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29. Data Report: Neogene Diatom Biostratigraphy, Antarctic Peninsula Pacific Margin, ODP Leg 178 Rise Sites[1]

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ABSTRACT

This paper documents the biostratigraphic distribution and abundance of diatoms from sites drilled during Ocean Drilling Program Leg 178, off the Pacific margin of the Antarctic Peninsula. Drift sediments cored on the continental rise at Sites 1095, 1096, and 1101 have good recovery and a well-defined paleomagnetic record. Well-preserved diatoms are present throughout the upper Miocene to middle Pliocene and in the upper Quaternary section of these sites. The stratigraphic occurrence of diatom species through these intervals defines numerous datum levels. Diatom events are given absolute age estimates through direct correlation to the established paleomagnetic stratigraphy of Sites 1095, 1096, and 1101. Leg 178 diatom biostratigraphic results enable the development of a regional stratigraphic framework for the Pacific sector of the Southern Ocean and record the interaction of open-ocean and shelf-margin diatom floras.

INTRODUCTION

During Ocean Drilling Program (ODP) Leg 178 we drilled 23 holes at nine sites on the continental shelf rise (Sites 1095, 1096, and 1101), continental shelf (Sites 1097, 1100, 1102, and 1103), and Palmer Deep (Sites 1098 and 1099) off the Pacific margin of the Antarctic Peninsula. Table T1 presents general information about the sites included in this

T1. General information, Sites 1095, 1096, and 1101, p. 12.

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study. Further details about these sites, holes, and cores can be found in the Leg 178 *Initial Reports* volume (Barker, Camerlenghi, Acton, et al., 1999) and through the online Janus database. This report presents the final diatom biostratigraphic results of samples examined from Sites 1095, 1096, and 1101 located on the continental shelf rise of the Pacific margin of the Antarctic Peninsula as well as the species data charts for each site. Results from other diatom research from this leg are presented in Iwai (submitted), Sjunneskog and Taylor (in press), and Taylor and Sjunneskog (in press). The species referred to in this study are illustrated and treated systematically in Iwai and Winter (**Chap. 35,** this volume).

Previous Deep Sea Drilling Project and ODP Legs 28, 35, 71, 90, 113, 114, 119, 120, and 177 have built upon each other to increase our understanding of diatom biostratigraphy in the mid- to high-latitude ocean regions of the Southern Hemisphere (Schrader, 1976; Ciesielski, 1983, 1986; Gersonde et al., 1990; Thomas et al., 1990; Harwood and Maruyama, 1992; Gersonde and Bárcena, 1998; Gersonde, Hoddell, Blum, et al., 1999). The Pliocene diatom biostratigraphy of Antarctica shelf sediments have been illustrated (in the Ross Sea area) to closely correspond to the open-ocean record, allowing for direct comparisons with a few regional differences (Harwood, 1986; Winter and Harwood, 1997). The Neogene and Quaternary diatom zonal scheme utilized during Leg 178 was primarily the one proposed by Harwood and Maruyama (1992; Leg 120). The diatom biostratigraphic events, paleomagnetic calibration, and age estimates used during this leg are listed in table T4 and illustrated in figure F10 of the "Biostratigraphy" section of the Leg 178 "Explanatory Notes" chapter (Barker, Camerlenghi, Acton, et al., 1999). This zonation scheme, however, was not fully applicable to the diatom flora present in all the sediment recovered during Leg 178 because of the absence or low abundance of several marker species.

All of the absolute ages for the marker species datums have been recalculated to the timescale of Berggren et al. (1995). The revised ages repositioned some of the boundaries but did not necessitate any major changes in the zonal scheme. The reference ages for species datums are taken from various authors, whereas the ages for datum events within particular samples utilize the magnetostratigraphy determined from this cruise. A new marker species, *Thalassiosira oliverana,* was adopted for the base of the *Fragilariopsis reinholdii* Zone. This species is structurally more distinctive than *Thalassiosira miocenica,* the species used originally for this datum. The boundary age of this zone is not changed by the substitution. The zones in the detailed diatom biostratigraphy of Gersonde and Bárcena (1998) were not incorporated into our initial biostratigraphic scheme, as this data was drawn from more northerly drill cores. Gersonde, Hoddell, Blum, et al. (1999) indicate that the first occurrence (FO) of *Thalassiosira vulnifica,* which marks the base of the *Thalassiosira insigna–T. vulnifica* Zone of Harwood and Maruyama (1992), is a diachronous event. They tentatively replaced this zone with one called the *T. insigna* Zone and divided it into Subzones a–c. This new zone is defined wholly by the FO and last occurrence (LO) of *T. insigna* (total range zone). It is likely that both species experience diachroneity, particularly between deep-sea and shelf sections. As *T. insigna* is observed to occur in lower abundance in sites closer to the Antarctic continent, the older zonal definition has been retained for this study. Please refer to the "Explanatory Notes" chapter in the Leg 178 *Initial Reports* volume for a more detailed discussion of the timescale and chronological framework (Barker, Camerlenghi, Acton, et al., 1999).

PREPARATION TECHNIQUES

Materials used in the biostratigraphic analyses were taken from core catchers and within the split cores (usually one sample per section). Smear slides from these samples were examined for stratigraphically significant and other diatom species. Samples with a low overall abundance of diatoms were processed with hydrogen peroxide and 10% hydrochloric acid. Strewn slides were prepared from the acid-cleaned samples, and when necessary, the cleaned material was also sieved at >20 µm to remove excess clay material. Slides were routinely examined on a Zeiss compound microscope at 630× and 1000×, the higher power being reserved mainly for taxonomic identification. Slides examined from Site 1095 were generated using a quantitative pipetting technique.

Abundance of diatoms were based on the number of specimens observed per field of view at 630×. These abundance estimates were recorded as follows:

A = abundant (>10 valves per field of view).
C = common (>1 valve per field of view).
F = few (>1 valve per 10 fields of view and <1 valve per field of view).
R = rare (>3 valves per traverse of coverslip and <1 valve per 10 fields of view).
X = present (<3 valves per traverse of coverslip, including fragments).
B = barren (no valves observed in slide).

Preservation of diatoms were determined qualitatively and recorded as follows:

G = good (slight to no fragmentation and dissolution).
M = moderate (moderate fragmentation and dissolution).
P = poor (severe effects of fragmentation and dissolution).

RESULTS

Site 1095

The diatom biostratigraphy of Holes 1095A, 1095B, and 1095C is complex and contains an incomplete record of Pleistocene through upper Miocene datums. The Pliocene to Pleistocene is represented by glacial and interglacial hemipelagic sediments, whereas the Miocene consists mainly of turbidites. Many core intervals are barren or have low diatom abundance and richness. In samples that contain diatoms, reworking of older species is often noted. In spite of the obvious reworking, there is a strong biostratigraphic signal in the lower Pliocene and upper Miocene.

All datums and their associated hole/core depths at Site 1095 are listed in Table T2. The identification of diatom species observed at this site follows the taxonomic concepts of McCollum (1975), Schrader (1976), Fenner et al. (1976), Gombos (1977), Akiba (1982), Barron (1985), Yanagisawa et al. (1989), Gersonde (1989, 1990), Yanagisawa and Akiba (1990), Gersonde and Burckle (1990), Baldauf and Barron (1991), Fenner (1991), Harwood and Maruyama (1992), and Gersonde and Bárcena (1998). More details on species taxonomy can be found in

T2. Stratigraphically useful diatom events, Site 1095, p. 13.

Iwai and Winter (**Chap. 35,** this volume). Datum intervals are defined by the sample that contained either the first or last occurrence of that particular species and the sample immediately above (for a LO datum) or below (for a FO datum). The depths of these samples is given in meters below seafloor (mbsf). If the adjacent sample in the upcore or downcore direction (depending on type of datum) is barren, then the interval will only list one sample. Less confidence is placed on these datums, compared to those with a well-defined appearance or disappearance from the assemblage. Species abundance data can be found in Table **T3.**

T3. Diatom abundance data, Hole 1095A, p. 15.

The samples in Cores 178-1095B-29X through 45X contained a typical upper Miocene assemblage, with *Denticulopsis* species dominating. The species of *Denticulopsis* that are used as zonal boundary markers in older sediments, *D. dimorpha* and *D. praedimorpha,* were absent from the assemblage. One sieved sample, from Core 178-1095B-37X, contained *Asteromphalus kennettii,* which has been noted to have a FO age of 10.29 Ma in other studies. This datum also helps constrain the age of the lower part of Hole 1095B to the upper Miocene.

The neritic diatom *Paralia sulcata* is observed in samples from Cores 178-1095B-21X through 27X and is especially common in Cores 23X and 24X (290 to 310 mbsf) (see the "Biostratigraphy" and "Sedimentation Rate" sections in the "Site 1096" chapter of the Leg 178 *Initial Reports* volume [Barker, Camerlenghi, Acton, et al., 1999]). *Paralia sulcata* is a benthic neritic species that lives on coarse sediment in a relatively low-salinity shallow-water environment and can easily be transported to deep water. The transport from a shallow-water environment can occur through sediment transport or by an increased flow of a relatively low-salinity water from the shelf. The sporadic occurrence of benthic diatoms *Navicula* spp. and *Pinnularia* spp. and of the reworked middle Miocene diatom *Denticulopsis dimorpha* var. *areolata* in the same interval suggests shallow-water sediment transport. For the abundance of *P. sulcata* to have reached the observed proportion, it is possible that more of the shelf was in the photic zone and therefore shallower than today (M. Iwai, unpubl. data).

Site 1096

Compared with Site 1095, Site 1096 exhibits both increased sedimentation rates and better biogenic preservation. Calcareous nannofossils were unexpectedly recovered in material from this site within the upper ~170 mbsf. Below this depth, the biostratigraphy is primarily based on the diatom record. The change at 170 mbsf coincides with the lithologic change from Unit II to Unit III, which continues to the base of Hole 1096C. High sedimentation rates in this lower section expanded the biostratigraphic zones to approximately three times their thickness at Site 1095. The age of the bottom of Hole 1096C is believed to be early Pliocene.

Diatoms are generally rare to barren in sediments from Hole 1096A and the upper parts of Holes 1096B and 1096C. The exception to this is noted in brown-colored, possibly interglacial sediments occurring in the lower portion of Cores 178-1096A-2H and 178-1096B-2H and 3H in which diatoms are common and the assemblage is dominated by *Fragilariopsis kerguelensis, Thalassionema* spp., and *Thalassiothrix* spp. fragments. The occurrence of *Hemidiscus karstenii* also suggests that those core intervals are within 0.19 to 0.49 Ma (Gersonde and Bárcena, 1998).

The datums observed at this site are given in Table T4, and species abundance data are given in Tables T5, T6, and T7.

T4. Stratigraphically useful diatom events, Site 1096, p. 16.

T5. Diatom abundance data, Hole 1096A, p. 18.

T6. Diatom abundance data, Hole 1096B, p. 19.

T7. Diatom abundance data, Hole 1096C, p. 20.

Site 1101

At Site 1101 we recovered 217.7 m of Pleistocene and Pliocene hemipelagic silty clays. All four microfossil groups (diatoms, radiolarians, calcareous nannofossils, and foraminifers) were present. Calcareous microfossils were observed in the uppermost core as well as in a carbonate-rich unit from 50 to 134 mbsf. Siliceous microfossils were seen throughout the hole but are more abundant in the three lowest cores.

Diatom preservation and abundance varied throughout Hole 1101A. Intervals of increased well-preserved diatom material alternated with barren zones. Fragmentation of valves is very common in all of the upper 160 m of Hole 1101A. Diatoms in samples below Core 178-1101A-19X were more abundant than in the upper part of the hole. The lowest three cores (Cores 178-1101A-22X, 23X, and 24X) contained an open marine, diverse assemblage of diatoms. All zones from the Pleistocene to the upper Pliocene were identified at Site 1101. Table T8 lists the diatom datums noted at this site; intervals of these datums have both their sample position within the cores and their depth (in meters below seafloor) given. The species abundance data for Site 1101 can be found in Table T9.

T8. Stratigraphically useful diatom events, Site 1101, p. 22.

T9. Diatom abundance data, Hole 1101A, p. 23.

Further species datums discussion is included below in the "Discussion and remarks" section for each zone.

DIATOM ZONATION

Thalassiosira lentiginosa Partial Range Zone

Author: McCollum (1975), renamed by Kellogg and Kellogg (1986)
Definition of top: LO of *Thalassiosira lentiginosa* (still extant)
Definition of base: LO of *Actinocyclus ingens*
Age: 0–0.64 Ma
Discussion and remarks: Gersonde and Bárcena (1998) determined the first abundant occurrence (FAO) and last abundant occurrence (LAO) of *Hemidiscus karstenii* to be 0.19 and 0.42 Ma, respectively. These ages agree with those observed by Harwood and Maruyama (1992). In the material from this leg, *H. karstenii* was observed in low numbers in Holes 1095C, 1096A, 1096B, and 1101A. The LAO of this species was noted to be at 0.15 Ma (Hole 1095C) and 0.16 Ma (Holes 1096A and 1096B), and the FAO occurred at 0.29 Ma (Hole 1095C) and 0.26 Ma (Holes 1096A and 1096B). As the upper portions of all the holes exhibit noncontinuous diatom abundance and barren intervals, these ages should be considered with this in mind. *H. karstenii* was rarely observed in two samples from Hole 1101A, making age determinations in this hole imprudent. Site 1095 was the only one to include the last occurrence datum of *Actinocyclus ingens,* thereby definitely placing the lower boundary of the *T. lentiginosa* Zone at this site.

Actinocyclus ingens Partial Range Zone

Author: Gersonde (1990), modified by Harwood and Maruyama (1992), further modified in this zonation
Definition of top: LO of *Actinocyclus ingens*
Definition of base: LO of *Thalassiosira kolbei*
Age: 0.64–1.85 Ma
Discussion and remarks: This zone is a combination of two from Harwood and Maruyama (1992). The LO of *Fragilariopsis barronii* was used to define a boundary between their *A. ingens* and *F. kerguelensis* Zones. As *F. barronii* was not consistently observed in large numbers, we combined the two into one. The last occurrences of *Thalassiosira elliptipora* and *Thalassiosira torokina* were observed for this zone at Site 1095. This zone was not identified at Site 1096. The LO of *T. torokina* was also observed at Site 1101, as were *F. barronii* (LO) and *Thalassiosira fasciculata* (LO). The species datum indicating the base of this zone, the LO of *T. kolbei,* was not seen at any of the three sites; this taxon was only rarely observed in the present study.

Thalassiosira kolbei Partial Range Zone

Author: Ciesielski (1983), renamed by Baldauf and Barron (1991)
Definition of top: LO of *Thalassiosira kolbei*
Definition of base: LO of *Thalassiosira vulnifica*
Age: 1.85–2.4 Ma
Discussion and remarks: The base of this zone was defined at all three sites with the LO datum of *T. vulnifica*. The LOs of *T. complicata* and *T. inura* were also noted at both Sites 1095 and 1096, whereas the LO of *Actinocyclus karstenii* was the only datum observed within this zone at Site 1101.

Thalassiosira vulnifica Partial Range Zone

Author: Ciesielski (1983), renamed by Fenner (1991)
Definition of top: LO of *Thalassiosira vulnifica*
Definition of base: LO *Thalassiosira insigna*
Age: 2.4–2.6 Ma
Discussion and remarks: The LO datums of *F. interfrigidaria* and *T. insigna* were not observed at Site 1095, but some well-preserved specimens of these two species were observed in Holes 1095A and 1095D. Sites 1096 and 1101 did preserve the LO datums for both of these species. Sample 178-1096B-29X-CC (239.6 mbsf) contained an abundance of *T. insigna* poorly preserved central areas. These were often noted, in lower numbers, in other samples as well.

Thalassiosira insigna-*Thalassiosira vulnifica* Concurrent Range Zone

Author: Harwood and Maruyama (1992)
Definition of top: LO of *Thalassiosira insigna*
Definition of base: LO of *Thalassiosira vulnifica*
Age: 2.6–3.23 Ma

Discussion and remarks: The LO of *T. vulnifica* was found to occur at all three sites. Another datum within this zone, the LO of *Thalassiosira striata,* also occurred in Hole 1101A.

Fragilariopsis interfrigidaria Partial Range Zone

Author: McCollum (1975), modified in Weaver and Gombos (1981) and Harwood and Maruyama (1992)
Definition of top: FO of *Thalassiosira vulnifica*
Definition of base: FO of *Fragilariopsis interfrigidaria*
Age: 3.23–3.8 Ma
Discussion and remarks: The base of this zone was clearly defined at Sites 1095 and 1096 with the first occurrence of *F. interfrigidaria*. The base of Hole 1101A ended within this zone; *F. interfrigidaria* was included in the assemblage through the deepest sample. The FO of *T. insigna,* a datum occurring within this zone, was observed in Hole 1101A. This same species datum also occurred at Site 1096, but not at Site 1095. The FO of *Thalassiosira lentiginosa* was seen only at Site 1095.

Fragilariopsis barronii Partial Range Zone

Author: Weaver and Gombos (1981), renamed by Gersonde and Burckle (1990)
Definition of top: FO of *Fragilariopsis interfrigidaria*
Definition of base: FO of *Fragilariopsis barronii*
Age: 3.8–4.46 Ma
Discussion and remarks: The first occurrence of *F. barronii* was observed at both Sites 1095 and 1096. Each site also had an additional datum from within this zone. The FO of *Thalassiosira striata* was noted at Site 1095 and the LO of *Fragilariopsis praeinterfrigidaria* at Site 1096.

Thalassiosira inura Partial Range Zone

Author: Gersonde and Burckle (1990)
Definition of top: FO of *Fragilariopsis barronii*
Definition of base: FO of *Thalassiosira inura*
Age: 4.46–4.89 Ma
Discussion and remarks: The base of this zone occurs near the bottom of Hole 1096C. The FO datum of *T. inura,* was observed at both Sites 1095 and 1096. The FO datums of *T. fasciculata* and *T. complicata* also occur within this zone at Site 1095.

Thalassiosira oestrupii Partial Range Zone

Author: Baldauf and Barron (1991)
Definition of top: FO of *Thalassiosira inura*
Definition of base: FO of *Thalassiosira oestrupii*
Age: 4.89–5.59 Ma
Discussion and remarks: Three datums within this zone were observed at Site 1095: the FOs of *T. oestrupii, F. praeinterfrigidaria,* and *Thalassiosira tetraoestrupii*.

Nitzschia reinholdii **Partial Range Zone**

Author: Harwood and Maruyama (1992), modified in this study
Definition of top: FO of *Thalassiosira oestrupii*
Definition of base: FO of *Thalassiosira oliverana*
Age: 5.59–6.42 Ma
Discussion and remarks: The FO of *Thalassiosira oliverana* was substituted for the FO of *Thalassiosira miocenica* (the species used in the original zonal definition) (Harwood and Maruyama, 1992). The stratigraphic age of this boundary is not compromised with this substitution, as their previously observed ages are very close. Even though this change was made to facilitate zonal determination, the FO of *T. oliverana* was not observed at Site 1095. The LO of *A. ingens* var. *ovalis* was observed in this zone in Hole 1095B, which is well constrained above and below by several paleomagnetic reversals.

Actinocyclus ingens **var.** ***ovalis*** **Partial Range Zone**

Author: Harwood and Maruyama (1992)
Definition of top: FO of *Thalassiosira oliverana*
Definition of base: FO of *Actinocyclus ingens* var. *ovalis*
Age: 6.42–8.68
Discussion and remarks: The FO of *A. ingens* var. *ovalis* marks the base of this zone and occurs in Hole 1095B, bounded by paleomagnetic reversals that are interpreted with the ages of 6.57 and 6.94 Ma. The LO of *Thalassiosira mahoodii* occurs upcore from *A. ingens* var. *ovalis,* and is also well constrained with paleomagnetic ages.

Thalassiosira torokina **Partial Range Zone**

Author: Baldauf and Barron (1991), modified in Harwood and Maruyama (1992)
Definition of top: FO of *Actinocyclus ingens* var. *ovalis*
Definition of base: FO of *Thalassiosira torokina*
Age: 8.68–8.97 Ma
Discussion and remarks: This zone is the lowermost one in Hole 1095B. There are three diatom datums and three paleomagnetic reversals within this zone. The diatom datums, in order of increasing age, are the FO of *T. mahoodii,* the LO of *Denticulopsis crassa,* and the FO of *T. torokina.*

SUMMARY

The data revealed through examination of these Leg 178 sites add another facet to our expanding knowledge of Antarctic diatoms. The upper Quaternary sections of all three sites contained a noncontinuous record of an often sparse, fragmented diatom assemblage with many reworked species. This trend is consistent with other cores taken from around the Antarctic Continent (O'Brien, Cooper, Richter, et al., 2001). Even though the assemblage in this upper portion of the time column is often sparse, an interpretive biostratigraphic signal is present. The Pliocene–Pleistocene diatom biostratigraphic record is composed of a sequence of LO datums, with a few FOs and species acmes. Whereas upcore reworking and drilling make it more difficult to use LO datums, the presence of a rich assemblage of species that have been previously observed to co-occur adds reliability to such datums. The biostratigraphy developed from cores taken in the open ocean is applicable, with some regional differences, to these Antarctic margin sediments. Abundance and preservation, in general, was better in the Miocene and Pliocene intervals with an increased number of samples with well-preserved and diverse assemblages. Barren intervals in all three sites are readily identified in the diatom abundance data tables (Tables T3, T5, T6, T7, T9). These are to be expected with the glacially controlled nature of sedimentation.

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REFERENCES

Akiba, F., 1982. Late Quaternary diatom biostratigraphy of the Bellingshausen Sea, Antarctic Ocean. *Rept. Tech. Res. Cent. JNOC,* 16:31–74.

Baldauf, J.G., and Barron, J.A., 1991. Diatom biostratigraphy: Kerguelen Plateau and Prydz Bay regions of the Southern Ocean. *In* Barron, J., Larsen, B., et al., *Proc. ODP, Sci. Results,* 119: College Station, TX (Ocean Drilling Program), 547–598.

Barker, P.F., Camerlenghi, A., Acton, G.D., et al., 1999. *Proc. ODP, Init. Repts.,* 178 [Online]. Available from World Wide Web: <http://www-odp.tamu.edu/publications/178_IR/178TOC.HTM>. [Cited 2000-08-11]

Barron, J.A., 1985. Miocene to Holocene planktic diatoms. *In* Bolli, H.M., Saunders, J.B., and Perch-Nielsen, K. (Eds.), *Plankton Stratigraphy:* Cambridge (Cambridge Univ. Press), 763–809.

Berggren, W.A., Kent, D.V., Swisher, C.C., III, and Aubry, M.-P., 1995. A revised Cenozoic geochronology and chronostratigraphy. *In* Berggren, W.A., Kent, D.V., Aubry, M.-P., and Hardenbol, J. (Eds.), *Geochronology, Time Scales and Global Stratigraphic Correlation.* Spec. Publ.—Soc. Econ. Paleontol. Mineral. (Soc. Sediment. Geol.), 54:129–212.

Ciesielski, P.F., 1983. The Neogene and Quaternary diatom biostratigraphy of subantarctic sediments, Deep Sea Drilling Project Leg 71. *In* Ludwig, W.J., Krasheninnikov, V.A., et al., *Init. Repts. DSDP,* 71 (Pt. 2): Washington (U.S. Govt. Printing Office), 635–666.

————, 1986. Middle Miocene to Quaternary diatom biostratigraphy of Deep Sea Drilling Project Site 594, Chatham Rise, southwest Pacific. *In* Kennett. J.P., von der Borch, C.C., et al., *Init. Repts. DSDP,* 90 (Pt. 2): Washington (U.S. Govt. Printing Office), 863–885.

Fenner, J., Schrader, H.-J., and Wienigk, H., 1976. Diatom phytoplankton studies in the southern Pacific Ocean: composition and correlation to the Antarctic Convergence and its paleoecological significance. *In* Hollister, C.D., Craddock, C., et al., *Init. Repts. DSDP,* 35: Washington (U.S. Govt. Printing Office), 757–813.

Fenner, J.M., 1991. Late Pliocene–Quaternary quantitative diatom stratigraphy in the Atlantic sector of the Southern Ocean. *In* Ciesielski, P.F., Kristoffersen, Y., et al., *Proc. ODP, Sci. Results,* 114: College Station, TX (Ocean Drilling Program), 97–121.

Gersonde, R., 1989. Taxonomy and morphostructure of late Neogene diatoms from the Maude Rise (Antarctic Ocean). *Polarforschung,* 59:141–171.

————, 1990. Taxonomy and morphostructure of Neogene diatoms from the Southern Ocean, ODP Leg 113. *In* Barker, P.F., Kennett, J.P., et al., *Proc. ODP, Sci. Results,* 113: College Station, TX (Ocean Drilling Program), 791–802.

Gersonde, R., Abelmann, A., Burckle, L.H., Hamilton, N., Lazarus, D., McCartney, K., O'Brien, P., Spiess V., and Wise, S.W., Jr., 1990. Biostratigraphic synthesis of Neogene siliceous microfossils from the Antarctic Ocean, ODP Leg 113 (Weddell Sea). *In* Barker, P.F., Kennett, J.P., et al., *Proc. ODP, Sci. Results,* 113: College Station, TX (Ocean Drilling Program), 915–936.

Gersonde, R., and Bárcena, M.A., 1998. Revision of the late Pliocene–Pleistocene diatom biostratigraphy for the northern belt of the Southern Ocean. *Micropaleontology,* 44:84–98.

Gersonde, R., and Burckle, L.H., 1990. Neogene diatom biostratigraphy of ODP Leg 113, Weddell Sea (Antarctic Ocean). *In* Barker, P.F., Kennett, J.P., et al., *Proc. ODP, Sci. Results,* 113: College Station, TX (Ocean Drilling Program), 761–789.

Gersonde, R., Hodell, D.A., Blum, P., et al., 1999. *Proc. ODP, Init. Repts.,* 177 [CD-ROM]. Available from: Ocean Drilling Program, Texas A&M University, College Station, TX 77845-9547, U.S.A.

Gombos, A.M., 1977. Paleogene and Neogene diatoms from the Falkland Plateau and Malvinas Outer Basin: Leg 36, Deep Sea Drilling Project. *In* Barker, P., Dalziel, I.W.D., et al., *Init. Repts. DSDP,* 36: Washington (U.S. Govt. Printing Office), 575–687.

Harwood, D.M., 1986. Diatoms. *In* Barrett, P.J. (Ed.), *Antarctic Cenozoic History from the MSSTS-1 Drillhole, McMurdo Sound.* DSIR Bull. N. Z., 237:69–107.

Harwood, D.M., and Maruyama, T., 1992. Middle Eocene to Pleistocene diatom biostratigraphy of Southern Ocean sediments from the Kerguelen Plateau, Leg 120. *In* Wise, S.W., Jr., Schlich, R., et al., *Proc. ODP, Sci. Results,* 120: College Station, TX (Ocean Drilling Program), 683–733.

Iwai, M., submitted. Paleobathymetry of western Antarctic continental shelf and Polar Front migrations: evidence of diatoms from Ocean Drilling Program Site 1095, Antarctic Peninsula. *Mar. Micropaleontol.*

Kellogg, D.E., and Kellogg, T.B., 1986. Diatom biostratigraphy of sediment cores beneath the Ross Ice Shelf. *Micropaleontology,* 32:74–79.

McCollum, D.W., 1975. Diatom stratigraphy of the southern Ocean. *In* Hayes, D.E., Frakes, L.A., et al., *Init. Repts. DSDP,* 28: Washington (U.S. Govt. Printing Office), 515–571.

O'Brien, P.E., Cooper, A.K., Richter, C., et al., 2001. *Proc. ODP, Init. Repts.,* 188 [Online]. Available from World Wide Web: <http://www-odp.tamu.edu/publications/188_IR/188ir.htm>. [Cited 2001-06-26]

Schrader, H.-J., 1976. Cenozoic planktonic diatom biostratigraphy of the Southern Pacific Ocean. *In* Hollister, C.D., Craddock, C., et al., *Init. Repts. DSDP,* 35: Washington (U.S. Govt. Printing Office), 605–671.

Sjunneskog, C., and Taylor, F., in press. Postglacial marine diatom record of the Palmer Deep, Antarctic Peninsula (ODP Leg 178, Site 1098) II: diatom assemblages. *Paleoceanogr.*

Taylor, F., and Sjunneskog, C., in press. Postglacial marine diatom record of the Palmer Deep, Antarctic Peninsula (ODP Leg 178, Site 1098) I: total diatom abundance. *Paleoceanogr.*

Thomas, E., Barrera, E., Hamilton, N., Huber, B.T., Kennett, J.P., O'Connell, S.B., Pospichal, J.J., Speiss, V., Stott, L.D., Wei, W., and Wise, S.W., Jr., 1990. Upper Cretaceous–Paleogene stratigraphy of Sites 689 and 690, Maud Rise (Antarctica). *In* Barker, P.F., Kennett, J.P., et al., *Proc. ODP, Sci. Results,* 113: College Station, TX (Ocean Drilling Program), 901–914.

Weaver, F.M., and Gombos, A.M., 1981. Southern high-latitude diatom biostratigraphy. *In* Warme, T.E., Douglas, R.G., and Winterer, E.L. (Eds.), *The Deep Sea Drilling Project: A Decade of Progress:* Spec. Publ.—Soc. Econ. Paleontol. Mineral., 32:445–470.

Winter, D.M., and Harwood, D.M., 1997. Integrated diatom biostratigraphy of late Neogene drillholes in Southern Victoria Land and correlation to Southern Ocean records. *In* Ricci, C.A. (Ed.), *The Antarctic Region: Geological Evolution and Processes.* Terra Antart. Publ., 985–992.

Yanagisawa, Y., and Akiba, F., 1990. Taxonomy and phylogeny of the three marine diatom genera, *Crucidenticula, Denticulopsis* and *Neodenticula. Bull. Geol. Surv. Jpn.,* 41:197–301.

Yanagisawa, Y., Nakamura, K., Suzuki, Y., Sawamura, K., Yoshida, F., Tanaka, Y., Honda, Y., and Tanahashi, M., 1989. Tertiary biostratigraphy and subsurface geology of the Futaba district, Joban Coalfield, northeast Japan. *Bull. Geol. Surv. Jpn.,* 40:405–467.

Table T1. General information, Sites 1095, 1096, and 1101.

Hole	Latitude	Longitude	Water depth (m)	Number of cores	Interval cored (m)	Core recovered (m)	Percent recovered (%)	Drilled (m)	Penetration (m)
1095A	66°27′S	78°29.239′W	3841.6	10	87.3	86.5	99.1	0	87.3
1095B	66°59.127′S	78°29.270′W	3841.6	52	487.2	385.7	79.2	83	570.2
1095C	66°59.122′S	78°29.295′W	3841.6	1	2.9	2.9	99.0	0	2.9
1095D	66°59.121′S	78°29.285′W	3840.9	9	84.6	79	93.3	0	84.6
1096A	67°34.00864′S	76°57.79358′W	3152.0	15	140.7	118.5	84.2	0	140.7
1096B	67°34.00909′S	76°57.81189′W	3152.5	32	260.6	209.8	80.5	0	260.6
1096C	67°34.00909′S	76°57.82608′W	3152.5	43	409.9	345.0	84.2	197.8	607.7
1101A	64°22.33154′S	70°15.67062′W	3279.7	24	217.7	215.7	99.1	0	217.7

Table T2. Stratigraphically useful diatom events, Site 1095. (Continued on next page.)

Event	Chron	CK95 age (Ma)	Core, section, interval (cm)	Depth (mbsf)		Estimated age (Ma)		Core, section, interval (cm)	Depth (mbsf)		Estimated age (Ma)	
				t	b	t	b		t	b	t	b
			178-1095A-					178-1095B-				
TC *Hemidiscus karstenii*			—									
BC *Hemidiscus karstenii*			—									
T *Actinocyclus ingens*			1H-CC/2H-3, 90	5.67	9.80	0.26	0.45					
T *Thalassiosira elliptipora*			2H-3, 90/3H-6, 94	9.80	17.72	0.45	0.81					
	C1n(o)	**0.78**		**17.10**	**17.14**							
	C2n(t)	**1.77**		**58.82**	**61.96**							
T *Thalassiosira torokina*			<8H-3, 27-28		62.05							
T *Thalassiosira complicata*			—									
T *Thalassiosira inura*			8H-CC/9H-3, 130	68.90	72.60							
T *Thalassiosira vulnifica*			—									
	C2An.1n(t)	**2.581**		**58.82**	**61.96**			Top of Hole 1095B	83.00			
T *Fragilariopsis interfrigidaria*			9H-CC<	77.80				—				
T *Thalassiosira insigna*								—				
	C2An.1n(o)	**3.04**		**81.36**	**85.45**			—				
B *Thalassiosira vulnifica*			>10H-7, 14.5-15.5	86.94		3.15		1H-1, 101-103/2H-2, 57-58	84.01	94.57	3.06	3.38
	C2An.3n(o)	**3.58**	Bottom of Hole 1095A	87.30					**96.90**	**105.08**		
B *Thalassiosira lentignosa*								3H-5, 7-8/4H-1, 128-129	108.07	112.78	3.75	3.86
B *Fragilariopsis interfrigidaria*								3H-CC/4H-1, 104	111.50	112.54	3.88	3.90
	C3n.1n(t)	**4.18**							**126.18**	**126.22**		
B *Thalassiosira striata*								5H-6, 90-92/6H-3, 101-103	129.40	134.51	4.22	4.28
B *Fragilariopsis barronii*								5H-6, 90-92/6H-3, 101-103	129.40	134.51	4.22	4.28
B *Thalassiosira fasciculata*								5H-6, 90-92/6H-3, 101-103	129.40	134.51	4.22	4.28
	C3n.1n(o)	**4.29**							**134.86**	**135.08**		
	C3n.4n(t)	**4.98**							**163.66**	**165.32**		
B *Thalassiosira complicata*								10H-2, 60-61/10H-4, 60-61	170.60	173.60	5.09	5.15
	C3n.4n(o)	**5.23**							**177.32**	**178.40**		
B *Thalassiosira inura*								12H-4, 41-42/12H-5, 30-31	192.41	193.80	5.53	5.56
B *Fragilariopsis praeinterfrigidaria*								13H-4, 120-121/14X-1, 9-10	201.62	205.09	5.72	5.80
B *Thalassiosira tetraoestrupii*								13H-4, 120-121/14X-1, 9-10	201.62	205.09	5.72	5.80
B *Thalassiosira oestrupii*								15X-2, 59-61/16X-3, 35-36	216.79	227.65	6.05	6.18
	C3An.1n(t)	**5.894**							**209.30**	**210.17**		
	C3An.1n(o)	**6.137**							**217.60**	**224.38**		
	C3An.2n(t)	**6.269**							**239.44**	**239.48**		
T *Actinocyclus ingens* var. *ovalis*								17X-3, 65-68/17X-5, 31-33	237.55	240.21	6.26	6.28
	C3An.2n(o)	**6.567**							**252.82**	**262.78**		
T *Thalassiosira mahoodii*								22X-1, 92-94/22X-2, 42-44	283.02	284.02	6.84	6.85
	C3Bn(t)	**6.935**							**292.02**	**292.06**		
	C4n.2n(t)	**7.65**							**331.04**	**332.18**		
B *Actinocyclus ingens* var. *ovalis*								28X-5, 104/28X-CC	346.84	349.50	7.93	7.97
	C4n.2n(o)	**8.072**							**355.28**	**356.06**		
B *Thalassiosira mahoodii*								32X-5, 113-115/33X-1, 43-44	385.53	388.13	8.45	8.49
	C4r.2r-1(t)	**8.635**							**339.84**	**339.88**		
	C4An(t)	**8.699**							**411.70**	**411.74**		
T *Denticulopsis crassa*								35X-1, 100-101/35X-5, 117-119	407.60	413.77	8.67	8.72
B *Thalassiosira torokina*								36X-4, 8-10/36X-6, 118-120	420.78	424.88	8.79	8.82
	C4An(o)	**9.025**							**445.98**	**446.02**		
								Bottom of Hole 1095B	570.20			

Notes: T = top/last occurrence datum, B = base/first occurrence datum, BC = base common/first common occurrence datum, TC = top common/last common occurrence datum, t = top, b = bottom. (o) = onset, (t) = termination. CK95 = Cande and Kent (1995). * = Harwood and Maruyama (1992). † = Gersonde et al. (1999). ‡ = Gersonde and Bárcena (1998). Bold entries are estimated ages drawn from magnetostratigraphic information and the depths these events occurred in the cores.

Table T2 (continued).

Event	Chron	CK95 age (Ma)	Core, section, interval (cm)	Depth (mbsf) t	Depth (mbsf) b	Depth (mbsf) Average	Estimated age (Ma) t	Estimated age (Ma) b	Age (Ma) Site 1095 (estimated)	Age (Ma) Leg 178	Age (Ma) Leg 120*	Age (Ma) Leg 177†	Age (Ma) ‡
			197-1095D-										
TC *Hemidiscus karstenii*			1H-2, 40/1H-4, 40	1.90	4.90		0.08	0.21	0.082-0.212	0.15			0.19
BC *Hemidiscus karstenii*			1H-4, 40/1H-CC	4.90	8.47		0.21	0.37	0.212-0.366	0.29			0.42
T *Actinocyclus ingens*			<2H-3, 32		11.92			0.52	0.258-0.446	0.35	0.64	0.64	0.65
T *Thalassiosira elliptipora*			1H-CC<?	8.47			0.37		0.446-0.807	0.63	0.68	0.7	1.04-1.11*
	C1n(o)	**0.78**		**17.96**	**18.18**	**18.07**							
	C2n(t)	**1.77**		**58.84**	**58.88**	**58.86**							
T *Thalassiosira torokina*			<7H-4, 50		61.10					—	1.85	1.8	
T *Thalassiosira complicata*			<7H-CC		65.90					—	3.4	2.5	
T *Thalassiosira inura*			—							—	1.85	2.5	
T *Thalassiosira vulnifica*			—							—	2.28	2.5	2.3
	C2An.1n(t)	**2.581**	—										
T *Fragilariopsis interfrigidaria*			—							—	2.67	2.63	
T *Thalassiosira insigna*			6H-CC/7H-CC	55.30	65.90					—	2.57	2.63	2.6
	C2An.1n(o)	**3.04**	—										
B *Thalassiosira vulnifica*			Bottom of Hole 1095D	84.60					3.15-3.38	3.27	3.17	3.26	
	C2An.3n(o)	**3.58**											
B *Thalassiosira lentignosa*									3.75-3.86	3.81	4.2		
B *Fragilariopsis interfrigidaria*									3.83-3.85	3.84	3.8	3.8	
	C3n.1n(t)	**4.18**											
B *Thalassiosira striata*									4.22-4.28	4.25	4.48		
B *Fragilariopsis barronii*									4.22-4.28	4.25	4.48	4.44	
B *Thalassiosira fasciculata*									4.22-4.28	4.25			
	C3n.1n(o)	**4.29**											
	C3n.4n(t)	**4.98**											
B *Thalassiosira complicata*									5.09-5.15	5.12	4.62	4.44	
	C3n.4n(o)	**5.23**											
B *Thalassiosira inura*									5.53-5.56	5.55	4.85	4.92	
B *Fragilariopsis praeinterfrigidaria*									5.72-5.80	5.76	4.85	5.3	
B *Thalassiosira tetraoestrupii*									5.72-5.80	5.76			
B *Thalassiosira oestrupii*									6.05-6.18	6.12	5.62	5.56	
	C3An.1n(t)	**5.894**											
	C3An.1n(o)	**6.137**											
	C3An.2n(t)	**6.269**											
T *Actinocyclus ingens* var. *ovalis*									6.26-6.28	6.27	6.32	6.27	
	C3An.2n(o)	**6.567**											
T *Thalassiosira mahoodii*									6.84-6.85	6.85			
	C3Bn(t)	**6.935**											
	C4n.2n(t)	**7.65**											
B *Actinocyclus ingens* var. *ovalis*									7.917-7.964	7.94	8.68	8.68	
	C4n.2n(o)	**8.072**											
B *Thalassiosira mahoodii*									8.45-8.49	8.47			
	C4r.2r-1(t)	**8.635**											
	C4An(t)	**8.699**											
T *Denticulopsis crassa*									8.67-8.72	8.70	9.23		
B *Thalassiosira torokina*									8.79-8.82	8.81	8.92	9.01	
	C4An(o)	**9.025**											

Table T3. Diatom abundance data, Hole 1095A. [N1] (This table is available in an **oversized format**).

Table T4. Stratigraphically useful diatom events, Site 1096. (Continued on next page.)

Event	Chron	CK95 age (Ma)	Core, section, interval (cm)	Depth (mbsf)		Estimated age (Ma)		Core, section, interval (cm)	Depth (mbsf)		Estimated age (Ma)	
				t	b	t	b		t	b	t	b
			178-1096A-					178-1096B-				
TC *Hemidiscus karstenii*			2H-2, 16/2H-4, 127	9.36	13.47	0.12	0.19	<2H-4, 30		8.6		0.12
BC *Hemidiscus karstenii*			2H-6, 80/2H-7, 10	16.00	16.80	0.21	0.25	3H-1, 140<, 3H-CC	14.7	23.05	0.19	0.33
	Cn1(o)	**0.78**		**54.60**	**55.40**				**54.94**	**54.99**		
T *Thalassiosira inura*			Bottom of Hole 1096A	140.70				20H-2, 49/20H-4, 49	159.69	162.69	1.93	1.97
T *Thalassiosira vulnifica*								23X-CC/24X-4, 30	180.72	188.31	2.07	2.16
T *Thalassiosira complicata*								24X-CC/26X-1, 88	192.77	203.78	2.3	2.33
T *Thalassiosira insigna*								26X-3, 90/26X-CC	206.8	212.15	2.46	2.54
	C2An.1n(t)	**2.58**							**215.35**	**217.25**		
T *Fragilariopsis interfrigidaria*								28X-CC/29X-4, 63	226.83	236.83	2.62	2.67
B *Thalassiosira vulnifica*								29X-CC<	239.72		2.68	
B *Thalassiosira insigna*								32X-CC<	257.25		2.78	
	C2An.3n(t)	**3.33**						Bottom of Hole 1096B	260.6			
	C2An.3n(o)	**3.58**										
B *Fragilariopsis interfrigidaria*												
T *Fragilariopsis praeinterfrigidaria*												
	C3n.1n(t)	**4.18**										
	C3n.1n(o)	**4.29**										
B *Fragilariopsis barronii*												
	C3n.2n(t)	**4.48**										
B *Thalassiosira inura*												
	C3n.2n(o)	**4.62**										

Notes: T = top/last occurrence datum, B = base/first occurrence datum, BC = base common/first common occurrence datum, TC = top common/last common occurrence datum, t = top, b = bottom. (o) = onset, (t) = termination. CK95 = Cande and Kent (1995). * = Harwood and Maruyama (1992), ** = Gersonde et al. (1999), † = Gersonde and Bárcena (1998). Bold entries are estimated ages drawn from magnetostratigraphic information and the depths these events occurred in the cores.

Table T4 (continued).

Event	Chron	CK95 age (Ma)	Core, section, interval (cm)	Depth (mbsf) t	Depth (mbsf) b	Estimated age (Ma) t	Estimated age (Ma) b	Age (Ma) Site 1096 (estimated)	Age (Ma) Leg 178, Site 1096	Age (Ma) Leg 120*	Age (Ma) Leg 177**	Age (Ma) †
			178-1096C-									
TC *Hemidiscus karstenii*								0.12-0.19	0.16			0.19
BC *Hemidiscus karstenii*								0.19-0.33	0.26			0.42
	Cn1(o)	**0.78**	Top of Hole 1096C	114								
T *Thalassiosira inura*								1.93-1.97	1.95	1.85	2.50	
T *Thalassiosira vulnifica*								2.07-2.16	2.12	2.28	2.50	2.30
T *Thalassiosira complicata*								2.3-2.33	2.315	3.40	2.50	
T *Thalassiosira insigna*			<7X-CC		262.26			2.46-2.54	2.50	2.57	2.63	2.60
	C2An.1n(t)	**2.58**										
T *Fragilariopsis interfrigidaria*								2.62-2.67	2.645	2.67	2.63	
B *Thalassiosira vulnifica*			13X-1, 10<, <13X-2, 80	308.90	311.10	3.03	3.06	3.03-3.06	3.045	3.17	3.26	
B *Thalassiosira insigna*			8X-CC<, <9X-CC	270.68	280.37	2.85	2.90	2.85-2.90	2.875	3.40	3.40	
	C2An.3n(t)	**3.33**		**366.21**	**367.10**							
	C2An.3n(o)	**3.58**		**405.15**	**405.80**							
B *Fragilariopsis interfrigidaria*			30X-CC<, <31X-CC	482.50	492.10	4.02	4.09	4.02-4.09	4.055	3.80	3.80	
T *Fragilariopsis praeinterfrigidaria*			24X-CC<, <25X-2, 19	424.80	426.50	3.69	3.71	3.69-3.71	3.70	3.64	3.80	
	C3n.1n(t)	**4.18**		**507.89**	**511.55**							
	C3n.1n(o)	**4.29**		**536.45**	**536.60**							
B *Fragilariopsis barronii*			37X-CC<, <38X-3, 45	550.25	555.00	4.44	4.47	4.44-4.47	4.455	4.48	4.44	
	C3n.2n(t)	**4.48**		**553.60**	**553.80**							
B *Thalassiosira inura*			40X-CC<, <41X-CC	579.10	588.60	4.58	4.63	4.58-4.63	4.605	4.85	4.92	
	C3n.2n(o)	**4.62**		**583.85**	**584.05**							

Table T5. Diatom abundance data, Hole 1096A. [N1] (This table is available in an **oversized format**).

Table T6. Diatom abundance data, Hole 1096B. [N1] (This table is available in an oversized format).

Table T7. Diatom abundance data, Hole 1096C. (See table notes. Continued on next page.)

Core, section, interval (cm)	Depth (mbsf)	Abundance	Preservation	*Actinocyclus karstenii*	*Azpeitia tabularis*	*Chaetoceros* spp.	*Cocconeis* spp.	*Coscinodiscus marginatus*	*Denticulopsis simonsenii*	*Eucampia antarctica*	*Fragilariopsis aurica*	*Fragilariopsis barronii*	*Fragilariopsis curta*	*Fragilariopsis interfrigidaria*	*Fragilariopsis praecurta*	*Fragilariopsis praeinterfrigidaria*	*Nitzschia reinholdii*	*Fragilariopsis ritscheri*	*Paralia sulcata*	*Proboscia barboi*	*Rhizosolenia styliformis*	*Rouxia* spp.	*Stephanopyxis turris*	*Stephanopyxis* spp.	*Thalassionema nitzschiodes*	*Thalassiosira complicata*	*Thalassiosira fasciculata*	*Thalassiosira insigna*	*Thalassiosira inura*	*Thalassiosira kolbei*	*Thalassiosira lentiginosa*	*Thalassiosira oestrupii*	*Thalassiosira oliverana*	*Thalassiosira oliverana* var. *sparsa*	*Thalassiosira olivera* var. *umbonatus*	*Thalassiosira striata*	*Thalassiosira torokina*	*Thalassiosira vulnifica*	*Thalassiothrix* spp.
178-1096C-																																							
1X-CC	123.5	B																																					
2X-CC	176.5	B																																					
3X-4, 124	198.74	B																																					
3X-5, 120	200.2	B																																					
3X-6, 10	200.6	R	P	R																									R								R		
3X-6, 134	201.84	B																																					
3X-CC	202.6	B																																					
4X-CC	212.23	B																																					
5X-3, 104	216.24	R													R																							R	
5X-CC	219.66	B																																					
6X-3, 55	225.35	F		R															F																R				
6X-CC	228.98	B																																					
7X-CC	262.31	A	M	R														R										R	R			R	R		R		R	X	
8X-CC	270.73	C	M	R														R										F		R					R				
9X-CC	280.42	C	M	R								R				X													R		R	R	R				R		
10X-CC	289.84	B																																					
11X-CC	299.58	C	M								X	R			X												R				R	R				R	R		
12X-CC	309.19	C	M									R		X	R												R		R		R	R	R					X	
13X-1, 101	309.81	F	P																								X				R							X	
13X-2, 80	311.1	F	P									X			R												X		R		R								
13X-4, 46	313.76	X	P																								X												
13X-5, 88	315.68	X	P																											X									
13X-CC	317.08	F	M	X								R															X				R	R	X						
14X-2, 130	320.19	F	M									R															R	R	R				R				X		
14X-4, 120	323.09	F	M									R														X	X		X								R		
14X-6, 120	326.09	R	P									R															X										X		
14X-CC	328.39	R	P									X			X														R										
15X-CC	337.97	B																																					
16X-CC	347.69	B																																					
17X-CC	352.91	B																																					
18X-CC	366.77	R	P									R																											
19X-CC	377	B																																					
20X-CC	378.16	B																																					
21X-CC	395.55	B																																					
22X-CC	405.75	B																																					
23X-CC	414.43	B																																					
24X-CC	418.75	X	P												X							X							X										
25X-2, 19	426.49	R	P													X							R	X													X		

Table T7 (continued).

Core, section, interval (cm)	Depth (mbsf)	Abundance	Preservation	*Actinocyclus karstenii*	*Azpeitia tabularis*	*Chaetoceros* spp.	*Cocconeis* spp.	*Coscinodiscus marginatus*	*Denticulopsis simonsenii*	*Eucampia antarctica*	*Fragilariopsis aurica*	*Fragilariopsis barronii*	*Fragilariopsis curta*	*Fragilariopsis interfrigidaria*	*Fragilariopsis praecurta*	*Fragilariopsis praeinterfrigidaria*	*Nitzschia reinholdii*	*Fragilariopsis ritscherii*	*Paralia sulcata*	*Proboscia barboi*	*Rhizosolenia styliformis*	*Rouxia* spp.	*Stephanopyxis turris*	*Stephanopyxis* spp.	*Thalassionema nitzschiodes*	*Thalassiosira complicata*	*Thalassiosira fasciculata*	*Thalassiosira insigna*	*Thalassiosira inura*	*Thalassiosira kolbei*	*Thalassiosira lentiginosa*	*Thalassiosira oestrupii*	*Thalassiosira oliverana*	*Thalassiosira oliverana* var. *sparsa*	*Thalassiosira olivera* var. *umbonatus*	*Thalassiosira striata*	*Thalassiosira torokina*	*Thalassiosira vulnifica*	*Thalassiothrix* spp.
25X-CC	434.54	F	M		F																						R					R	R				F		
26X-CC	436.82	C	M	R	R							R				R											R						R			R	C		
27X-CC	453.63	C	M	R	R							R														R	R		R			R	R			R	F		
28x-6, 14	461.12	A	M									F		F		R						R	C	R		F			F										
28X-CC	463.7	C	M	R								R		R		R						X							F				R						
29X-CC	473.19	C	M									R				R										R			R			R	R				R		
30X-1, 85	473.75	R	P							X		X				X						X	X		X	X			X										
30X-3, 59	476.49	R	P							X		X												X		X													
30X-5, 84	479.74								X			X	X										X	X				X	X										
30X-6, 18	480.58	F	M									R		X		R						X		X					R							X			R
30X-CC	482.8	F	M									R		X	X											R			R			X				X			
31X-1, 71	483.21	C	M				F	F				F				R					R	X	F		R	R			R			X	R						F
31X-3, 52	485.9	F	P			X																		X	F								X						
31X-4, 124	488.12	F	P						X			X									X			X	F							X							X
31X-6, 53	490.41	R	P			X				X		X				X																							
31X-CC	492.38	B																																					
32X-2, 123	494.83	R	P																					X	R														
32X-CC	501.84	B																																					
33X-CC	509.05	B																																					
34X-CC	521.39	R	P																						X				X										X
35X-CC	527.54	X	P																							X													
36X-CC	540.06	R	P	X							X	R														R			X			X	R						
37X-CC	550.3	R	P									X				X				X									R			R		X			X		
38X-3, 45	553.55	C	P													X	X												R			X	X				R		
38X-CC	559.42	R	P	R											X					X						X											R		
40X-CC	573.52	F	P	F							R				X					R									X			R	R	R			F		
41X-CC	588.84	R	P	R																																	R		

Notes: Abundance: A = abundant, C = common, F = few, R = rare, X = scarce, B = barren. Preservation: G = good, M = moderate, P = poor. Diatoms: A = abundant, C = common, F = few, X = scarce, ? = uncertain.

Table T8. Stratigraphically useful diatom events, Site 1101.

Event	Chron	CK95 age (Ma)	Core, section, interval (cm)	Depth (mbsf)		Site 1101 (estimated)		Age (Ma)			
				t	b	t	b	Leg 178, Site 1101	Leg 120*	Leg 177**	†
			178-1101A-								
TC *Hemidiscus karstenii*			<3H-2, 110		20.80		0.29	—			0.19
BC *Hemidiscus karstenii*			>3H-4, 110	23.80		0.34		—			0.42
	Cn1(o)	**0.78**		**54.60**	**55.40**						
T *Thalassiosira fasciculata*			6H-CC, 7H-1, 75	47.70	48.60	0.66	0.70	0.68	1.70	0.70	
T *Fragilariopsis barronii*			>9H-CC, <10H-3, 30	76.05	79.50	1.06	1.13	1.095	1.39	1.40	1.30
T *Thalassiosira torokina*			<14H-4, 44		119.14		1.76	—	1.85	1.80	
T *Actinocyclus karstenii*			>13H-5, 52, <13H-6, 68	111.22	112.88	1.62	1.64	1.63	1.78-2.9		
T *Thalassiosira vulnifica*			17X-CC, <18X-CC	150.50	160.12	2.33	2.50	2.415	2.28	2.50	2.30
T *Thalassiosira insigna*			19X-3, 70, <20X-3, 70	165.30	173.40	2.55	2.66	2.605	2.57	2.63	2.60
	C2An.1n(t)	**2.58**		**215.35**	**217.25**						
T *Fragilariopsis interfrigidaria*			18X-CC, 19X-2, 70	160.12	162.30	2.50	2.52	2.51	2.67	2.63	
T *Thalassiosira striata*			>21X-3, 58, <21X-4, 40	182.88	184.20	2.76	2.78	2.77	2.92-3.4		
B *Thalassiosira vulnifica*			>21X-3, 58, <21X-4, 40	182.88	184.20	2.76	2.78	2.77	3.17	3.26	
B *Thalassiosira insigna*			>23X-1, 29,<23X-CC	198.79	208.23	2.92	3.03	2.975	3.40	3.40	

Notes: T = top/last occurrence datum, B = base/first occurrence datum, BC = base common/first common occurrence datum, TC = top common/last common occurrence datum, t = top, b = bottom. (o) = onset, (t) = termination. CK95 = Cande and Kent (1995). * = Harwood and Maruyama (1992), ** = Gersonde et al. (1999), † = Gersonde and Bárcena (1998). Bold entries are estimated ages drawn from magnetostratigraphic information and the depths these events occurred in the cores.

Table T9. Diatom abundance data, Site 1101A. (See **table notes.** Continued on next page.)

Core, section, interval (cm)	Depth (mbsf)	Abundance	Preservation	*Actinocyclus actinochilus*	*Actinocyclus ingens*	*Actinocyclus karstenii*	*Actinocyclus maccollumii*	*Actinocyclus octonarius*	*Actinoptychus senarius*	*Cocconeis* spp.	*Coscinodiscus marginatus*	*Coscinodiscus oculusiridus*	*Denticulopsis simonsenii*	*Denticulopsis lauta*	*Eucampia antarctica*	*Fragilariopsis aurica*	*Fragilariopsis barronii*	*Nitzschia claviceps/lacrima?*	*Fragilariopsis curta*	*Fragilariopsis interfrigidaria*	*Fragilariopsis kerguelensis*	*Fragilariopsis obliquecostata*	*Fragilariopsis ritscherii*	*Hemidiscus karstenii*	*Odontella* spp.	*Paralia sulcata*	*Rhizosolenia hebetata* var.	*Rhizosolenia styliformis*	*Rouxia antarctica*	*Rouxia* spp.	*Stephanopyxis turris*	*Thalassionema nitzschiodes*	*Thalassiosira antarctica*	*Thalassiosira complicata*	*Thalassiosira convexa* var. *aspinosa*	*Thalassiosira elliptipora*	*Thalassiosira fasciculata*	*Thalassiosira gracilis*	*Thalassiosira insigna*	*Thalassiosira inura*	*Thalassiosira lentiginosa*	*Thalassiosira oestrupii*	*Thalassiosira oliverana*	*Thalassiosira oliverana* var. *sparsa*	*Thalassiosira striata*	*Thalassiosira torokina*	*Thalassiosira vulnifica*	*Thalassiothrix* spp.
178-1101A-																																																
1H-1, 80	0.80	F	P																		F																											
1H-2, 80	2.30	F	P										X		X						X																											
1H-3, 80	3.80	F	P												X						X												X															
1H-4, 80	5.30	F	P			X															X											X																
1H-CC	8.32	A	M	F															R		F	X				R															F		X					
2H-1, 76	9.46	C	M	X											R						F							R					X															
2H-1, 115	9.85	F	M												X						X		X																									
2H-3, 90	12.80	R	P																		X																											
2H-4, 90	14.10	R	P												X						X																											
2H-5, 90	15.60	R	P	X											X						X																											
2H-7, 20	17.90	R	P	X		X									X						X												X															
2H-CC	18.20	F	P	X																	F												R?													R?		
3H-2, 110	20.80	R	P					X													X			X																								
3H-3, 110	22.30	F	P												X						X																				X							
3H-4, 34	23.04	C	M		X										R						C			X	X													X			F							F
3H-6, 110	26.80	R	P										X								X																											
3H-CC	27.67	F	P	X	??					X					R						F												X								R					X		
4H-4, 130	33.60	F	P		X										X						X																									X		
4H-CC	37.59	F	P		X								X													X		X	X					X			X						X					
5H-CC	37.69	B																																														
6H-CC	48.04	B																																														
7H-1, 75	48.45	F	P	X	X																F																F									R		
7H-CC	57.41	F	M		X						X	X	X		X		X				X										X				X		X		X	X								
8H-CC	66.72	X	P		X																																											
9H-CC	76.01	F	M		R	X				X											F						X	X									R			X			R					
10H-CC	84.94	F	P			R				X					X		R				X						R										X					X	R					
11H-CC	94.19	R	P		X					X			X		X																																	
12H-CC	104.20	R	M		R	X					X				X											X		X														X	R					
13H-1, 138	106.08	B																																														
13H-2, 96	107.18	B																																														
13H-3, 48	108.18	R	M					X					X													X		X												X			X					
13H-4, 72	109.92	B																																													
13H-5, 52	111.22	R	P	X	X								X													X					X																	
13H-6, 68	112.88	R	M			X							X		X		X									X																	X					
13H-7, 34	113.54	B																																														
13H-CC	113.94	B																																														
14H-1, 97	115.17	R	P		X								X																														X					
14H-1, 145	115.85	R	P		X					X				X			X											X																				

Table T9 (continued).

Core, section, interval(cm)	Depth (mbsf)	Abundance	Preservation	*Actinocyclus actinochilus*	*Actinocyclus ingens*	*Actinocyclus karstenii*	*Actinocyclus maccollumii*	*Actinocyclus octonarius*	*Actinoptychus senarius*	*Cocconeis* spp.	*Coscinodiscus marginatus*	*Coscinodiscus oculusiridus*	*Denticulopsis simonsenii*	*Denticulopsis lauta*	*Eucampia antarctica*	*Fragilariopsis aurica*	*Fragilariopsis barronii*	*Nitzschia claviceps/lacrima?*	*Fragilariopsis curta*	*Fragilariopsis interfrigidaria*	*Fragilariopsis kerguelensis*	*Fragilariopsis obliquecostata*	*Fragilariopsis ritscherii*	*Hemidiscus karstenii*	*Odontella* spp.	*Paralia sulcata*	*Rhizosolenia hebetata* var.	*Rhizosolenia styliformis*	*Rouxia antarctica*	*Rouxia* spp.	*Stephanopyxis turris*	*Thalassionema nitzschiodes*	*Thalassiosira antarctica*	*Thalassiosira complicata*	*Thalassiosira convexa* var. *aspinosa*	*Thalassiosira elliptipora*	*Thalassiosira fasciculata*	*Thalassiosira gracilis*	*Thalassiosira insigna*	*Thalassiosira inura*	*Thalassiosira lentiginosa*	*Thalassiosira oestrupii*	*Thalassiosira oliverana*	*Thalassiosira oliverana* var. *sparsa*	*Thalassiosira striata*	*Thalassiosira torokina*	*Thalassiosira vulnifica*	*Thalassiothrix* spp.
14H-3, 44	117.64	B																																														
14H-4, 44	119.14	R	P						X																		X																			X		
14H-5, 90	121.1	X	P																																													
14H-6, 31	122.01	B																																														
14H-7, 32	123.52	B																																														
14H-CC	123.8	R	P		X					X			X														X															X						
15H-1, 81	124.51	X	P																																													
15H-2, 12	125.32	R	P	X				X		X			X		X						X		X																									
15H-3, 20	126.9	R	P			X																												X?												X		
15H-4, 3	128.23	R	P			X																									X									X						X		
15H-5, 70	129	X	P																																													
15H-6, 90	130.7	X	P																																													
15H-7, 90	132	X	P																																													
15H-CC	133.2	B																																														
16H-CC	141	X	P																																													
17X-CC	152.2	R	P																																													
18X-CC	159.9	R	P																	X																						X				R	X	
19X-1, 70	160.8	F	M			F									R								R																				R				R	
19X-2, 70	162.3	F	M		R	F									R		R			R						F											F						R			F	X	
19X-3, 70	163.8	F	M			R		F							R															F										R						R	F	
19X-CC	166.5	R	P																																													
20X-3, 70	173.4	R	P			X																															X		X	X			X			X	X	
20X-6, 36	177.56	F	P		X	X																				X											R		F	X								
20X-CC	179	F	M																																				C									
21X-3, 58	182.88	F	M			R																				X										X?	F		F	R			R			F	X	
21X-4, 40	184.2	F	M			R									R								X																F	R			X	X	X	F		
21X-6, 20	187	F	M				X																R														R		F	F						F	R	
21X-CC	188.8	C	M			X	X																			R											R		C	R			R			X		
22X-1, 89	189.79	F	M			R											R																				F		F	F			R			F		
22X-4, 37	193.77	C	G			F									F		X	X					F														F		C	X			X					
22X-5, 59	195.49	C	G			F											R	R	R	R			F														F		C	R			R					
22X-CC	198.3	F	M													?	X			X			X														R		R	R						R		
23X-1, 29	198.79																																															
23X-CC	207.9	F	M																				F														R						X		X?	R		
24X-CC	217.7	F	M														F			R										F												X	X		R	X		A

Notes: Abundance: A = abundant, C = common, F = few, R = rare, X = scarce, B = barren. Preservation: G = good, M = moderate, P = poor. Diatoms: A = abundant, C = common, F = few, R = rare, X = scarce, ? = uncertain.

CHAPTER NOTE*

N1. 2 July—After this chapter was published, several errors were found in Tables T3, T5, and T6. The diatoms species *Nitzschia aurica, N. interfrigidaria, N. praecurta, and N. praeinterfrigidaria* (Table T3) and *N. separanda* (Tables T5 and T6) should have been identified as *Fragilariopsis aurica, F. interfrigidaria, F. praecurta, F. praeinterfrigidaria, and F. separanda,* respectively. Also in Table T3, *Simonseniera barboi* should have been identified as *Proboscia barboi*. The correct species appear in this version. In addition, some spelling errors in Table T3 have been corrected.

*Dates reflect file corrections or revisions.