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SOME EOCENE DIATOMS FROM SOUTH ATLANTIC CORES

Part 1. New and rare species of *Arachnoidiscus*

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ABSTRACT: Six Eocene cores have been recovered from the South Atlantic Ocean in the neighbourhood of the Falkland Platform in water depths ranging from 1044 to 2880 meters. Benthic diatoms make up the bulk of the fossil flora in which 11 species of *Arachnoidiscus* were identified, 6 being new to science. Their presence suggests that this area was covered by a shallow sea in Eocene time. A post-Eocene subsidence of the sea floor carrying the fossils to greater depths is indicated.

SOME EOCENE DIATOMS FROM SOUTH ATLANTIC CORES

Part II. *Rutilaria* Greville

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ABSTRACT: Among the diatoms selected from Eocene samples from cores taken in the South Atlantic by the research vessel VEMA were some specimens of the genus *Rutilaria* Greville. These represent five species, three of which are new; of the remaining two, one is known from the Eocene to the present and the other occurs as three subspecies. One of them, that represented in the VEMA material, known only from the Upper Eocene or Oligocene of Oamaru, New Zealand.

CALIFORNIA ACADEMY OF SCIENCES/GOLDEN GATE PARK/SAN FRANCISCO

SOME EOCENE DIATOMS FROM SOUTH ATLANTIC CORES

Part I. New and rare species of *Arachnoidiscus*

By

G Dallas Hanna, N. Ingram Hendey, A. L. Brigger

Among the many genera of marine diatoms which have living representatives, there are several which live exclusively in shallow waters. Some species are found as bottom dwellers, either free or attached by various means to rocks, algae or other substrates; these are not pelagic and consequently are not normally reported in plankton studies except in those collections taken in close proximity to land masses. Currents may carry them out to sea for short distances but they are seldom found in collections taken in waters more than a few hundred meters in depth. The shallow water genera to which reference is made are usually large, heavily silicified diatoms in which species of *Isthmia, Arachnoidiscus, Sticto-discus, Eupodiscus, Aulacodiscus, Hyalodiscus* and several others are often strongly represented.

Since 1966 we have been engaged in a monographic study of Eocene diatoms from a series of cores taken in the South Atlantic in an area referred to in oceanographic literature as the Falkland Platform, (see chart, fig. 1), Seventeen samples were taken from 6 cores recovered from localities extending from Lat. 41° 30′ S to 53° 01′ S and from Long. 48° 29′ W to 59° 40′ W. The depths of the water at these sites being from 1044 meters to 2880 meters. The cores were taken on cruises 12, 17 and 18 of R/V VEMA, being part of a program conducted under the direction of the late Dr. Maurice Ewing then of Lamont-Doherty Geological Observatory of Columbia University. The chart, fig. 1, indicates the position of these cores, and the descriptions of those used in the preparation of this paper are given on p. 5.

Many species found in the material are the same as, or similar to forms found in such well-known Eocene formations as those exposed at Mors, Denmark; Simbirsk and Kamishev, U.S.S.R.; Oamaru, New Zealand; Barbados, West Indies; and several localities in California. Some of these may fall in the Paleocene epoch. Many of the species are new and have not yet been described.

The mere fact that shallow water species are abundant in these relatively deep waters, at once raises questions as to how they reached their present positions. Four possible answers come readily to mind. It might be supposed that these abundant shallow water species grew in situations similar to those in which they live today and were carried to the present depths by currents. However, if this took place during the Eocene it should be doing so today. We have examined many cores taken from the ocean localities and different distances from land or shallow water, but on no occasion have we found such shallow water genera as those listed above, except where the locality was reasonably close to shore. The best evidence against this "current drifting" explanation is given by an examination of the abundant literature records of core studies by competent diatomists. For example, Lohman, 1941, made a thorough study of North Atlantic cores and found that pelagic diatoms were abundant but no inshore forms belonging to the genera mentioned above were recorded. His samples were from localities which crossed the North Atlantic in an irregular line between the easternmost part of the Newfoundland Banks and the banks off the southwest coast of Ireland. Not even the mid-Atlantic ridge yielded such an assemblage of littoral forms. Lohman found many diatoms that normally grow inshore but are not attached or bottom-dwelling species. These are usually termed neritic, as contrasted to littoral, or pelagic open ocean forms. All deposits of marine diatoms that are familiar to us contain representatives of all three categories, as might be expected, but to find abundant littoral forms in localities far from land in deep water is certainly difficult to explain by any process of current drifting. Muller-Melchers (1959), working on samples off the coast of Brazil found no littoral diatoms; Hendey, (1937), in his study of the "DISCOVERY" material collected in the Antarctic, had both plankton and bottom samples but found no shallow water forms except in the Bransfield Strait, where *Arachnoidiscus ehrenbergii* was found. This species is usually found attached to littoral substrates such as other algae. Similar results are recorded in a great many reports on oceanographic expeditions. The possibility that the littoral forms found in the South Atlantic cores had different life habits in the Eocene than they have today seems too remote for serious consideration. We know of no evidence to substantiate such a conclusion. A plausible explanation for the presence of the fossil remains of organisms which we cannot imagine grew in waters other than a few hundred meters depth at the most, now being found in depths of a thousand meters or more, is that in Eocene time the water was shallow. This implies that the surface of the sea was lowered sufficiently for such organisms to grow, or that the sea bottom was elevated so that it would furnish a habitat at a depth that would be conducive to the growth and development of shallow water benthic species; that is, that at the time these diatoms flourished, the sea in that area was relatively shallow and that since that time the bottom has sunk to its present depth, taking with it the assemblage of micro-fossils that had already accumulated. The problem is not entirely new. The Swedish Deep Sea Expedition of 1947-1948 collected a large number of cores in the Indian, Atlantic and Pacific Oceans. The diatoms found in these cores were reported upon by Kolbe (1954-57). While no fossils comparable in age to those we have been studying were taken on that expedition, Kolbe (1953) and (1957b) found many freshwater diatoms mixed with marine forms in the Atlantic series of cores. In one of them (552 cm. below the top of core 234) the sample was a pure freshwater deposit except for one small fragment. This is almost incontrovertible evidence showing that the fossils grew in a freshwater habitat, although the most abundant species, *Melosira granulata*, has been found by us in a marine deposit of middle Miocene age on San Clemente Island, California.

After discussing other possibilities for the presence of shallow water diatoms in the deep water of the mid-Atlantic, Kolbe, (1957b) p. 17, asked: "Is it too bold to assume that the abundance of benthonic species in the district might be explained by geological factors? The whole district may have formerly belonged to a shallow sea and its floor might have sunk to its present considerable depth at a not very remote period, as only two — rather questionable extinct Pre-Quaternary species have been observed." Malaise, (1951), (1956), discussed this theory, especially in regard to its bearing on the occurrence of the freshwater diatoms. The presence of exposed land or even shallow seas in the mid-Atlantic brings up the question of an Atlantis which he seems to have favoured. Rigby and Burckle, (1958), after considering the three possibilities expressed by Kolbe (1957b), namely, potamic, aeolian and Atlantis added another possible explanation to account for the observed facts. This involved turbidity currents as a means of transport. However applicable this might be to account for the freshwater diatoms it seems to us that the subsidence of the sea floor after the diatoms had been deposited, is a better explanation for the presence of the abundant shallow water marine forms observed in the South Atlantic cores obtained by the Lamont-Doherty Geological Observatory's Research Vessel "VEMA".

The examination of the Eocene diatoms recovered by R/V VEMA from the South Atlantic cores was commenced by G Dallas Hanna with one of the authors, A. L. Brigger, in 1966. During this preliminary period a great deal of preparatory work was accomplished, such as the cleaning of many samples of material, preparing both strewn and single mounts of selected specimens and the preparation of more than a thousand photomicrographs. Later, it was agreed that a third author, N. Ingram Hendey, should assist in this work. The original intention was to prepare a monograph dealing with all the species of diatoms identified in the material. To this end more than 100 plates of illustrations were prepared and plans were made to apportion the work between the three authors. Some progress had been made in this when the regrettable demise of the senior author on November 20th, 1970, necessitated a reappraisal of the whole project and it soon became evident that the extensive survey of the South Atlantic Eocene diatoms that had been planned would have to be curtailed, or at least, held in abeyance. In view of the circumstances it was considered advantageous to produce a series of short papers on the separate genera, as the completed work on them becomes available.

ACKNOWLEDGMENTS

The materials examined were recovered from cores taken in the South Atlantic during 1961-62 by personnel of the R/V VEMA in a survey originally organized and directed by the late Dr. Maurice Ewing, then Director of the Lamont-Doherty Geological Observatory, Columbia University, New York. Cores were supplied to the California Academy of Sciences by Lloyd Burckle to whom the authors wish to express their indebtedness. Funds for the VEMA Cruises were provided by the National Science Foundation and the Office of Naval Research.

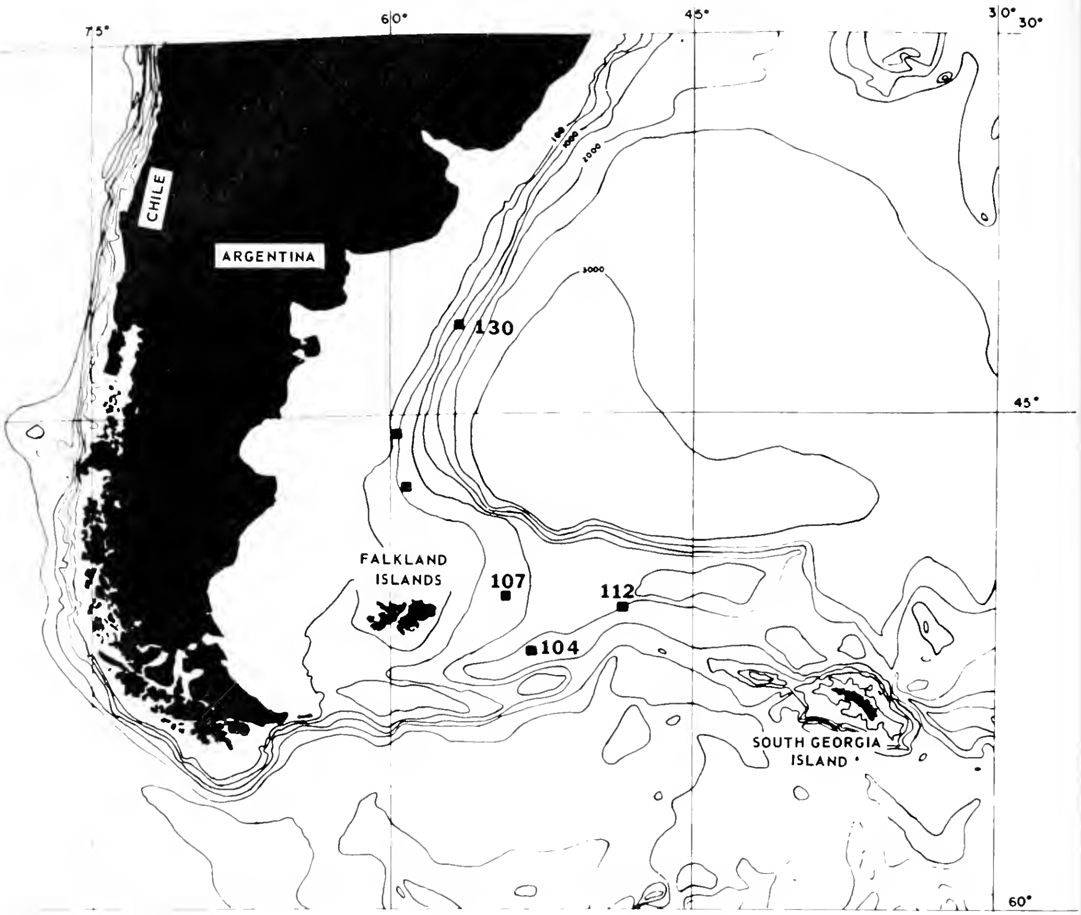

FIGURE 1. Chart shows the positions of the six cores containing Eocene diatoms. Species of *Arachnoidiscus* described in this paper were recovered from VEMA Cruise 17, core 107 and VEMA Cruise 18, cores 104, 112, 130. Descriptions of these cores are given in the text.

LOCALITIES

The pertinent locality information is as follows (sample numbers are California Academy of Sciences Geology catalogue numbers): *

Cruise	Core	Depth meters	Lat.	Long.	Length of core	C.A.S. No.*
V-17	107	1525	51°08′ S	54°22′ W	200 cm.	39573/8,9,10,11
V-18	104	2880	53°01′ S	52°52′ W	333 cm.	39574/13
V-18	112	2429	51°40′ S	48°29′ W	260 cm.	39575/14,15
V-18	130	1414	41°30′ S	56°36′ W	115 cm.	39650/16

The descriptions of the sections were furnished by Lloyd Burckle of Lamont-Doherty Geological Observatory.

C.A.S. No. 39573/8, (50 cm.)

3-55 cm. Putty colored, fibrous diatomaceous material with faint burrow mottling (one distinct) oval grey burrow appears at 42 cm. and scattered darker colored patches of manganese (micronodules). Underlying contact is gradational and is defined by a color change from light (putty) to light brown. This zone is well mottled apparently by burowing organisms which have moved material from below upward and vice versa.

C.A.S. No. 39573/9, (120 cm.), *39573/10,* (175 cm.), *39573/11,* (245 cm.)

73-200 cm. Greyish-olive green colored, silty, clayey, diatomaceous material generally similar to that overlaying in all ways except color. This color difference is assumed to be the result of some sort of physical or chemical change in local environmental conditions. A slightly darker colored layer, (perhaps due to increased silt or clay content) approximately one centimeter thick, appears at 155 cm. Although this structure is faintly defined, it is nevertheless clearly horizontal and therefore indicates that the core is good (in spite of general absence of structural features) at least to this depth. This layer is well mottled by burrowing throughout its entire vertical extent.

C.A.S. No. 39574/13, (330-335 cm.)

260-333 cm. Firm, dark greyish-brown lutite interlaminated with poorly discernible pale yellow lutite bands. Thin, irregular lenses of glauconitic silt occur at 313-315 cm. White specks composed of diatom frustules are sporadically found at 310 cm. to the bottom. Burrow markings are uncommon except for two or three at 277-283 cm. A 3 mm. thick lamina of hydrotroilite is present at the top of the layer. Percentage of carbonate here near base is only about 0.5%.

C.A.S. No. 39575/14, (100 cm.), *39575/15,* (325-330 cm.)

96-260 cm. Yellowish grey (5Y7/2), moderately sorted, diatomaceous, slightly silty lutite mixed with about 5-7% minerals and rock fragments. The lutite contains diatoms and sponge spicules as the major constituent and a minor amount of radiolaria.

C.A.S. No. 39650/16, (50 cm.)

24-69 cm. Pale greenish-yellow lutite mixed 5-10% silty to fine grained glauconite. Sponge spicules abound. No trace of carbonate was observed. Gradational bottom contact.

The diatoms were cleaned with mineral acid, washed with distilled water and mounted in Styrex-A, a highly refractive medium described by Brigger (1960). This medium has a refractive index of 1.64 and is eminently suitable for diatoms.

SYSTEMATIC DESCRIPTIONS

Arachnoidiscus Deane

Deane ex Pritchard, Hist. Infus. ed. 3, 1852, p. 318.

Cells solitary, valves discoid, with a circular, sub-circular or sub-triangular outline. Valve surface flat or nearly so, but often with the central portion slightly raised or depressed. Valve surface divided into sectors by radiating costae (furrows or ribs). The primary costae proceed from the margin and almost reach the small circular and often hyaline central area. Between these are shorter secondary costae that usually penetrate the valve to a distance equal to about half the radius or less, while others, the tertiary costae, are usually much shorter and often restricted to the marginal zone as an elongated punctum. Valve surface of the inter-costal sectors areolate, areolae moderately large, usually sub-quadrate, sub-circular or sub-triangular, frequently more or less uniform in size though a little reduced as they approach the valve margin. Areolae usually in continuous concentric circles, but in some species the lines of areolae on one sector alternate with those on contiguous sectors. When the valve is intact, the areolae are furnished with dendritic outgrowths or volae that partially occlude the aperture through the valve. In many fossil species these structures are missing due to erosion. In some species a hexagonal system of ridges is superimposed upon the walls of the areolae, often these are eroded to provide an irregluar pattern. Sometimes the walls of the areolae are verrucose bearing small pustules at the intersection of the walls; in others fine costae or a series of reticulate lines are also arranged concentrically linking the primary radial costae and anastomosing over the valve surface giving it the appearance of a spider's web. *Arachnoidiscus* is usually found sessile on some of the smaller red algae that gather around the holdfasts of the larger kelps, and appears to favour the temperate and sub-tropical zones.

Arachnoidiscus Deane ex Pritchard, (type *Arachnoidiscus japonicus* (Shadbolt ex Pritchard) has been conserved against *Hemiptychus* Ehrenberg and *Arachnodiscus* J. W. Bailey, ex Ehrenberg, see Stafleu et al. (1972) p. 245, in the code of Botanical Nomenclature as adopted by the International Botanical Congress, Seattle, Aug. 1969, (Utrecht 1972).

The structure on the *Arachnoidiscus* valve appears at first sight to be particularly regular, but upon closer examination the frustule is seen to be composed of dissimilar valves. The small hyaline central area on the one is surrounded by a fairly well defined ring of linear, radially arranged slit-like markings which appear to bear no secondary structures, while the central area of the other valve is furnished with a ring of cuneate or comma-like markings or they may be reduced to a few irregular puncta, or the area may be occupied by a large scattered areolae. In most of these, secondary structures similar to those on the remaining areolae may be seen. This difference of valve structure can be easily seen if a recent gathering of *Arachnoidiscus* spp. is carefully cleaned so as to prevent the valves from falling apart. By careful focusing the structure on both valves may been seen. This observation has particular significance when attempting to identify fossil species from submarine cores as in such material whole and complete cells are seldom if ever found, and when examining two valves from the same material having different structures at their centers, it is impossible to determine whether they represent two species or whether they are the upper and lower valves of the same species. In the core material from the South Atlantic numerous specimens of *Arachnoidiscus* were observed whose general structures were similar but whose central areas were different. In such cases it was considered expedient to interpret the species somewhat liberally and so reduce the use of names that future research might show to be superfluous. Very few species in the genus appear to be clearly defined and intermediate forms tend to blur specific limits. Brown (1933), who produced the only monograph on the genus stressed the importance of the color, black or white, of the areolae and the costae with alterations of focus; but as these color changes depend upon the optical qualities of the objectives used and upon the refractive index of the medium in which the diatoms are mounted, little reliance can be placed upon them.

The degree to which the costae penetrate towards the valve center is also a factor that has been used to separate species, but again, this appears to vary from specimen to specimen in any one species. Another character of a little more worth, is the arrangement of the rows of areolae in the inter-costal sectors; in some species they may be alternate while in others they form continuous concentric circles clearly separated by inter-areolate spaces. Perhaps the most useful feature might prove to be the ultimate structure of the areolae, but insufficient information on the electron microscope structure of the various species places this beyond our reach for the time being — in any case, most fossil species suffer a certain amount of abrasion during which some of the finer structures are inevitably destroyed.

Though the range of variation seen in the *Arachnoidiscus* from the core material might suggest that a large number of species is present, it is more likely that the reverse is true and that the specimens observed indicate the degree of variability within a relatively few species.

Arachnoidiscus is closely related to the genus *Stictodiscus,* and Mann, 1907, in his account of the diatoms collected during the "Albatross" voyages recognized that "good definitions are hard to formulate, nevertheless the utility of the two genera is considerable." Boyer, (1927), in his Synopsis of North American Diatomaceae, states that *Stictodiscus* is "distinguished from *Arachnoidiscus* chiefly by the absence of a central space".

Van Heurck, (1896) pointed out that *Arachnoidiscus* has the internal costae joined by a central lamina and that the central area is hyaline. None of these differences alone is sufficient to separate the two genera as seen in the South Atlantic core material, but taken together with the ultimate structure of the areolae, (i.e. as much as we now know of it) a reasonable attempt at separation can be achieved. In the genus *Arachnoidiscus* the areolae are moderately large, with poroids partially occluded by marginal outgrowths or volae, *vide* Ross & Sims (1972, p. 144, fig. 5.) In *Stictodiscus* the valve is not furnished with internal septa at the margin and beneath the central area, the central area is not large and hyaline, or surrounded by a ring of slit-like apertures, the valves are not dissimilar, and the areolae do not possess volae. However, the South Atlantic material produced several forms of *Arachnoidiscus* that bore a superficial resemblance to members of *Stictodiscus*. This resemblance was prompted by a small central area and the superimposition upon the areolation of a hexagonal system of ridges; the presence however, of a ring of slit-like apertures at the central area, the presence of internal septa the presence of dissimilar valves and clearly marked volae in the areolae confirm the identification as *Arachnoidiscus*.

Arachnoidiscus atlanticus Hanna, Hendey & Brigger, new species (Plate 1, figure 2.)

Valve circular, slightly depressed at the center. Valve surface divided into sectors by 17 primary costae which penetrate toward the center as far as the second circle of areolae. Secondary costae about 1/3 the length of the primaries, tertiary costae about 1/3 the length of the secondaries. Valve surface of each inter-costal sector strongly convex, giving a fluted appearance to the sectors, causing the costae to widen slightly as they reach the center. Valve surface areolate, areolae subcircular to sub-quadrate, mostly in continuous concentric circles, not alternating at the primary costae. The areolae are slightly decreased in size as they approach the valve margin, which is a hyaline zone furnished with four large apertures to each sector. Areolae partially occluded by secondary structures in the form of a bar with a central expansion across the middle of each poroid. At least, this is the impression gained from examination with the light microscope. The areolae are somewhat difficult to examine owing to the convexity of the sectors and those on the margins of the sectors are seen only in a somewhat distorted side-view. Central area small, surrounded by a ring of short slit-like areolae which are surrounded by a row of circular areolae. These appear to penetrate the thickened part of the central area somewhat obliquely. The concentric spaces between these first three rows of areolae are moderately wide, being as wide as the diameter of areolae themselves, whereas the width of the inter-areolate spaces over the remainder of the valve is usually about half that distance. Valve margin furnished with a moderately deep internal septum which is extended along the sides of the primary rays as narrow flanges. These marginal flanges terminate at the inner apices of the sectors and the thickened central area extends outward to become confluent with the primary costae.

Holotype No. 55172 (Calif. Acad. Sci. Dept. Geol. Type Coll.) Diameter 204μ

Eocene, South Atlantic core 112, C.A.S. Locality No. 39575(15). Lat. 51°40'S. Long. 48°29'W.

Arachnoidiscus deficiens Brown
(Plate 1, figures 3 & 5.)
Brown, 1933, p. 64, pl. 5, fig. 5.

Arachnoidiscus ehrenbergii var. *oamaruensis* A. Schmidt, e.p. in Schmidt's Atlas, 1874—, pl. 147, figs. 2 & 4. (1890).

Valve circular, slightly depressed at the center. Valve surface divided into sectors, (usually 18-30) by primary costae that penetrate toward the center to the second circle of areolae. Secondary costae short, usually 1/4 to 1/3 the length of the primaries, tertiary costae very short, about 1/10 to 1/4 the length of the secondaries, but may be absent altogether. Valve surface of the inter-costal sectors areolate, areolae usually quadrate and partially occluded by secondary structures in the form of dendritic volae. These are clearly seen in Plate 1, figure 5. Above the areolae (i.e. super-imposed upon) and occupying the inter-areolate spaces is a network of ridges, roughly hexagonal near the valve center where they enclose a single areola at the apices of each sector, but more remote from the center the short intervening walls tend to break down or become eroded and the hexagons become confluent forming short lines, leaving intact the walls along the concentric spaces, thereby giving the impression that the areolae are in blocks of two, three, or four as they approach the margin of the valve. The ridges suggest that the areolae are sunk in pits and as the walls that lie upon the primary costae are the strongest and thickest they are more prominent and the angular ends of the hexagons give a zig-zag appearance to the underlying primary costae - the costae themselves however, are quite straight. These ridges are seen in Plate 1, figure 5. Because of this zig-zag formation, the lines of areolae do not form continuous concentric circles, but appear to alternate, though often less so as the areolae approach the valve margin. The areolae near the margin are reduced in size to about half or even less, but the extreme margin of the valve is a narrow hyaline zone. Central area usually small, upon one valve the area is surrounded by a ring of slit-like areolae beyond which is the second row of areolae which are subcircular. The areolae of the remaining circles are often laterally expanded, some having the appearance of two areolae merging to form one large one. Valve margin furnished with a very narrow septum, sometimes absent, but a slight thickening at the margin is extended to strengthen the primary costae though no definite flanges are evident. The primary costae appear to merge into the thickened central area, but no separate internal septum was evident in the specimens examined.

The adjacent valve, as in all species of this genus, has a slightly different structure. The innermost ring of slit-like openings is absent and the somewhat irregular central area is furnished with a few indeterminate structures or irregular puncta that are the vestiges of eroded ridges that surround the areolae. Plate 1, figure 5, enlarged view, shows such a central area, together with the surrounding areolae separated by the prominent ridges corresponding to and superimposed upon the inter-areolate spaces.

Hypotype No. 55173 (Calif. Acad. Sci. Dept. Geol. Type Coll.) Diameter 316μ

Eocene, South Atlantic core 112, C.A.S. Locality No. 39575(14). Lat. 51°40'S. Long. 48°29'W.

Arachnoidiscus indicus Ehrenberg
(Plate 1, Figure 1.)

Ehrenberg, 1854, p. 165, 166, Atlas pl. 36 C, fig. 34. (1854)
Brown, 1933, p. 66, pl. 5, fig. 9.
Reinhold, 1937, p. 84, pl. 4, figs. 7 & 8.

Valve circular, moderately flat and divided into sectors by numerous primary costae that penetrate towards the center as far as fourth or third row of areolae. Secondary costae short about 1/3 the length of the primaries, tertiary costae very short, often reduced to an elongated punctum. Valve surface of the inter-costal sectors areolate, areolae sub-quadrate and arranged in continuous concentric circles not alternating at the primary costae. The areolae are partially occluded by secondary structures in the form of dendritic volae and the areolae decrease slightly in size as they approach the valve margin. The two outermost rows of areolae are subcircular and irregularly crowded together. Beyond this the margin is occupied by a narrow hyaline zone. The tertiary costae are confined to this marginal zone. The central area is small and surrounded by a circle of short cuneate areolae, often forming an irregular circle, beyond which are two or three rows of areolae separated by moderately wide concentric spaces. The areolae of the second row are often very large, sometimes irregular in shape and occasionally one or more of the areolae are divided into two small ones, though occupying little more space than the single areola. Valve margin furnished with a moderately broad internal septum which is extended to define the sides of the primary costae which merge into the thickened central area which is devoid of an internal septum.

Hypotype No. 55171 (Calif. Acad. Sci. Dept. Geol. Type Coll.) Diameter 74μ

Eocene, South Atlantic core 112, C.A.S. Locality No. 39575(14). Lat. 51°40'S. Long. 48°29'W.

Arachnoidiscus japonicus (Shadbolt) Pritchard
(Plate 2, figure 1.)

Pritchard, 1852, p. 319, pl. 24, figs. 18-21.
Arachnodiscus ornatus Ehrenberg, 1849, p. 64, (1850).
Hemiptychus ornatus Ehrenberg in Mann, 1907, p. 267.
Arachnoidiscus ornatus Ehrenberg in Pritchard, 1861, p. 842, pl. 15, figs. 18-21.
Schmidt's Atlas, 1874—, pl. 73, figs. 4-10, (1882).
Pantocsek, 1886, 1, p. 69;
Brown, 1933, p. 49, pl. 3, figs. 2-5;
Reinhold, 1937, p. 85, pl. 4, fig. 1;
Hajós, 1968, p. 119, pl. 29, fig. 12.

Valve circular, moderately flat, though often having the central area slightly raised or depressed. Valve surface divided by numerous, usually 15-33, primary costae, usually prominently marked and extending almost to the center of the valve. Secondary costae about a third of the length of the primaries and much less definitely marked; tertiary costae much reduced and seldom extending beyond the margin. Valve surface of the inter-costal sectors covered with small areolae arranged in short transverse lines, often somewhat crowded together. Areolae about the same size throughout the entire valve surface. Inter-costal sectors crossed by a series of transverse, sub-parallel lines or costae, often curved or oblique near the valve margin. The areolae may also be in oblique lines in this area. Central area moderately large, with the first circles of areolae being either wedge-shaped or radially linear. The linear areolae at the center are immediately surrounded by a single circle of elliptical areolae that appear to be separate from those between the primary costae, the latter being defined by a line or thickening around the apex of the center. The elliptical areolae of the second row are about twice the number of the linear inner row.

Hypotype No. 55175 (Calif. Acad. Sci. Dept. Geol. Type Coll.) Diameter 260μ

Eocene, South Atlantic core 107, C.A.S. Locality No. 39573(10). Lat. 51°08'S. Long. 54°22'W.

The specimen illustrated on Plate 2, figure 1 was referred to *Arachnoidiscus japonicus* with a certain amount of diffidence, for although the valve surface clearly bore the characteristic "cobweb"-like markings, the usually deep internal septum around the margin was missing and was replaced by a narrow and somewhat irregular ledge and that at the center was almost suppressed. The marginal septa in this species are usually extended to run along the sides of the primary rays to form flanges before joining the central septum, but in the specimen illustrated here the primary rays, though very strongly marked were merely grooves and their edges were without flanges. The other valve markings however, were characteristic of the species. The inter-radial areolae were usually elliptical with the longer axis corresponding to the radius of the valve, and they appeared to be devoid of secondary structures.

The species was rare in the material examined and too few specimens were recovered to determine any possible range of variation.

The generic term *Arachnodiscus* used by Ehrenberg in 1849 was a *nomen nudum* and the first species to be accompanied by a description and an illustration was *A. japonicus* by Shadbolt in Pritchard in 1852 where the spelling of the name was changed to *Arachnoidiscus japonicus.* As explained previously, the generic term *Arachnoidiscus,* first suggested by Deane was conserved against *Hemiptychus* Ehrenberg and *Arachnodiscus* J. W. Bailey ex Ehrenberg taking *Arachnoidiscus japonicus* Shadbolt ex Pritchard as the type species. *Arachnoidiscus japonicus* (Shadbolt) ex Pritchard is synonymous with *Arachnodiscus ornatus* Ehrenberg and *Arachnoidiscus ornatus* Ehrenberg of other authors.

Arachnoidiscus magister Hanna, Hendey & Brigger, new species (Plate 2, figures 4 & 5.)

Valve circular, gently and evenly depressed from an abrupt margin towards the center. Valve surface divided by numerous primary costae, (the holotype has more than 50), which penetrate 3/4 of the distance toward the valve center. Secondary costae very short, marginal, about 1/16 the length of the primaries, tertiary costae absent. Valve surface of the inter-costal sections covered with a roughly hexagonal areolation to about half the distance from the center beyond which the areolae tend to become subquadrate, gradually decreasing in size to the valve margin where finally, they are sub-circular. The walls of the hexagonal areolae are thin but very clearly marked having slight swellings at their intersections and cover the entire valve including the primary costae, the angles of the hexagons giving a slightly zig-zag appearance to the primary costae which may be seen at a lower focus. As the marginal regions of the surface are reached the transverse (or concentric) walls of the areolae remain clear and precise, forming short groups that by reason of the angles of the hexagons alternate with those in adjacent costae; but the short radial walls dividing the separate areolae become fainter and less ridged. Each areola is closed by a velum bearing a central sub-circular poroid which is partially occluded by small dendritic volae. The central area of the valve is more or less hyaline but bears several dark puncta which are vestiges of the intersectional swellings of walls that have been suppressed. Marginal and central internal septa absent. A large and very beautiful species, *Arachnoidiscus magister* was rare in the material examined.

Holotype No. 55178 (Calif. Acad. Sci. Dept. Geol. Type Coll. Diameter 418μ

Eocene, South Atlantic core 107, C.A.S. Locality No. 39573(8). Lat. 51°08'S. Long. 54°22'W.

Arachnoidiscus magnificus Hanna, Hendey & Brigger, new species (Plate 1, figure 4.)

Valve circular, with a gently curved margin and a slightly depressed center. Valve surface divided into sectors by numerous (more than 60) primary costae that reach to the central area. Secondary costae about 1/4 to 1/3 the length of the primaries; teritary costae 1/6 to 1/4 the length of the secondaries. Valve surface of the inter-costal sectors areolate, areolae small, 2-5 μ in diameter, (more than 60 rows from center to valve margin) sub-quadrate to sub-circular, in crowded rows, which in most cases are opposite those of contiguous sectors and therefore form continuous concentric circles with them. However, as the rows are crowded the smaller areolae in the middle of a sector sometimes tend to be pushed slightly out of line and this, together with the fact that the interareolate spaces are very narrow, obscure any definite impression of clear concentricity often seen in this genus. Central area furnished with irregularly scattered areolae, usually larger than those on the remainder of the valve surface. All areolae furnished with secondary structures in the form of dendritic outgrowths, or volae. The holotype here described and illustrated in Plate 1, figure 4, though partially eroded, showed positive signs of these volae. The extreme margin of the valve was furnished with a narrow hyaline space and a narrow internal septum which was extended to strengthen the sides of the primary rays. The central area was devoid of an internal septum.

Holotype No. 55174 (Calif. Acad. Sci. Dept. Geol. Type Coll.) Diameter 686μ

Eocene, South Atlantic core 104, C.A.S. Locality No. 39574(13). Lat. 53°01'S. Long. 52°52'W.

Arachnoidiscus oamaruensis Brown
(Plate 2, figure 2.)
Brown, 1933, p. 60, pl. 5, figs. 2,3;
Reinhold, 1937, p. 85, pl. 4, fig. 3.
Arachnoidiscus ehrenbergii var. *oamaruensis* A. Schmidt, in Schmidt's Atlas, 1874—, pl. 147, figs. 1 & 3. (1890).

Valve circular, moderately flat, sometimes slightly depressed at the center. Valve surface divided by numerous, (usually 20-33) primary costae which extend toward the center as far as the second or third circle of areolae. Secondary costae about 1/4 the length of the primaries; tertiary costae reduced to a slightly elongated punctum restricted to the valve margin. Valve surface of the intercostal sectors covered with sub-quadrate areolae closely placed in crowded rows that are opposite at the costae, i.e. forming continuous or almost continuous concentric circles. Though the areolae are more or less the same size throughout, those nearest the valve margin are usually slightly smaller. Central area moderately large, hyaline, and surrounded by a ring of elongated or slit-like areolae, beyond which is the second ring of areolae which are usually sub-circular. These two inner rows are reasonably well spaced apart and are separated by a distance equal to about half the diameter of the sub-circular areolae. They therefore appear clearly defined. The concentric spaces between the areolae over the remainder of the valve are much narrower and are equal to about 1/4 to 1/3 the diameter of the areolae themselves, while the radial spaces between the areolae within the inter-costal sectors are much less, often these areolae appear almost to touch each other.

The valve margin is usually turned over somewhat abruptly and is furnished with a narrow internal septum. The central area has no internal septum, but each inter-costal sector appears to be bounded by a line or slight thickening that clearly defines it and separates it from the central area.

Hypotype No. 55176 (Calif. Acad. Sci. Dept. Geol. Type Coll.) Diameter 204μ

Eocene, South Atlantic core 107, C.A.S. Locality No. 39573(9). Lat. 51°08'S. Long. 54°22'W.

Arachnoidiscus primordialis Hanna, Hendey & Brigger, new species. (Plate 3, figures 5 & 6.)

Valve triangular, with broad rounded angles and convex sides. Valve surface divided by about 18 primary radial costae that penetrate to about 3/4 of the distance towards the valve center. Primary costae deep and widening slightly as they approach the center. Secondary costae few, sometimes in pairs, and vary in length from 1/4 to 1/3 the length of the primaries. The radial sectors formed by the primary costae appear to be raised or convex and they slope gently towards the abrupt valve margin. The margins of the primary costae are thickened and project inwards towards the center of the valve as narrow walls and they become slightly more distant as they reach the valve margin, thereby producing a flared or trumpet-shaped end which is connected with the flared ends of the adjacent rays. This produces a slight thickening at the valve margin which is in the nature of a reduced internal septum. Valve surface covered with subcircular areolae, irregularly scattered, more or less the same size throughout the entire surface, but a little less densely arranged towards the center which is occupied by a hyaline area. The areolae are devoid of secondary structures and the characteristic ring of slit-like openings around the central area are absent. There appears to be no separate internal septum at the valve center, but the inter-costal sectors are thinner than the central area and this difference in the thickness of the silica clearly defines the central area.

Holotype No. 55183 (Calif. Acad. Sci. Dept. Geol. Type Coll.) Diameter 393μ

Paratype No. 55184 (Calif. Acad. Sci. Dept. Geol. Type Coll.) Diameter 105μ

Eocene, South Atlantic core 107, C.A.S. Locality No. 39573(11). Lat. 51°08'S. Long. 54°22'W.

Arachnoidiscus primordialis appeared to be rare in the material examined, two specimens only being recovered and they have been placed in this genus with much diffidence. The irregular arrangement of the areolae, the absence of secondary structures and the absence of slit-like openings around the central area, all suggest an affinity with the genus *Stictodiscus*, but the formation of the primary rays and the convex inter-radial sectors together with the presence of the primitive marginal septum around the valve edge all suggest a closer connection with *Arachnoidiscus*. The valves of both specimens examined showed signs of erosion, as did many specimens recovered from these Eocene cores and this might account for the absence of secondary structures within the valve.

Arachnoidiscus sendaicus Brown
(Plate 2, figure 6.)

Brown, 1933, p. 57, pl. 1, fig. 1.; pl. 4, figs. 6-8

Valve circular, moderately flat, though sometimes slightly depressed in the center. Valve surface divided into sectors by numerous, (22 to 40) primary costae that penetrate towards the center almost to the second circle of areolae. Secondary costae usually about 1/5 to 1/4 the length of the primaries, tertiary costae about half the length of the secondaries. Valve surface of the intercostal sectors areolate, areolae elliptic-quadrate or elliptic-cuneate, arranged in groups of 2-3 at the inner end and 6-8 at the outer or marginal end of the sectors. Areolate in more or less continuous concentric circles, not alternating at the primary costae with the concentric spaces between the rows often as much as 3/4 the longer axis of the areolae. The areolae are more or less uniform in size except for the row at the extreme margin, which is about half the diameter of the others. Beyond the marginal row is a narrow hyaline margin which is turned over abruptly to a narrow valve mantle which slopes outwards very slightly. This valve mantle is also areolate. Central area small to medium, hyaline and surrounded by a ring of short elliptic-cuneate areolae, beyond which is the second row of areolae, usually sub-circular, or sub-quadrate and these penetrate the thickened central area somewhat obliquely. The valve margin is furnished with a moderately wide internal septum which is extended to form wide flanges along the sides of the primary rays and finally expand to join together to form an internal septum beneath the central area. This central septum appears to be attached to the central area. *Arachnoidiscus sendaicus* is very similar to *Arachnoidiscus oamaruensis* but the latter does not possess a central internal septum.

Hypotype No. 55179 (Calif. Acad. Sci. Dept. Geol. Type Coll.) Diameter 278μ

Eocene, South Atlantic core 112, C.A.S. Locality No. 39575(15). Lat. 51°40'S. Long. 48°29'W.

Arachnoidiscus sokoli Hanna, Hendey & Brigger new species. (Plate 2, figure 3.)

Valve circular, gently and evenly depressed from the margin to the center. Valve surface divided by about 29-30 primary costae which penetrate to the third ring of areolae. Secondary costae usually very long, varying from 1/2 to 3/4, or even more, the length of the primaries; tertiary costae 1/8 to 1/6 the length of the primaries. Valve surface of the inter-costal sectors covered with sub-quadrate areolae, more or less the same size throughout, but slightly smaller near the valve margin. Areolae usually in blocks of two or three, seldom four. Each block is slightly depressed and the vertical walls dividing the separate areolae within a block very indistinct or thin. The concentric walls separating the blocks of areolae are clear, prominent, though slightly flattened, i.e. not ridged, so that the blocks do not appear to be sunk into pits. Each inter-radial sector is slightly convex and many of the blocks of areolae in the marginal regions of the valve appear to be placed obliquely. The areolae are not alternate but are arranged to form irregular concentric circles, the slight irregularity being caused by some areolae being more obliquely placed than others. Central area small, with a few scattered puncta and surrounded by a ring of short wedge-shaped areolae. Beyond these are two rows of small circular areolae, occasionally interspersed by one or two cuneate areolae. Marginal and central septa are absent. The areolae were devoid of secondary structures though each appeared to be closed by a very thin velum, or it may be that the areolae have lost their secondary structures by erosion. This species is named for William Sokol of Culver City, California, a keen student of diatoms.

Holotype No. 55177 (Calif. Acad. Sci. Dept. Geol. Type Coll.) Diameter 214μ

Eocene, South Atlantic core 130, C.A.S. Locality No. 39650(16). Lat. 41°30'S. Long. 56°36'W.

Arachnoidiscus stictodiscoides Hanna, Hendey & Brigger, new species. (Plate 3, figures 1-4.)

Valve circular, moderately flat, or only very slightly raised at the center. Primary costae 25-35, usually indistinctly formed and appear as faint "watery" lines or grooves visible for about 2/3 to about 3/4 of the radius. Secondary costae very short, marginal. Valve surface covered with a coarse sub-hexagonal network of raised walls forming areolae, with thickening at the intersections of the walls. Loculi about 10μ in diameter near the center of the valve but increasing slightly at a distance equal to about half the radius, after which they decrease as the margin is approached. The "floor" or velum of each areola is slightly domed and furnished with a circular, sub-elliptical or sub-rectangular poroid, partially occluded by dendritic outgrowths or volae. The poroids are about 1/3 the diameter of the areolae and the roughly hexagonal shape of the latter tends to place the much smaller poroids in somewhat irregular concentric circles. The coarse hexagonal areolation is superimposed upon the primary costae, crossing them, thereby rendering them somewhat difficult to observe. At the center of the valve the hexagonal areolation becomes less pronounced and somewhat irregular, breaking down to provide a small hyaline central area, surrounded by a ring of irregularly placed narrow slits, usually 10-12, which do not appear to be furnished with volae.

Valve margin furnished with a short internal septum with scalloped margins that appear to extend slightly down the sides of the primary costae, weakly defining them; no internal septum is visible around the central area.

Holotype No. 55180 (Calif. Acad. Sci. Dept. Geol. Type Coll.) Diameter 186μ

Eocene, South Atlantic core 107, C.A.S. Locality No. 39573(8). Lat. 51°08'S. Long. 54°22'W.

Arachnoidiscus stictodiscoides appeared to be reasonably constant in structure and the two paratypes examined showed little variation, though one of them, plate 3, figure 3, taken from Locality No. 39574(13) at a depth of more than 330 cm., appeared to be a little more finely marked, particularly near the valve margin.

This specimen shown on Plate 3, figure 3, having a diameter of 204μ, is slightly depressed at the center and the primary rays are more pronounced than in the holotype. The central area is small, hyaline and furnished with a ring of 12 longitudinal slits that are only indistinctly visible in the figure. Paratype shown on plate 3, figure 2, taken from Locality No. 39573 (10), from a depth of 175 cm. had a diameter of 241μ and the internal septum at the margin was much more clearly defined and continued as a ridge or lines along the sides of the primary costae to a distance of about 1/3 of the radius from the valve margin. The central area was small, hyaline, though ornamented with a few walls forming irregularly shaped areolae, often incomplete. The longitudinal slits were absent.

Plate 3, figure 4, shows the central area of another valve showing the irregular arrangement of the ring of slits, they are usually in groups of two or three separated by the wall of an incomplete areola.

In some specimens the radial walls of the areolae form well-marked zig-zag lines from the confused center to the valve margin; these lines correspond with the primary costae and are clearly seen over them. Often the radial walls of some areolae lying between the primary costae are missing, thus causing two or three to merge as one; or they may be present, but appear as watery lines, far less distinct than the zig-zag walls that define the primary costae.

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PLATE 1

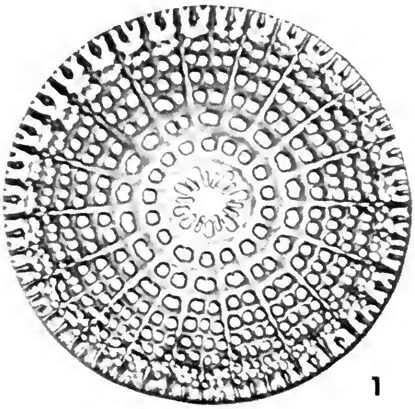
FIGURE 1. *Arachnoidiscus indicus* Ehrenberg. Hypotype No. 55171 (Calif. Acad. Sci. Dept. Geol. Type Coll.) Diameter 74μ. Eocene, South Atlantic core 112, C.A.S. Locality No. 39575(14). Lat. 51°40'S. Long. 48°29'W.

FIGURE 2. *Arachnoidiscus atlanticus* Hanna, Hendey & Brigger, new species. Holotype No. 55172 (Calif. Acad. Sci. Dept. Geol. Type Coll.) Diameter 204μ. Eocene, South Atlantic core 112, C.A.S. Locality No. 39575(15). Lat. 51°40'S. Long. 48°29'W.

FIGURE 3. *Arachnoidiscus deficiens* Brown. Hypotype No. 55173 (Calif. Acad. Sci. Dept. Geol. Type Coll.) Diameter 316μ. Eocene, South Atlantic core 112, C.A.S. Locality No. 39575(14). Lat. 51°40'S. Long. 48°29'W.

FIGURE 4. *Arachnoidiscus magnificus* Hanna, Hendey & Brigger, new species. Holotype No. 55174 (Calif. Acad. Sci. Dept. Geol. Type Coll.) Diameter 686μ. Eocene, South Atlantic core 104, C.A.S. Locality No. 39574(13). Lat. 53°01'S. Long. 52°52'W.

FIGURE 5. *Arachnoidiscus deficiens* Brown. Enlarged view, showing the areolae of the central area of valve without the inner ring of slit-like openings. Same specimen as figure 3.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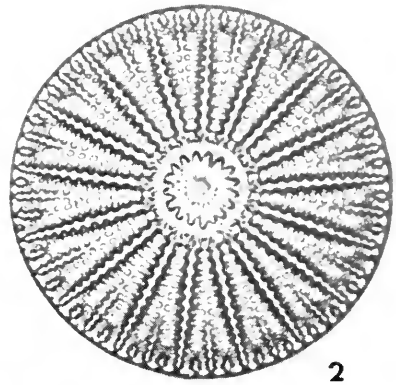
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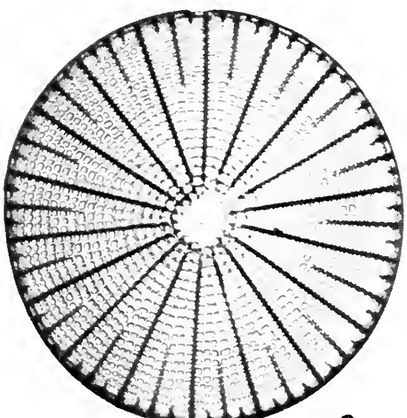
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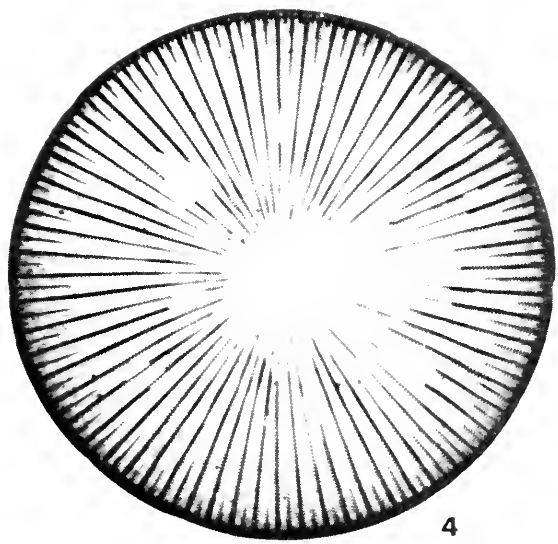
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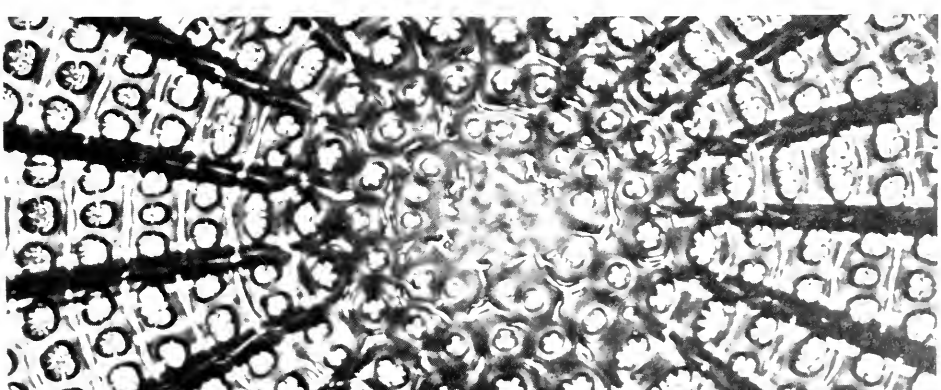
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PLATE 2

FIGURE 1. *Arachnoidiscus japonicus* (Shadbolt) ex Pritchard. Hypotype No. 55175 (Calif. Acad. Sci. Dept. Geol. Type Coll.) Diameter 260μ. Eocene, South Atlantic core 107, C.A.S. Locality No. 39573(10). Lat. 51°08′S. Long. 54°22′W.

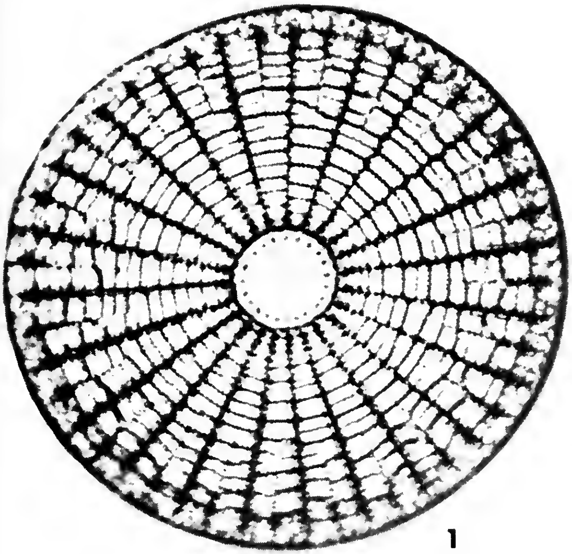
FIGURE 2. *Arachnoidiscus oamaruensis* Brown. Hypotype No. 55176 (Calif. Acad. Sci. Dept. Geol. Type Coll.) Diameter 204μ. Eocene, South Atlantic core 107, C.A.S. Locality No. 39573(9). Lat. 51°08′S. Long 54°22′W.

FIGURE 3. *Arachnoidiscus sokoli* Hanna, Hendey & Brigger, new species. Holotype No. 55177 (Calif. Acad. Sci. Dept. Geol. Type Coll.) Diameter 214μ. Eocene, South Atlantic core 130, C.A.S. Locality No. 39650(16). Lat. 41°30′S. Long. 56°36′W.

FIGURE 4. *Arachnoidiscus magister* Hanna, Hendey & Brigger, new species. Holotype No. 55178 (Calif. Acad. Sci. Dept. Geol. Type Coll.) Diameter 418μ. Eocene, South Atlantic core 107, C.A.S. Locality No. 39573(8). Lat. 51°08′S. Long. 54°22′W.

FIGURE 5. *Arachnoidiscus magister* Hanna, Hendey & Brigger, new species. Enlarged view of the central area of Figure 4, showing the areolae.

FIGURE 6. *Arachnoidiscus sendaicus* Brown. Hypotype No. 55179 (Calif. Acad. Sci. Dept. Geol. Type Coll.) Diameter 278μ. Eocene, South Atlantic core 112, C.A.S. Locality No. 39575(15). Lat. 51°40′S. Long. 48°29′W.



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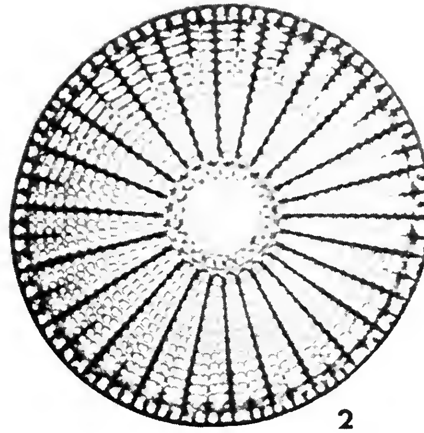

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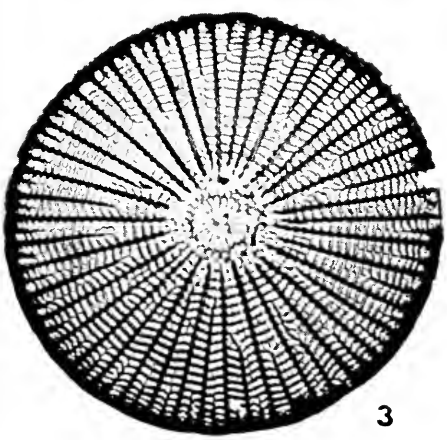

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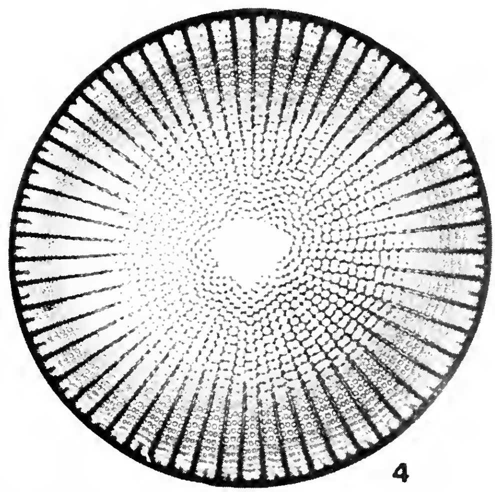

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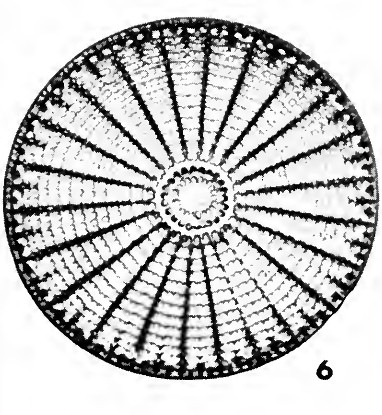

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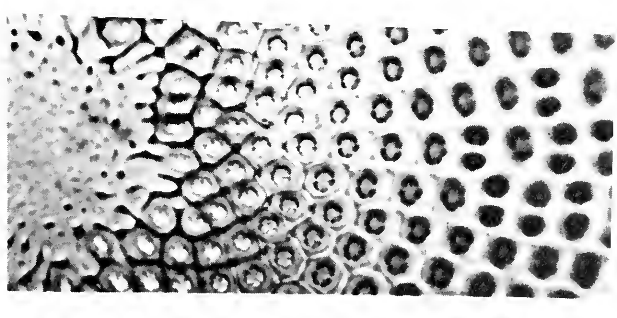

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PLATE 3

FIGURE 1. *Arachnoidiscus stictodiscoides* Hanna, Hendey & Brigger, new species. Holotype No. 55180 (Calif. Acad. Sci. Dept. Geol. Type Coll.) Diameter 186μ. Eocene, South Atlantic core 107, C.A.S. Locality No. 39573(8). Lat. 51°08'S. Long. 54°22'W.

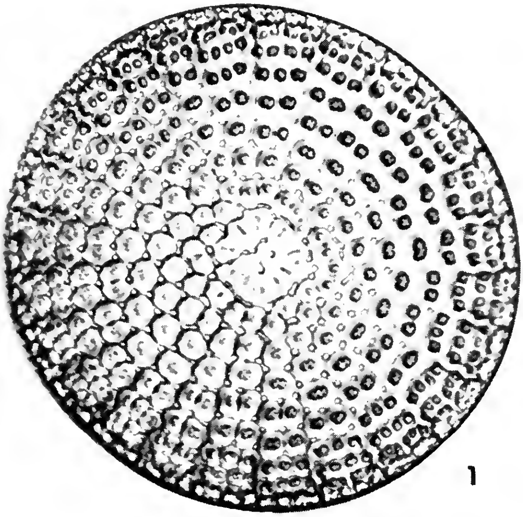
FIGURE 2. *Arachnoidiscus stictodiscoides* Hanna, Hendey & Brigger, new species. Paratype No. 55181 (Calif. Acad. Sci. Dept. Geol. Type Coll.) Diameter 241μ. Eocene, South Atlantic core 107, C.A.S. Locality No. 39573(10). Lat. 51°08'S. Long. 54°22'W.

FIGURE 3. *Arachnoidiscus stictodiscoides* Hanna, Hendey & Brigger, new species. Paratype No. 55182 (Calif Acad. Sci. Dept. Geol. Type Coll.) Diameter 204μ. Eocene, South Atlantic core 104, C.A.S. Locality No. 39574(13). Lat. 53°01'S. Long. 52°52'W.

FIGURE 4. *Arachnoidiscus stictodiscoides* Hanna, Hendey & Brigger, new species. Paratype No. 55182 (Calif. Acad. Sci. Dept. Geol. Type Coll.) Diameter 286μ. Eocene, South Atlantic core 107, C.A.S. Locality No. 39573(9). Lat. 51°08'S. Long. 54°22'W.

FIGURE 5. *Arachnoidiscus primordialis* Hanna, Hendey & Brigger, new species. Holotype No. 55183 (Calif. Acad. Sci. Dept. Geol. Type Coll.) Diameter 393μ. Eocene, South Atlantic core 107, C.A.S. Locality No. 39573(11). Lat. 51°08'S. Long. 54°22'W.

FIGURE 6. *Arachnoidiscus primordialis* Hanna, Hendey & Brigger new species. Paratype No. 55184 (Calif. Acad. Sci. Dept. Geol. Type Coll.) Diameter 105μ. Eocene, South Atlantic core 107, C.A.S. Locality No. 39573(11). Lat. 51°08'S. Long. 54°22'W.



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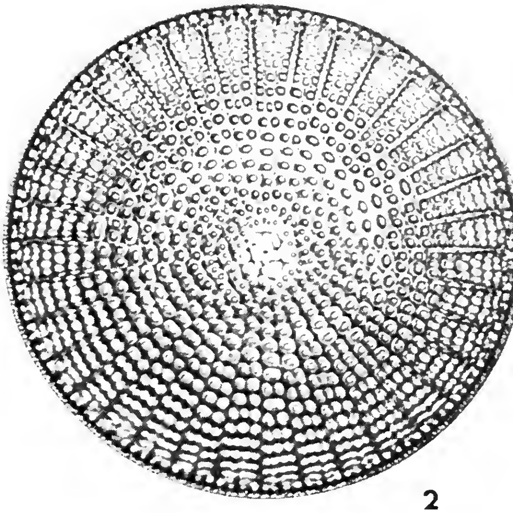

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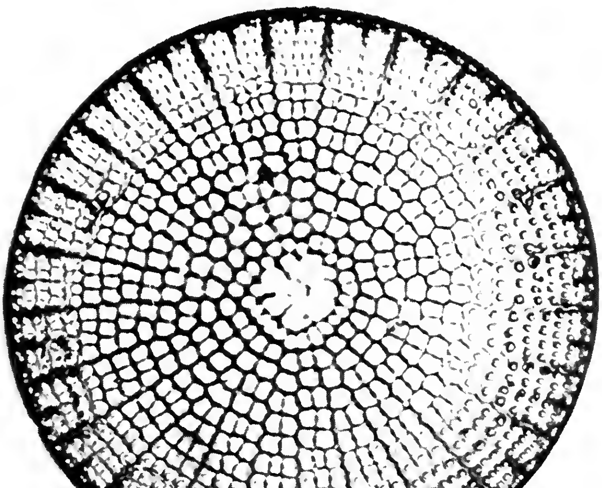

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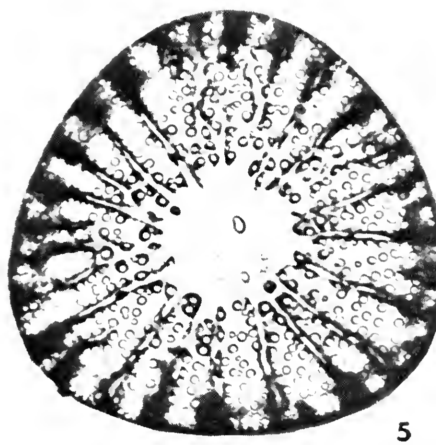

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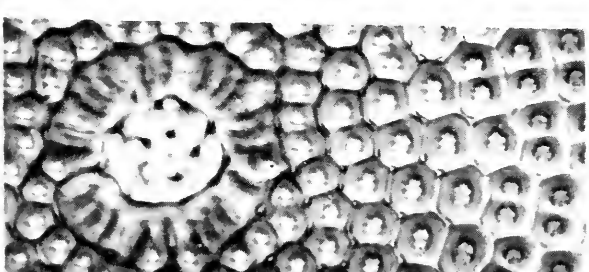

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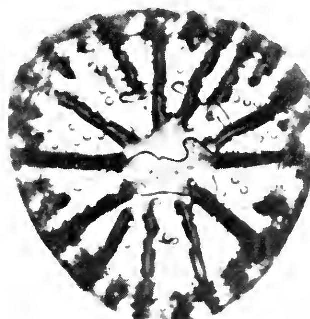

6

SOME EOCENE DIATOMS FROM SOUTH ATLANTIC CORES

Part II. *Rutilaria* Greville

By

R. Ross

British Museum (Natural History)

Among the diatoms selected from Eocene samples from cores taken in the South Atlantic by the research vessel VEMA were some specimens of the genus *Rutilaria* Greville. These represent five species, three of which are new; of the remaining two, one is known from the Eocene to the present day and the other occurs as three subspecies, one of them, that represented in the VEMA material, known only from the Upper Eocene of Oamaru, New Zealand, one from the Upper Eocene or Oligocene of Barbados, and one Recent.

Details of all but one of the samples from which the representatives of the genus *Rutilaria* came are given in the previous paper in this series (Hanna, Hendey & Brigger, 1976). The sample not listed in their paper is: California Academy of Sciences Geology catalogue No. 39576 (7).
VEMA cruise 12, core 46, Lat 47°28.7'S., Long. 59° 20.6' W., Depth 1167 m.; 630 cm. from top of core.

C.A.S. No. 39576 (7), 12-712 cm. Very light gray lutite with faintly greenish tinge due to minute particles of glauconite. Upper 40 cm. much stained by pipe rust. Fairly distinct burrow mottling from 50-100 cm. but none seen below 100 cm. Absence of burrow mottling may be due to flow of sediment into the coring tube. The sediment is quite uniform from 100 cm to the bottom. Sediment reacts vigorously with HCl.

Rutilaria Greville

Rutilaria Greville, 1863, p. 227.

The distinguishing feature of this genus is the process in the center of the valve which links it with the adjacent valve of the next frustule. For this process Jurilj (1965) has suggested the term periplekton; its structure is briefly discussed by Ross & Sims (1972), who illustrate it with a scanning electron micrograph. Another feature of this genus, not mentioned in any description so far published but indicated in some published illustrations, is the comparatively small ocellus, often vertical in the valve mantle, that occurs at either apex. This indicates that the genus should probably be placed in the family Eupodiscaceae.

Rutilaria erinaceus R. Ross, new species
(Plate 1, figure 1.)

Valve slightly depressed in the center, broadly ovate, with very slightly produced obtuse apices. Central hyaline area broadly elliptical, 0.024 mm. x 0.020 mm. Puncta in radiating striae, striae about 11 in 0.01 mm., closer near the margins, puncta about 22 in 0.01 mm. No marginal spines but superficial spines 0.002-0.003 mm. apart throughout, except on and close to the central area. Periplekton with stout stem, center 0.012 mm. tall; ring with broad equal arms closely clasping stem of periplekton of adjacent valve, 0.015 mm. x 0.018 mm; line joining the stems of adjacent periplekta strongly inclined to the apical axis. Terminal processes slightly elevated, ocelli large and nearly vertical.

Holotype No. 55185 (Calif. Acad. Sci. Dept. Geol. Type Coll.)

Length 0.089 mm., breadth 0.067 mm. Eocene, South Atlantic core 46. C.A.S. Locality No. 39576 (7). Lat. 47°28.7'S. Long. 59°20.6'W.

Only one specimen of this species was found. It bears some resemblance to *Rutilaria limoniformis* R. Ross (see below), but its striae are continuous, not interrupted, it lacks the definite row of marginal spines, and its surface is more densely spiny.

Rutilaria interrupta R. Ross, new species
(Plate 1, figures 2-3.)

Valves depressed in the center, margins parallel or slightly concave in the middle portion of the valve, tapering gradually into shorter or longer prolongations that are sometimes slightly expanded at the rounded-cuneate apices. Central hyaline area extending to the margins. Puncta in radiating striae that stop 0.002 mm. from the margin of the valve, striae 20-25 in 0.01 mm. against the central area, much more distant and interrupted towards the apices, puncta 18-25 in 0.01 mm. No marginal or superficial spines. Periplekton large with stem center 0.01 mm. tall, curved distally towards that of the adjacent valve and not appressed to it; ring with equal arms, subtriangular, or circular with a projection at the junction with the stem, 0.020-0.027 mm. x 0.0175-0.022 mm. Terminal processes elevated, ocelli large, vertical, sometimes slightly askew. Valve mantle center 0.006 mm. deep, hyaline. Length 0.068-0.226 mm., breadth 0.021-0.030 mm. Holotype No. 55186 (Calif. Acad. Sci. Dept. Geol. Type Coll.)

Length 0.128 mm., breadth 0.021 mm. Eocene, South Atlantic core 107. C.A.S. Locality No. 39573 (8). Lat. 51°08′S. Long. 54°22′W.

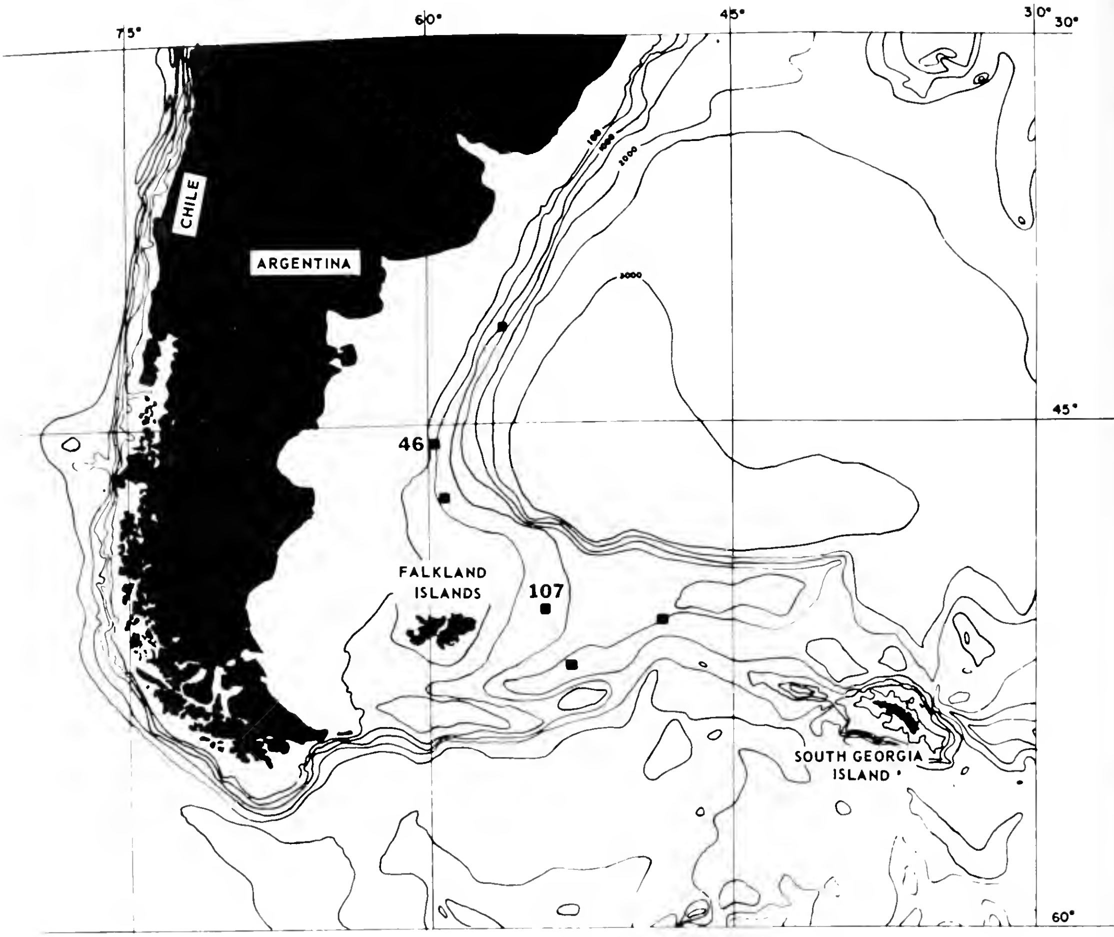

FIGURE 1. Chart showing the positions of the six cores containing Eocene diatoms. Species of *Rutilaria* described in this paper were recovered from VEMA cruise 12, core 46 and VEMA cruise 17, core 107. Descriptions of these cores are given in the text.

This species is close to *Rutilaria radiata* Grove & Sturt (1886), from which it differs in the much larger periplekton and central area, the closer striae in the middle part of the valve, the absence of marginal spines, and the raised terminal processes. It is even closer to an undescribed species present in the Eocene Bastendorf shale from Oregon and in the fossil material dredged from the Bering Sea at U.S.S. ALBATROSS station 4029 H, for which a Miocene date has been suggested (Hanna, 1929). Specimens were found in the samples from 50 cm., 120 cm. and 175 cm. in VEMA cruise 17, core 107, (C.A.S. Locality Nos. 39573 (8), (9), (10), but not in that from 245 cm. in the same core, and also in the sample from 330-335 cm. in VEMA cruise 18, core 104 (C.A.S. Locality No. 39574 (13)), but not that from 50 cm. in this core.

In the specimens from 39573 (8) and (9) the ring of the periplekton is subtriangular and clasps the stem closely, whereas in that from 39574 (13) it is circular with a projection and clasps the stem loosely. In the single specimen from 39573 (10) the periplekton is broken and only part of one arm of the ring remains. It appears, however, to have been intermediate in shape between those from 39573 (8) and (9) and that from 39574 (13).

Rutilaria limoniformis R. Ross, new species
(Plate 1, figure 4.)

Valve broadly ovate with very slightly produced obtuse apices. Central hyaline area circular, 0.014-0.017 mm. diameter. Puncta scattered individually or in much interrupted radiating striae, converging toward the apices, striae about 20 in 0.01 mm., puncta about 25 in 0.01 mm., but very rarely more than 8 continuous puncta in a row, the longest rows of puncta being in those striae directed towards the apices. Marginal spines in a sometimes rather irregular row reaching to the apices, 6-8 in 0.01 mm.; scattered small superficial spines between the central area and the apices. Periplekton with a stout stem, center 0.01 mm. tall; ring with equal arms closely clasping stem of periplekton of the adjacent valve, 0.007-0.0085 mm. x 0.0085 - 0.010 mm.; line joining the stems of adjacent periplekta inclined to the apical axes of the valves. Terminal processes slightly elevated, ocelli large and nearly vertical. Length 0.040-0.048 mm., breadth 0.032-0.033 mm.

Holotype No. 55188 (Calif. Acad. Sci. Dept. Geol. Type Coll.)

Length 0.048 mm., breadth 0.033 mm. Eocene, South Atlantic core 107, C.A.S. Locality No. 39573 (9). Lat. 51°08'S. Long. 54°22'W.

This species is close to *Rutilaria obesa* Greville ex Cleve (1881, p. 19), in which also the line joining the stems of the periplekta of adjacent valves is sometimes inclined to the apical axes of the valves. In that species, however, the puncta are scattered individually, except near the apices, and do not form interrupted striae; also the ring of the periplekton has a thin flange at its outer edge in *R. obesa* but not in *R. limoniformis*. The other species that is close is *R. erinaceus* R. Ross, but in that the radial striae are not interrupted and are much further apart; also there is no definite line of marginal spines.

This species is comparatively rare in the material studied, single specimens only having been found in the samples from 50 cm. and 120 cm. in VEMA cruise 17, core 107, (C.A.S. Locality Nos. 39573 (8) and (9)).

Rutilaria philippinarum Cleve & Grove
(Plate 1, figure 5.)

Rutilaria philippinarum Cleve & Grove (1891, p. 64, pl. 10 figs. 1-2).

Rutilaria pulchra A. Schmidt (1893, pl. 183 fig. 20).

This species is known from the Eocene to the present day, when it is confined to the Indian Ocean and the waters around the Philippines. As a fossil, it occurs in the Eocene of the Volga basin, U.S.S.R. and of Oamaru, New Zealand, the Upper Eocene or Oligocene of Barbados, and the Miocene of California and of Hungary and Czechoslovakia. It occurs in the samples from 50 cm., 120 cm. and 175 cm. in VEMA cruise 17, core 107, (C.A.S. Locality Nos. 39573 (8), (9) and (10)). One of the specimens from the 120 cm. level is larger than any without prolongations that I have previously encountered, being 0.080 mm. x 0.031 mm.; the ring of the periplekton is also larger than in any other specimen seen, being 0.0085 mm. in diameter, as against 0.005-0.006 mm. in all others. These are, however, the only ways in which this specimen differs from other members of the species.

Hypotype No. 55189 (Calif. Acad. Sci. Dept. Geol. Type Coll.)

Length 0.108 mm. breadth 0.026 mm. Eocene, South Atlantic core 107. C.A.S. Locality No. 39573 (8). Lat 51°08'S. Long. 54°22' W.

Rutilaria tenuicornis subsp. **tenuis** (Grove & Sturt) R. Ross, subsp. nov. (Plate 1, figure 6.)

Rutilaria epsilon var. *tenuis* Grove & Sturt (1887, p. 75, pl. 6 fig. 13).

Rutilaria tenuis (Grove & Sturt) Brun & Tempere (1889, p. 54).

Valves depressed in the center, median part circular or elliptical, tapering gradually into linear prolongations. Central hyaline area circular, separated from the margin by striae consisting of 1 or 2 puncta only. Puncta in radiating rows around the central area and logitudinal rows on the prolongations, rows 14-22 in 0.01 mm., puncta 12-16 in 0.01 mm. Marginal spines present except opposite the central area, reaching to the apices, 3-4 in 0.01 mm. A few superficial spines close to the central area. Stem of periplekton straight, center 0.01 mm tall, ring with unequal arms and a broad flange interrupted for a short distance near the junction with the stem. Terminal ocelli on slightly raised processes. Length 0.075-0.175 mm., breadth 0.014-0.018 mm.

Hypotype No. 55190 (Calif. Acad. Sci. Dept. Geol. Type Coll.)

Length 0.164 mm., breadth 0.018 mm. Eocene, South Atlantic core 107. C.A.S. Locality No. 39573 (8). Lat. 51°08'S. Long. 54°22'W.

This subspecies occurs in the samples from 50 cm., 175 cm. and 245 cm. in VEMA cruise 17, core 107 (C.A.S. Locality Nos. 39573 (8), (10) and (11)) and in the sample from VEMA cruise 18, core 112 (C.A.S. Locality No. 39574 (14)). The specimens match exactly those from the Upper Eocene of Oamaru, New Zealand. The only differences between the Eocene specimens and Recent ones from the seas around the East Indies and Japan are that the Recent ones have a smaller hyaline central area opposite which there is no gap in the row of marginal spines. It does not seem appropriate to recognize taxa with such slight morphological differences at any higher level than subspecies, and these Eocene diatoms are therefore treated as forming subspecies of the Recent *Rutilaria tenuicornis* Grunow in Van Heurck (1883, pl. 105 fig. 10). There is a third subspecies, not yet described, in the Upper Eocene or Oligocene of Barbados; the differences that this shows are no greater.

Although this is not a new taxon but one previously recognized that is here given a new position and rank, a description is provided since no adequate one has previously been published and Grove & Sturt's original figure is very inaccurate; it shows a central area no larger than the stem of the periplekton, and the marginal spines not interrupted in the median part of the valve. However, the holotype in the British Museum (Natural History) (B.M. 46635, ex coll. Sturt) has the large central area and the gap in the marginal spines that characterize this subspecies.

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PLATE 1

FIGURE 1. *Rutilaria erinaceus* R. Ross, new species. Holotype No. 55185 (Calif. Acad. Sci. Dept. Geol. Type Coll.) Length 0.089 mm., breadth 0.067 mm. Eocene, South Atlantic core 46, C.A.S. Locality No. 39576(7). Lat. 47°28.7'S. Long. 59°20.6'W.

FIGURE 2. *Rutilaria interrupta* R. Ross, new species. Holotype No. 55186 (Calif. Acad. Sci. Dept. Geol. Type Coll.) Length 0.128 mm., breadth 0.021 mm. Eocene, South Atlantic core 107, C.A.S. Locality No. 39575(8). Lat. 51°08'S. Long. 54°22'W.

FIGURE 3. *Rutilaria interrupta* R. Ross, new species. Paratype No. 55187 (Calif. Acad. Sci. Dept. Geol. Type Coll.) Specimen in girdle view. Lenth 0.114 mm. Eocene, South Atlantic core 107, C.A.S. Locality No. 39573(8).

FIGURE 4. *Rutilaria limoniformis* R. Ross, new species. Holotype No. 55188 (Calif. Acad. Sci. Dept. Geol. Type Coll.) Length 0.048 mm., breadth 0.033 mm. Eocene, South Atlantic core 107, C.A.S. Locality No. 39573(9). Lat. 51°08'S. Long. 54°22'W.

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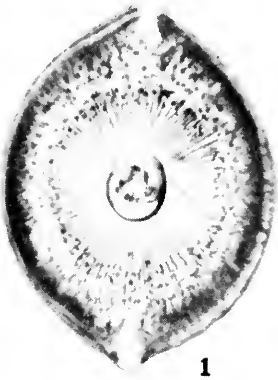
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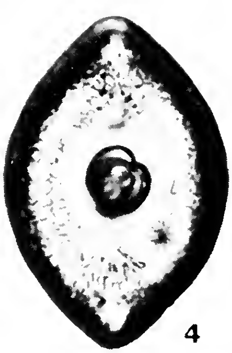
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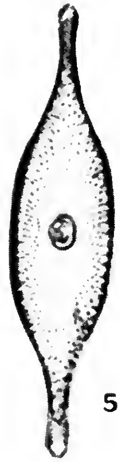
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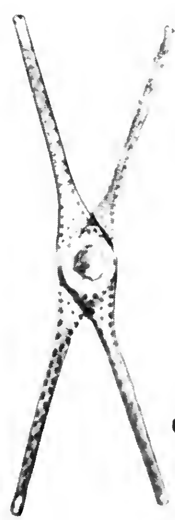
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SAN FRANCISCO

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