Taxonomy and Morphostructure of Late Neogene Diatoms from Maud Rise (Antarctic Ocean)

By Rainer Gersonde

Summary: Based on light microscopic (LM) and scanning electron microscopic (SEM) observations late Neogene diatom taxa of the genera Nitzschia, Rhizosolenia and Thalassiosira that were recovered during RV "Polarstern" cruise ANT IV/4 with gravity and piston cores on the Maud Rise (SE Weddell Sea) are described and discussed. Five Nitzschia species (N. arenata, N. auricula, N. barrantii, N. lacuum, N. prasina), two Thalassiosira species (T. complicata, T. incrusta), and Rhizosolenia costata are described new. Some of the treated taxa are useful stratigraphic markers. Their stratigraphic range in the southern high latitudes is described and their significance for paleoceanographic reconstructions is briefly discussed.


1. INTRODUCTION

Pioneer studies on marine fossil and subfossil diatoms from the southern high-latitude Ocean were accomplished by HEIDEN & KOLBE (1928), and JOUSE et al. (1962) on surface sediment samples recovered in the Indian sector of the Antarctic Ocean. In 1970 DONAHUE submitted a PhD-dissertation on the paleoclimatic significance of Pleistocene diatoms from high-latitudes of the Pacific Ocean including a series of species descriptions with photographic documentations. Unfortunately these descriptions were never published, nor were holotypes or type levels defined. Thus, according to the rules of the International Code of Botanical Nomenclature (GREUTER et al. 1988) these descriptions are not valid. More comprehensive investigations on the taxonomy of marine Neogene and Quaternary diatoms from the Southern Ocean were included by MCCOLLUM (1975), SCHRADER (1976), GOMBOS (1977), CIESIELSKI (1983), and GOMBOS & CIESIELSKI (1983) in their primarily biostratigraphically orientated studies on Deep Sea Drilling Project (DSDP) cores. Especially SCHRADER (1976) contributed to the knowledge of Neogene diatom taxa from the Antarctic Ocean by describing 24 well-documented new taxa, and by illustrating a number of undescribed forms. More specialized contributions by GOMBOS (1974), BRADY (1977), and HENDEY (1981) focused at the description and the documentation of Neogene Antarctic diatom taxa. Recent studies of sediment cores recovered during Ocean Drilling Program (ODP) Legs in the Southern Ocean that were accomplished by Gersonde (1990) on Leg 113 material, and by BALDAUF & BARRON (in press) on Leg 119 sections, resulted in the description of new Neogene diatom taxa ranging in the Miocene.

The present study is focused at the description and documentation of diatom taxa occurring in late Neogene sediment cores that were recovered in 1986 during expedition ANT IV/4 with RV „Polarstern“. The investigated sample material originates in cores, which were gathered on Queen Maud Rise, an isolated topographic elevation located in the deep sea area off Dronning Maud Land and covered by pelagic Cenozoic sediments. In 1987 these sediments were cored successfully at two sites (Sites 689 and 690) during ODP Leg 113 with the drillship „JOIDES Resolution“ (BARKER, KENNETT et al. 1988). The well-preserved sediment sections gathered during Leg 113 allowed the establishment of an integrated diatom and geomagnetic stratigraphy for the Neogene time period (Gersonde & BURCKLE 1990, Gersonde et al. 1990). Based on the integrated stratigraphy Neogene diatom species ranges could be accurately tied to the geomagnetic time scale. Some of the taxa newly described or documented in the present paper are used as important stratigraphic marker species and are nominate species.

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Manuscript received: 08. 08.1990; accepted: 15. 09.1990
of diatom zones established by GERSONDE & BURCKLE (1990), e.g. *Nitzschia barronii* sp. nov. and *Thalassiosira inura* sp. nov. The stratigraphic ranges, the first appearance datum (FAD) and last appearance datum (LAD), and the paleoceanographic significance of the studied taxa is presented and summarized in this paper (Fig. 1).

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**Fig. 1:** Stratigraphic ranges of discussed taxa, correlated with the geomagnetic time scale and the Neogene diatom zonations proposed by GERSONDE & BURCKLE (1990) and BALDAUF & BARRON (in press). Stippled boxes indicate the range of uncertain age assignment for zonal boundaries. The geomagnetic time scale and absolute ages are from BERGGREN et al. (1985) and the nomenclature of geomagnetic events follows that of SPIESS (1990).
2. MATERIAL AND METHODS

The material used for the present study originates in two sediment cores. Core PS1458-2 was recovered with a gravity core at 65°59.34’S, 1°51.54’E at a water depth of 2487 m. The core has a length of 5.22 m and penetrates at its base upper Pliocene sediments (Nitzschia interfrigida/Cosmiodiscus insignis diatom Zone, Fig. 1). Piston core PS1467-1 was gathered at 64°06.51’S, 1°18.36’E in 3550 m of water. The core length is 10.99 m. The core interval between 1.6 mbsf (meters below sea floor) and the core base covers a time interval ranging in the early Pliocene (upper Cosmiodiscus intersectus to lowermost Nitzschia interfrigida/Cosmiodiscus insignis Zone, Fig. 1). For further stratigraphic details of the cores the reader is referred to ABELMANN et al. (1990).

The cleaning of the sediment samples, preparation of permanent mounts (using the resin Mountex, nd = 1.67) for light microscopy (LM) and scanning electron microscopy (SEM) investigations were accomplished according to the methods described by ABELMANN et al. (in prep.). Light microscopical investigations were made with a Leitz Orthoplan microscope with apochromatic optics. Micrographs were made with an automatic Leitz Orthomat camera. The scanning electron microscope investigations were completed with a Philips SEM 515.

Measurements of the diatom valve structure and the terminology for the siliceous components follows the suggestions given by ANONYMUS (1975) and ROSS et al. (1979). For the description of one Rhizosolenia species an amended terminology proposed by SUNDSTRÖM (1986) is used. Types were marked on LM-slides with a diamon marker and are deposited at the Friedrich-Hultetal Diatom Collection at the Alfred Wegener Institute for Polar and Marine Research, Bremerhaven.

3. DESCRIPTION OF DIATOM TAXA

Genus Nitzschia Hassall

A comprehensive study of the taxonomy and morphology of the genus Nitzschia was achieved by Hasle (1964, 1965a, b), based on extensive light and electron microscope investigations.

Nitzschia arcula sp. nov. (Pl. 2, Fig. 4; Pl. 4, Fig. 4; Pl. 5, Figs. 1-6)

Description: Valve linear oblong, isopolar. Apices obtusely rounded. Apical axis 15 - 43 µm, transapical axis 3.5 - 8 µm (Fig. 2). Transapical interstriae generally straight and heavily silicified (Pl. 2, Fig. 4). Interstriae next to apices slightly curved and branched towards the apices, 8 - 14 intersstriae in 10 µm (Fig. 3). Striae with two or three rows of regular to irregular spaced poroids (32 - 40 in 10 µm) (Pl. 4, Fig. 4). Raphe, located in the junction between valve face and mantle. Central nodule absent (Pl. 4, Fig. 4). Generally number of fibulae as number of

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Fig. 2: Length - width ratio of Nitzschia arcula.

Abb. 2: Längenbreiten-Verhältnis von Nitzschia arcula.
interstriae, or inconsiderably greater (Pl. 2, Fig. 4).

Holotype: Deposited in the Friedrich-Hustedt Collection No. Zu 4/3 (Pl. 5, Fig. 1).

Type locality: Core PS1467-1, Maud Rise, southeast Weddell Sea.

Type level: Marine early Pliocene, Sample PS1467-1, 804 cm.

Paratype: Deposited in the Friedrich-Hustedt Collection No. Zu 4/3 (Pl. 5, Fig. 3) from Sample PS1467-1, 804 cm.

Stratigraphic occurrence: In the Cosmiodiscus intersectus, Thalassiosira inula and the lower portion of the Nitzschia barronii diatom Zones (late late Miocene to early Pliocene, Fig. 1) (GERSONDE & BURCKLE 1990).

Derivation of name: arcula (Latin) = small box.

Discussion and remarks: N. arcula differs from the Pliocene species N. pseudocylindrica Schrauder described from the Norwegian Sea area (in SCHRADER & FENNER 1976, p. 992, pl. 1, figs. 3-5, 12, 15-18) by its more heavily silicified interstriae and the strial structure. The striae of N. pseudocylindrica consist of one row of poroids. N. arcula differs from N. cylindrus (Grun.) Hasle (description in HASLE 1965b, p. 34, pl. 12, figs. 6 - 12; pl. 14, figs. 1 - 10; pl. 17, figs. 2 - 4 as Frugilariapaceus cylindrus) by its coarser valve interstitial and strial structure. N. arcula differs from N. linearis (Cast.) Hasle (description in HASLE 1965b, p. 37, pl. 12, fig. 17; pl. 15, figs. 9 - 11 as Fragilariapaceus linearis) by its generally smaller valve length and its more delicate strial and interstitial structure.

Nitzschia arcula

![Diagram of Nitzschia arcula](image)

Fig. 3: Correlation between valve length and number of interstriae in 10 μm of Nitzschia arcula.

Nitzschia aurica sp. nov.

(Pl. 1, Figs. 18 - 25; Pl. 3, Figs. 5; Pl. 4, Figs. 5, 6; Pl. 7, Fig. 6)

Description: Valve broadly elliptical to subcircular, isopolar, few specimens very slightly heteropolar. Apices broadly rounded. Apical axis 7 - 31 μm, transapical axis 4.5 - 10 μm, length and width positively correlated (Fig. 4). Transapical interstriae straight in the middle portion of valve face and distinctly curved towards the apices. 9 - 16 in 10 μm, number of interstriae negatively correlated with valve length (Fig. 5). Interstriae next to apices branched towards apices (Pl. 4, Figs. 5, 6). Striae with one or two rows of regular to irregular spaced poroids (in general 30 - 40 in 10 μm), in the median area of the valve often discontinuous, leading to small hyaline fields (Pl. 4, Figs. 5, 6). Raphe eccentric, located in the junction between valve face and mantle, Central nodale absent (Pl. 7, Fig. 6). Number of fibulae as number of interstriae or slightly smaller. Near apices often number of interstriae greater than number of fibulae.
*Nitzschia aurica*

![Graph](image1.png)

**Fig. 4**: Length - width ratio of *Nitzschia aurica*.

**Abb. 4**: Längen/Breiten-Verhältnis von *Nitzschia aurica*.

![Graph](image2.png)

**Fig. 5**: Correlation between valve length and number of interstriae in 10 μm of *Nitzschia aurica*.

**Abb. 5**: Korrelation zwischen Schalenlänge und Anzahl der Interstriae in 10 μm von *Nitzschia aurica*.

Holotype: Deposited in the Friedrich-Hustedt Collection No. Zu 4/3 (Pl. 1, Fig. 19).
Type locality: Core PS1467-1, Maud Rise, southeast Weddell Sea.
Type level: Marine early Pliocene, Sample PS1467-1, 804 cm.
Paratype: Deposited in the Friedrich-Hustedt Collection No. Zu 4/3 (Pl. 1, Fig. 20) from Sample PS1467-1, 804 cm.

Stratigraphic occurrence: Trace in the *Nitzschia praecurta* and *Asteromphalus kennettii* diatom Zones (early late Miocene) and consistent in the *Cosmodiscus intersectus*, *Thalassiosira inara* and the lower portion of the *Nitzschia barronii* diatom Zones (late late Miocene to early Pliocene, Fig. 1) (GERSONDE & BURCKLE 1990).

Derivation of name: After my daughter Aurica.

Discussion and remarks: *N. aurica* is distinct from *N. praecurta* by its elliptical to subcircular valve shape. Both species have similar stratigraphic ranges (Fig. 1) but their abundance pattern is different (GERSONDE &
Nitzschia barronii sp. nov. (Pl. 3, Fig. 6; Pl. 4, Figs. 1 - 3; Pl. 5, Figs. 7 - 17)

**Fragilariopsis lanceolata nom. nud. DONAHUE 1970**, p. 190, pl. 7, figs. m-p

**Nitzschia angulata** nesc. (O'Meara) Hasle, BARRON 1985, p. 267, fig. 14.13,14

Description: Valve outline variable elliptical to rhombic, isopolar or slightly heteropolar. Heteropolar specimen tapering more to one apex. Apical axis 13 - 52 μm, transapical axis 6 - 17 μm at widest point. Length and width positively correlated, length/width ratio in average 2.3 (Fig. 6). Transapical interstriae heavily silicified, straight to slightly oblique in middle of valve face and curved towards the apices, 7 - 11 in 10 μm. Number of interstriae in 10 μm and negatively correlated with valve length (Fig. 7). Striae in apical sectors of valve face with two rows of regular spaced poroids (in general 17 - 18 in 10 μm, total range 13 - 26 in 10 μm) located close to interstriae (Pl. 4, Figs. 1 - 3). Striae in central part of valve face with one or two rows of regular to irregularly spaced poroids, often discontinuous, leading to hyaline, non-perforated fields (Pl. 3, Fig. 6; Pl. 4, Fig. 2). Raphe eccentric, located in the junction between valve face and valve mantle. Valve mantle low, hyaline. Central nodule absent (Pl. 4, Fig. 1). Number of fibula as number of interstriae or considerably smaller.

Holotype: Deposited in the Friedrich-Hustedt Collection No. Zu 4/7 (Pl. 5, Fig. 14).

Type locality: Core PS1467-1, Maud Rise, southeast Weddell Sea.

Type level: Marine early Pliocene, Sample PS1467-1, 200 cm.

Paratype: Deposited in the Friedrich-Hustedt Collection No. Zu 4/6 (Pl. 5, Fig. 13) from Sample PS1467-1, 200 cm.

Stratigraphic occurrence: Nominate species of the early Pliocene N. barronii diatom Zone of GERSONDE & BURCKLE (1990). FAD, at ca. 4.2 - 4.1 Ma, defines the base of the N. barronii diatom Zone; LAD in the lower portion of the Actinozygma ingens Zone (early Pleistocene, Fig. 1) (GERSONDE & BURCKLE 1990, BALDAUF & BARRON in press).
Discussion and remarks: Nitzschia barronii has affinities to Nitzschia angulata (O'Meara) Hasle considering the valve outline and the arrangement of the interstriae (for a comprehensive description of N. angulata, syn. Fragilaropsis rhombica see HASLE 1965b, p. 24). N. barronii differs from N. angulata by its distinct coarser striatal structure and the presence of hyaline, non-perforated areas on the valve face.

Both, N. angulata and N. barronii are endemic to the Southern Ocean. However, while N. angulata is a prominent extant species, N. barronii is extinct. Probably N. barronii is a phylogenetic precursor of N. angulata. However, a phylogenetic transition between both taxa could not yet be documented.

Another taxon close to N. barronii is Nitzschia sp. A (Pl. 5, Fig. 21). This heteropolar taxon differs from N. barronii by its valve shape: the more lanceolate outline and a length/width ratio > 4.0 (Fig. 6). Its apical interstriae are less curved. Nitzschia sp. A will be described in more detail in a separate paper.

N. barronii is probably conspecific with N. angulata, the nominate species of the N. angulata diatom Zone defined by WEAVER & GOMBOS (1981). Unfortunately WEAVER & GOMBOS did not photographically document the species, nor was this done by CIESIELSKI (1983), who also used the FAD of a N. angulata. In a compilation of Neogene diatom biostratigraphies and biostratigraphic marker species BARRON (1985) labels a species as N. angulata which, based on its photographically documented outline (fig. 14.13, 14 in BARRON, 1985), is conspecific with N. barronii.

In ODP Leg 113 Holes 689B and 690B drilled on Maud Rise the FAD of N. barronii is correlated to the lower part of the geomagnetic Subchron C3N-2 (ca. 4.2 Ma). At the same age it was also found in piston core PS147-1. However, at ODP Leg 113 Holes 695A and 697B, drilled southeast of the South Orkney Islands, the FAD of N. barronii is correlated to the top of Subchron C3N-2 (4.1 Ma) (GERSONDE & BURCKLE 1990). Also WEAVER & GOMBOS (1981) place the FAD of their N. angulata (=? N. barronii) at the top of Subchron C3N-2. CIESIELSKI (1983) notes that the FAD of N. angulata (=? N. barronii) is diachronous and ranges within Subchron C3N-2 from about 4.2 to 4.1 Ma. He states however, that in most of his cores the FAD is at about 4.2 Ma. Also BALDAUF & BARRON (in press) place the FAD of N. barronii at 4.2 Ma, based on the study of ODP Leg 119 holes drilled in the Indian sector of the Southern Ocean, south of the present Antarctic Polar Front.
**Nitzschia lacrima** sp. nov. 
(Pl. I, Fig. 1-6, 26; Pl. 2, Figs. 1 - 3)

Description: Valve clavate. One apex more broadly rounded and the other one tapering to an acutely rounded tip. Apical axis 21 - 60 μm, transapical axis 7 - 12 μm at widest point. Transapical interstriae straight in middle of valve face and slightly curved towards the apices, 10 - 12 in 10 μm. Interstria close to broadly rounded apex branched towards apex. Striae with one or two rows of poroids (ca. 40 in 10 μm) intermitted by regular spaced and apically oriented thickenings (11 - 12 in 10 μm) (Pl. 2, Figs. 1, 2). Raphe eccentric, located in the junction between valve face and valve mantle. Central nodule absent (Pl. 1, Fig. 26; Pl. 2, Fig. 1). Number of fibulae as number of interstriae.


Type locality: Core PS 1467-1, Maud Rise, southeast Weddell Sea.

Paratypes: Deposited in the Friedrich-Hustedt Collection No. Zu 4/5 (Pl. I, Figs. 1, 4), from Sample PS 1467-1, 866 cm.

Stratigraphic occurrence: In the *Thalassiosira incua* and *Nitzschia barronii* diatom Zones and the lower portion of the *Nitzschia interfrigidaria/Cosmiodiscus insignis* Zone (early Pliocene, Fig. 1) (GERSONDE & BURCKLE 1990).

Derivation of name: lacrima (Latin) - tear.

Discussion: Another clavate-shaped *Nitzschia* taxon is *N. clementia* Gombos (1977, pl. 8, Figs. 18, 19) that occurs in the late Miocene to early Pliocene of the Southern Ocean (GOMBOS 1977, GERSONDE & BURCKLE 1990). *N. lacrima* is distinct from *N. clementia* by its coarser strial structure.

**Nitzschia praecurta** sp. nov.
(Pl. I, Figs. 7 - 17; Pl. 2, Fig. 5, 6; Pl. 3, Fig. 3, 4; Pl. 10, Fig. 7)

Description: Valve linear-oblong, isopolar to very slightly heteropolar. Apices broadly rounded. Apical axis 8 - 42 μm, transapical axis 3.3 - 8.3 μm (Fig. 8). Transapical interstriae straight in the middle portion of valve face and curved towards the apices, generally 10 - 15 in 10 μm (Fig. 9). Interstria next to the apices branched towards apex. Striae with one or two rows of regular to irregular spaced poroids (27 - 35 in 10 μm), in the median area of the valve often discontinuous, leading to hyaline, non-perforate fields (Pl. 2, Figs. 5, 6; Pl. 3, Figs. 3, 4; Pl. 10, Fig. 7). Raphe eccentric, located in the junction between valve face and mantle. Central nodule absent (Pl. 3, Fig. 3). In median part of valve number of fibulae as number of interstriae or slightly smaller. Near apices number of interstriae often greater than number of fibulae.

Holotype: Deposited in the Friedrich-Hustedt Collection No. Zu 4/4 (Pl. I, Fig. 11).

Type locality: Core PS 1467-1, Maud Rise, southeast Weddell Sea.

Type level: Marine early Pliocene, Sample PS 1467-1, 790 cm.

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*Nitzschia praecurta* sp. nov.

(Pl. I, Fig. 1-6, 26; Pl. 2, Figs. 1 - 3)

Description: Valve clavate. One apex more broadly rounded and the other one tapering to an acutely rounded tip. Apical axis 21 - 60 μm, transapical axis 7 - 12 μm at widest point. Transapical interstriae straight in middle of valve face and slightly curved towards the apices, 10 - 12 in 10 μm. Interstria close to broadly rounded apex branched towards apex. Striae with one or two rows of poroids (ca. 40 in 10 μm) intermitted by regular spaced and apically oriented thickenings (11 - 12 in 10 μm) (Pl. 2, Figs. 1, 2). Raphe eccentric, located in the junction between valve face and valve mantle. Central nodule absent (Pl. 1, Fig. 26; Pl. 2, Fig. 1). Number of fibulae as number of interstriae.


Type locality: Core PS 1467-1, Maud Rise, southeast Weddell Sea.

Paratypes: Deposited in the Friedrich-Hustedt Collection No. Zu 4/5 (Pl. I, Figs. 1, 4), from Sample PS 1467-1, 866 cm.

Stratigraphic occurrence: In the *Thalassiosira incua* and *Nitzschia barronii* diatom Zones and the lower portion of the *Nitzschia interfrigidaria/Cosmiodiscus insignis* Zone (early Pliocene, Fig. 1) (GERSONDE & BURCKLE 1990).

Derivation of name: lacrima (Latin) - tear.

Discussion: Another clavate-shaped *Nitzschia* taxon is *N. clementia* Gombos (1977, pl. 8, Figs. 18, 19) that occurs in the late Miocene to early Pliocene of the Southern Ocean (GOMBOS 1977, GERSONDE & BURCKLE 1990). *N. lacrima* is distinct from *N. clementia* by its coarser strial structure.

**Nitzschia praecurta** sp. nov.
(Pl. I, Figs. 7 - 17; Pl. 2, Fig. 5, 6; Pl. 3, Fig. 3, 4; Pl. 10, Fig. 7)

Description: Valve linear-oblong, isopolar to very slightly heteropolar. Apices broadly rounded. Apical axis 8 - 42 μm, transapical axis 3.3 - 8.3 μm (Fig. 8). Transapical interstriae straight in the middle portion of valve face and curved towards the apices, generally 10 - 15 in 10 μm (Fig. 9). Interstria next to the apices branched towards apex. Striae with one or two rows of regular to irregular spaced poroids (27 - 35 in 10 μm), in the median area of the valve often discontinuous, leading to hyaline, non-perforate fields (Pl. 2, Figs. 5, 6; Pl. 3, Figs. 3, 4; Pl. 10, Fig. 7). Raphe eccentric, located in the junction between valve face and mantle. Central nodule absent (Pl. 3, Fig. 3). In median part of valve number of fibulae as number of interstriae or slightly smaller. Near apices number of interstriae often greater than number of fibulae.

Holotype: Deposited in the Friedrich-Hustedt Collection No. Zu 4/4 (Pl. I, Fig. 11).

Type locality: Core PS 1467-1, Maud Rise, southeast Weddell Sea.

Type level: Marine early Pliocene, Sample PS 1467-1, 790 cm.

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Fig. 8: Length - width ratio of *Nitzschia praecurta*. 
Abb. 8: Länge/Weite-Verhältnis von *Nitzschia praecurta*. 148
Paratype: Deposited in the Friedrich-Hustedt Collection, No. Zu 4/4 (Pl. 1, Fig. 10), from Sample PS1467-1, 790 cm.

Stratigraphic occurrence: Nominate species of the early late Miocene N. praecurta diatom Zone of GERSONDE & BURCKLE (1990). FAD at ca. 10.5 Ma, defines base of the N. praecurta diatom Zone; LAD in the Nitzschia barronii Zone (early Pliocene, Fig. 1) (GERSONDE & BURCKLE 1990).

Discussion and remarks: N. praecurta is distinct from N. aurica by its linear-oblong valve shape. Very probably N. praecurta is conspecific with a taxon labeled Nitzschia sp. 14 (SCHRADER 1976, pl. 2, figs. 8, 36). N. praecurta has affinities to N. curta (v. Heurck) Hasle and N. linearis (Castr.) Hasle, two prominent extant species endemic to the Antarctic Ocean. Descriptions of these taxa are in HASLE (1965b, p. 32, pl. 6, fig. 6; pl. 12, figs. 2 - 5; pl. 13, figs. 1 - 6; pl. 16, fig. 6; pl. 17, fig. 5 as Fragilariaopsis curta, and p. 37, pl. 12, fig. 17; pl. 15, figs. 9 - 11 as Fragilariaopsis linearis). N. praecurta differs from N. curta by the less expressed heteropolarity and the more broadly rounded apices, N. praecurta is distinct from N. linearis by its shorter length and more delicate strial/interstrial structure. Probably N. praecurta is a phylogenetic precursor of N. curta or N. linearis. However, a phylogenetic transition between N. praecurta and one of the extant taxa could not yet be documented.

Genus Rhizosolenia Brightwell

A modern revision of the taxonomy of Rhizosolenia was accomplished by SUNDSTRÖM (1986). In this monograph an emended diagnosis of Rhizosolenia, emended circumscriptions comprising 24 Rhizosolenia species, five new species and four infraspecific taxa were proposed.

**Rhizosolenia costata** sp. nov.
(Pl. 9, Figs. 1 - 6; Pl. 10, Figs. 1 - 6)

Description: Valve circular, apical portion of valve conoidal-cylindrical, central and basal part conoidal enlarged. Apical portion of valve and process heavily silicified, central and basal part more weakly silicified. Valve perforated by areolae arranged in radially oriented striae (ca. 9 - 24 striae /10 µm). Length of individual striae irregular. Arrangement of areolae not regular in apical portion of valve (Pl. 10, Figs. 3 - 5), more regular in central and basal part (Pl. 3, Figs. 1, 2), ca. 14 - 19 areolae in 10 µm. Vela were not observed. Valve ornamented by radially oriented costae, irregular in length. Costae strongly silicified and wall-like in conoidal-cylindrical apical portion of valve, less developed in central and basal part (Pl. 10, Figs. 1, 2). Apical end of costa wall broadly rounded (Pl. 10, Figs. 1, 3 - 5). Costae wall may be strutted by tangentially oriented thickenings (Pl. 10, Figs. 4,
5. Generally only heavily silicified apical portion of valve and process preserved. Length of only encountered specimen with preserved basal part of valve is 125 µm (Pl. 10, Fig. 1). Contiguous area not observed. Process 18 - 29 µm in length, slightly tapering from base with rounded tip. Process with internal lumen, length ca. 1/3 of process length, broad in basal part (Pl. 9, Fig. 3), tapering into narrow canal that opens at tip (Pl. 9, Fig. 2). A labiate structure could not be observed at connection between lumen and valve interior. No girdles were observed.

Holotype: Deposited in the Friedrich-Hustedt Collection No. Zu 4/8 (Pl. 9, Figs. 1-3).
Type locality: Core PS 1467-1, Maud Rise, southeast Weddell Sea.
Type level: Marine Pliocene, Sample PS1467-1, 970 cm.

Paratype: Deposited in the Friedrich-Hustedt Collection No. Zu 4/8 (Pl. 9, Figs. 4 -6) from Sample PS1467-1, 970 cm.

Stratigraphic occurrence: In the early Pliocene Nitzschia barronii and Thalassiosira inura diatom Zones that range from 4.47 to 3.6 Ma (GERSONDE & BURCKLE 1990) (Fig. 1).

Derivation of name: eosta (Latin) = rib.

Discussion and remarks: The eostae of the described species are probably structures close to otaria, which are typical apical structures of a number of Rhizosolenia species, such as R. styliformis Brightwell, R. polydactyla Castracane, R. borealis Sundström, and R. sima Castracane (also compare SUNDSTRÖM 1986). However, a true otarium is a regular structure that occurs as a pair, located nearly opposite to each other, according to ROSS et al. (1979). More irregular occurring apical thickenings of the valve were reported from the infraspecific taxa, R. polydactyla f. squamosa Sundström and R. sima f. silacea Sundström. Both are restricted to the southern high-latitude ocean and can be regarded as „resting spores“, according to SUNDSTRÖM (1986).

Genus Thalassiosira Cleve

The genus Thalassiosira is characterized by the presence of strutted processes and areolae having external foramina and internal cribrum. The strutted processes are arranged in a near-marginal ring and usually at least one near the valve center or in a ring on the valve face. Each valve has one or more labiate processes (also compare descriptions in HASLE 1973 a,b and JOHANSEN & FRYXELL 1985).

Thalassiosira complicata sp. nov.

Pl. 3, Figs. 1, 2; Pl. 5, Figs. 18 - 20; Pl. 6, Figs. 1 - 6; Pl. 7, Figs. 1 - 5)

Description: Valve disc-shaped, 16 - 65 µm in diameter, with smoothly curved shallow valve mantle and small central depression. Dense areolation at valve mantle and marginal part of valve face, 17 - 28 areolae in 10 µm, arranged in tangential rows at valve mantle and more curved rows with radial orientation in marginal part of valve face (Pl. 7, Fig. 4). Central part of valve face with areolae arranged in radial and subradial rows, 12 - 18 in 10 µm (Pl. 3, Fig. 1, 2; Pl. 5, Fig. 18; Pl. 7, Fig. 2). Marginal part of valve face separated from central part by concentric ring of strutted processes. Areolae with slender cylinderiform chambers (Pl. 7, Fig. 5). Central area hyaline and sunken in, often marked by distinct circular depression (Pl. 7, Fig. 2). Valve mantle with ring of strutted processes close to valve margin. Strutted processes regularly and densely spaced (6 - 10 in 10 µm), flat on outside of valve, with internally short extensions and opercula covering the four satellite pores (Pl. 7, Fig. 3). Strutted processes of concentric ring on valve face of same structure as marginal strutted processes, less densely spaced (4 - 8 in 10 µm), each located on a radial row of areolae that extends from the margin to the central hyaline area (Pl. 7, Figs. 1, 2). Single labiate process, located near valve face margin between marginal and median rings of strutted processes. Labiate process on stalk internally, the slit being parallel or nearly parallel to the marginal tangent (Pl. 7, Fig. 1).

Holotype: Deposited in the Friedrich-Hustedt Collection No. Zu 4/7 (Pl. 6, Figs. 1-3).
Type locality: Core PS 1467-1, Maud Rise, southeast Weddell Sea.
Type level: Marine Pliocene, Sample PS1467-1, 200 cm.

Paratype: Deposited in the Friedrich-Hustedt Collection No. Zu 4/7 (Pl. 6, Figs. 4, 5) from Sample PS1467-1, 200 cm.

Stratigraphic occurrence: FAD in the upper portion of the early Pliocene Thalassiosira inura Zone at ca. 4.3 Ma; LAD near the boundary of the late Pliocene Nitzschia interfrigidaria/Cosmiodiscus insignis and the Thalassiosira kotbeli Zones at ca. 2. 5 Ma (GERSONDE & BURCKLE 1990).
Discussion and remarks: *T. complicata* has some affinities to *T. opposita* Koizumi, described from upper Miocene sediments in the northwest Pacific Ocean (KOIZUMI 1980, p. 396, pl. 1, figs. 15 - 17) in the arrangement of areolae and the marginal and median rings of strutted processes. *T. opposita* differs by the presence of two central opposite processes that are surrounded by large and conspicuous areolae.

**Thalassiosira inura** sp. nov.  
(Pl. 6, Figs. 7 - 14; Pl. 8, Figs. 1 - 6)

*Cestodiscus* ? sp., GOMBOS 1977, pl. 5, Fig. 8.

**Description:** Valve convex, depressed in the center, 12 - 30 μm in diameter. Dense areolation in marginal portion of valve, 15 - 22 areolae in 10 μm (in average 18), with mostly cylindriform chambers (Pl. 8, Fig. 6) arranged in curved rows (Pl. 8, Figs. 1, 3, 4). Marginal area of valve with cylindriform areolae distinct from median valve portion with areolae having bulbous inflated chambers (Pl. 8, Fig. 6). 8 - 14 in 10 μm, arranged in curved rows or disordered. Central area hyaline and sunken in, diameter 1/3 to 1/5 of valve diameter, marked by distinct circular depression in valve center, around 1 μm in diameter (Pl. 8, Figs. 3, 4). Valve mantle with ring of strutted processes located 2 - 3 areolae off valve margin. Strutted processes evenly spaced (3 - 4 in 10 μm), processes flat on outside of valve, with internally short extensions and opercula covering the four satellite pores (Pl. 8, Fig. 2). Single strutted process located about midway between valve center and valve margin in the area with bulbous chambered areolae (Pl. 8, Figs. 1 - 5), of same structure than marginal strutted processes. Single labiate process, located opposite to strutted process on valve face near boundary between marginal area with cylindriform areolae and median area with bulbous chambered areolae. Slit of labiate process parallel to the marginal tangent (Pl. 8, Fig. 2).

**Holotype:** Deposited in the Friedrich-Hustedt Collection No. Zu 4/7 (Pl. 6, Figs. 7, 8).

**Type locality:** Core PS1467-1, Maud Rise, southeast Weddell Sea.

**Type level:** Marine Pliocene, Sample PS1467-1, 200 cm.

**Paratype:** Deposited in the Friedrich-Hustedt Collection No. Zu 4/7 (Pl. 6, Figs. 9, 10) from Sample PS1467-1, 200 cm.

**Stratigraphic occurrence:** Nominates species of the early Pliocene *T. inura* diatom Zone of GERSONDE & BURCKLE (1990). FAD at 4.47 Ma, defines base of the *T. inura* diatom Zone; LAD in the lower portion of the *Actinocyclus ingens* Zone at ca. 3.17 Ma (early Pleistocene, Fig. 1; GERSONDE & BURCKLE 1990).

**Derivation of name:** inura (Latin) - flatten down.

Discussion and remarks: *T. inura* has some affinities to *T. jacksonii* Koizumi & Barron, described from upper Miocene and Pliocene sediments in the northwest Pacific Ocean (KOIZUMI 1980, p. 396, pl. 1, figs. 11 - 14) in valve size and shape, and the arrangement of areolae. *T. jacksonii* differs by its more delicate areolation and by the presence of a strutted process located in the hyaline central area according to the description given by KOIZUMI. *T. gracilis* differs from *T. inura* by the lack of a distinct hyaline central area marked by a circular depression, and by the presence of a nearly central strutted process. In their study of Neogene sediments from Leg 113 holes GERSONDE & BURCKLE (1990) could not encounter *T. gracilis* (Karsten) Hustedt in lower Pliocene sediments from the Atlantic sector of the Southern Ocean, nor was this taxon found in the early Pliocene of Core PS1467-1. It should however be stated that, similar to *T. inura*, *T. gracilis* (Karsten) Hustedt is characterized by bulbous areola chambers in the central part of the valve and more slender, cylindriform chambers on the margin (see FRYXELL & HASLE 1979, fig. 18).

4. CONCLUSION

In the present paper eight diatom species that occur in the late Neogene of the southern high-latitude ocean are described and photographically documented by light and scanning electron microscopy. Up to now these taxa were only reported from the Antarctic Ocean, and it can be speculated that they are endemic to the southern high-latitudes. Five of the described taxa, *Nitzschia aurica*, *N. barronii*, *N. praecurta*, *Thalassiosira complicata*, and *T. inura*, are biostratigraphically useful species because of their consistent occurrence in late Neogene sediment sections of the Southern Ocean. The first appearance date (FAD) of *N. praecurta*, *N. barronii* and *T. inura* was used for the definition of the base of diatom zones by GERSONDE & BURCKLE (in press) (Fig. 1).
Five of the described species, *Nitzschia barronii*, *N. lacrima*, *Thalassiosira complicata*, *T. inurn*, and *Rhizosolenia costata*, have their FAD in the early Pliocene at around 4.5 to 4.2 Ma. This is a time interval that follows a climatic optimum in the Southern Ocean marked by the invasion of several low- and mid-latitude species into the high-latitudes of the Southern Ocean, an event which started at about 4.8 Ma (ABELMANN et al. 1990). The first appearance of a series of species that are very probably endemic to the Southern Ocean area may be indication for an increase of latitudinal thermal contrast during the late early Pliocene and the decline of surface water temperatures. Probably, the late early Pliocene extinction of *N. procera*, *N. aurita*, and *N. auricula*, which have their first appearances within the late Miocene, is linked to this paleoenvironmental development.

Yet another series of diatom taxa ranging in the late Neogene of the Southern Ocean is not well described or still unknown. Further taxonomic investigation of these taxa is in progress, and their stratigraphical and paleoenvironmental significance is under study.

5. ACKNOWLEDGMENT

The author is grateful to Grethe R. Hasle, Greta A. Fryxell, and Andrea Abelmann for critical review of the manuscript. I also thank Ruth Cornell and Ute Bock for laboratory assistance. This work was supported by the Deutsche Forschungsgemeinschaft. This is Alfred Wegener Institute contribution No. 276.

References


Plate E: All specimens at x 1,500, unless otherwise indicated. 1-6, 26: *Nitzschia barronii* sp. nov, Sample PS1467-1, 804 cm. (1-4) Paratypes, (2-3) holotype. (26) SEM oblique view of valve margin and raphe, bar = 10 mum. 7-17: *Nitzschia procera* sp. nov, (10) paratype, Sample PS1467-1, 780 cm. (7, 9, 12, 14) Sample PS1467-1, 804 cm. (8, 11, 13, 15, 16) Sample PS1467-1, 804 cm. (17) Sample PS1467-1, 816 cm. 18-22: *Nitzschia lacrima* sp. nov, (19) holotype, Sample PS1467-1, 804 cm. (20) paratype, Sample PS1467-1, 804 cm. (18, 23-25) Sample PS1467-1, 804 cm. (21-22) Sample PS1467-1, 811 cm.

Table 1: Neogene diatoms at 1,500 was used and arranged: 1-6, 26: *Nitzschia lacrima* sp. nov, Probe PS1467-1, 806 cm. (1-4) Paratypes, (2-3) holotypes, (26) REM Au-technique on Schottlamellar and Raphe, bar = 10 mum. 7-17: *Nitzschia procera* sp. nov, (10) Paratypes, Probe PS1467-1, 780 cm. (11) holotype, Probe PS1467-1, 780 cm. (7, 9, 12, 14) Probe PS1467-1, 806 cm. (8, 11, 13, 15, 16) Probe PS1467-1, 804 cm. (17) Probe PS1467-1, 816 cm. (18-22) *Nitzschia aurita* sp. nov, (19) holotype, Probe PS1467-1, 804 cm. (20) Paratypes, Probe PS1467-1, 804 cm. (18, 23-25) Probe PS1467-1, 804 cm. (21-22) Probe PS1467-1, 811 cm. 152

Plate 1: Scale bar = 10 µm. 1-3: Nitella havniae sp. nov., Sample PS 1467-1, 866 cm (1'-2') outside view of some specimen in Pl. 1, Fig. 26. (3) oblique side view. 4: Nitella arctica sp. nov., inside view. Sample PS 1467-1, 1050 cm. 5: & Nitzschia prasinissima sp. nov., inside view, easily discernible bilaterally and tetrarial structure. (5) Sample PS 1467-1, 760 cm. 6: Sample PS 1467-1, 800 cm.
Table 1: Malaya 10-15 µm. 1-3: Nitella havniae sp. nov., Probe PS 1467-1, 866 cm (1'-2') Aufflache der gleichen Schale wie in Tab. 1, Abb. 26. (2) inside view. 3: Frustules and divided rachides. (3) Probe PS 1467-1, 1050 cm. 4: Nitzschia prasinissima sp. nov., inner umschacht, deutlich erkennbare Filalaken und Aufbau der Spirale. (5) Probe PS 1467-1, 760 cm. 6: Probe PS 1467-1, 800 cm.
Plate 3: Scale bar = 10 μm. 1-2: *Thalassiosira complicata* sp. nov., outside view of valve face with median ring of stunted processes, central hyaline area and outer opening of labiate process (arrow). Sample PS1467-1, 200 cm. 3-4: *Nitzschia praecurta* sp. nov., oblique outside view on valve, Sample PS1467-1, 200 cm. 5: *Nitzschia aurica* sp. nov., outside view of valve face, Sample PS1467-1, 600 cm. 6: *Nitzschia barronii* sp. nov., outside view of valve face, Sample PS1467-1, 1,200 cm.
Plate 4: Scale bar = 10 μm unless otherwise indicated. 1 - 3: *Nitzschia barronii* sp. nov., (1) outside view of valve face, marginal raphe easily discernible. Sample PS1467-1, 200 cm. (2 - 3) Inside view of valve face. Sample PS1467-1, 200 cm. 4: *Nitzschia arcula* sp. nov., outside view of valve face, marginal raphe well discernible. Sample PS1467-1, 804 cm. 5 - 6: *Nitzschia aurica* sp. nov., inside view of valve face. (5) corroded valve. Sample PS1467-1, 600 cm. (6) Sample PS1467-1, 1090 cm. bar = 1 μm.
Plate 5: All specimens at x 1,500: 1 - 6: *Nitzschia australa* sp. nov. (1) holotype, Sample PS 1467-1, 804 cm. (2) Sample PS 1467-1, 811 cm. (3) paratype, Sample PS 1467-1, 804 cm. (4 - 6) Sample PS 1467-1, 804 cm. 7 - 17: *Nitzschia harrvai* sp. nov., Sample PS 1467-1, 200 cm. (13) paratype. (14) holotype. 18 - 20: *Thalassiosira complicata* sp. nov. (18) labiate process indicated by arrow. Sample PS 1467-1, 100 cm. (19 - 20) single specimens at different focus. Sample PS 1467-1, 200 cm. 21: *Nitzschia* sp. A, Sample PS 1467-1, 200 cm.

Tafel 5: Verkleinerung x 1,500: 1 - 6: *Nitzschia australa* sp. nov. (1) Holotypus, Probe PS 1467-1, 804 cm. (2) Probe PS 1467-1, 811 cm. (3) Paratypus, Probe PS 1467-1, 804 cm. (4 - 6) Probe PS 1467-1, 804 cm. 7 - 17: *Nitzschia harrvai* sp. nov., Probe PS 1467-1, 200 cm. (13) Paratypus. (14) Holotypus. 18 - 20: *Thalassiosira complicata* sp. nov. (18) Lippenfortsatz durch Pfeil markiert, Probe PS 1467-1, 100 cm. (19 - 20) Schale bei unterschiedlicher Fokussierung, Probe PS 1467-1, 200 cm. 21: *Nitzschia* sp. A, Probe PS 1467-1, 200 cm.
Tafel 6: Vergroßerung x 1,500: 1 - 6: Thalassiosira complicata sp. nov. (1 - 3) Holotypus bei unterschiedlicher Fokussierung. Lippenfortsatz durch Pfeil markiert. Probe PS 1467-1, 700 cm. 7 - 8: Paratypus bei unterschiedlicher Fokussierung. Probe PS 1467-1, 800 cm. 9 - 10: Paratypus bei unterschiedlicher Fokussierung. (12 - 13) Sonne specimen at different focus.
Plate 7: Scale bar = 10 μm unless otherwise indicated. 1. \textit{Thalassiosira complanata} sp. nov., (1) oblique inside view of valve face, labiate process indicated by arrow. Sample PS1467-1, 700 cm. (2) outside view of valve face, inner opening of labiate process indicated by arrow. Sample PS1467-1, 866 cm. (3) close up of specimen in (1) with median and marginal arched processes with small internal extensions and opercula covering the four satellite pores. bar = 5 μm. (4) oblique outside view of specimen in (3). (5) broken valve showing cross-section of areolae with cylindrical structure of areolar chambers. Sample PS1467-1, 200 cm. 

Nitzschia aurita sp. nov., outside view of valves face with raphe. Sample PS1467-1, 600 cm. bar = 1 μm.
Plate 8: Scale bar = 10 µm. (1) Oblique outside view of valve face, outer opening of single median strung process left arrow, opening of labiate process right arrow. Sample PS1467-1, 866 cm. (2) Oblique inside view of valve face, easily discernible central hyaline area lacking processes, position of single labiate and strung process and structure of central process with small internal extensions and opercula covering the inner satellite pores. Sample PS1467-1, 866 cm. (3) Outside view of valve face with central circular depression. Sample PS1467-1, 866 cm. (4) Oblique inside view of valve face. Sample PS1467-1, 300 cm. (5) Broken valve showing cross-section of areolae with large bulbous inflated chambers in the central portion of valve and narrow cylindrical chambers near the margin. Sample PS1467-1, 866 cm.
Plate 9: All specimens at x 1,500. 1 - 6: Rhizosolenia costata sp. nov. (1 - 3) holotype at different focus, Sample PS1467-1, 970 cm, (3 - 6) paratype at different focus, Sample PS1467-1, 970 cm.

Tafel 9: Vergroßerung x 1,500; 1 - 6: Rhizosolenia costata sp. nov. (1 - 3) Holotypus bei unterschiedlicher Fokussierung, Probe PS1467-1, 970 cm, (3 - 6) Paratypus bei unterschiedlicher Fokussierung, Probe PS1467-1, 970 cm.
Plate 10: Scale bar = 10 μm unless otherwise indicated; 1 - 6: *Rhizosolenia costata* sp. nov., (1) oblique view of valve. Sample PS1467-1, 500 cm. bar = 100 μm, (2) close up of inside of basal valve portion of specimen in (1), (3) outside view. Sample PS1467-1, 700 cm, (4 - 5) outside views, showing costae walls straited by tangentially oriented thickenings. Sample PS1467-1, 700 cm. (6) process with outer opening of specimen in (3), 7: *Nitrososira paucisum* sp. nov., outside view of valve face. Sample PS1467-1, 700 cm. bar = 5 μm.

Tafel 10: Maßstab = 10 μm, außer wenn anders angegeben; 1 - 6: *Rhizosolenia costata* sp. nov., (1) Außenansicht der Schalenfläche. Probe PS1467-1, 500 cm, Maßstab = 100 μm, (2) Detail der Innenstruktur an der Basis der Schale in (1), (3) Außenansicht, Probe PS1467-1, 700 cm, (4 - 5) Außenansicht mit Costae, die durch tangential angeordnete Verdickungen gestützt werden, Probe PS1467-1, 700 cm, (6) Prozess mit äußeres Öffnung der Schale in (3), 7: *Nitrososira paucisum* sp. nov., Außenansicht der Schalenfläche, Probe PS1467-1, 700 cm, Maßstab = 5 μm.