Revising the Miocene through Pleistocene diatom biostratigraphy on the drill cores recovered in DSDP Leg 19 results in the dating of Neogene sequences especially for Sites 183 and 192 in the far North Pacific Ocean. Ages for the basal part of the lithologic unit A (opal-A), diatom ooze to diatomaceous mud, overlying the unit B (opal-CT), mudstone with no diatom, are older than 10 Ma at 210 mbsf in Site 183, about 9.5 Ma at 718 mbsf in Site 192, and about 4.6 Ma at 582 mbsf in Site 188, at 370 mbsf in Site 187, at 587 mbsf in Site 185 and at 599 mbsf in Site 184, and about 3.2 Ma at 521 mbsf in Site 191, at 618 mbsf in Site 190, at 541 mbsf in Site 189 and at 926 mbsf in Site 186. The diagenetic boundary between opal-A and opal-CT distinctively forms a diachronic plane in the subarctic Pacific. Fossil diatoms in the dredged samples from the Bering Sea indicate stratigraphically major increasing times of diatom mass accumulation rates in the North Pacific: 10-9 Ma, 7-6 Ma, and 3-2 Ma.

Keywords: subarctic North Pacific Ocean, Bering Sea, DSDP Leg 19, Neogene diatoms, opal-A (biogenic silica) /opal-CT (cristobalite)
1. Introduction

Integrated Ocean Drilling Program (IODP) operated to drilling sail in the Bering Sea for the paleoceanographic research within July-to-September, 2009. As early as 1971, Leg 19 of the Deep Sea Drilling Project (DSDP) achieved drilling in the far North Pacific and the Bering Sea, and investigated the Cenozoic and Late Mesozoic history of sedimentation and biostratigraphic development (Creager, Scholl, et al., 1973). DSDP started in 1968, and during the early stages focused mainly on determining the age of the oceanic basement, age of sediments, and general character of sediments. Core recovery was poor in quantity and quality but DSDP Leg 19 is still unique in the drilling the Bering Sea. Naturally, later in 1992 Leg 145 of the Ocean Drilling Program (ODP) has provided much more continuous cores of excellent quality by using the hydraulic piston coring from the subarctic North Pacific (Rea, Basov, Scholl and Allan, 1995; Fig. 1).

The DSDP and ODP have also provided sequences thick and old enough to know diagenetic process and lithification of sediments. In Bering Sea, opal-A (biogenic silica) in the sediment is transformed to opal-CT (cristobalite) at the temperatures between 35°C and 50°C produced by the effect of both depth of burial and local geothermal gradient. This range of the temperature corresponds to the sub-bottom depth of about 600 m and to the area where silicification is most active (Hein et al., 1978). The diagenetic front is represented as the Bottom Simulating Reflector (BSR) in the seismic profiles.

Diatoms are very abundant with high diversity in the far North Pacific and provide the primary biostratigraphic means for dating and correlation for the Neogene sequences in this area. Over the past 35 years, diatom biostratigraphy ranging from Miocene through Pleistocene in the subarctic North Pacific region has refined the precedent results since pioneering papers of Schrader (1973) and Koizumi (1973a). Now we have major papers by Barron and Gladenkova (1995), Barron (2003), Watanabe and Yanagisawa (2005), Gladenkova (2006). A number of feasible zonal marker diatom species have been early selected and taxonomically examined. The first appearances and/or last appearances (extinction) of stratigraphically useful diatoms in the subarctic North Pacific have been defined, and consequently accurate datum levels or age of appearance and extinction have been established. The taxa which are easy to identify, constantly present or relatively abundant, and show a definite and stable stratigraphic ranges are chosen as zonal marker taxa (Koizumi, 1973b; Gladenkova, 2006).

The purpose of this paper is to review the diatom biostratigraphic results of DSDP Leg 19 and to present revised age-estimates for diagenetic opal-A-opal-CT boundary at Leg 19 sites and to revise diatom zones representing geologic ages for the dredged samples from the Bering Sea based on the build-up data concerning biostratigraphy, correlation and chronology in the far North Pacific (Table 1).

Table 1. Station localities of Leg 19 sites (Creager, Scholl, et al., 1973) and of the dredge-samples given by Drs. J. Grow, D.M. Hopkins, and D.W. Scholl.

<table>
<thead>
<tr>
<th>Drill Station</th>
<th>Latitude</th>
<th>Longitude</th>
<th>Depth</th>
</tr>
</thead>
<tbody>
<tr>
<td>Site 103</td>
<td>52° 34'0'' N</td>
<td>161° 12'3'' W</td>
<td>4790 m</td>
</tr>
<tr>
<td>Site 104</td>
<td>52° 42'4'' N</td>
<td>170° 05'39'' W</td>
<td>1910 m</td>
</tr>
<tr>
<td>Site 105</td>
<td>54° 25'7'' N</td>
<td>160° 14'59'' W</td>
<td>2110 m</td>
</tr>
<tr>
<td>Site 106</td>
<td>51° 09'8'' N</td>
<td>174° 00'34'' W</td>
<td>4522 m</td>
</tr>
<tr>
<td>Site 107</td>
<td>51° 09'6'' N</td>
<td>173° 57'25'' W</td>
<td>4597 m</td>
</tr>
<tr>
<td>Site 108</td>
<td>53° 45'21'' N</td>
<td>178° 39'56'' E</td>
<td>2548 m</td>
</tr>
<tr>
<td>Site 109</td>
<td>54° 36'1'' N</td>
<td>170° 13'38'' E</td>
<td>3433 m</td>
</tr>
<tr>
<td>Site 110</td>
<td>55° 33'5'' N</td>
<td>171° 38'42'' E</td>
<td>3975 m</td>
</tr>
<tr>
<td>Site 111</td>
<td>55° 56'70'' N</td>
<td>168° 10'22'' E</td>
<td>3014 m</td>
</tr>
<tr>
<td>Site 112</td>
<td>55° 00'57'' N</td>
<td>164° 42'61'' E</td>
<td>3014 m</td>
</tr>
</tbody>
</table>

Dredge Station

<table>
<thead>
<tr>
<th>Lat/Lon</th>
<th>Depth</th>
</tr>
</thead>
<tbody>
<tr>
<td>70A-11</td>
<td>52° 34'0'' N</td>
</tr>
<tr>
<td>70A-14D</td>
<td>54° 36'4'' N</td>
</tr>
<tr>
<td>70A-14F</td>
<td>55° 40'2'' N</td>
</tr>
<tr>
<td>70A-15</td>
<td>56° 09'2'' N</td>
</tr>
<tr>
<td>70A-15</td>
<td>56° 40'2'' N</td>
</tr>
<tr>
<td>70A-15</td>
<td>53° 02'7'' N</td>
</tr>
<tr>
<td>70A-15</td>
<td>54° 28'9'' N</td>
</tr>
<tr>
<td>70A-15</td>
<td>58° 22'1'' N</td>
</tr>
<tr>
<td>70A-15</td>
<td>60° 20'6'' N</td>
</tr>
<tr>
<td>70A-15</td>
<td>56° 09'3'' N</td>
</tr>
<tr>
<td>70A-15</td>
<td>57° 14'5'' N</td>
</tr>
<tr>
<td>70A-15</td>
<td>53° 31'9'' N</td>
</tr>
</tbody>
</table>
Miocene diatom datum levels was supplemented at Site 887 by Watanabe and Yanagisawa (2005). Earlier the paleomagnetic calibration of the Pleistocene datum levels was performed on the piston cores from the middle to high latitudes North Pacific by Koizumi (1975b) and Donahue (1979), and the calibration on the Pliocene to Pleistocene drill cores by the DSDP Leg 86 was accomplished by Koizumi and Tanimura (1985) and Koizumi (1986). These studies presented the Neogene diatom biochronology for the subarctic North Pacific. Diatom biostratigraphy on DSDP Leg 19 cores in Bering Sea have only a few follow-up studies (Koizumi, 1973a).

The Neogene oceanic diatom zonation, which primarily depended on the deep sea drilling cores by ODP Leg 145 in the subarctic North Pacific (Barron and Gladenkov, 1995; Watanabe and Yanagisawa, 2005), was successfully applied to the Neogene sequences on marginal seas and land areas in the middle to high latitudes North Pacific region, and promoted the refinement and revision of the correlation and dating of stratigraphic sequences and regional stages (Yanagisawa and Akiba, 1998; Gladenkov et al., 2000; Gladenkov, 2006; Koizumi et al., 2009). And the diatom biostratigraphy obtained from the investigation on DSDP Leg 19 drill cores in the subarctic North Pacific and dredged samples from the Bering Sea was revised based on the standard Miocene through Pleistocene diatom zonation refined in the middle-high latitudes North Pacific region (Barron and Gladenkov, 1995; Motoyama and Maruyama, 1998; Maruyama, 2000; Koizumi et al., 2009; Fig. 2).

Diatoms are most abundant and preserved above the diagenetic boundary opal-A/opal-CT (mentioned later; Fig. 5). Nine of diatom zones were identified at Site 183 near ODP Site 887 (Fig. 1), but the Denticulopsis katayamae Zone could not be identified because the marker species D. katayamae did not

Fig. 1. Localities of Sites 183-192 in Leg 19 of the Deep Sea Drilling Project, and Sites 882-884 and Site 887 in Leg 145 of the Ocean Drilling Program in the subarctic North Pacific Ocean including Bering Sea.

Fig. 2. Diatom zones and datum levels for zonal boundaries with absolute ages (Koizumi et al., 2009). Ages of zonal boundary are indicated in parentheses. Magnetochronology of Cande and Kent (1995; CK 95) and the epoch boundaries of Berggren et al. (1995; BKSA 95) were used in this paper. D.: Denticulopsis, C.: Crucidenticula, R.: Rouxia, N.: Neodenticula, A.: Actinocyclus, P.: Proboschia. F.: first occurrence, FC: first common or consistent occurrence, LC: last common or consistent occurrence, L.: last occurrence.
occur (Table 2, Fig. 3). The range of *D. katayamae* is 9.3-8.6 Ma (million years ago) and that of *D. praekatayamae* is 9.5-8.5 Ma (Motoyama and Maruyama, 1998). The zonal assignment to the sequences below the *D. dimorpha* Zone are unidentified, because the disorder of diatom datum levels occurs in the sequence. The last occurrence of *Neodenticula koizumii* at 2.0 Ma, which indicates the Pliocene/Pleistocene boundary, occurred at about 101 mbsf. And the first occurrence of *Thalassiosira oestrupii* at 5.5 Ma indicating the Miocene/Pliocene boundary was recognized at about 160 mbsf (Figs. 2 and 3).

At Site 192, located atop Meiji Guyot at the northwest end of the Emperor Seamount near ODP Sites 882-884, ten diatom zones, continuously from the *D. dimorpha* Zone through the *Neodenticula seminae* Zone were identified (Table 3, Fig. 4). However, the first occurrence of *D. dimorpha* was

---

**Fig. 3.** Ranges and abundances of stratigraphically important diatoms, and diatom zones at Site 183. White triangles on the right side of the range indicate the stratigraphically reliable positions.

**Fig. 4.** Ranges and abundances of stratigraphically important diatoms, and diatom zones at Site 192. White triangles on the right side of the range indicate the stratigraphically reliable positions.
Table 2. Occurrence of diatoms and diatom zones in the drilled cores at Site 183 of Leg 19 in the far northeast Pacific.
Table 3. Occurrence of diatoms and diatom zones in the drilled cores at Site 192 of Leg 19 in the far northwest Pacific.
not recognized. The Pliocene/Pleistocene boundary is situated at about 79 mbsf and the Miocene/Pliocene boundary at about 376 mbsf (Fig. 4).

3. Diatom zones recognized in the dredged samples from the Bering Sea

Fossil diatoms in the dredged samples from the Bering Sea have been reported twice, by Hanna (1929), and Baldauf and Barron (1987). The geological ages are obscure because of the absence of the zonal marker diatoms which latest diatom biostratigraphy define. Hanna (1970) indicated that the diatom assemblages from the Pribilof Islands of Bering Sea are similar to the Pliocene assemblages in Sakhalin Islands and Kamchatka, based on Sheshukova-Poretskaya (1967), which described systematically the Neogene diatoms from Kamchatka and Sakhalin, and identified five stratigraphic stages for the development of the far eastern marine Neogene diatoms: late Eocene-Oligocene, middle Miocene, late Miocene, Pliocene, and Pleistocene. Gladenkov (1994) recognized three diatom zones in the Olkhovian Formation distributed in the eastern Kamchatka: the late Pliocene Neodenticula koizumii Zone, the early Pleistocene Actinocyclus oculatus Zone, and the late Pleistocene Proboscia curvirostris Zone. These diatom assemblages may correspond to Pliocene in Sheshukova-Poretskaya (1967).

Diatoms are most abundant and well preserved in the samples 70-B52-1D; 70-B55-2D; 70-B55-2D3; 70-B56-3D1, 3D2 and 3D3; 70-B81-1D; 70-B92- 3D2; 70-B101-1D; 70-B111-1D1 (Table 4). These samples show zonal marker species constantly and sometimes in combination of several marker species, which are assigned to the zones above D. dimorpha Zone.

4. Uplift in diatom sedimentation after late Miocene

The diatom zoning after Denticulopsis dimorpha Zone, ranging from 10.0 Ma to 9.2 Ma, was confirmed in the diatomaceous sequences recognized in the drill cores at DSDP Sites 183 and 192. And the diatom zones, D. dimorpha Zone, Neodenticula kamtschatica Zone at 7.4-5.5 Ma, N. koizumii-N. kamtschatica Zone at 3.9-2.6 Ma, and N. koizumii Zone at 2.6-2.0 Ma, were exclusively recognized in the dredged samples from the Bering Sea. These zones coincide with the major increasing times in diatom mass accumulation rates (MARs), which Barron (1998) recognized on ODP Leg 145 cores. It means that, according to Barron (1998), the four major changes in diatom MARs occurred in response to cooling in the high latitudes after 10 Ma, and changing in surface and deep-water circulation due to shoaling of the Isthmus of Panama. The first change Event A (Barron, 1998) at about 9 Ma is characterized by a warming trend in the middle to high latitudes (Barron and Keller, 1983; Wright et al., 1992). The "carbonate crash", which is a widespread carbonate dissolution event throughout the equatorial Pacific, occurred between 10 and 9 Ma (Lyle et al., 1995). Event B at 6.2 Ma postdates a major cooling event in the high latitudes at about 6.5 Ma (Kennett, 1986) and also the 6.7 Ma onset of "latest Miocene-earliest Pliocene biogenic bloom", which is characterized by significant increases in both CaCO3 and opal MARs in the eastern equatorial Pacific (Farrell et al., 1995). In the western equatorial Pacific, biogenic carbonate sedimentation peaks at 6.6 Ma and declines steadily from 5 Ma (Berger et al., 1993). Event C at about 4.5 Ma occurs in the midst of the Thalassiosira oestrupii Zone at 5.5-3.5 Ma. Samples dredged from the Bering Sea were assigned to the interglacial interval from 4.5 to 2.4 Ma, and did not contain diatoms. A warmer paleotemperatures in the high latitudes and paleoceanographic changes which the shoaling of the Panama Isthmus caused obviously weakened diatom productivity in sub-boreal and boreal areas (Lagoe et al., 1993; Shackleton et al., 1995; Haug et al., 1995). Warm-water species in the Azpeitia nodulifera group, on the other hand, diverged during the warm period 4.5-3.5 Ma (Shiono and Koizumi, 2002b). Event D at 2.7 Ma is situated at the boundary between the Neodenticula koizumii-Neodenticula kamtschatica Zone and the N. koizumii Zone. After 2.7 Ma, diatom accumulation rates declined abruptly and coincidently with a major increase in ice rafted detritus in the high latitudes of the North Pacific, showing the onset of Northern Hemisphere glaciation (Haug et al., 1995; Prueher and Rea, 1998).
Table 4. Occurrence of diatoms and diatom zones in the dredged samples from the Bering Sea.

<table>
<thead>
<tr>
<th>Zone</th>
<th>Zone</th>
<th>Zone</th>
<th>Zone</th>
<th>Zone</th>
<th>Zone</th>
<th>Zone</th>
<th>Zone</th>
<th>Zone</th>
<th>Zone</th>
<th>Zone</th>
<th>Zone</th>
<th>Zone</th>
<th>Zone</th>
<th>Zone</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*Note: Detailed analysis and data available in the report.*
5. Age of the opal-A/opal-CT boundary

Throughout the drill cores from all sites occupied by DSDP Leg 19, diatom frustules are scattered and corroded, or altered and partly dissolved in mudstone which underlie diatomaceous ooze. X-ray diffraction analysis was tentatively carried out for several mudstone samples (Koizumi, 1973a). The presence of cristobalite, which the opal frustules of diatom were transformed, was recognized in 190-16, CC at 627 mbsf. The quartz was present below 191-12-1, 121cm at 526 mbsf, and a negligible amount of cristobalite and quartz occurred at 192-27, CC at 755 mbsf and 192-31, CC at 995 mbsf. Hein et al. (1978) observed textural and mineralogical properties of authigenic minerals in detail by using of EDAX (Energy Dispersive Analysis by X-rays) and SEM (Scanning Electron Microscope). They indicated that the biogeneic silica (opal-A) diagenetically transformed into opal-CT through a series of stages in 400-600 mbsf, and opal-CT formed in abundance near 600 mbsf. The upper boundary of intense silicification is marked as a regional acoustic reflector BSR, which mirrors the sea floor topography. The diagenetic front of silification moved upward along with migrating of the thermal boundary.

The ages so far assigned were revised by extrapolating the sedimentation rates based on diatom datum levels for the basal part of the lithologic unit A which represents diatom ooze to diatomaceous mud is estimated to be older than 10 Ma below the Denticulopsis dimorpha Zone at 210 mbsf of Site 183. The D. dimorpha Zone at 718 mbsf of Site 192 is estimated to be about 9.5 Ma. The Thalassiosira oestrupii Zone at 582 mbsf of Site 188, at 370 mbsf of Site 187, at 587 mbsf of Site 185 and at 599 mbsf of Site 184 is estimated to be in about 4.6 Ma. The Neodenticula koizumii-Neodenticula kamtschatica Zone at 521 mbsf of Site 191, at 618 mbsf of Site 190, at 541 mbsf of Site 189 and at 926 mbsf of Site 186 is to be about 3.2 Ma (Fig. 5). The diagenetic boundary between sediment layers containing biogenic opal-A and containing opal-CT forms distinctively diachronic plane in the subarctic North Pacific, as in the Japan Sea (Koizumi, 1992).

Fig. 5. Schematic columnar sections and the epoch based on diatom biostratigraphy, and diatom zone for the basal part of the lithologic unit A (Opal-A) underlay the unit B of mudstone with no diatom (Opal-CT). D.d: Denticulopsis dimorpha, N.koi-N.kam: Neodenticula koizumii-Neodenticula Kamtschatica, T.o: Thalassiosira oestrupii, T.y: Thalassiosira yabei.
6. Conclusion

Revised diatom biostratigraphy indicated the presence of early late Miocene Denticulopsis dimorpha Zone (10.0-9.2 Ma) at the basal part of diatomaceous mud in both Site 183 of the western side and Site 192 of the eastern side in the subarctic North Pacific. However, the Denticulopsis katayamae Zone could not recognized because of the disappearance of zonal marker species D. katayamae. Fifteen samples dredged from the Bering Sea are assigned to the Denticulopsis dimorpha Zone (10.0-9.2 Ma), Neodenticula kamtschatica-Neodenticula koizumii Zone (3.9-2.6 Ma), and N. koizumii Zone (2.7-2.0 Ma). These zonal times and the zoning in diatomaceous sequences in both Sites 183 and 192 correlate to the major increasing times in diatom mass accumulation rates after 10 Ma due to cooling in the high-latitudes and shoaling of the Panama Isthmus (Barron, 1998).

Revised diatom biostratigraphy indicated the distinctively diachronous plane for the diagenetic boundary between opal-A and opal-CT in the subarctic North Pacific Ocean.

Acknowledgment

Leg 19 of the Deep Sea Drilling in 1971 summer drilled at 11 sites in the subarctic North Pacific including the Bering Sea and I was one of the scientists on board the drillship Glomar Challenger. I am grateful of Dr. David W. Scholl of the U.S. Geological Survey and Prof. Joe S. Creager of the University of Washington, who invited me. I had experienced about two months life on board six times afterwards, and realized that based on the primary studies on the recovered core materials, succeeding researches had developed advanced stages of investigations and had resulted in a great contribute to our knowledge. I thank all friends and colleagues, whose efforts resulted in the succeeding programs for scientific drilling of the deep sea floor. The sample of ANTIPODE 37D was transferred from Dr. John Crow at the Scripps Institution of Oceanography, 70Anc 75 and samples of 70-B series were given from Drs. David M. Hopkins and David W. Scholl of the Pacific-Arctic Branch of Marine Geology, Geological Survey of USA. I am also grateful of all diatomists, whose contribution to the progress of Neogene diatom biostratigraphy in the North Pacific region is remarkable. I thank Editor Dr. Narumi Takahashi, and reviewers Drs. Shinichi Kuramoto of JAMSTEC and Jonaotaro Onodera of Kochi University for their suggestions for improvement that helped to make this a better paper.

Taxonomic references

All taxa used in this paper are documented. They are arranged alphabetically. The taxa which are treated in Hustedt (1927-1933, 1937, 1958) are referred directly to Hustedt (op. cit.). As for the taxa which are not treated in Hustedt, the references to the original descriptions as far as possible are made. References are chosen from the representative illustrations, and all illustrations documented by Koizumi (1973a) are revised. Stratigraphically important taxa are illustrated with figure numbers in brackets.

2) Actinocyclus ingens Rattray, 1890, p. 149, pl. 11, fig. 7; Koizumi, 1973a, p. 831, pl. 1, fig. 13. [Plate, Figure 21]
3) Actinocyclus ingens var. nodus Baldauf in Baldauf and Barron, 1980, p. 104, pl. 1, figs. 5-9; Koizumi and Matoba, 1989, pl. 1, fig. 15 = Actinocyclus ingens Rattray 1890; Koizumi, 1973a, pl. 1, fig. 14, pl. 2, figs. 1-2.
4) Actinocyclus ochotensis Jousé, 1968, p. 17, pl. 2, figs. 2-5; Koizumi, 1973a, p. 831, pl. 2, figs. 3-7; Sancetta, 1982, p. 224-225, pl. 1, figs. 4-6.
5) Actinocyclus octonarius Ehrenberg, 1838; Hendey 1964, p. 83, pl. 24, fig. 3 = Actinocyclus ehrenbergii Ralfs in Pritchard, 1861; Hustedt, 1929, p. 525, fig. 298; Koizumi, 1973b, pl. 20, fig. 11.
6) Actinocyclus oculus Jousé, 1968, p. 18, pl. 2, figs. 6-7; Koizumi, 1973a, pl. 2, figs. 8-9. [Plate, Figure 14]
7) Actinoptychus senarius (Ehrenberg) Ehrenberg, 1843; Hendey, 1964, p. 95, pl. 23, figs. 1-2; Sancetta, 1982, p. 225, pl. 1, fig. 7 = Actinocyclus undulatus (Bailey) Ralfs in Pritchard, 1861; Hustedt, 1929, p. 475, fig. 264; Koizumi, 1973b, pl. 20, figs. 2a-3b.
8) Asterolampra marylandica Ehrenberg, 1845; Hustedt, 1929, p. 485, figs. 270-271; Schrader, 1973, pl. 21, fig. 2; Koizumi, 1980, pl. 2, fig. 24.
9) Asteromphalus arachne (Brébisson) Ralfs in Pritchard, 1861; Hustedt, 1929, p. 493, fig. 276.
10) Asteromphalus darwinii Ehrenberg, 1844; Schmidt, 1876, pl. 38, fig. 16; Hanna, 1970, pl. 1, fig. 90; Koizumi, 1980, pl. 2, fig. 26.
11) Asteromphalus flabellatus (Brébisson) Greville, 1859; Hustedt, 1929, p. 498, fig. 279.
12) Asteromphalus robustus Castracane, 1875; Hustedt, 1929,
p. 496, fig. 278; Sancetta, 1982, p. 226, pl. 1, fig. 10; Koizumi, 1986, pl. 3, fig. 3.
13) Azpeitia endoi (Kanaya) P.A. Sims and G. Fryxell in Fryxell et al., 1986, p. 16; Shiono and Koizumi, 2002a, p. 68, pl. 1, figs. 1-6, pl. 3, figs. 1-3, pl. 6, fig. 1, pl. 7, fig. 1 = Coscinodiscus endoi Kanaya, 1959, p. 76, pl. 3, figs. 8-11; Koizumi, 1973a, pl. 2, fig. 10.
15) Bacillaria paradoxa Gmelin, 1788; Hustedt, 1928, p. 396, fig. 755 = Bacillaria pixillifer (Müller) Hendey, 1964, p. 274, pl. 21, fig. 5.
16) Bacteriosira fragilis Gran, 1900; Jousé, 1962, pl. 2, fig. 15; Sheshukova-Poretzkaya, 1967, p. 202, pl. 33, figs. 3a-b; Koizumi, 1975a, pl. 2, figs. 5-6; Sancetta, 1982, p. 227, pl. 2, figs. 1-4.
17) Biddulphia tuomeyi (Bailey) Roper, 1859; Hustedt, 1930, p. 834, fig. 491.
18) Cocconeis californica Grunow, 1881; Hustedt, 1933, p. 343, fig. 796; Sheshukova-Poretzkaya, 1967, p.269, pl. 45, fig. 1.
19) Cocconeis costata Gregory, 1855; Hustedt, 1933, p. 332, fig. 785; Sheshukova-Poretzkaya, 1967, p. 262, pl. 44, figs. 4a-b.
20) Cocconeis scutellum Ehrenberg, 1938; Hustedt, 1933, p. 337, fig. 790; Sheshukova-Poretzkaya, 1967, p. 264, pl. 44, fig. 7.
21) Cocconeis virtea Brun, 1891, p. 19, pl. 18, fig. 2; Kanaya, 1959, p. 110, pl. 10, fig. 6; Sheshukova-Poretzkaya, 1967, p. 271, pl. 45, figs. 3a-b (non fig. 3c).
22) Coscinodiscus elegans Greville, 1866; Kanaya, 1959, p. 75, pl. 3, figs. 6-7.
23) Coscinodiscus marginatus Ehrenberg, 1843; Cupp, 1943, p. 55, fig. 19; Sancetta, 1982, p. 228-229, pl. 2, fig. 10; Koizumi, 1986, p. 3, fig. 7 = Coscinodiscus marginatus Ehr. forma fossilis Jousé, 1961, p. 832, pl. 3, figs. 12-14.
24) Coscinodiscus oculus-iridis Ehrenberg, 1841; Hustedt, 1928, p. 454, fig. 252; Sancetta, 1982, p. 229, pl. 2, fig. 11.
26) Coscinodiscus pustulatus Mann, 1907, p. 257, pl. 48, fig. 3; Hanna, 1970, p. 185, figs. 12, 19-20, 23; Koizumi, 1973a, p. 832, pl. 4, figs. 1-4.
27) Coscinodiscus radiatus Ehrenberg, 1839; Cupp, 1943, p. 56, fig. 20; Sheshukova-Poretzkaya, 1967, p. 153, pl. 17, fig. 2; Hanna, 1970, p. 185, figs. 4, 8, 17.
28) Cosmiodiscus insignis Jousé, 1961, p. 67, pl. 2, fig. 8; Sheshukova-Poretzkaya, 1967, p. 175, pl. 25, fig. 2a-c; Hanna, 1970, p. 186, figs. 9-11, 30, 32; Koizumi, 1973a, p. 832, pl. 4, figs. 7-11. [Plate, Figure 23]
30) Crucidenticula nicobarica (Grunow) Akiba and Yanagisawa, 1986, p. 486, pl. 1, fig. 9, pl. 2, figs. 1-7, pl. 5, figs. 1-9; Yanagisawa and Akiba, 1990, p. 232, pl. 1, figs. 23-29.
32) Cyclotella striata (Kützing) Grunow, 1880; Hustedt, 1928, p. 344, fig. 176.
33) Cymatosira delbyi Temp. and Brun in Brun and Tempere, 1889, p. 36, pl. 7, figs. 18a-b; Sheshukova-Poretzkaya, 1967, p. 237, pl. 40, fig. 7, pl. 41, fig. 6.
35) Delphineis margalitalimbata (Mertz) Koizumi, 1992, p. 262 = Rhaphoneis margalitalimbata Mertz, 1966, p. 27, pl. 6, figs. 1-3; Koizumi, 1973b, pl. 20, fig. 18.
37) Denticulopsis dimorpha (Schrader) Simonsen, 1979, p. 64; Koizumi and Tanimura, 1985, pl. 1, fig. 1; Akiba and Yanagisawa, 1986, p. 488, pl. 15, figs. 1-25, pl. 16, figs. 1-11; Yanagisawa and Akiba, 1990, p. 254, pl. 4, figs. 40-54 = Denticula lauta Bailey, 1854; Koizumi, 1973a, pl. 5, figs. 24-28. [Plate, Figure 8]
38) Denticulopsis hyaline (Schrader) Simonsen, 1979; Koizumi and Tanimura, 1985, pl. 1, fig. 3; Akiba and Yanagisawa, 1986, p. 488, pl. 10, figs. 1, figs. 11, 14-16, pl. 11, figs. 1-10, pl. 12, figs. 1-5; Yanagisawa and Akiba, 1990, p. 240, pl. 2, figs. 14, 33-34, pl. 9, figs. 8-9. [Plate, Figure 9]
39) Denticulopsis katayamae Maruyama, 1984, p. 158, pl. 12, figs. 1a-6, pl. 17, figs. 1-13, 15-16, 18-23; Koizumi and Tanimura, 1985, pl. 1, figs. 5-6; Akiba and Yanagisawa, 1986, p. 489, pl. 17, figs. 1-3, 6, pl. 19, figs. 6-9, pl. 20, figs. 1, 4-5, 7; Yanagisawa and Akiba, 1990, p. 245, pl. 3, figs.
Denticulopsis lauta (Bailey) Simonsen, 1979; Akiba and Yanagisawa, 1986, p. 489, pl. 7, fig. 29, pl. 9, figs. 2-9; Koizumi and Matoba, 1989, pl. 1, fig. 5; Yanagisawa and Akiba, 1990, p. 235, pl. 2, figs. 6-8, 15, pl. 5, figs. 1-3, pl. 9, fig. 1.

Denticulopsis praedimorpha Barron in Akiba, 1982, p. 46, pl. 11, figs. 9a-16, 18-27b; Koizumi and Tanimura, 1985, pl. 1, fig. 2; Akiba and Yanagisawa, 1986, p. 489, pl. 13, figs. 1-28, pl. 14, figs. 1-12; Yanagisawa and Akiba, 1990, p. 249, pl. 4, figs. 1-24, 34-35, pl. 5, figs. 4-12, pl. 7, figs. 5-13, pl. 12, figs. 9-14.

Denticulopsis praehyalina Tanimura, 1989, p. 172, pl. 1, figs. 1-4, 6-9b, pl. 2, figs. 1-3b, 5-7; emend Yanagisawa and Akiba, 1990, p. 239, pl. 2, figs. 28-32, pl. 9, figs. 5-7.


Denticulopsis simonsenii Yanagisawa and Akiba, 1990, p. 242-243, pl. 3, figs. 1-3, pl. 11, figs. 1.5 = Denticulopsis hustedtii (Kanaya and Simonsen) Simonsen, 1979, p. 64; Koizumi and Tanimura, 1985, pl. 1, figs. 7-8.

Diploneis smithii (Brébisson) Cleve, 1894; Hustedt, 1937, p. 647, fig. 1051; Hendey, 1964, p. 225, pl. 32, fig. 32.

Eucampia balaustium Castracane, 1886; Hustedt, 1958, p. 136, pl. 5, figs. 40-43; Sheshukova-Poretzkaya, 1967, p. 209, pl. 34, figs. 2a-d.


Fragilariopsis oceanica (Cleve) Hasle, 1965, p. 11, pl. 1, figs. 15-19, pl. 2, figs. 6-9, pl. 3, figs. 1-2, pl. 16, figs. 1-2 = Nitzschia grunowii Hasle, 1972; Sancetta, 1982, p. 233, pl. 3, figs. 8-10; Koizumi and Tanimura, 1985, pl. 3, figs. 5-6; Nitzschia extincta Kozyrenko and Sheshuk in Sheshukova-Poretzkaya, 1967; Koizumi, 1972, p. 351, pl. 42, figs. 10a-11b; Koizumi, 1973b, pl. 20, figs. 16-17.

Goniotheicum tenue Brun, 1894; Sheshukova-Poretzkaya, 1967, p. 232, pl. 39, figs. 6a-b, pl. 40, figs. 5a-b; Koizumi, 1973a, p. 833, pl. 7, figs. 7-9.

Hemiaulus ambiguus Grunow, 1884, Hustedt, 1930, p. 876, fig. 520.

Hemidiscus cuneiformis Wallich, 1860; Hustedt, 1930, p. 904, fig. 542; Koizumi, 1975a, pl. 4, fig. 2.

Kisseleviella carina Sheshuk. 1962, Sheshukova-Poretzkaya, 1962, p. 206, figs. 2a-c, pl. 1, figs. 1a-b; Sheshukova-Poretzkaya, 1967, p. 236, pl. 40, figs. 6a-c, pl. 41, figs. 5a-c; Koizumi, 1973a, p. 833, pl. 7, figs. 3-4.

Lithodesmium undulatum Ehrenberg, 1840; Hustedt, 1930, p. 789, fig. 461; Cupp, 1943, p. 150, fig. 108; Hanna, 1970, p. 190, fig. 91.

Mediaria splendida Sheshuk. 1962, Sheshukova-Poretzkaya, 1962, p. 210, fig. 5, pl. 1, figs. 2; Sheshukova-Poretzkaya, 1967, p. 306, pl. 47, fig. 14, pl. 48, fig. 8; Koizumi, 1973a, p. 833, pl. 7, figs. 5-6.

Melosira albicans Sheshuk. 1964, Sheshukova-Poretzkaya, 1964, p. 69, figs. 1-2, pl. 1, fig. 3; Sheshukova-Poretzkaya, 1967, p. 124, pl. 10, figs. 2a-b, pl. 11, figs. 1a-b; Koizumi, 1972, p. 351, pl. 43, figs. 1-2.

Neodenticula kamtschatica (Zabelina) Akiba and Yanagisawa, 1986, p. 490, pl. 21, figs. 7-21, pl. 22, figs. 1-12; Yanagisawa and Akiba, 1990, p. 259, pl. 7, figs. 27-37 = Denticulopsis hustedtii (Kanaya and Simonsen) Simonsen, 1979; Koizumi and Tanimura, 1985, pl. 6, fig. 7; Denticula kamtschatica Zabelina, 1934; Koizumi, 1973a, p. 832, figs. 14-17.

Neodenticula koizumii Akiba and Yanagisawa, 1986, p. 491, pl. 21, figs. 22-28, pl. 23, figs. 1-12, pl. 24, fig. 19; Yanagisawa and Akiba, 1990, p. 262, pl. 7, figs. 389-44 = Denticula seminae Simonsen and Kanaya, 1961; Koizumi, 1973a, p. 832, pl. 5, figs. 7-13.

Neodenticula seminae (Simonsen and Kanaya) Akiba and Yanagisawa, 1986, p. 491, pl. 24, figs. 1-11, pl. 26, figs. 1-10; Yanagisawa and Akiba, 1990, p. 263, pl. 7, figs. 45-49 = Denticula seminae Simonsen and Kanaya, 1961; Koizumi, 1973a, p. 832, pl. 5, figs. 1-6 (non figs. 7-13).

Nitzschia challengeri Burckle in Akiba, 1982, p. 46, pl. 11, figs. 15-19, pl. 2, figs. 6-9, pl. 3, figs. 1-2, pl. 16, figs. 1-2 = Nitzschia grunowii Hasle, 1972; Sancetta, 1982, p. 233, pl. 3, figs. 8-10; Koizumi and Tanimura, 1985, pl. 3, figs. 5-6; Nitzschia extincta Kozyrenko and Sheshuk in Sheshukova-Poretzkaya, 1967; Koizumi, 1972, p. 351, pl. 42, figs. 10a-11b; Koizumi, 1973b, pl. 20, figs. 16-17.


Nitzschia reinholdii Burckle, 1972, p. 240, pl. 2, figs. 17-20; Schrader, 1973, pl. 4, figs. 20-23; Koizumi, 1980, pl. 3, figs. 9-10.

63) Nitzschia rolandii (Grunow in Van Heurck, 1880-1881; Hustedt, 1927, p. 100, figs. 1-2; Schrader, 1973, p. 708, pl. 5, figs. 31, 42, pl. 26, figs. 3-4; Yanagisawa and Akiba, 1990, p. 258, pl. 7, figs. 17-26 = Nitzschia rolandii Schrader emend. Koizumi, 1980, p. 396, pl. 2, figs. 15-20; Akiba and Yanagisawa, 1986, pl. 21, figs. 1-6. [Plate, Figure 3]

64) Nitzschia sukeoensis Koizumi, 1980, p. 394, pl. 1, figs. 1-6.

65) Odontella aurita (Lyngbye) Agardh, 1830; Sancetta, 1982, p. 234, pl. 3, figs. 11-12; Koizumi, 1986, pl. 3, fig. 2.


70) Proboscia alata (Brightwell) Sundström, 1986; Jordan et al., 1991, p. 65, figs. 1-9; Takahashi et al., 1994, p. 413, figs. 2-7.


72) Proboscia curvirostris (Joussé) Jordan and Priddle, 1991, p. 57, figs. 5-7; Akiba and Yanagisawa, 1986, p. 297, pl. 42, figs. 1-2, pl. 45, figs. 1-6 = Rhizosolenia curvirostris Joussé, 1968; Koizumi, 1973a, pl. 5, figs. 29-33. [Plate, Figure 13]

73) Proboscia praebarboi (Schrader) Jordan and Priddle, 1991, p. 57, figs. 8-9; Akiba and Yanagisawa, 1986, p. 497, pl. 42, figs. 8-9, pl. 43, figs. 1-9.

74) Pseudoeunotia elegans Sheshuk. 1964, Sheshukova-Poretzkaya, 1964, p. 75, fig. 3, pl. 2, figs. 4-5; Sheshukova-Poretzkaya, 1967, p. 178, pl. 24, fig. 3, pl. 25, fig. 4; Koizumi, 1973a, pl. 4, fig. 14; Sancetta, 1982, p. 236, pl. 4, figs. 1-2.

75) Pterotheca kittoniana (Grunow) Forti var. kantschatica Gaponov, 1927; Sheshukova-Poretzkaya, 1967, p. 229, pl. 39, figs. 3a-f.

76) Pterotheca subalata Grunow in Van Heurck, 1880-1881; Sheshukova-Poretzkaya, 1967, p. 230, pl. 39, fig. 4, pl. 40, fig. 3.

77) Rhabdonema arcuatum (Lyngbye) Kützing, 1844; Hustedt, 1931, p. 20-22, fig. 549-550; Hendey, 1964, p. 279, pl. 35, figs. 10-12.

78) Rhabdonema japonicum Temp. and Brun in Brun and Tempère, 1889, p. 53, pl. 1, fig. 6; Sheshukova-Poretzkaya, 1967, p. 258, pl. 43, fig. 14, pl. 44, figs. 1a-d; Hanna, 1970, p. 192, figs. 47, 92-93, 95.


80) Rhizosolenia hebetata (Bailey) Gran, 1904; Hustedt, 1929, p. 588, fig. 337; Koizumi, 1973a, pl. 5, figs. 34-35; Sancetta, 1982, p. 237, pl. 4, figs. 5-6 = Rhizosolenia sp. a, Koizumi, 1973a, p. 833, pl. 5, fig. 39; Rhizosolenia sp. c, Koizumi, 1973a, p. 833, pl. 5, figs. 37-38; Rhizosolenia sp. e, Koizumi, 1973a, p. 833, pl. 5, fig. 39.


82) Rhizosolenia styliformis Brightwell, 1858; Hustedt, 1929, p. 584, fig. 333-335; Koizumi, 1975a, pl. 1, fig. 33; Sancetta, 1982, p. 238, pl. 4, figs. 7-8.

83) Rouxia californica Peragallo in Tempère and Peragallo, 1910; Hanna, 1930, p. 186, pl. 14, figs. 6-7; Schrader, 1973, p. 710, pl. 3, figs. 18-20, 22, 26 = Rouxia peragalli Brun and Herib. forma californica (Perag.) Sheshuk, 1967, Sheshukova-Poretzkaya, 1967, p. 295, pl. 43, fig. 19, pl. 73, figs. 5a-b; Koizumi, 1973a, p. 833, pl. 7, fig. 11. [Plate, Figure 19]

84) Rouxia naviculoides Schrader, 1973, p. 710, pl. 3, figs. 27-32.

85) Stellaria stellaris (Roper) Hasle and Sims, 1986, p. 111 = Coscinodiscus stellaris Roper; Sancetta, 1982, p. 229, pl. 2, fig. 12; Coscinodiscus stellaris var. symbolophora (Grunow) Jørgensen, 1958; Koizumi, 1973a, pl. 5, figs. 4-5-6.

86) Stephanodiscus astraea (Ehrenberg) Grunow, 1880, Hustedt, 1927, p. 100, fig. 85.

87) Stephanogonia polygona Ehrenberg, 1844; Sheshukova-Poretzkaya, 1967, p. 231, pl. 40, fig. 4.

88) Stephanopyxys horrida Koizumi, 1972, p. 348, pl. 42, figs. 1a-2b; Koizumi, 1973a, pl. 6, figs. 1-4 = Stephanopyxys schenckii Kanaya, 1959; Koizumi, 1973a, pl. 6, figs. 11-12.

89) Stephanopyxys inermis Joussé, 1961, p. 60, pl. 1, fig. 2, pl. 3, figs. 1-2; Sheshukova-Poretzkaya, 1967, p. 135, pl. 11, figs. 5a-b; Koizumi, 1973a, p. 833, pl. 6, figs. 5-10.

Thalassiosira convexa
Koizumi, 1973a, p. 834, pl. 8, figs. 1-2; Sancetta, 1982, p. 242, pl. 5, figs. 4-5.

104) *Thalassiosira jacksonii* Koizumi and Barron in Koizumi, 1980, p. 396, pl. 1, figs. 11-14. [Plate, Figure 20]

105) *Thalassiosira kryophila* (Grunow) Jørgensen, 1905; Sheshukova-Poretzkaya, 1967, p. 146, pl. 14, fig. 6; Koizumi, 1973a, p. 834, pl. 8, fig. 3.


108) *Thalassiosira manifesta* Sheshuk. 1964, Sheshukova-Poretzkaya, 1964, p. 72, pl. 1, figs. 6-7; Sheshukova-Poretzkaya, 1967, p. 147, pl. 14, figs. 9a-b; Koizumi, 1975a, pl. 5, fig. 6.

109) *Thalassiosira minatissima* Oreshkina in Barron and Gladenkov, 1995, p. 17, figs. 8a-d. [Plate, Figures 15-16]


111) *Thalassiosira nidulans* (Tempère and Brun) Jousé, 1961, p. 63, pl. 3, figs. 4-5; Sheshukova-Poretzkaya, 1967, p. 140, pl. 11, figs. 8a-b; Koizumi, 1973a, pl. 7, figs. 25-26. [Plate, Figure 12]

112) *Thalassiosira nodensköldii* Cleve, 1875; Hasle, 1968, p. 196, figs. 2, 4, 8; Koizumi, 1973a, p. 834, pl. 8, fig. 4; Sancetta, 1982, p. 243, pl. 5, figs. 8-9.

113) *Thalassiosira oestrupii* (Ostenfeld) Proskina-Lavrenko, 1956; Jousé, 1968, p. 13, figs. 3-7; Koizumi, 1973a, p. 834, pl. 7, fig. 27; Shiono and Koizumi, 2000, p. 361, figs. 25-27, 31-33, 35, 37-38. [Plate, Figure 22]


115) *Thalassiosira punctata* Jousé, 1961, p. 64, pl. 1, figs. 7-9; Sheshukova-Poretzkaya, 1967, p. 151, pl. 14, fig. 10, pl. 17, figs. 1a-b; Hanna, 1970, p. 194, figs. 5-6; Koizumi, 1973a, p. 834, pl. 8, figs. 7-9.


117) *Thalassiosira trifulta* Fryxell in Fryxell and Hasle, 1979, p. 16, figs. 1-24; Sancetta, 1982, p. 244, pl. 5, figs. 10-12, pl. 6, figs. 1-2; Koizumi and Tanimura, 1985, pl. 3, fig. 7; Shiono and Koizumi, 2000, p. 378, figs. 61, 63-66 =
coscinodiscus excentricus Ehrenberg, 1839; Koizumi, 1973a, pl. 2, figs. 11-12; Coscinodiscus excentricus Eh. var. fasciculata Hustedt, 1928; Koizumi, 1973a, p. 831, pl. 2, figs. 13-16; Coscinodiscus excentricus Eh. var. jousei Kanaya in Kanaya and Koizumi, 1966; Koizumi, 1973a, p. 832, pl. 3, figs. 1-6; Coscinodiscus excentricus Eh. var. leasareolatus Kanaya in Kanaya and Koizumi, 1966; Koizumi, 1973a, p. 832, pl. 3, figs. 7-11.

118) Thalassiosira undulosa (Mann) Sheshu. 1967, Sheshukova-Poretzkaya, 1967, p. 148, pl. 16, figs. 1a-c; Koizumi, 1973a, pl. 8, figs. 5-6.

119) Thalassiosira usatschevii Jousé, 1961, p. 64, pl. 3, fig. 6; Sheshukova-Poretzkaya, 1967, p. 150, pl. 15, figs. 3a-d; Koizumi, 1973a, p. 834, pl. 8, figs. 13-15.

120) Thalassiosira yabei (Kanaya) Akiba and Yanagisawa, 1986, p. 493, pl. 27, figs. 1-2, pl. 28, figs. 1-9; Tanimura, 1996, p. 186, figs. 65-70.

121) Thalassiosira zabelinae Jousé, 1961; Sheshukova-Poretzkaya, 1967, p. 149, pl. 16, figs. 2a-d; Koizumi, 1973a, p. 834, pl. 8, figs. 10-12.

122) Thalassiothrix longissima Cleve and Grunow, 1880; Hustedt, 1932, p. 247, fig. 726; Sheshukova-Poretzkaya, 1967, p. 250, pl. 42, fig. 11; Koizumi, 1973a, p. 8, fig. 16; Sancetta, 1982, p. 245, pl. 6, figs. 3-4.

123) Trachyneis aspera (Ehrenberg) Cleve, 1894; Hendey, 1964, p. 236, pl. 29, fig. 13.


125) Trochosira spinosa Kitton, 1870-1871; Sheshukova-Poretzkaya, 1967, p. 137, pl. 11, figs. 6a-b, pl. 13, figs. 4a-b.
Stratigraphically important diatom taxa in the drill cores from DSDP Sites 183 and 192 are illustrated.

1. *Synedra jouseana* Sheshuk.; DSDP 183-18-2, 81 cm,
2. *Neodenticula seminac* (Simonsen and Kanaya) Akiba and Yanagisawa; DSDP 184-2, 3 cm,
3. *Nitzschia rolandi* Schrader; DSDP 192-23, CC,
4. *Neodenticula kamtschatica* (Zabelina) Akiba and Yanagisawa; DSDP 183, 18-2, 81 cm,
5. *Neodenticula koizumii* Akiba and Yanagisawa; DSDP 183-11-3, 81 cm,
6. *Denticulopsis praehyalina* Tanimura; DSDP 183-20, CC,
7. *Denticulopsis praekatayamae* Yanagisawa and Akiba; DSDP 183-19-2, 81 cm,
8. *Denticulopsis dimorpha* (Schrader) Simonsen; DSDP 183-19-2, 81 cm,
9. *Denticulopsis hyalina* (Schrader) Simonsen; DSDP 183-20, CC,
10. *Denticulopsis simonsenii* Yanagisawa and Akiba; DSDP 183-19-2, 81 cm,
11. *Denticulopsis katayamae* Maruyama; DSDP 192-24-2, 20 cm,
12. *Thalassiosira nidulus* (Temp. and Brun) Jousé; DSDP 192-9, CC,
13. *Proboschia curvirostris* (Jousé) Jordan and Priddle; DSDP 192-4-5, 16 cm,
14. *Actinocyclus oculatus* Jousé; DSDP 183-9-3, 131 cm,
15-16. *Thalassiosira minutissima* Oreshkina; DSDP 192-24, CC,
17. *Thalassionea hirosakiensis* (Kanaya) Schrader; DSDP 183-18-2, 81 cm,
18. *Thalassionea schraderi* Akiba; DSDP DSDP 183-18-3, 81 cm,
19. *Rouxia californica* Peragallo; DSDP 183-18, CC,
20. *Thalassiosira jacksonii* Koizumi and Barron; DSDP 192-18-2, 50 cm,
21. *Actinocyclus ingens* Rattray; DSDP 183-20-1, 141 cm,
22. *Thalassiosira oestrupii* (Ostenfeld) Proshkina-Lavrenko; DSDP 192-8-1, 136 cm,
23. *Cosmiodiscus insignis* Jousé; DSDP 192-20-1, 30 cm.
References


Barron, J.A. (2003), Planktonic marine diatom record of the past 18 m.y.: appearances and extinctions in the Pacific and Southern Oceans. Diatom Research, 18, 203-224.


Hustedt, F. (1930), Die Kieselalgen Deutschland, Oeserreichs und der Schweiz unter Berücksichtigung der übrigen
Länder Europas sowie der angrenzenden Meeresgebiete. 

Hustedt, F. (1931), Die Kieselalgen Deutschlands, Oesterreichs und der Schweiz unter Berücksichtigung der übrigen Länder Europas sowie der angrenzenden Meeresgebiete. 

Hustedt, F. (1932), Die Kieselalgen Deutschlands, Oesterreichs und der Schweiz unter Berücksichtigung der übrigen Länder Europas sowie der angrenzenden Meeresgebiete. 

Hustedt, F. (1933), Die Kieselalgen Deutschlands, Oesterreichs und der Schweiz unter Berücksichtigung der übrigen Länder Europas sowie der angrenzenden Meeresgebiete. 

Hustedt, F. (1937), Die Kieselalgen Deutschlands, Oesterreichs und der Schweiz unter Berücksichtigung der übrigen Länder Europas sowie der angrenzenden Meeresgebiete. 


Kanaya, T. (1959), Miocene diatom assemblages from the Onnagawa Formation and their distribution in correlative formations in northeast Japan. Science Reports of the Tohoku University, 2nd Ser., 30, 1-130.


Koizumi, I. (1986), Pliocene and Pleistocene diatom levels


Sheshukova-Poretzkaya, V.S. (1962), New and rare Bacillariophyta from diatom suite of North Sakhalin. *Leningrad University, Biological Institute, Ser. Biology, 49*, 203-211.

Sheshukova-Poretzkaya, V.S. (1964), New and rare diatoms from the Neogene of Sakhalin and Kamtschatka. *Novitates*


