1 ash? ← 5G 8/1 ash? ← 5G 8/1 ash1	Bioturbation common (Zoophyr Iron sulfides halo chains common	cos, <i>Planolites</i> -like, etc.).
						2						SMEAR SLIDE SUMMARY: 2, 56 2, 80 M D Texture:	6, 60 D
											← 5G 8/1 ash?	Sand i I Silt C C Clay D D Composition: Quartz - T	
flocent						3					- 5G 8/1 ash?	Feldspar – – Volcanic glass. T – Pyrite T T Carbonate unspec. T T Foraminifers R C Cale. namofossiis D D	T T C D
late N						-					ash?	Diatoma T T Radiolarians T T Sponge spicules – –	R T T
						4					ash?		
						5					ash?		
	V. continuosa VN10					6				1	ash? ash?		

A HI			FO	AC	L TER							
UNIT	ZONE	FORAMINIFERS	NANNOFOSSILS	RADIOLARIANS	DIATOMS	SECTION	METERS	GRAPHIC LITHOLOGY	DRILLING DISTURBANCE SEDIMENTARY STRUCTURES	SAMPLES	LITHOLOGIC	DESCRIPTION
late Milocane M. continuose	NN10	A	A			1 2 CC	0.5		0000	•	NANNOFOSSII (N9), soft (due: lamina (56 8/1) Bioturbed stru Core 7. ■ 56 8/2 SMEAR SLIDE ► 56 8/2 SMEAR SLIDE ► 106 8/2 Sand Sint Clay Camposition: Heavy minerals Volcanic glass Pyrite Volcanic glass Pyrite Cathorate unpy Foraminitars Cate, nanofossi Diatoms Redictarian	CHALK, very light green (NB) to white coring) to firm. ture (burrows) are less abundant than in reen (10G 6/2) thin laminae remarkable. SUMMARY: 1,70 D T T R D T T R D T T T T T T T T T T T T T

115	591	G., J	101	.Е	в		ORE	9 CORED	INTER	VAL	346.8-356.4 m		
×	APHIC		F	OSSI	TER								
UNIT UNIT	BIOSTRATIGRI ZONE	FORAMINIFERS	NANNOFOSSILS	RADIOLARIANS	DIATOMS	and a second sec	METERS	GRAPHIC LITHOLOGY	DISTURBANCE DISTURBANCE SEDIMENTARY STRUCTURES	SAMPLES		LITHOLOGIC DE	SCRIPTION
									0000			Very disturbed by a	poring, poor recovery.
eue	10						0.	5	No.			NANNOFOSSIL C	HALK, very light gray (N8), predom-
6	NN		11		11	1	1		ŏ			inantly soft by con	ing except for biscuits of firm sediment
8												with parallel lamin	nation of thin grayish green (5G 5/2)
3					11		19					ignin koc.	
												SMEAR SLIDE SU	MMARY:
					1 1	- F	+	1 1 1 1	411	11			2,93
010	1.1		Α						431				D
8	eso,						1		4]			Sand	т
2	tine						2				- 22 C	Silt	c
(pp	uo: 6								43	l h	5G 5/2	Clay	D
E	2.2			1.1	11				411	. (Composition:	
-	1.1	A	A			cct	_					Quartz	T
1	11	122	1			P	-	-p				Volcanic glass	т
												Carbonate unspec.	R
												Foraminiters	R
												Calc. nannofossils	D
					1	1						Radiolarians	1

~	PHIC		F	OSSI	TER						
TIME - ROCI	BIOSTRATIGRA ZONE	FORAMINIFERS	NANNOFOSSILS	RADIOLARIANS	DIATOMS	SECTION	METERS	GRAPHIC LITHOLOGY	DRILLING DISTURBANCE SEDIMENTARY STRUCTURES	SAMPLES	LITHOLOGIC DESCRIPTION
						1	0.5				5G 7/2 Very disturbed by coring. 5G 7/2 FORAMINIFER-BEARING NANNOFOSSIL CHALK, very light gray (NB) to white (N9) with thin lamins of pale green (5G 7/2) to light greenish gray (5G 8/1). SMEAR SLIDE SUMMARY:
middle Miocene	3. mayeri NNB					2					- IW 2,77 5G.8/1 Texture: Sand T 5G.7/2 Slit R Composition: Pyrite T Carbonate unspec. R Foraministers C Calc. namofosilis D Diatoms T Rediolarians T

SITE	59	1	HOL	.E	в	C	ORE	12 COREL	DINTE	RVAL	375.6–385.2 m
×	PHIC	_	F	BAG	IL		1				
TIME - ROC UNIT	BIOSTRATIGRA	FORAMINIFERS	NANNOFOSSILS	RADIOLARIANS	DIATOMS	SECTION	METERS	GRAPHIC LITHOLOGY	DRILLING DISTURBANCE SEDIMENTARY	STRUCTURES	LITHOLOGIC DESCRIPTION
middle Miocene	G. mayori NN7	•	A .			2	0.5				FORAMINIFER-BEARING NANNOFOSSIL CHALK, very light gray (NB) to white (NB), naturally firm, very disturbed by coring with very thin laminae of dusky green (5G 3/2). SMEAR SLIDE SUMMARY: 160 160 160 170 180 180 180 180 180 180 180 180 180 18

SITE 591 HOLE B CORE 13 CORED INTERVAL 385.2-394.8 m

×	VPHIC		F	OSS	IL						
TIME - ROC UNIT	BIOSTRATIGRI	FORAMINIFERS	NANNOFOSSILS	RADIOLARIANS	DIATOMS	SECTION	METERS	GRAPHIC LITHOLOGY	DRILLING DISTURBANCE SEDIMENTARY	SAMPLES	LITHOLOGIC DESCRIPTION
	NNB		A			1	0.5				FORAMINIFER-BEARING NANNOFOSSIL CHALK, very light greenish gray (5GY 8/1N9), biscuits with very thin laminae of grayish green (5G 5/2) and pyrite and iron sul- fides of grayish purple (5P 4/2).
viddle Miocene						-	1.0				SMEAR SLIDE SUMMARY 1,50 D Texture: Sand T Sand T Sit C Clay D
e	ayeri	1				2					Composition: Quartz T Carbonate unspec. R Foraminifers C Calc. nemotossilis D Radiolarians T
	G. m NN6	A	A			3					

2	PHIC		FICHA	OSSI RAC	L TER						
UNIT UNIT	BIOSTRATIGRA	FORAMINIFERS	NANNOFOSSILS	RADIOLARIANS	DIATOMS		SECTION	METERS	GRAPHIC LITHOLOGY	DRILLING DISTURBANCE SEDIMENTARY STRUCTURES SAMPLES	LITHOLOGIC DESCRIPTION
au	6NN		A					0.5			FORAMINIFER-BEARING NANNOFOSSIL CHALK, very light gray (N8), originally firm, with parallel thin lamina of pale green (5G 7/2).
Mioce	F						1	-			SMEAR SLIDE SUMMARY
middle	. mayer							1.0			Texture:
	02					-				911	Sand T
	1000	A	A			CC	-				Sit C
											Citay D
						1					Feldspar T
											Heavy minerals T
							L				Carbonate unspec. T
											Foraminifers C
											Calc. nannofossils D
							I				Radiolarians T



×	APHIC	j.	F	OSSI RAC	L				ПП		
TIME - ROC UNIT	BIOSTRATIGRA	FORAMINIFERS	NANNOFOSSILS	RADIOLARIANS	DIATOMS	SECTION	METERS	GRAPHIC ITHOLOGY	DRILLING DISTURBANCE SEDIMENTARY STRUCTURES SAMPLES	LITHOLOGIC DESCRIPTION	
Miccene	G. fohsi s. l. NNB	^	A			1	1111			FORAMINIFER-BEARING NANNOFOSSIL CHALK, very light gray (N8) to light gray (N7), completely bioturbed with dense piles of burrow lenses.	ļ
										SMEAR SLIDE SUMMARY: 1, 62 D	
									ľ	Texture: Sand T Skit R	
										Composition: Ouartz T Pyrite T	
										Carbonate unspec. T Foraminifers C Calc. nannofossils D	
										Diatoms T Radiolarians T	

×	APHIC		F	RAC	TER	2							
TIME - ROC UNIT	BIOSTRATIGRU	FORAMINIFERS	NANNOFOSSILS	RADIOLARIANS	DIATOMS		SECTION	METERS	GRAPHIC LITHOLOGY	DRILLING DISTURBANCE SEDIMENTARY STRUCTURES SAMPLES		LITHOLOGIC DE	SCRIPTION
							1	0.5			ash?	NANNOFOSSIL C erate drilling distu green laminae. Zi ere present.	HALK, very light gray (NB), firm, mod- urbance, with lots of trace fossils and bophycos- and <i>Planolites</i> -like burrows
								1.0			ash?	SMEAR SLIDE SU	ммаку: 2,70 D
middle Miccene							2	and the state of the state		1 1 1 1 1 1	ash?	sand Sitt Clay Composition: Ouartz Pyrite Foraminifers Calc, namofossils Diatoms Radiolarians Sponge spicules	M D T T R D T T T T
	G. fohti's. I. NN6	A	A			CC .	3	and an en		2	ash?		

4	APHIC		F	OSSI	L TER												
UNIT	BIOSTRATIGR	FORAMINIFERS	NANNOFOSSILS RADIOLARIANS		NANNOFOSSILS RADIOLARIANS		DIATOMS	SECTION	METERS	GRAPHIC LITHOLOGY	DRILLING DISTURBANCE SEDIMENTARY STRUCTURES	SAMPLES		LITHOLOGIC DE	SCRIP	TION	
						1	0.5				ash?l	FORAMINIFER-BI light gray (N8) wit gray (N8), firm, v parallel laminae (gra	EARINA h a few with ser syish gr	G NAN 20nes veral 20 een (50	NOFOSSIL CHALK, ver of burrow lenses of ligh ones of fine intervals o 3 6/2]).		
							1.0			- L		SMEAR SLIDE SU	MMAR	ł¥:			
							1	1 1 1 1	1	8 I.	ash??		1, 53	2,7	2,43		
							-	1 1 1 1				Texture:		100			
							1.3					Sand	т	-	т		
							1.1		4			Silt	R		R		
				r i	11		-			-		Ciay	D	-	D		
						2	1.12	1 1 1 1				Quartz	т	-	T		
						1	1.85			1	÷.	Feldspar	-	2	т		
ĉ.							1		4		N7 ash?	Volcanic glass	т	-	-		
8							1.23		4			Pyrite	-	D	-		
ž					11		1	1 1 1				Carbonate unspec.	т	-	т		
de la							1.1		t			Foraminifers	С	-	C		
P.												Calc. nannofossils	D	R	D		
							1.0	T 1 1 1				Diatoms	т	22	T		
								T 1 1 1		1	N7 anh?	Radiolarians	-	-	T		
	that s. l,					3					ash?	Sponge spicules		2	T		
	G. fo					4											

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SITE 591 HOLE B	CORE 18 CORED INTERVAL	433.2-442.8 m	SITE 591 HOLE B CORE 19 CORED INTERVAL 442.8-452.4 m	
TIME – ROCK UNI TUNU TUNU FORAMINIFERS FORAMINIFERS AMANOPOSSILLS RADIOLATIANS MANOPOSSILLS RADIOLATIANS MANOPOSSILLS RADIOLATIANS RADI	SHITTER CONTRACT OF CONTRACT O	LITHOLOGIC DESCRIPTION		LITHOLOGIC DESCRIPTION
A suturaritia i nilddle Micenne A suturaritia i NNS > > > > >		ash? FORAMINIFER BEARING NANNOFOSSIL CHALK, pre- dominantly, very light gray (NB) to white (NB) with chemi- cally charged zones of light gray (ND) to motion gray (NB). Parallel laminas of gravith gree (G5 7/2) and burrow lenses typically gray (NB) common. Bioturbation distinct. SMEAR SLIDE SUMMARY: Sand T R R Sand T R R D M D Texture: Carbonate unspec. T C R Foraminifer C A C Calc, nonclossit C A D Distom - T - Rediclarian T T T Sponge spicules T T T Songe spicules T T T Sand Si J ash? N6 Burrow lenses N6 + 5G 7/2 ash?	1 0.5 1 1.0	DRAMINIFER-BEARING NANNOFOSSIL CHALK, very try hard, entire sequence is moderately bioturbated int 2004/bcca and Planofiber-like burrows. The ISG 11 Interbeds are beginning to show flaser type struc- re. Pyrite nodules rare. MEAR SLIDE SUMMARY: 3,88 D organities: uartz T Otanic glass T stronate unspec. A areanifers C areanifers T organistics T stronate speciales T

SITE 591 HOLE B CORE 20 CORED INTERVAL	452.4-482.0 m	SITE 591 HOLE B CORE 21 CORED INTERVAL 462.0-471.6 m	
	LITHOLOGIC DESCRIPTION	TIME - ROCK INIT PIOSENTATION INIT INITERAHIC SONE MANOFORSILS AMONOPULIT SOUCHANAN AMONOFORSILS AMONOFULIS SECTION MANOFORSILS AMONOFONOFONOFONOFONOFONOFONOFONOFONOFONO	LITHOLOGIC DESCRIPTION
	- Void FORAMINIFER-BEARING NANNOFOSSIL CHALK, very SG 8/1 light gray (N8) with cyclic interbods of very light graenish SG 8/1 gray (SG 8/1) that are bioturbated and show flager back. N8 Zoophycos- and Planofite-like burrows. Finnly laminated N8 SMEAR SLIDE SUMMARY: N8 Soft Dotation T Carbonate unspec: A FG 8/1 D N8 Sponge splcules N8 Soft Soft N8 Soft Soft Soft Soft Soft Soft Soft Soft	Image: second	NANNOFOSSIL CHALK, very light gray (NB) with cyclic interbeds of various hues of light graenish gray (GB 2/1). Bioturbated throughout with Planoliterilies and Zoophy- cor burrows. Very hard. A few pack of pyrite. SMEAR SLIDE SUMMARY: 1, 109 D Composition: Cathorate unspec. A Foraminifiers R Calc. nannofossils A Rediolarises T
	5G 8/1		

ITE	591	1	HOI	.E	в	C	ORE	22	CORED	INTER	VAL	471.6-481.2 m		2
	PHIC		F	OSS	TER									
UNIT	BIOSTRATIGRA	FORAMINIFERS	NANNOFOSSILS	RADIOLARIANS	DIATOMS	SECTION	METERS	L	GRAPHIC ITHOLOGY	DRILLING DISTURBANCE SEDIMENTARY STRUCTURES	SAMPLES		LITHOLOGIC D	ESCRIPTION
						1	0.5			000	-	5GY 8/1	FORAMINIFER-B ternating cycles o 8/1) and very lig throughout. Flaser beds. Iron sulfide b SMEAR SLIDE SL	EARING NANNOFOSSIL CHALK, al- f light greenish gray (BGY 8/1 and 5G ht gray (NB), very hard. Bioturbated structure developed in (5G 8/1) inter- ands rare. MMARY: 4,95
						+	-	E		14		NB	Composition:	D
						2						5G 8/1 NB 5G 8/1	Volcanic glass Carbonate unspec. Foraminiters Calc. nannofosils Diatoms Radiolarians Sponge spicules	T A C A T T T
early Miccene						3		FI				NB 5G 8/1 NB 5G 8/1 N8 5G 8/1 SG 8/1 NB		
						4		IFIFIFIFIFIFIFIFIFIFIFIFIFIFIFIFIFIFIF				5G 8/1 NB 5G 8/1 NB		
	informa and					5	-					5G ¥ 8/1 N8 5G 8/1 SG 8/1 5G 8/1 5G 8/1 N8 5G 8/1 N8 5G 8/1		

	PHIC		F	OSS	TER						
UNIT UNIT	BIOSTRATIGRA ZONE	FORAMINIFERS	NANNOFOSSILS	RADIOLARIANS	DIATOMS	SECTION	METERS	GRAPHIC LITHOLOGY	DRILLING DISTURBANCE SEDIMENTARY STRUCTURES SAMPLES		LITHOLOGIC DESCRIPTION
early Miccine						3	0.5		과 바이 나라 바이라 아버지는 아프 바이 아프 바이 아프 바이다 아파 아파 아파 아파 아프	NB 11 5G 8/1 NB 12 5G 8/1 NB 14 NB 15 5G 8/1 NB 15 5G 8/1 NB 15 5G 8/1 16 5G 8/1 17 NB 18 5G 8/1 19 5G 8/1 11 NB 12 5G 8/1 13 5G 8/1 14 5G 8/1 15 5G 8/1 16 5G 8/1 17 NB 17 NB 18 5G 8/1 19 5G 8/1 19 5G 8/1 10 5G 8/1 11 NB 12 5G 8/1 13 5G 8/1 14 5G 8/1 15 5G 8/1 17 16 5G 8/1 18 5G 8/1 19 17 19 17 10 5G 8/1 11 17 11 18 12 5G 8/1 13 16 14 17 15 16	FORAMINIFER-BEARING NAMNOFOSSIL CHALK, wry light gray (N8) with alternating light greenish gray (ISOY 8/1 and 5G 8/1), iron suffice streaks and spot common. Totally blourbated and extremely hard – almost line stone. Reser structure developed in some (5G 8/1) interbeds. SMEAR SLIDE SUMMARY: 4, 0 Composition: Voleonic glas Foraminifers Cate: nanorosolis A Radiolarians T Sponge spicules T
	anious NN					0	-		1	N8	

L 55	-	HO	LE	В	CC	DRE	24 CORED	INTER	VAL	490.8-500.4 m	
PHIC		CHA	OSS	TER							
UNIT BIOSTRATIGRA ZONE	FORAMINIFERS	NANNOFOSSILS	RADIOLARIANS	DIATOMS	SECTION	METERS	GRAPHIC LITHOLOGY	DRILLING DISTURBANCE SEDIMENTARY STRUCTURES	SAMPLES		LITHOLOGIC DESCRIPTION
					1	0.5		2 framerica		N8 5G 8/1 + N8 N8 5G 8/1 N8	FORAMINIFER-BEARING NANNOFOSSIL CHALK, very light gray (NB), light graenish gray (SGY 8/1 and 5Y 8/1) interbedded. Very hard and almost a limestone. Thoroughly bioturbated and a few zones show falser structures. Zoo phycos very rate. All contacts between interbeds are gra- dational, burrowed but horizontal. SMEAR SLIDE SUMMARY:
					2	and see to see		fronthe and had the		5GY 8/1 5G 8/1 5G 8/1 5G 8/1 5G 8/1 5G 8/1 5G 8/1 5G 8/1	3, 99 D Composition: Carbonate unspec. A Foramiliafers C Cale, namorosalis A Sponge spicules T
					3	the second se		44 	*	5GY 8/1 5G 8/1 Flasers 5G 8/1 5 5G 8/1 5 5G 8/1	
ozea 47					4	and a set of set		****		5G 8/1 Flasers 5GY 8/1	
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SITE 591 (HOLE 591)

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	4-7	4,CC	5-1		5-3	5-4	5-5	5-6	5,CC	6-1	6-2



SITE 591 (HOLE 591)





-0 cm	11-1	11-2	11-3	11-4	11-5	11-6	11,CC	12-1	12-2	12-3	12-4	12-5
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-	1 Ad	1.14	1		15	24		2	150	1200		107 A.S.
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	1	- 1		人演	to finds	19		1	list	S.B.	1748	1.1
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SITE 591 (HOLE 591A)









-0 cm	9-3	9-4	9-5	9,CC	10-1	10-2	10-3	10-4	10-5	10,CC	11-1	11-2
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-0 cm	11-3	11-4	11-5	11-6	_11,CC	12-1	12-2	12-3	12-4	12-5	12-6	12,CC
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-	PARE TO	3	100	1. 1. 1. 1.		1		ALC: NO		1.2	1	100 - 11 - Y
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SITE 591 (HOLE 591B)
















SITE 591 (HOLE 591B)



485

