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4. NEOGENE DIATOM BIOSTRATIGRAPHY OF SITE 892, CASCADIA MARGIN[1]

Elisabeth Fourtanier[2]

ABSTRACT

Diatom assemblages are documented from Holes 892A, 892D, and 892E on the Cascadia Margin off Oregon. Stratigraphic correlation is provided, using previously published North Pacific diatom datum levels. Sediments at Site 892 range in age from middle Miocene to Quaternary. The stratigraphic record, however, is not continuous or in stratigraphic order as many reversals (where older sediments overlie younger sediments) and unconformities are present. Four intervals of reversed stratigraphy are documented in Hole 892A at ~49 meters below sea floor (mbsf), 66 mbsf, 116–125 mbsf, and 145–164 mbsf. Seven intervals of reversed stratigraphy are observed in Hole 892D at ~59 mbsf, 60 mbsf, 62 mbsf, 65–71 mbsf, 74–111 mbsf, 129–139 mbsf, and 151–157 mbsf. One reversal at ~38 mbsf is present in Hole 892E, which recovered only a short section of sediments.

Three unconformities where uppermost Miocene and lower Pliocene sediments are missing are recognized in Hole 892A at ~21–29 mbsf, 62 mbsf, and 125–145 mbsf, and sediments from the middle part of the upper Miocene (8.3–6.2 Ma) are missing at an additional unconformity at ~30–39 mbsf. In Hole 892D, three similar unconformities, where the uppermost Miocene and most of the lower Pliocene are missing, are observed at ~61 mbsf, 123–129 mbsf, and 161 mbsf. The middle part of the Pliocene (3.7–2.6 Ma) is missing at a fourth unconformity at ~72 mbsf. Two additional unconformities, where upper Pliocene sediments overlie lower upper Miocene sediments, which, in turn, overlie upper middle Miocene sediments, are also recognized in Hole 892D at ~38 mbsf and 58 mbsf, respectively.

Despite differences between Holes 892A and 892D, some of the reversals and unconformities are correlative between the two holes. Diatom stratigraphy confirms the position of a fault at ~50 mbsf that was inferred from the formation microscanner log and a fault zone between 62.5 and 67 mbsf that was suggested by structural evidence and a temperature anomaly. The presence of an active fault zone at ~106–116 mbsf is also supported by diatom stratigraphy.

INTRODUCTION

A primary goal of Ocean Drilling Program Leg 146 was the investigation of fluid flow and sediment deformation within the accretionary wedge that forms the Cascadia margin. Site 892 is located at 44°40′N, 125°7′W, on the Oregon continental slope at 674 meters below sea level. The site was positioned on the western flank of the second ridge within the accretionary wedge to intersect both the bottom-simulating reflector (BSR) at about 73 m below sea floor (mbsf) and a hydrologically active, landward-dipping fault (~105 mbsf) (Shipboard Scientific Party, 1994).

Shipboard radiolarian stratigraphy (Shipboard Scientific Party, 1994) confirmed the position of the fault zones and suggested a very complicated stratigraphy with several stratigraphic reversals and hiatuses. Radiolarians, although useful in the upper part of Site 892, are absent below 80 mbsf. In addition, the foraminifers recovered at Site 892 were generally not age diagnostic, and the magnetostratigraphy was not conclusive (Shipboard Scientific Party, 1994). Diatoms, which are present throughout the section cored at Site 892, were not initially studied onboard the *JOIDES Resolution.*

Over the past 20 years, Neogene North Pacific diatom stratigraphy has developed rapidly from the pioneering papers of Schrader (1973) and Koizumi (1973) through later papers by Koizumi (1980, 1985, 1992), Burckle and Opdyke (1977), Koizumi and Tanimura (1985), Barron (1980a, 1981, 1985, 1992a), Akiba (1986), and Barron and Gladenkov (in press). These excellent studies and the calibration of diatom stratigraphy to magnetostratigraphy (Koizumi and Tanimura, 1985; Barron, 1992a; Barron and Gladenkov, in press) have made diatoms a powerful stratigraphic tool in the Neogene of the North Pacific.

A shore-based study of the diatoms of Site 892 was initiated with the objective of providing a detailed stratigraphy of Site 892, which is needed as a foundation for structural interpretations.

METHODS

Sampling

Diatoms were studied from 89 samples (one per section) from Holes 892A, -D, and -E. Most samples were splits of those studied for radiolarians by J.-P. Caulet (Caulet, this volume), allowing for better comparison between radiolarian and diatom stratigraphies.

Sample Preparation

Samples (1–2 cm^3) were boiled in 30% hydrogen peroxide (15 mL). The residues were rinsed by washing in distilled water in a 250 mL beaker, were settled for a minimum of 8 hr, and the liquid decanted. This cycle was repeated three times. Strewn slides were prepared by sampling the suspended residue with a pipette, spreading it on a 22 × 30 mm cover slip, which was dried on a hot plate and then mounted in Hyrax.

Observation and Diatom Identification

At least one entire slide for each sample was scanned under the light microscope at 500× and identification of species was checked at 1250×. Particular attention was given to stratigraphic markers.

The taxonomy used follows that of Koizumi (1980, 1992), Akiba (1986), Yanagisawa and Akiba (1990), and Fenner (1991) and is summarized in the Appendix.

[1]Carson, B., Westbrook, G.K., Musgrave, R.J., and Suess, E. (Eds.), 1995. *Proc. ODP, Sci. Results,* 146 (Pt. 1): College Station, TX (Ocean Drilling Program).
[2]Diatom Collection, Department of Invertebrate Zoology and Geology, California Academy of Sciences, Golden Gate Park, San Francisco, CA 94118, U.S.A.

Time Scale

In this paper, absolute ages are given according to Cande and Kent's (1992) geomagnetic polarity time scale. Absolute ages of diatom datum levels, previously published according to Berggren et al.'s (1985) time scale (i.e., Barron 1992a), have been updated according to Cande and Kent (1992), either in Barron and Gladenkov (in press) or in this paper.

Zonation

The diatom zonation of Barron (1981, 1986) for the North Pacific is used in this paper (Figure 1).

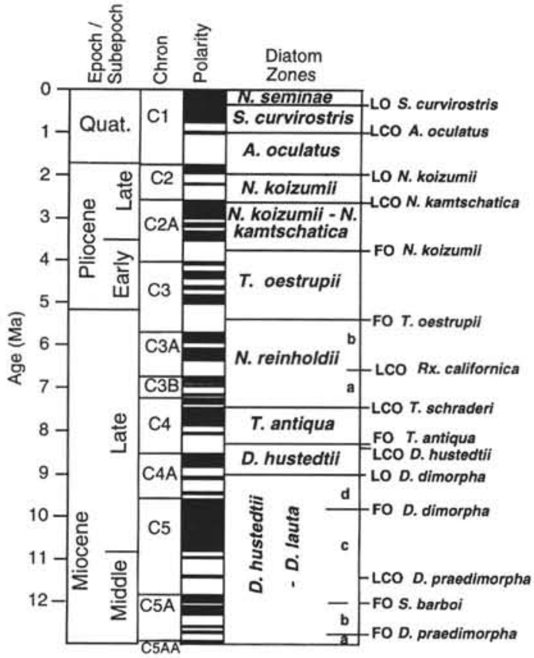

Figure 1. North Pacific diatom zonation for the last 13 m.y. used in this study. After Barron (1981, 1986). LO = last occurrence; LCO = last common occurrence; FO = first occurrence.

Datum Levels

Most datum levels used in this paper (Table 1) are from Koizumi and Tanimura (1985) and Barron (1992a) for the ages younger than 6.0 Ma and from Barron and Gladenkov (in press) for the ages older than 6.0 Ma.

Table 1. North Pacific diatom datum levels.

	Taxon	Age (Ma)	Area	Source
LO	*Simonseniella curvirostris*	0.3	NP	4
LO	*Thalassiosira jouseae*	0.3–0.41	NP	4
LO	*Nitzschia reinholdii*	0.50–0.55	NP	4
LO	*Nitzschia fossilis*	0.59–0.61	NP	4
LO	*Actinocyclus oculatus*	1.0	NP	4
FO	*Simonseniella curvirostris*	1.6	NP	4
LO	*Thalassiosira antiqua*	1.8	NP	1
FO	*Pseudoeunotia doliolus*	2.0	NP	4
LO	*Neodenticula koizumii*	2.0	NP	3
LO	*Thalassiosira convexa*	2.4	NP	4
LCO	*Neodenticula kamtschatica*	2.63–2.7	NP	4
FO	*Neodenticula seminae*	2.7	NP	3
FO	*Rhizosolenia praebergonii* v. *praebergonii*	3.1	EQP	1
FO	*Stephanopyxis dimorpha*	3.7	NP	2
FO	*Neodenticula koizumii*	3.51–3.85	NP	4
LO	*Lithodesmium cornigerum*	4.7	CA	2
LO	*Thalassiosira nativa*	5.2	CA	2
FO	*Neodenticula kamtschatica*	5.4	CA	1
FO	*Thalassiosira oestrupii*	5.4; 5.7	EQP	1; 4
LO	*Rouxia californica*	5.7	NP	4
FO	*Lithodesmium cornigerum*	5.7	CA	2
LO	*Thalassiosira miocenica*	5.7	NP	5
LO	*Nitzschia miocenica*	6.0	EQP	1
FO	*Thalassiosira miocenica*	6.2	NP	5
LO	*Synedra jouseana*	6.5–6.6	NP	5
LCO	*Rouxia californica*	6.6	CA	3
FO	*Nitzschia reinholdii*	6.9; 7.2–7.3	CA	1; 5
FO	*Neodenticula kamtschatica*	7.1–7.2	NP	5
LCO	*Thalassionema schraderi*	7.4–7.5	NP	5
LO	*Distephanus pseudofibula* (silicofl.)	7.7	CA	6
FO	*Nitzschia rolandii*	7.8–7.9	NP	5
LO	*Denticulopsis katayamae*	8.1–8.2	NP	5
LO	*Thalassiosira minutissima*	8.2–8.3	NP	5
LO	*Nitzschia praereinholdii*	8.3	NP	5
FO	*Thalassiosira antiqua*	8.3	CA	1
FO	*Nitzschia fossilis*	8.4	NP	5
LCO	*Denticulopsis hustedtii*	8.4	NP	5
FO	*Thalassionema schraderi*	8.6–8.5	CA	1
LO	*Thalassiosira brunii*	8.7	EQP	1
LO	*Rouxia fusiformis*	8.9	NP	1
LO	*Rhizosolenia miocenica*	9.0	NP	1
LO	*Denticulopsis dimorpha*	9.0	NP	5
FO	*Thalassionema schraderi*	9.3; 9.4	NP	5
FO	*Denticulopsis katayamae*	9.4; 9.1	NP	5
FO	*Thalassiosira minutissima*	9.4; 9.1	NP	5
LO	*Rhizosolenia praebarboi*	9.5	NP	5
FO	*Denticulopsis dimorpha*	9.8–9.9	NP	5
FO	*Hemidiscus cuneiformis*	10.4–10.9	EQP	5
LCO	*Denticulopsis praedimorpha*	11.4	NP	5
FO	*Nitzschia praereinholdii*	11.8–11.7	NP	1
FO	*Thalassiosira brunii*	11.9	EQP	1
FO	*Simonseniella barboi*	12.0–12.4	NP	5
FO	*Denticulopsis praedimorpha*	12.8	NP	5

Notes: Absolute ages according to the Cande and Kent (1992) time scale. LO = last occurrence; LCO = last common occurrence; FO = first occurrence; 1 = Barron (1992a); 2 = Barron (1992b); 3 = Koizumi (1992); 4 = Koizumi and Tanimura (1985); 5 = Barron and Gladenkov (in press); 6 = Barron (1976); NP = North Pacific; EQP = equatorial Pacific; CA = California.

RESULTS

Diatom assemblages were present in 83 of the 89 samples from Holes 892A, -D, and -E, processed for diatom analysis, including, for most samples, age diagnostic species that permit their stratigraphic correlation. The assemblages recovered from Site 892 are Quaternary, Pliocene, and Miocene in age; however, due to several stratigraphic breaks, the assemblages do not form a continuous sequence, and are not in stratigraphic order.

Stratigraphic breaks at Site 892 can be grouped in two categories: (1) Stratigraphic breaks where younger sediments overlie older sediments with a missing interval of time between (these could be the result of hiatuses or faults); and (2) stratigraphic breaks where older sediments overlie younger sediments (these could be the result of faults, displaced allochthonous elements within an otherwise continuous section, or folds that would create alternating normal and upside-down sections). Biostratigraphy alone can establish the presence and location of such breaks, but it does not provide evidence as to their cause. In this paper, in order to simplify the discussion, the first category of stratigraphic breaks will be referred to as hiatuses/unconformities and the second category as reversals.

Pliocene and Quaternary assemblages contain common to abundant diatoms that are characterized by moderate to good preservation in the upper part (above 100 mbsf) and poor to moderate preservation in the lower part of the section cored at Site 892. The assemblages are dominated by *Chaetoceros* spores and *Thalassionema nitzschioides,* as expected in a region associated with a coastal upwelling (Sancetta, 1992). Stratigraphic markers such as *Simonseniella curvirostris, Neodenticula koizumii, N. kamtschatica,* and *Stephanopyxis dimor-*

Table 2. Occurrence and relative abundance of stratigraphically significant diatoms in Hole 892A.

Core, section:	1X-1	1X-2	1X-3	2X-3	3X-1	3X-2	4X-1	4X-2	6X-1	6X-2	6X-3	7X-1
Interval (cm):	128–130	126–129	7–9	52–54	14–16	28–30	64–66	28–30	34–35	93–95	32–33	49–52
Depth (mbsf):	1.29	2.77	3.04	13.02	19.14	20.78	29.14	29.80	39.34	41.43	42.34	48.99
Abundance:	A	C	C	C	C	A	A	A	A	A	A	A
Preservation:	G	M	M	M(G)	M	G(M)	M	M(G)	G	G	M	G
Actinocyclus curvatulus		R	R							F		
Actinocyclus ingens					R				R			F
Actinoptychus senarius			R	R	R		F	R	R	F	F	F
Azpeitia nodulifera		R						R	F	R	R	R
Chaetoceros spores	A	A	A	A	A	A	A	A	F	A	A	A
Coscinodiscus marginatus	R		R		F	F	F	R		F		R
Coscinodiscus spp. (large forms)				R	R		F	F			F	R
Delphineis spp.	R	F		R	R	R			F		R	
Denticulopsis hustedtii (group)					r?			R?	C–A	C	F–C	R
Denticulopsis katayamae										?	R	C
Denticulopsis spp.												
Hemidiscus cuneiformis	R		R			R						
Lithodesmium cornigerum												
Neodenticula kamtschatica					R	R						
Neodenticula koizumii												
Neodenticula seminae	F–C	F	F	F	R	F						
Neodenticula seminae-koizumii (undiffer.)												
Nitzschia cylindrica												
Nitzschia fossilis							R					
Nitzschia marina												
Nitzschia miocenica							R	R(F)				
Nitzschia praereinholdii									R?		R	R
Nitzschia reinholdii			R		R?	R						
Nitzschia aff. *rolandii*												
Paralia sulcata			R		R		R					R(F)
Proboscia alata								R				R
Rhizosolenia miocenica												R
Rhizosolenia praebergonii s.str.												
Rhizosolenia styliformis	F	R		R	R	R		R		F		R
Rouxia californica					R				F	C	F	F
Simonseniella barboi	R	R	R	R		R				R	R	R
Simonseniella curvirostris	R?	R										
Simonseniella praebarboi									R			
Stellarima sp.									F	R		F
Stephanopyxis dimorpha	F–C	C	C	C	F(R)	F(R)						
Stephanopyxis spp.					R							R
Synedra jouseana												
Thalassionema nitzschioides	C	C	C	C	C	A	C	C	A	C	A	A
Thalassionema schraderi												R
Thalassiosira antiqua					R		F	F				
Thalassiosira brunii												R
Thalassiosira convexa var. *aspinosa*					R		R	R				
Thalassiosira convexa var. *convexa*							R					
Thalassiosira aff. *jacksonii*												
Thalassiosira jouseae		R		R								
Thalassiosira leptopus												
Thalassiosira minutissima												
Thalassiosira miocenica							R?					
Thalassiosira multipora	R	R	R									
Thalassiosira nativa								R			F	R
Thalassiosira oestrupii	R	R	R			R						
Thalassiosira temperei												R
Thalassiosira spp.	F			F	F	R					F	F
Thalassiothrix longissima	F	R	R	R	F	R	R	R	R	R	R	R
Freshwater diatoms	R	R	R	R		R	R		R		R	
*Distephanus pseudofibula**										R–F		R
Epoch/Subepoch	Quaternary				u. Pliocene		upper Miocene					

Notes: A = abundant; C = common; F = few; R = rare; E = excellent; G = good; M = moderate; P = poor; * = silicoflagellate. Lower case abundances represent reworked specimens.

pha allow stratigraphic correlation. Reworking of upper Miocene diatoms is common.

Miocene assemblages (mostly late Miocene) contain common to abundant diatoms with good to excellent preservation. Assemblages are dominated by *Thalassionema nitzschioides, Chaetoceros* spp., and to a lesser extent, by extinct taxa such as *Thalassiosira antiqua, Rouxia californica,* and *Denticulopsis* spp.

Diatom assemblages of Holes 892A, -D, and -E are documented in the checklists (Tables 2, 3, and 4, respectively). The biostratigraphic interpretation of Site 892 is discussed in the following section where each hole is described from top to bottom.

Diatom Biostratigraphy of Hole 892A

Quaternary–Upper Pliocene Interval

Well-preserved diatom assemblages characterized by numerous *Chaetoceros* spores, *Neodenticula seminae* (in sediments younger than 2.7 Ma), *Thalassionema nitzschioides,* and *Stephanopyxis dimorpha.* were observed in the upper part of Hole 892A.

Sample 146-892A-1X-1, 128–130 cm, to Sample 146-892A-1X-2, 126–129 cm (1.29–2.77 mbsf)

This interval is dated as Quaternary (1.6–0.3 Ma) based on the occurrence of *Simonseniella curvirostris.*

Sample 146-892A-1X-3, 7–9 cm, to Sample 146-892A-2X-3, 52–54 cm (3.04–13.02 mbsf)

The absence of *Simonseniella curvirostris* and the occurrence of *Neodenticula seminae* without *Neodenticula kamtschatica* indicate a late Pliocene to early Quaternary age (2.7–1.6 Ma). The absence of *Thalassiosira antiqua* (last occurrence [LO]: 1.8 Ma), *Neodenticula koizumii* (LO: 2.0 Ma), and *Thalassiosira convexa* (LO: 2.4 Ma) favors correlation with the upper part of this time interval: that is, 1.8–1.6 Ma (early Quaternary).

Table 2 (continued).

Core, section:	7X-2	7X-3	7X-4	7X-6	8X-2	8X-3	8X-4	8X-5	9X-1	11X-1	11X-3	12X-1	13X-1
Interval (cm):	41–43	30–33	63–65	98–100	116–118	24–26	104–106	38–40	42–45	44–46	16–19	15–18	14–15
Depth (mbsf):	50.43	51.82	53.67	57.02	60.68	61.27	63.49	64.33	67.92	78.44	80.61	87.65	97.14
Abundance:	A	C	A	C	C	C	A	A	C	C	C	Barren	F
Preservation:	G(M)	M	M	M(P)	M	M	G	G	M	M	M		P
Actinocyclus curvatulus							R			R	R		
Actinocyclus ingens	R		R	R		R							
Actinoptychus senarius	F	F		R	R	R	R	F	R	R			
Azpeitia nodulifera	R	R	R		R	R	R	R	R				
Chaetoceros spores	A	A	A	C	C	C	A	A	C	C	A		R
Coscinodiscus marginatus	R	R	R		F	R	R	R	R	R			F
Coscinodiscus spp. (large forms)	R						R	R			R		
Delphineis spp.		R		R	R	R		F		R			
Denticulopsis hustedtii (group)	f		f	r		r	R	R	R				
Denticulopsis katayamae	R							r?					
Denticulopsis spp.			r										
Hemidiscus cuneiformis	R			F		R	R	R		R			
Lithodesmium cornigerum							R?	R					
Neodenticula kamtschatica	R	R	R	R	R	R			F	R	R		
Neodenticula koizumii	R?	R	R	R	R				R				
Neodenticula seminae	R			R?									
Neodenticula seminae-koizumii (undiffer.)	R	R	R	R	R				R		R		
Nitzschia cylindrica													
Nitzschia fossilis	R							R					
Nitzschia marina								R			R?		
Nitzschia miocenica							R						
Nitzschia praereinholdii			r?										
Nitzschia reinholdii	R												
Nitzschia aff. *rolandii*													
Paralia sulcata	R	R		R	R	R	R			R			F
Proboscia alata	R		R		R	R	R						
Rhizosolenia miocenica													
Rhizosolenia praebergonii s.str.				R									
Rhizosolenia styliformis	R	R	R				R	R					R
Rouxia californica	f	r	c(f)			R	R		R				
Simonseniella barboi	R	F	F	R	R	R					R		R
Simonseniella curvirostris													
Simonseniella praebarboi													
Stellarima sp.							R	R					
Stephanopyxis dimorpha	R	R	R	R	R(F)	R			R		R		
Stephanopyxis spp.					R	R					R		
Synedra jouseana	r												
Thalassionema nitzschioides	A	A	A	C	C	A	A	A	A	C	A		F
Thalassionema schraderi	r		r										
Thalassiosira antiqua	R	R	R	F	R	F	C	F–C	F	F	R		F
Thalassiosira brunii													
Thalassiosira convexa var. *aspinosa*	R	F	R		R(F)		R?						
Thalassiosira convexa var. *convexa*	R	R	R		R(F)								
Thalassiosira aff. *jacksonii*													
Thalassiosira jouseae													
Thalassiosira leptopus			R										
Thalassiosira minutissima			f										
Thalassiosira miocenica							R?	R					
Thalassiosira multipora													
Thalassiosira nativa	r		f				F						
Thalassiosira oestrupii	R	R	R			R			R				
Thalassiosira temperei													
Thalassiosira spp.		F		R	R		R			R			
Thalassiothrix longissima		R		R	R	R	R	R	R	R			R
Freshwater diatoms		R	R	R	R	R	R	R		R	R		
*Distephanus pseudofibula**			r										
Epoch/Subepoch	Pliocene						u. Mio.		Pliocene			?	lower Pliocene

Sample 146-892A-3X-1, 14–16 cm, to Sample 146-892A-3X-2, 28–30 cm (19.14–20.78 mbsf)

The co-occurrence of *Neodenticula seminae* and *Neodenticula kamtschatica* indicates a late Pliocene age (~2.7–2.6 Ma). The coincidence of the last occurrences of *Thalassiosira antiqua* (1.8 Ma), *Thalassiosira convexa* (2.4 Ma), and *Neodenticula kamtschatica* (2.6 Ma) in Sample 146-892A-3X-1, 14–16 cm suggests that the uppermost Pliocene interval between 2.6 Ma and 1.8 Ma may be missing between Samples 146-892A-2X-3, 52–54 cm and 146-892A-3X-1, 14–16 cm. The presence of a hiatus between Core 146-892A-2X and Core 146-892A-3X, however, is not supported by the radiolarian stratigraphy (Caulet, this volume).

Miocene Interval

Sample 146-892A-4X-1, 64–66 cm, to Sample 146-892A-4X-2, 28–30 cm (29.14–29.80 mbsf)

Moderately to well-preserved diatom assemblages dominated by *Thalassionema nitzschioides, Chaetoceros* spores, *Thalassiosira antiqua* were encountered in this section of Hole 892A. The occurrence

Table 2 (continued).

Core, section: Interval (cm): Depth (mbsf):	13X-2 36–38 97.65	13X-4 55–57 99.33	13X-7 138–140 103.33	13X-8 91–93 104.36	14X-1 46–47 106.96	15X-1 42–44 116.42	16X-1 14–15 125.64	17X-1 33–34 135.33	18X-1 95–96 145.45	20X-1 19–20 163.69	20X-1 142–144 164.92	20X-2 44–46 165.46	20X-2 133–134 166.35
Abundance:	F	C	C	F	Barren	F	F	C	A	C	F	F	F
Preservation:	P	M	P	P		P	P	P	G	M	M	P	P
Actinocyclus curvatulus		R									F		
Actinocyclus ingens	R							R					
Actinoptychus senarius	R	R	R					R	F			R	R
Azpeitia nodulifera	R	R	R	R				R	R				
Chaetoceros spores	F	F	R	R		F	R	C	A	A	F	F	F
Coscinodiscus marginatus	R	F	F	R		R	F	R	R		R		
Coscinodiscus spp. (large forms)									R	F			
Delphineis spp.		R	R	R			F	F	C	F		R	F
Denticulopsis hustedtii (group)													
Denticulopsis katayamae													
Denticulopsis spp.													R
Hemidiscus cuneiformis		R						R					R
Lithodesmium cornigerum													
Neodenticula kamtschatica	R	R	R	R		R	R						R
Neodenticula koizumii							R			R?	R?		
Neodenticula seminae										R	R		
Neodenticula seminae-koizumii (undiffer.)											R		
Nitzschia cylindrica									R				
Nitzschia fossilis												R	
Nitzschia marina			R?	R				R				R?	
Nitzschia miocenica													
Nitzschia praereinholdii													
Nitzschia reinholdii	R		R?			R						R?	
Nitzschia aff. *rolandii*									R				
Paralia sulcata	R	R	F	R		R		F	R			R	F
Proboscia alata			R										
Rhizosolenia miocenica													
Rhizosolenia praebergonii s.str.													
Rhizosolenia styliformis	R	R	R	R					R			R	
Rouxia californica						r			F				
Simonseniella barboi	R	F	F	R			R			F	R	R	
Simonseniella curvirostris													
Simonseniella praebarboi													
Stellarima sp.									R				
Stephanopyxis dimorpha										R			
Stephanopyxis spp.	R			R		R	F		F	F	R	F–C	
Synedra jouseana													
Thalassionema nitzschioides	F	F	F	F		F	R	C	A	C	F	F–C	F
Thalassionema schraderi													
Thalassiosira antiqua	R	F	R	R		R		F	C	R	R?		
Thalassiosira brunii													
Thalassiosira convexa var. *aspinosa*													
Thalassiosira convexa var. *convexa*													
Thalassiosira aff. *jacksonii*		R				R							
Thalassiosira jouseae													
Thalassiosira leptopus									F				
Thalassiosira minutissima													
Thalassiosira miocenica													
Thalassiosira multipora										R			
Thalassiosira nativa									F?				
Thalassiosira oestrupii				R								R	R
Thalassiosira temperei													
Thalassiosira spp.								R	F				
Thalassiothrix longissima	R	R	R	R		R	R		R	R	R	R	R
Freshwater diatoms	R	R	R	R		R	R	R		R	R	R	R
*Distephanus pseudofibula**													
Epoch/Subepoch	lower Pliocene				?	l. Plio.?	Pliocene	?	u. Mio.	Quat.–u. Pliocene		Pliocene	

of *Nitzschia miocenica, Thalassiosira convexa* var. *aspinosa, Thalassiosira nativa,* and *Thalassiosira miocenica* are indicative of a latest Miocene age (6.2–6.0 Ma). This Miocene age is supported by the absence of any Pliocene markers (*Neodenticula* spp., *Thalassiosira oestrupii,* and *Stephanopyxis dimorpha* are not recognized in this interval).

Sample 146-892A-6X-1, 34–35 cm, to Sample 146-892A-7X-1, 49–52 cm (39.34–48.99 mbsf)

Well-preserved diatom assemblages in these samples are dominated by *Thalassionema nitzschioides, Chaetoceros* spores, *Rouxia californica, Denticulopsis hustedtii,* and *D. katayamae.* The occurrence of common *D. hustedtii,* along with *D. katayamae, Rouxia californica, Thalassionema schraderi, Nitzschia praereinholdii, Rhizosolenia miocenica,*and the silicoflagellate *Distephanus pseudofibula* are indicative of the late Miocene *Denticulopsis hustedtii* Zone (9.0–8.3 Ma). The occurrence of *Thalassionema schraderi* in Sample 146-892A-7X-1, 49–52 cm suggests that this interval may correlate with the upper part of this Zone (8.6–8.3 Ma).

Upper Pliocene Interval with Reworked Upper Miocene Floras

Sample 146-892A-7X-2, 42–43 cm, to Sample 146-892A-8X-3, 24–26 cm (50.43–61.27 mbsf)

The diatom assemblages are moderately preserved and usually contain a younger (Pliocene) component (*Neodenticula kamtschatica, N. seminae* and/or *N. koizumii, Thalassiosira oestrupii,* and *Stephanopyxis dimorpha*) mixed with an older component reworked from the Miocene (*Actinocyclus ingens, Denticulopsis hustedtii, Rouxia californica, Synedra jouseana, Thalassionema schraderi, Thalassiosira nativa,* and *Thalassiosira minutissima*). In most samples, the Pliocene assemblages are characteristic of the 3.7–2.6 Ma

Table 3. Occurrence and relative abundance of stratigraphically significant diatoms in Hole 892D.

Core, section:	2X-1	2X-2	3X-1	4X-1	4X-3	5X-1	5X-2	5X-3	6X-1	6X-3	6X-4	6X-5
Interval (cm):	6–9	6–8	5–7	29–31	28–30	52–54	95–97	125–127	83–86	91–94	74–77	67–70
Depth (mbsf):	8.56	10.06	18.05	27.79	30.30	37.52	39.45	41.25	47.33	50.16	51.49	52.92
Abundance:	C	C	C	A	C	C	A	A	A	C	A	C
Preservation:	G(M)	G(M)	G(M)	G	G(M)	M	G	G	G	M(P)	G	M
Actinocyclus curvatulus	R		R	R	R		R	R	R			
Actinocyclus ingens								R	R		R–F	R
Actinoptychus senarius		R	R		R	R	R	R	F	R–F	F	R
Azpeitia nodulifera									R		R	R
Chaetoceros spores	A	A	A	A	A	A	A	A	A	F	A	F
Coscinodiscus marginatus		F				R	R	R	R		R	
Coscinodiscus spp. (large forms)	R	R	R	R	R		F	F	F	F	R	
Crucidenticula sp.										R		
Delphineis spp.	F–C	F	R	R	F	F	F		F	R	R	R
Denticulopsis dimorpha												
Denticulopsis hustedtii (group)			r			r	F	F	F	F	C	C
Denticulopsis katayamae								R	F			
Denticulopsis praedimorpha												
Denticulopsis spp.											R	
Hemidiscus cuneiformis		R				R						
Lithodesmium californicum												
Lithodesmium cornigerum						R						
Neodenticula kamtschatica				R		R						
Neodenticula koizumii					R							
Neodenticula seminae	C	R	R?	F–C	C	R–F						
Neodenticula seminae-koizumii (undiffer.)												
Nitzschia cylindrica												
Nitzschia fossilis												
Nitzschia marina		R		R								
Nitzschia miocenica												
Nitzschia praereinholdii												
Nitzschia reinholdii						R						
Nitzschia aff. *rolandii*												
Paralia sulcata				R		R	R		R	F	R	F
Proboscia alata		R	R			R		R				
Pseudoeunotia doliolus												
Rhizosolenia miocenica									R?			R
Rhizosolenia styliformis	R		R	R				R	R	R	F	R
Rouxia californica	r			r		r	C	F	C	R	F	F
Rouxia fusiformis												
Simonseniella barboi		R	R	R	R			R	R		R	R
Simonseniella curvirostris		R										
Simonseniella praebarboi												
Stephanopyxis dimorpha	F	F	F	R	F	F						
Stephanopyxis spp.							R				R	
Synedra jouseana											R	R
Thalassionema nitzschioides	F	F–C	C	F	C	C	A	C–A	A	A	A	A
Thalassionema schraderi							R			R	R	R
Thalassiosira antiqua				R?	F	R–F						
Thalassiosira aff. *antiqua*				R	F–R							
Thalassiosira brunii									R			
Thalassiosira convexa var. *aspinosa*						R						
Thalassiosira *convexa* var. *convexa*												
Thalassiosira grunowii											R–F	
Thalassiosira aff. *jacksonii*												
Thalassiosira jouseae	R											
Thalassiosira leptopus							R	R				
Thalassiosira minutissima							F	F–C				
Thalassiosira miocenica												
Thalassiosira multipora	R		R	R	R							
Thalassiosira nativa							R		F			
Thalassiosira oestrupii	R	R		R	R	R						
Thalassiosira temperei												
Thalassiosira yabei												
Thalassiosira spp.	F	F	F	F	F	F	F	F–C	F		R	
Thalassiothrix longissima	R	R	R	R		R	R	R	R	R	R	R
Freshwater diatoms	R	R	F–R	R	R	R	R	R	R	R	R	R
*Distephanus pseudofibula**						R	F	C	F			
Epoch/Subepoch	Quaternary		lower Quaternary–upper Pliocene				upper Miocene					

Notes: See Table 2. Barren intervals = Samples 146-892D-10X-1, 34–35; -10X-2, 32–33; -10X-3, 45–48; -10X-6, 98–100; -10X-7, 26–27; -11X-1, 20–22.

interval (mid- to late Pliocene) based on the occurrence of *Neodenticula kamtschatica, N. seminae* and/or *N. koizumii* and *Stephanopyxis dimorpha.* Sample 146-892A-7X-6, 98–100 cm, which contains *Rhizosolenia praebergonii,* however, is not older than 3.1 Ma. In addition, *N. seminae* was observed in Samples 146-892A-7X-2, 41–43 cm and -7X-3, 30–33 cm, suggesting a possible younger age for these two samples (2.7 Ma or younger). The reworked Miocene assemblages are characteristic of the *Denticulopsis hustedtii* Zone (9.0–8.3 Ma).

Reworking of older diatoms in younger sediments is not uncommon in deep sea cores. However, contamination of younger material in older sediments is also possible. The amount of Miocene reworking varies from abundant in Sample 146-892A-7X-4, 63–65 cm, where Miocene diatoms are dominant over Pliocene diatoms, to non-

Table 3 (continued.)

Core, section: Interval (cm): Depth (mbsf):	7X-1 73–76 54.73	7X-2 25–28 55.75	7X-3 74–77 57.50	7X-4 113–116 59.39	7X-5 32–34 60.08	7X-6 21–23 61.24	8X-1 43–45 62.13	8X-2 57–60 63.57	8X-2 117–119 64.17	8X-3 65–67 65.15	9X-1 33–34 69.63
Abundance:	A	A	A	A	C	C	A	C	C	C	Barren
Preservation:	G	G	G	G	P(M)	M	G(M)	M	M(P)	M(P)	
Actinocyclus curvatulus											
Actinocyclus ingens		R	R	R		R	R				
Actinoptychus senarius	F	F	F	R	F	R	R			R	
Azpeitia nodulifera	R		R	F	R		R	R			
Chaetoceros spores	A	F	A	C	F	F	A	A	C	F	
Coscinodiscus marginatus	R	R	R	R	F	F	F	F	F	F	
Coscinodiscus spp. (large forms)	F	R	R	R	F	R	F			R	
Crucidenticula sp.				R							
Delphineis spp.	F	R	R	R		R	F	F	R	R	
Denticulopsis dimorpha							r				
Denticulopsis hustedtii (group)	F	F	F	C		r	F–R		r	r	
Denticulopsis katayamae		R	C								
Denticulopsis praedimorpha				C							
Denticulopsis spp.				R	R		F				
Hemidiscus cuneiformis						R	R		R		
Lithodesmium californicum			R								
Lithodesmium cornigerum											
Neodenticula kamtschatica						F	R	R	R	R	
Neodenticula koizumii								R			
Neodenticula seminae											
Neodenticula seminae-koizumii (undiffer.)						R				R	
Nitzschia cylindrica	R						R				
Nitzschia fossilis			R			R	R				
Nitzschia marina											
Nitzschia miocenica											
Nitzschia praereinholdii			R								
Nitzschia reinholdii					R					R	
Nitzschia aff. *rolandii*											
Paralia sulcata		F		R	F	R	R		R	R	
Proboscia alata							R				
Pseudoeunotia doliolus											
Rhizosolenia miocenica		R	R	R							
Rhizosolenia styliformis	R	F				R	R			R	
Rouxia californica	C	F	F	F		f	C	R			
Rouxia fusiformis							r				
Simonseniella barboi			R			R	R	R		R	
Simonseniella curvirostris											
Simonseniella praebarboi				R							
Stephanopyxis dimorpha						R?				F	
Stephanopyxis spp.	R			R	C	R				F	
Synedra jouseana		R	R	R		R	R				
Thalassionema nitzschioides	A	A	A	A	C	A	A	C	C	F	
Thalassionema schraderi			R?			r?	R				
Thalassiosira antiqua					F	F–C	F	F	R	F	
Thalassiosira aff. *antiqua*											
Thalassiosira brunii											
Thalassiosira convexa var. *aspinosa*									R–F	F	
Thalassiosira *convexa* var. *convexa*											
Thalassiosira grunowii				R							
Thalassiosira aff. *jacksonii*											
Thalassiosira jouseae											
Thalassiosira leptopus	R	R			R	R					
Thalassiosira minutissima	F–C	F–C	R				R				
Thalassiosira miocenica					R						
Thalassiosira multipora											
Thalassiosira nativa	F	R	R				R				
Thalassiosira oestrupii								R			
Thalassiosira temperei			R								
Thalassiosira yabei				R							
Thalassiosira spp.	F		F	R				R		R	
Thalassiothrix longissima	R	R	R	R	R	R	R	R	R	R	
Freshwater diatoms	R	R	R	R		R	R	R	R	R	
*Distephanus pseudofibula**	F		R–F				r				
Epoch/Subepoch		upper Miocene		m. Mio	u. Mio.	Plio.	u. Mio.?		upper Pliocene		?

existent in Sample 146-892A-8X-2, 116–118 cm, where the entire assemblage is Pliocene.

Uppermost Miocene Interval

Sample 146-892A-8X-4, 104–106 cm, to Sample 146-892A-8X-5, 38–40 cm (63.49–64.33 mbsf)

The diatom assemblages of this interval are moderately preserved and are dominated by *Thalassionema nitzschioides, Chaetoceros* spores, and *Thalassiosira antiqua.* A latest Miocene age (6.2–6.0 Ma) is assigned to this interval based on the occurrence of *Nitzschia miocenica, Thalassiosira miocenica, Thalassiosira nativa, Thalassiosira convexa,* and the silicoflagellate *Distephanus aspera clinata.* This Miocene age is supported by the absence of any diatoms restricted to the Pliocene.

Pliocene Interval

Sample 146-892A-9X-1, 67–69 cm, to Sample 146-892A-17X-1, 33–34 cm (67.92–135.33 mbsf)

The assemblages are poorly preserved in this interval and accurate diatom stratigraphy is difficult to interpret. Samples from Cores 146-

Table 3 (continued).

Core, section:	9X-2	9X-3	9X-4	9X-5	11X-2	12X-2	12X-3	13X-CC	14X-1	15X-1	15X-2	15X-3
Interval (cm):	33–34	35–36	34–35	33–34	46–48	91–93	81–83	13–14	76–77	80–83	37–39	77–79
Depth (mbsf):	71.13	71.96	72.93	73.85	111.46	121.41	122.81	128.63	138.76	148.30	149.37	151.27
Abundance:	A	A	A	F(C)	A	C	F	A	F	C(F)	A	C
Preservation:	G(M)	M	P	P	G(M)	M(P)	P	M	M	M(P)	G	M
Actinocyclus curvatulus											R	R
Actinocyclus ingens						R						
Actinoptychus senarius			F				R				R	
Azpeitia nodulifera					R			R		R		
Chaetoceros spores	A	A	C	F	A	A	F	F	C	C	A	A
Coscinodiscus marginatus	R		C	F		R	R	F–C	R		F	R–F
Coscinodiscus spp. (large forms)	F		R		F				F	R		R
Crucidenticula sp.					F–R							
Delphineis spp.	F	F	F					F	R			
Denticulopsis dimorpha												
Denticulopsis hustedtii (group)	R											
Denticulopsis katayamae												
Denticulopsis praedimorpha												
Denticulopsis spp.												
Hemidiscus cuneiformis								R			R	
Lithodesmium californicum												
Lithodesmium cornigerum												
Neodenticula kamtschatica			F	R				aff. R				R–F
Neodenticula koizumii	R	R							R		R?	
Neodenticula seminae					F	R						R
Neodenticula seminae-koizumii (undiffer.)					F	R	R			R	R	R
Nitzschia cylindrica												
Nitzschia fossilis						R		R–F			R	
Nitzschia marina								R–F				
Nitzschia miocenica												
Nitzschia praereinholdii												
Nitzschia reinholdii					R–F			R–F				
Nitzschia aff. *rolandii*								R				
Paralia sulcata			R	F			R		R			
Proboscia alata									R			
Pseudoeunotia doliolus												
Rhizosolenia miocenica												
Rhizosolenia styliformis					R	R		F	R		R	
Rouxia californica								R				
Rouxia fusiformis												
Simonseniella barboi	R		R		R		R		R	R	F	
Simonseniella curvirostris												
Simonseniella praebarboi												
Stephanopyxis dimorpha	F	F			R	F			R	R	R	F
Stephanopyxis spp.	C	F						R	R	R	R	
Synedra jouseana												
Thalassionema nitzschioides	F	C	C	C	C–F	F	F	C	F	C	A	A
Thalassionema schraderi												
Thalassiosira antiqua		R	C			R	R	F	F			R
Thalassiosira aff. *antiqua*												
Thalassiosira brunii												
Thalassiosira convexa var. *aspinosa*												
Thalassiosira *convexa* var. *convexa*												
Thalassiosira grunowii												
Thalassiosira aff. *jacksonii*			R									
Thalassiosira jouseae												
Thalassiosira leptopus				R				R				
Thalassiosira minutissima												
Thalassiosira miocenica												
Thalassiosira multipora												
Thalassiosira nativa								R aff.				
Thalassiosira oestrupii			R	F				R aff.			R	R
Thalassiosira temperei												
Thalassiosira yabei												
Thalassiosira spp.	F	R	R					R		R	R	
Thalassiothrix longissima	R	R	R	R	R	R	R	R	R	R	R	F
Freshwater diatoms	R	R	R		R	R	R	F	R	R	F	R
*Distephanus pseudofibula**												
Epoch/Subepoch	u. Pliocene		l. Pliocene		l. Quaternary–u. Plio.			u. Mio.	upper Pliocene			

892A-9X, -11X, and -16X contain *Neodenticula kamtschatica* and *N. koizumii,* suggesting correlation with the mid- to late Pliocene *N. koizumii-N. kamtschatica* Zone (3.7–2.6 Ma), which is also consistent with the occurrence of *Stephanopyxis dimorpha* in Cores 146-892A-9X and -11X. Samples examined from Cores 146-892A-13X and -15X are probably early Pliocene in age (5.4–3.7 Ma) based on the occurrence of *Thalassiosira oestrupii* in Core 146-892A-13X and *Neodenticula kamtschatica* in Core 146-892A-15X and on the absence of *N. koizumii* and *S. dimorpha*; however, these markers may be lacking due to poor preservation. Sample 146-892A-17X-1, 33–34 cm does not contain stratigraphic markers, and Samples 146-892A-12X-1, 15–18 cm and 146-892A-14X-1, 46–47 cm are barren of diatoms.

Uppermost Miocene Interval

Sample 146-892A-18X-1, 95–96 cm (145.45 mbsf)

This sample, which contains well-preserved assemblages, is dated as latest Miocene (ca 7.3–6.6 Ma) based on the occurrence of *Nitzschia praereinholdii, Nitzschia* aff. *rolandii, Nitzschia reinholdii, Rouxia californica, Synedra jouseana,* and *Thalassiosira antiqua.*

Table 3 (continued).

Core, section: Interval (cm): Depth (mbsf):	16X-1 37–38 157.37	16X-2 31–32 158.34	16X- 35–36 159.86	16X 106–108 162.09	16X 53–55 163.06
Abundance: Preservation:	A M(G)	A M(G)	A M(G)	A M(G)	A G
Actinocyclus curvatulus					
Actinocyclus ingens	R	R			
Actinoptychus senarius				R	F
Azpeitia nodulifera					
Chaetoceros spores	C	A	A	A	A
Coscinodiscus marginatus	R			F	F
Coscinodiscus spp. (large forms)	F	F	F		F
Crucidenticula sp.					
Delphineis spp.	R	F	F		F
Denticulopsis dimorpha					
Denticulopsis hustedtii (group)	R	R		R	
Denticulopsis katayamae					
Denticulopsis praedimorpha					
Denticulopsis spp.					
Hemidiscus cuneiformis					
Lithodesmium californicum					
Lithodesmium cornigerum					
Neodenticula kamtschatica					R
Neodenticula koizumii					
Neodenticula seminae	F	F	F		
Neodenticula seminae-koizumii (undiffer.)					
Nitzschia cylindrica					
Nitzschia fossilis	R	R	R		
Nitzschia marina					
Nitzschia miocenica					
Nitzschia praereinholdii				R	
Nitzschia reinholdii	R	R		R	
Nitzschia aff. *rolandii*				R	
Paralia sulcata				R	
Proboscia alata					
Pseudoeunotia doliolus	R	R	R?		
Rhizosolenia miocenica					
Rhizosolenia styliformis		R		R	R–F
Rouxia californica				F	R–F
Rouxia fusiformis					
Simonseniella barboi		R			
Simonseniella curvirostris					
Simonseniella praebarboi					
Stephanopyxis dimorpha	R-F	F	R		
Stephanopyxis spp.					
Synedra jouseana					
Thalassionema nitzschioides	C	A	C	A	A
Thalassionema schraderi					
Thalassiosira antiqua				F–C	F–C
Thalassiosira aff. *antiqua*			R		
Thalassiosira brunii					
Thalassiosira convexa var. *aspinosa*					
Thalassiosira *convexa* var. *convexa*					
Thalassiosira grunowii					
Thalassiosira aff. *jacksonii*					
Thalassiosira jouseae					
Thalassiosira leptopus					R
Thalassiosira minutissima					
Thalassiosira miocenica					
Thalassiosira multipora					
Thalassiosira nativa					
Thalassiosira oestrupii	R				
Thalassiosira temperei					
Thalassiosira yabei					
Thalassiosira spp.					
Thalassiothrix longissima	R	R	R	R	R
Freshwater diatoms		R	R		
*Distephanus pseudofibula**					
Epoch/Subepoch	Quaternary			u. Mio.	u. Mio.?

Pliocene–Quaternary Interval

Sample 146-892A-20X-1, 19–20 cm, to Sample 146-892A-20X-2, 133–134 cm (163.69–166.35 mbsf)

The diatom assemblages are very well-preserved in Section 146-892A-20X-1 and indicate a latest Pliocene to Quaternary age (2.6–1.6 Ma) based on the occurrence of *Neodenticula seminae* and *Thalassiosira antiqua.*

Preservation is poor in Section 146-892A-20X-2 and accurate correlation is not possible. Sample 146-892A-20X-2, 44–46 cm is younger than 5.7 Ma based on the occurrence of *Thalassiosira oestrupii.* Sample 146-892A-20X-2, 133–134 cm is probably middle to early Pliocene (5.4 to 2.6 Ma) based on the co-occurrence of *Thalassiosira oestrupii* and *Neodenticula kamtschatica* (Table 1).

Table 5 summarizes the ages of the intervals studied in Hole 892A as well as the depth and age of the unconformities/hiatuses (labeled H1[A] to H4[A]) and reversals (labeled R1[A] to R4[A]).

Diatom Biostratigraphy of Hole 892D

Pliocene–Quaternary Interval

Sample 146-892D-2X-1, 6–9 cm, to Sample 146-892D-2X-2, 6–8 cm (8.56–10.06 mbsf)

The age of these well-preserved diatom assemblages is Quaternary (1.6 to 0.3 Ma) based on the co-occurrence of *Neodenticula seminae* and *Simonseniella curvirostris.*

Table 4. Occurrence and relative abundance of stratigraphically significant diatoms in Hole 892E.

Core, section: Interval (cm): Depth (mbsf):	1X-2 38–40 0.64	3H-3 54–56 35.7	3H-4 47–49 37.11	3H-6 20–22 39.83	4H-1 104–106 43.54
Abundance:	C	A	A	C	A
Preservation:	M	G	G	P	G(M)
Actinocyclus curvatulus			R		
Actinocyclus ellipticus					R–F
Actinoptychus senarius		F	R–F		F
Azpeitia nodulifera			R		
Chaetoceros spores	C	A	A	F	A
Coscinodiscus marginatus	F		R	C	F
Coscinodiscus sp.	F	F	R		F
Denticulopsis hustedtii (group)		F	F		R
Denticulopsis katayamae			F–C?		
Denticulopsis spp.					
Hemidiscus cuneiformis					R
Lithodesmium californicum		R			
Lithodesmium sp.					R
Neodenticula seminae	C				
Nitzschia fossilis				R?	
Nitzschia sp.					F–R
Paralia sulcata	R		R	F	R
Proboscia alata		R			R
Rhizosolenia styliformis		R			R
Rouxia californica		C–A	C		F
Simonseniella barboi	R		R		R
Stephanopyxis dimorpha	C				
Synedra jouseana		R	F		F
Thalassionema nitzschioides	C	A	A	F	A
Thalassionema schraderi		R	F–C		
Thalassiosira antiqua				R?	
Thalassiosira minutissima					R
Thalassiosira nativa		F	F		F
Thalassiosira oestrupii	R				
Thalassiosira temperei		R	R		
Thalassiosira spp.					F
Thalassiothrix longissima	R	R	A	R	R
Freshwater diatoms	R				R
*Distephanus pseudofibula**			R		
Epoch/Subepoch	Quat.–u.Plio.	upper Miocene		Quat.–Mio.	u. Mio.

Note: See Table 2.

Table 5. Age and depth of the various stratigraphic units in Hole 892A with position of the stratigraphic breaks (hiatuses, reversals).

Samples (core, section, interval)	Depth (mbsf)	Age (Ma)
146-892A-		
1X-1, 128–130 cm, to 1X-2, 126–129 cm	1.29 to 2.77	1.6–0.3
1X-3, 7–9 cm, to 2X-3, 52–54 cm	3.04 to 13.02	1.8–1.6
3X-1, 14–16 cm, to 3X-2, 28–30 cm	19.14 to 20.78	2.7–2.6
Hiatus H1(A)	*20.78/29.14*	*6.0–2.7*
4X-1, 64–66 cm, to 4X-2, 28–30 cm	29.14 to 29.80	6.2–6.0
Hiatus H2(A)	*29.80/39.34*	*8.3–6.2*
6X-1, 34–35 cm, to 7X-1, 49–52 cm	39.34 to 48.99	8.6–8.3
Reversal R1(A)	48.99/50.43	
7X-2, 42–43 cm, to 8X-3, 24–26 cm	50.43 to 61.27	3.7–2.6
Hiatus H3(A)	*61.27/63.49*	*6.0–3.7*
8X-4, 104–106 cm, to 8X-5, 38–40 cm	63.49 to 64.33	6.2–6.0
Reversal R2(A)	64.33/67.92	
9X-1, 42–45 cm, to 11X-3, 16–19 cm	67.92 to 80.61	3.7–2.6
12X-1, 15–18 cm	87.65	barren
13X-1, 14–15 cm, to 13X-8, 91–93 cm	97.14 to 104.36	5.4–3.7
14X-1, 46–47 cm	106.96	barren
15X-1, 42–44 cm	116.42	5.4–3.7?
Reversal R3(A)	116.42/125.64	
16X-1, 14–15 cm	125.64	3.7–2.6
17X-1, 33–34 cm	135.33	no markers
Hiatus H4(A)?	*125.64/145.45*	*6.6–3.7?*
18X-1, 95–96 cm	145.45	7.3–6.6
Reversal R4(A)	145.45/163.69	
20X-1, 19–20 cm, to 20X-1, 142–144 cm	163.69 to 164.92	2.6–1.6
20X-2, 44–46 cm, to 20X-2, 133–134 cm	165.56 to 166.35	5.4–2.6

Notes: / = separated constraining depths; ? = uncertain.

Sample 146-892D-3X-1, 5–7 cm, to Sample 146-892D-5X-1, 52–54 cm (18.05–37.52 mbsf)

The presence of *Neodenticula seminae* without *Simonseniella curvirostris* places this interval between 2.6 Ma and 1.6 Ma (latest Pliocene to early Quaternary). The last occurrence of *Thalassiosira antiqua* (1.8 Ma) is recorded in Sample 146-892D-4X-3, 28–30 cm (or 146-892D-4X-1, 29–31 cm), and the last occurrence of *Thalassiosira convexa* (2.4 Ma) is observed in Sample 146-892D-5X-1, 52–54 cm.

Miocene Interval

Sample 146-892D-5X-2, 95–97 cm, to Sample 146-892D-7X-3, 74–77 cm (39.45–57.5 mbsf)

The occurrence of common *Denticulopsis hustedtii,* common *Rouxia californica, Rhizosolenia miocenica, Thalassionema schraderi, Thalassiosira nativa, Thalassiosira minutissima,* and the silicoflagellate *Distephanus pseudofibula* is characteristic of the late Miocene *Denticulopsis hustedtii* Zone (9.0–8.3 Ma). This Miocene age is supported by the absence of any Pliocene stratigraphic markers.

Sample 146-892D-7X-4, 113–116 cm (59.39 mbsf)

This sample contains a well-preserved middle Miocene assemblage, and is dated as 12.8–11.4 Ma based on the occurrence of *Denticulopsis praedimorpha, Simonseniella praebarboi, Rhizosolenia miocenica, Thalassiosira yabei,* and *Thalassiosira grunowii*, and the absence of *Simonseniella barboi.*

Sample 146-892D-7X-5, 32–34 cm (60.08 mbsf)

This sample is dated as latest Miocene (6.2–5.7 Ma) based on the occurrence of *Thalassiosira antiqua* and *Thalassiosira miocenica.*

Pliocene Interval with Abundant Miocene Reworking

Sample 146-892D-7X-6, 21–23 cm (61.24 mbsf)

Despite the occurrence of few specimens of *Rouxia californica, Denticulopsis hustedtii,* and *Thalassionema schraderi* which are suggestive of the upper Miocene, this sample is dated as Pliocene (3.7–2.6 Ma) based on the occurrence of few specimens of *Neodenticula kamtschatica* and *Neodenticula koizumii* and/or *N. seminae.* The older component is interpreted as reworked.

Sample 146-892D-8X-1, 43–45 cm (62.13 mbsf)

The majority of the assemblage of this sample is characteristic of the late Miocene and correlates with the *Thalassiosira antiqua* Zone (8.3–7.45 Ma) based on the occurrence of *Thalassiosira antiqua* and *Thalassionema schraderi.* However, the occurrence of rare (two specimens) of *Neodenticula kamtschatica,* which typically does not range below the Pliocene in the middle-latitude northeast Pacific, may suggest a younger age. No other Pliocene markers were observed, so the presence of *Neodenticula kamtschatica* is possibly due to contamination. This sample contains also *Denticulopsis dimorpha* (range: 9.9–9.0 Ma) and *Rouxia fusiformis* (top = 8.9 Ma) which are reworked from the lower part of the upper Miocene.

Pliocene–Quaternary Interval

Sample 146-892D-8X-2, 57–60 cm, to Sample 146-892D-8X-3, 65–67 cm (63.57–65.15 mbsf)

An early late to late early Pliocene age (3.7–2.6 Ma) is given to this interval based on the occurrence of *Neodenticula kamtschatica, Stephanopyxis dimorpha,* and *Neodenticula koizumii.* There are a small amount of late Miocene reworked diatoms.

Sample 146-892D-9X-1, 33–34 cm, (69.63 mbsf) is barren of diatoms.

Sample 146-892D-9X-2, 33–34 cm, to Sample 146-892D-9X-3, 35–36 cm (71.13–71.96 mbsf)

This interval is late Pliocene in age (2.6–2.0 Ma) based on the occurrence of *Neodenticula koizumii* and *Stephanopyxis dimorpha* and the absence of *Neodenticula kamtschatica.*

Sample 146-892D-9X-4, 34–35 cm, to Sample 146-892D-9X-5, 33–34 cm (72.93–73.85 mbsf)

This interval is early Pliocene in age (5.4–3.7 Ma) based on the occurrence of *Neodenticula kamtschatica* and *Thalassiosira oestrupii* and the absence of *Neodenticula seminae* and/or *N. koizumii.*

Samples 146-892D-10X-1, 34–35 cm, to Sample 146-892D-11X-1, 20–22 cm (100.34–109.7 mbsf) are barren of diatoms.

Sample 146-892D-11X-2, 46–48 cm, to Sample 146-892D-12X-3, 81–83 cm (111.46–122.81 mbsf)

These samples are of latest Pliocene to earliest Quaternary (2.7–1.8 Ma) age based on the occurrence of *Thalassiosira antiqua* and *Neodenticula seminae.*

Miocene Interval

Sample 146-892D-13X-CC, 13–14 cm (128.63 mbsf)

This sample correlates with the interval between the last common *Rouxia californica* (6.6 Ma) and the first *Thalassiosira oestrupii* (5.4 Ma). This latest Miocene age (6.6–5.4 Ma) is supported by the occurrence of *Thalassiosira* aff. *oestrupii, Thalassiosira* aff. *nativa, Nitzschia* aff. *rolandii,* and *Neodenticula* aff. *kamtschatica.*

Pliocene–Quaternary Interval

Sample 146-892D-14X-1, 76–77 cm, to Sample 146-892D-15X-3, 77–79 cm (138.76–151.27 mbsf)

Samples in this interval are late Pliocene (2.7–1.8 Ma) in age based on the occurrence of *Thalassiosira antiqua, Neodenticula koizumii* and/or *N. seminae. Neodenticula kamtschatica* is present only in Sample 146-892D-15X-3, 77–79 cm, where it co-occurs with *Neodenticula seminae.*

Sample 146-892D-16X-1, 37–38 cm, to Sample 146-892D-16X-3, 35–36 cm (157.37–159.86 mbsf)

This interval is assigned to the Quaternary (2.0–0.5 Ma) based on the presence of *Neodenticula seminae, Pseudoeunotia doliolus,* and *Nitzschia reinholdii.*

Miocene Interval

Sample 146-892D-16X-4, 106–108 cm (162.09 mbsf)

The occurrence of *Rouxia californica* and *Thalassiosira antiqua* and the absence of *Thalassionema schraderi* allows the correlation of this sample with the Subzone A of the *Nitzschia reinholdii* Zone (7.45–6.6 Ma).

Sample 146-892D-16X-5, 53–55 cm (163.06 mbsf)

A late Miocene age (7.2–6.6 Ma) is suggested for this sample based on the occurrence of *Rouxia californica, Neodenticula kamtschatica,* and *Thalassiosira antiqua.* A Pliocene age (5.4–2.6 Ma) is possible, however, if the specimens of *Rouxia californica* are considered to be reworked.

Table 6. Age and depth of the various stratigraphic units in Hole 892D with position of the stratigraphic breaks (hiatuses, reversals).

Samples (core, section, interval)	Depth (mbsf)	Age (Ma)
146-892D-		
2X-1, 6–9 cm, to 2X-2, 6–8 cm	8.56 to 10.06	1.6–0.3
3X-1, 5–7 cm, to 5X-1, 52–54 cm	18.05 to 37.52	2.6–1.6
Hiatus H1(D)	*37.52/39.45*	*8.3–2.6*
5X-2, 95–97 cm, to 7X-3, 74–77 cm	39.45 to 57.5	9.0–8.3
Hiatus H2(D)	*57.5/59.39*	*11.4–9.0*
7X-4, 113–116 cm	59.39	12.8–11.4
Reversal R1(D)	59.39/60.08	
7X-5, 32–34 cm	60.08	6.2–5.7
Reversal R2(D)	60.08/61.24	
7X-6, 21–23 cm	61.24	3.7–2.6
Hiatus H3(D)	*61.24/62.13*	*7.45–3.7*
8X-1, 43–45 cm	62.13	8.3–7.45
Reversal R3(D)	62.13/63.57	
8X-2, 57–60 cm, to 8X-3, 65–67 cm	63.57 to 65.15	3.7–2.6
8X-CC cm, to 9X-1, 33–34 cm	69.30 to 69.63	Barren
Reversal R4(D)	65.15/71.13	
9X-2, 33–34 cm, to 9X-3, 35–36 cm	71.13 to 71.96	2.6–2.0
Hiatus H4(D)	*71.96/72.93*	*3.7–2.6*
9X-4, 34–35 cm, to 9X-5, 33–34 cm	72.93 to 73.85	5.4–3.7
10X-1, 34–35 cm, to 11X-1, 20–22 cm	100.34 to 109.07	Barren
Reversal R5(D)	73.85/111.46	
11X-2, 46–48 cm, to 12X-3, 81–83 cm	111.46 to 122.81	2.7–1.8
Hiatus H5(D)	*122.81/128.63*	*5.4–2.7*
13X-CC, 13–14 cm	128.63	6.6–5.4
Reversal R6(D)	128.63/138.76	
14X-1, 76–77 cm, to 15X-3, 77–79 cm	138.76 to 151.27	2.7–1.8
Reversal R7(D)	151.27/157.37	
16X-1, 37–38 cm, to 16X-3, 35–36 cm	157.37 to 159.86	2.0–0.5
Hiatus H6(D)	*159.86/162.09*	*6.6–2.0*
16X-4, 106–108 cm	162.09	7.45–6.6
16X-5, 53–55 cm	163.06	7.2–6.6 ?

Note: See Table 5.

Table 6 summarizes the ages of the intervals studied in Hole 892D as well as the depth and age of the unconformities/hiatuses (labeled H1[D] to H6[D]) and reversals (labeled R1[D] to R7[D]).

Diatom Biostratigraphy of Hole 892E

Pliocene–Quaternary Interval

Sample 146-892E-1X-2, 38–40 cm (0.64 mbsf)

The occurrence of *Neodenticula seminae* indicates a latest Pliocene to Quaternary age (2.7–0 Ma).

Miocene Interval

Sample 146-892E-3H-3, 54–56 cm, to Sample 146-892E-3H-4, 47–49 cm (35.7–37.11 mbsf)

The occurrence of *Denticulopsis hustedtii, Rouxia californica, Synedra jouseana, Thalassionema schraderi, Thalassiosira nativa,* and *Distephanus pseudofibula* allows the correlation of this interval with the late Miocene *Denticulopsis hustedtii* Zone (9.0–8.3 Ma).

Sample 146-892E-3H-6, 20–22 cm (39.83 mbsf)

The occurrence of *Nitzschia reinholdii* (range: 7.3–0.5 Ma) and *Thalassiosira antiqua* (range: 8.3–1.8 Ma) suggests a late Miocene to earliest Quaternary age (7.3–1.8 Ma); however, poor preservation of the material and a lack of stratigraphic markers limits interpretation.

Sample 146-892E-4H-1, 104–106 cm (43.54 mbsf)

This well-preserved diatom assemblage is characteristic of the late Miocene *Denticulopsis hustedtii* Zone (9.0–8.3 Ma).

Table 7 summarizes the ages of the intervals studied in Hole 892E as well as the depth and age of the unconformity/hiatus H1(E) and reversal R1(E).

Table 7. Age and depth of the various stratigraphic units in Hole 892E with position of the stratigraphic breaks (hiatuses, reversals).

Samples (core, section, interval)	Depth (mbsf)	Age (Ma)
146-892E-		
1X-2, 38–40 cm	0.64	2.7–0
3H-3, 54–56 cm, to 3H-4, 47–49 cm	35.70 to 37.11	9.0–8.3
Reversal R1(E)	37.11/39.83	
3H-6, 20–22 cm	39.83	7.3–1.8
Hiatus H1(E)	*39.83/43.54*	*8.3–7.3*
4H-1, 104–106 cm	43.54	9.0–8.3

Note: See Table 5.

DISCUSSION

Correlation of Holes 892A, 892D, and 892E and Interpretation of Stratigraphic Results

The stratigraphy of Site 892 appears to be very complicated as many reversals (R) and hiatuses/unconformities (H) are revealed by the diatom analysis (Tables 5–7). In addition, the sequences observed between Holes 892A and -D are somewhat different and correlation is not always obvious between the two holes. Figure 2 attempts to correlate the three holes and to interpret the various reversals observed. The reader is also referred to Fourtanier and Caulet (this volume) where age vs. depth plots are constructed for Holes 892A and 892D by a combination of diatom and radiolarian biostratigraphies.

The upper part of Site 892 (Cores 146-892A-1X to -6X, and 146-892D-1X to -7X) corresponds to a Quaternary to middle Miocene sequence, with several hiatuses (or unconformities) and reversals. In Hole 892A, hiatuses H1(A) and H2(A) correspond to hiatuses of the time intervals 6.0–2.7 Ma and 8.3–6.1 Ma, respectively. In Hole 892D, H1(D) corresponds to a hiatus between 8.3 and 2.6 Ma and possibly correlates with a combined H1(A) and H2(A). Hiatus H2(D), separating sediments of late Miocene age (9.0–8.3 Ma) above and middle Miocene (12.8–11.4 Ma) below, is not recognized in Hole 892A, as no middle Miocene sediments are observed in that hole (Table 2).

In Hole 892A, a reversal R1(A) occurs between 48.99 and 50.43 mbsf, separating sediments of late Miocene age above and late Pliocene age below. There is another reversal R2(A) between 64.33 and 67.92 mbsf where uppermost Miocene sediment overlies upper Pliocene sediment. In Hole 892D, reversals at similar depths and also observed; however, the situation is different as four reversals are present within 12 m-long interval: R1(D) (59.39–60.08 mbsf), R2(D) (60.08–61.24 mbsf), R3(D) (62.13–63.57 mbsf) and R4(D) (65.15–71.13 mbsf). Reversal R1(D) separates middle Miocene sediments above from underlying upper Miocene sediments, whereas upper Miocene sediments overlie mid- to upper Pliocene sediments at reversals R2(D) and R3(D). At Reversal R4(D) mid- to upper Pliocene sediments overlie a younger upper Pliocene interval. As a matter of fact, the section of Hole 892D lying between 57 and 73 mbsf appears to be particularly disturbed as three unconformities and four reversals are observed within a 16-m-thick interval. It seems that this interval of Hole 892D may correspond to a fault zone. It is likely that R1(A) and/or R2(A) of Hole 892A correlate with this disturbed interval of Hole 892D.

Reversal R1(A) (between 48.99 and 50.43 mbsf) probably corresponds to a fault at about 50 mbsf. A fault at 52 mbsf was inferred from changes in dip bedding and by fractures in the formation microscanner (FMS) log (Shipboard Scientific Party, 1994). Similarly, the occurrence of reversal R2(A) between 64.33 and 67.92 mbsf provides additional evidence for a fault zone as suggested by the occurrence of shear bands and stratal disruption between 62.5 and 67 mbsf, and by a temperature anomaly at 67.5 mbsf (Shipboard Scientific Party, 1994).

The BSR (~71 mbsf) is located just a few meters below R2(A) and R4(D). Downhole logs and a vertical seismic profile (VSP) have established that the BSR is caused by free gas below about 71 mbsf (Leg 146 Shipboard Scientific Party, 1993).

Sediments in the middle part of the section cored at Site 892 are mostly Pliocene in age. In Hole 892A reversal R3(A) is observed in the interval between 116.42 mbsf and 125.64 mbsf, where lower Pliocene sediments overlie mid- to upper Pliocene sediments. Reversal R5(D) in Hole 892D between 73.85 mbsf and 111.46 mbsf is also characterized by lower Pliocene sediments above upper Pliocene sediments, so it is possible that R3(A) and R5(D) are correlative. A fault zone was recognized between Cores 146-892A-15X- and -18X, based on observations of stratal disruption and shear bands. It was speculated that Core 146-892A-14X (106.5–116 mbsf) may represent the active fault zone, and that the deeper cores (146-892A-15X through -18X) may be earlier formed fabrics (Shipboard Scientific Party, 1994).

In the lower part of the section cored at Site 892, hiatuses H4(A) (125.64–145.45 mbsf) and H5(D) (122.81–128.63 mbsf), which separate upper Pliocene and uppermost Miocene sediments, may be correlative. Reversals R4(A) (145.45–163.69 mbsf) and R6(D) (128.63–138.76 mbsf) may also be correlative. Another reversal R7(D) (51.27–157.37 mbsf) and hiatus H6(D) (159.86–162.09 mbsf) are observed in Hole 892D; however, the correlations implied in Figure 2 suggest that the correlative interval may lie beneath the section cored in Hole 892A.

CONCLUSIONS

This study established the stratigraphy of Holes 892A, 892D, and 892E based on diatom assemblages. It demonstrated the occurrence of sediments ranging in age from the middle Miocene to the late Quaternary at Site 892. It also established the position of several reversals in the section cored, as older sediments were often found above younger sediments. There are many different ways of interpreting these reversals, as they can be the results of: (1) faults, (2) displaced allochthonous elements within an otherwise continuous section, (3) folds that would create alternating normal and upside-down sections, or (4) a combination of all or some of these features. Further studies of sedimentary fabric and structural relationships, as well as consideration of the general setting of Site 892 and its seismic stratigraphy are necessary to accurately interpret the significance of the reversals observed.

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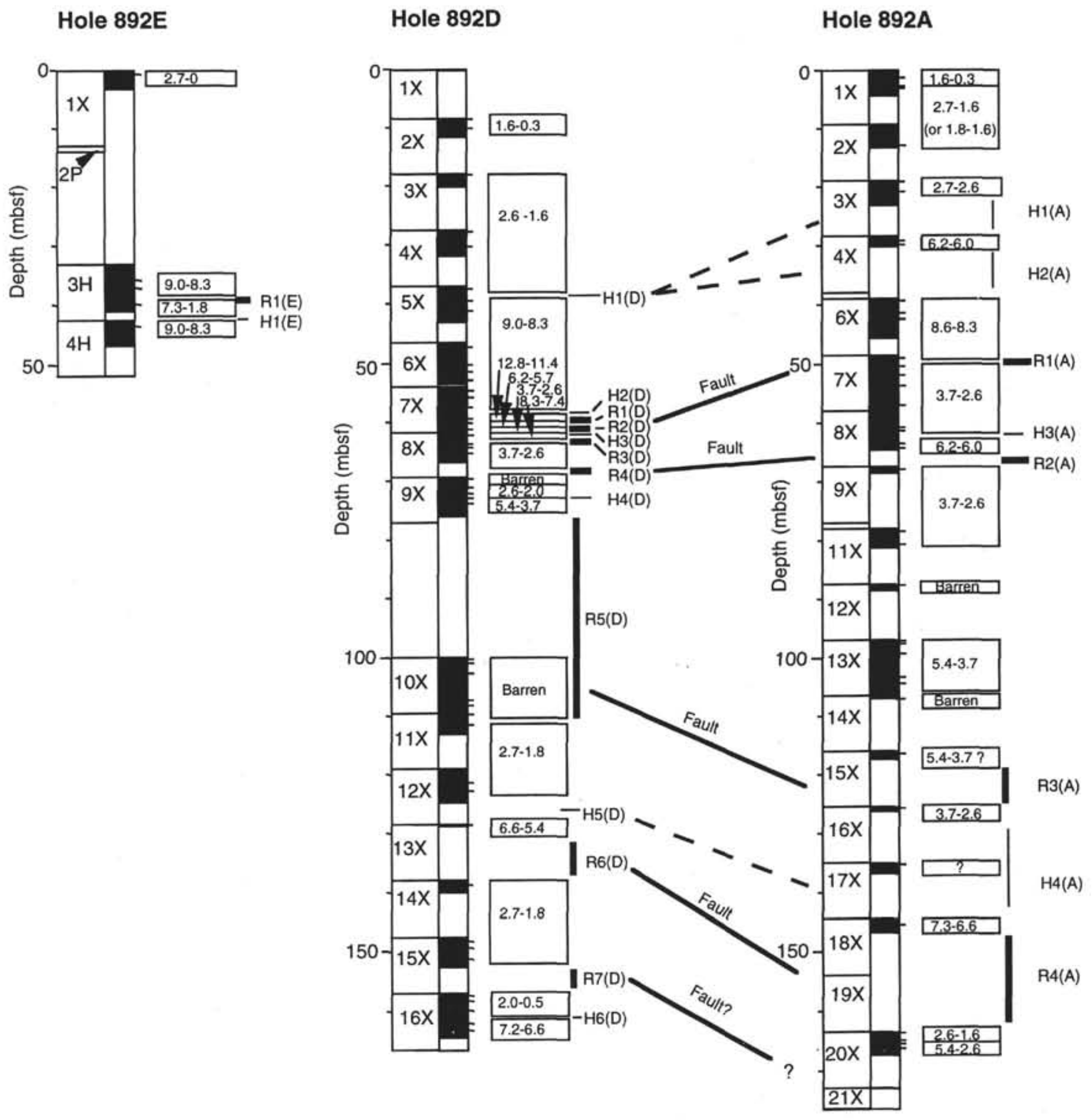

Figure 2. Interpretation of the diatom stratigraphy (age in Ma) and tentative correlation between Holes 892A, 892D, and 892E. Stratigraphic reversals (labeled "R") and hiatuses/unconformities (labeled "H") (after Tables 5–7). Black = recovered sediments; tick marks = samples studied.

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APPENDIX

Taxonomic References

The following list gives the formal citation for the species used in the checklists. Reference to at least a good figure is provided for each species and the reader is referred to these references for a more thorough taxonomic treatment.

Diatoms

Actinocyclus curvatulus Janisch *in* Schmidt; Koizumi, 1973, pl. 1, figs. 1–6.
Actinocyclus ingens Rattray; Barron, 1985, fig. 9.15.
Actinocyclus octonarius Ehrenberg; as *Actinocyclus ehrenbergii:* Barron, 1980b, pl. 1, fig. 5.
Actinoptychus senarius (Ehrenberg) Ehrenberg; Sancetta 1982, pl. 1, fig. 7.
Azpeitia nodulifera (Schmidt) Fryxell *et* Sims *in* Fryxell et al.; as *Coscinodiscus nodulifer:* Barron, 1985, figs. 10.10 and 10.11.
Coscinodiscus marginatus Ehrenberg; Koizumi, 1973, pl. 3, figs. 12–14.
Denticulopsis dimorpha (Schrader) Simonsen; Akiba, 1986, pl. 26, fig. 9, pl. 27, figs. 1–13.
Denticulopsis hustedtii (Simonsen *et* Akiba) Simonsen; Akiba, 1986, pl. 28, figs. 5–18.
Denticulopsis katayamae Maruyama; Akiba, 1986, pl. 28, figs. 1–4.
Denticulopsis praedimorpha Barron *ex* Akiba; Akiba, 1986, pl. 26, fig. 8, pl. 27, figs. 14–26.
Hemidiscus cuneiformis Wallich; Akiba, 1986, pl. 16, figs. 3–4.
Lithodesmium californicum Grunow *in* Van Heurck; Barron, 1976, pl. I, fig. 13.
Lithodesmium cornigerum Brun; Barron, 1976, pl. I, fig. 14.
Neodenticula kamtschatica (Zabelina) Akiba *et* Yanagisawa; Akiba, 1986, pl. 25, figs. 7–27.
Neodenticula koizumii Akiba *et* Yanagisawa (synonym: *Denticulopsis seminae* f. *fossilis* Koizumi); Koizumi, 1973, pl. 5, figs. 30, 37, 38.
Neodenticula seminae (Simonsen *et* Kanaya) Akiba *et* Yanagisawa *in* Akiba; Akiba, 1986, pl. 25, figs. 28–32.
Neodenticula koizumii-seminae. Remarks: Included here are taxa that could not be differentiated.
Nitzschia cylindrica Burckle; Barron, 1985, fig. 13.6.
Nitzschia fossilis (Frenguelli) Kanaya *et* Koizumi; Akiba, 1986, pl. 22, figs. 1–2; Barron, 1985, fig. 13.3.
Nitzschia marina Grunow *in* Cleve and Grunow; Schrader, 1973, pl. 4, figs. 17–19.
Nitzschia miocenica Burckle; Akiba, 1986, pl. 23, figs. 10–14.
Nitzschia praereinholdii Schrader; Schrader, 1973, pl. 5, figs. 20, 23–26.
Nitzschia reinholdii Kanaya *ex* Schrader; Akiba, 1986, pl. 22, figs. 4 and 5.
Nitzschia rolandii Schrader, Akiba, 1986, pl. 25, fig. 1–6.
Paralia sulcata (Ehrenberg) Cleve; Akiba, 1986, pl. 29, figs. 4 and 5.
Pseudoeunotia doliolus (Wallich) Grunow; Schrader, 1973, pl. 4, figs. 1–8.
Proboscia alata (Brightwell) Sundström; as *Rhizosolenia alata:* Schrader, 1973, pl. 10, fig. 12.
Rhizosolenia miocenica Schrader, 1973, pl. 10, figs. 2–6.
Rhizosolenia praebergonii Mukhina; Barron, 1985, fig. 12.2.
Rhizosolenia styliformis Brightwell; Schrader, 1973, pl. 10, fig. 18–21.
Rouxia californica Péragallo; Akiba, 1986, pl. 21, figs. 5 and 6.
Rouxia fusiformis Tsumura; Barron, 1976, pl. III, figs. 18 and19.
Simonseniella barboi (Brun) Fenner; as *Rhizosolenia barboi* Brun: Akiba, 1986, pl. 18, fig. 2.
Simonseniella curvirostris (Jousé) Fenner; as *Rhizosolenia curvirostris* Jousé: Akiba, 1986, pl. 18, fig. 3.
Simonseniella praebarboi (Schrader) Fenner; as *Rhizosolenia praebarboi:* Schrader, 1973, fig. 24, fig. 1–3.
Stephanopyxis dimorpha Schrader; Schrader, 1973, pl. 15, figs. 9–11.
Synedra jouseana Sheshukova-Poretzkaya; Schrader, 1973, pl. 23, figs. 21–23, 25, 38.
Thalassionema nitzschioides (Grunow) Van Heurck; Schrader, 1973, pl. 23, figs. 2, 6, 8–10, 12–13, 26, 29, 34.
Thalassionema schraderi Akiba; Akiba, 1986, pl. 21, figs. 13–16.
Thalassiosira antiqua (Grunow) Cleve-Euler; Barron, 1985, fig. 11.2.
Thalassiosira brunii Akiba *et* Yanagisawa (synonym: *Coscinodiscus temperei* var. *delicata* Barron); Barron, 1985, figs. 10.7, 10.8.
Thalassiosira convexa var. *aspinosa* Schrader; Barron, 1985, figs. 11.8 and 11.12.
Thalassiosira convexa var. *convexa* Mukhina; Barron, 1985, fig. 11.13; Akiba, 1986, pl. 8, fig. 1.
Thalassiosira grunowii (Grunow *in* Schmidt) Akiba *et* Yanagisawa; as *Coscinodiscus plicatus* Grunow: Schrader, 1973, pl. 6, fig. 23; Barron 1985, figs. 10.1 and 10.2.
Thalassiosira jacksonii Koizumi *et* Barron *in* Koizumi; Akiba, 1986, pl. 11, fig. 2.

Thalassiosira jouseae Akiba, 1986, pl. 6, figs. 8–10. Synonym: *T. nidulus* (Tempère *et* Brun) Jousé sensu Schrader, 1973, pl. 11, figs. 1–7.

Thalassiosira leptopus (Grunow) Hasle *et* Fryxell; Hasle and Fryxell, 1977, figs. 1–14, 94–96.

Thalassiosira minutissima Oreshkina *in* Barron and Gladenkov, in press, figs. 8a–d. (synonym: *Thalassiosira* sp. 1 sensu Barron, 1980a, pl. 5, figs. 6 and 7; *Thalassiosira* cf. *praeconvexa* Schrader sensu Akiba. 1986, pl. 8, fig. 5)

Thalassiosira multipora Whiting *et* Schrader, 1985, pl. 2, figs. 11, 16, and 17.

Thalassiosira nativa Sheshukova-Poretzkaya; Barron, 1985, fig. 11.4.

Thalassiosira oestrupii (Ostenfeld) Proshkina-Lavrenko; Akiba, 1986, pl. 14, figs. 1–6.

Thalassiosira simonsenii Hasle *et* Fryxell; Hasle and Fryxell, 1977, figs. 26, 34, and 97.

Thalassiosira temperei (Brun *in* Brun and Tempère) Akiba *et* Yanagisawa; as *Coscinodiscus temperei* Brun: Barron, 1985, figs. 10.5 and 10.6.

Thalassiosira yabei (Kanaya) Akiba *et* Yanagisawa; as *Coscinodiscus yabei* Kanaya: Schrader, 1973, pl. 6, fig. 1–6, 15; Barron, 1985, fig. 10.3.

Thalassiothrix longissima Cleve *et* Grunow *in* Cleve and Möller; Schrader, 1973, pl. 23, fig. 7, 17, and18.

Silicoflagellates

Dictyocha aspera clinata Bukry, 1975, pl. 1, figs. 1–5.

Distephanus pseudofibula (Schulz) Bukry; Barron, 1976, pl. III, fig. 29.