Bull. Soc. belge Géol., Paléont., Hydrol.	T. 79	fasc. 2	pp. 175-184	Bruxelles 1970
Bull. Belg. Ver. Geol., Paleont., Hydrol.	V. 79	deel 2	blz. 175-184	Brussel 1970

COILING RATIOS AND OTHER VARIATIONS OF *GLOBIGERINA PACHYDERMA* (EHRENBERG, 1861) AND THE STRATIGRAPHICAL SIGNIFICANCE IN THE NEOGENE DEPOSITS OF THE ANTWERPEN AREA (BELGIUM) [1].

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SUMMARY. The planktonic foraminifer *Globigerina pachyderma* (EHRENBERG, 1861) occurs in the Upper Miocene and Plio-Pleistocene deposits of the Antwerpen area. The authors state a change in the dominantly coiling direction of this foraminifer, accompanied with other morphological variations. The stratigraphical level of this change coincides with the admitted Mio-Pliocene boundary in this area. According to several authors, it may be attributed to climatological oscillations.

1. *Introduction*

The importance of the coiling ratio of the planktonic foraminifer *Globigerina pachyderma* (EHRENBERG, 1861) in both recent and fossil material has been clearly demonstrated by several authors during the last ten years. KENNETT (1968) states that the change in coiling direction is accompanied by other variations. BANDY (1968) investigates the paleoclimatological variations in Neogene sediments. He deduces these variations from the distribution of dextrally and sinistrally coiling forms of *G. pachyderma* according to latitude. We refer to these works for more detailed bibliography on this subject.

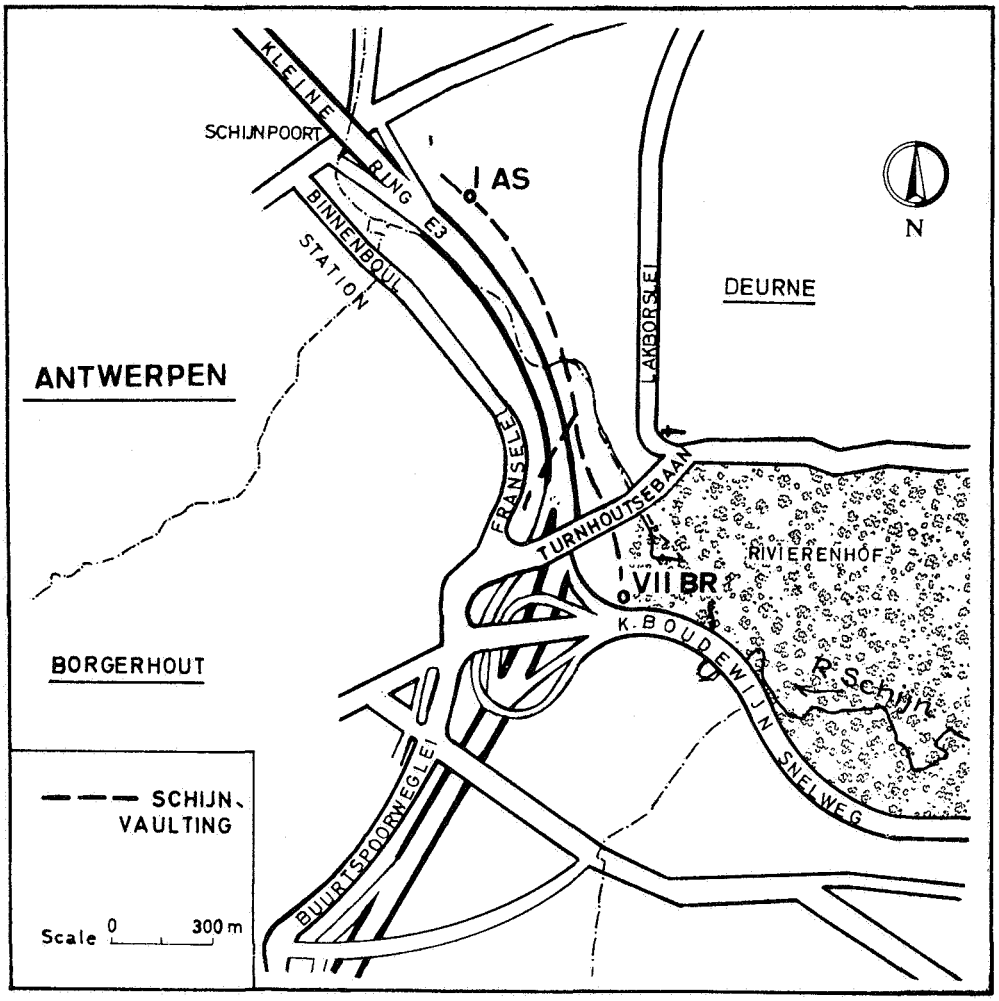
Important public works have been executed around the city of Antwerpen for the E-3 highway and in the harbour area North of this city during the last five years. The first author (F.D.M.) is busy studying the foraminifera of the Miocene deposits; the second (P.L.) those of the Plio-Pleistocene deposits. The two subjects are bounded by the Mio-Pliocene boundary as defined by the resolutions of the Gent Symposium in 1961 (published in 1963). The stratigraphical succession outlined in this Symposium is followed in this paper.

The Upper Miocene and the Plio-Pleistocene deposits of Antwerpen contain only one species of planktonic foraminifer, which is determined as *G. pachyderma*. The variations of this species, particularly the change in coiling direction through the consecutive Members, seem to be of stratigraphical value.

2. *Studied sections and biostratigraphical results*

The Rivierenhof section (VII BR) was examined on the occasion of the vaulting works of the Schijn River. The section was situated at the SW side of the Rivierenhof, near the centre of Deurne (text-figure 1). The lithostratigraphical succession of the Members is given in DE MEUTER, LAGA, RINGELÉ and ROOSE (1967). The Deurne Sands, lying between the Antwerpen Sands and the Katten-

[1] This paper was written after the closure of the East Anglia Colloquium, but since it falls within the scope of the Colloquium it was thought that it could conveniently be added to the papers presented earlier this year (M. GULINCK).



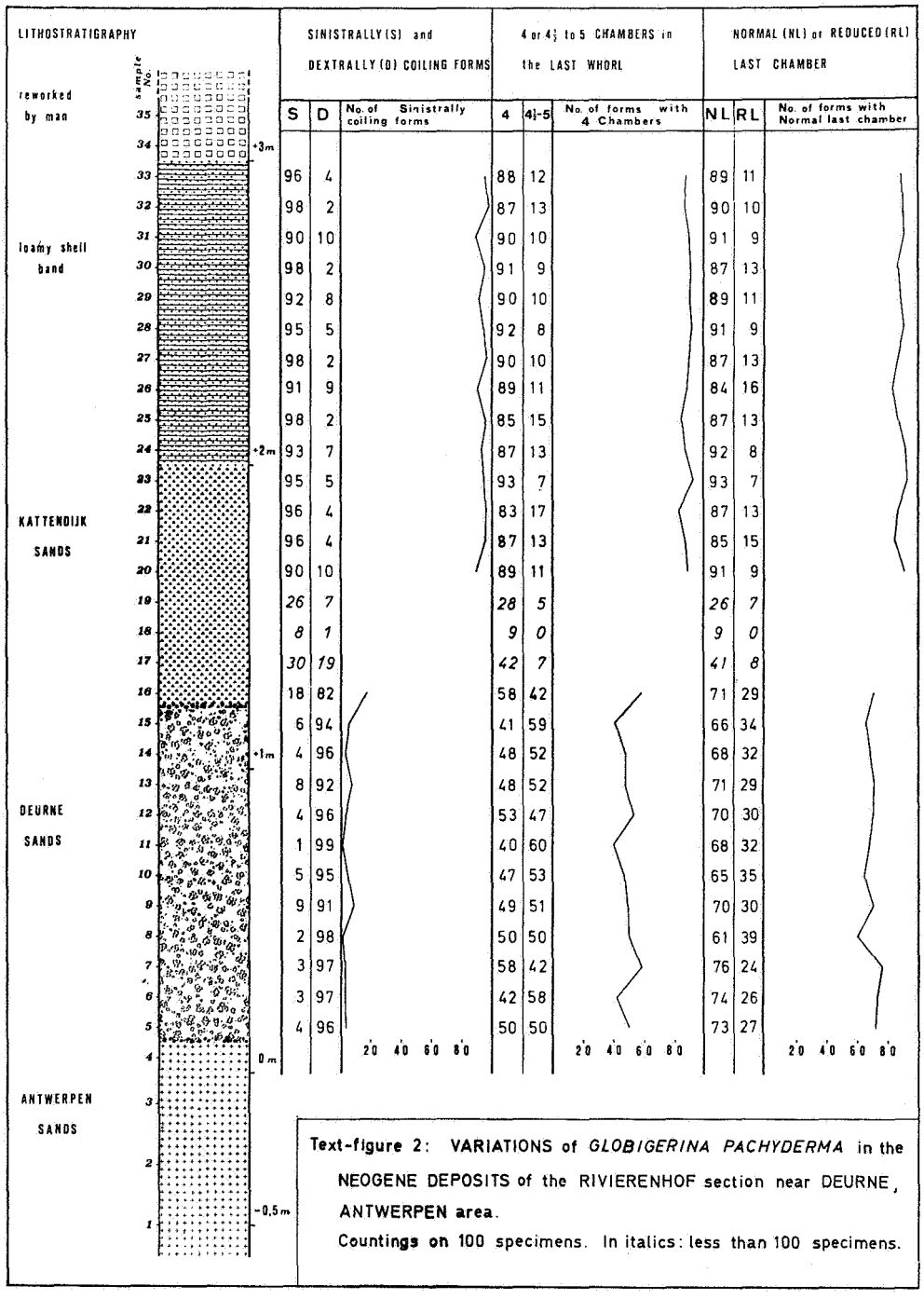
Text-figure 1 LOCATION MAP

dijk Sands, were observed only in the close vicinity of the studied section.

A hundred grams of the sediment, sampled each 10 cm, were washed on a sieve of 0,125 mm mesh width. Foraminifera were concentrated by the carbon tetrachloride flotation method. A hundred specimens of *G. pachyderma* could be counted, except in the poor samples 17 to 19.

Text-figure 2 shows the variation of three features of *G. pachyderma* through the succession of the Members of the section. The transition of the dominantly dextrally coiled forms from the Deurne Sands to the dominantly sinistrally coiled ones in the Kattendijk Sands is clear. Both forms are found together in the lower 20 cm of the Kattendijk Sands. Together with the change in coiling ratio, other variations occur. Generally we can state that the specimens show a *G. bulloides* trend: four chambers in the last whorl (umbilical view), mostly inflated and thick-walled chambers and rarely with a reduced last chamber.

In other sections of the Antwerpen area, the Deurne Sands are lacking. We have investigated the Schijnpoort section (text-figure 1, I AS) and different sections in the harbour area North of Antwerpen. A hundred



sample No.	S	D	4	4½-5	NL	RL
35	96	4	88	12	89	11
34	98	2	87	13	90	10
33	90	10	90	10	91	9
32	98	2	91	9	87	13
31	92	8	90	10	89	11
30	95	5	92	8	91	9
29	98	2	90	10	87	13
28	91	9	89	11	84	16
27	98	2	85	15	87	13
26	93	7	87	13	92	8
25	95	5	93	7	93	7
24	96	4	83	17	87	13
23	96	4	87	13	85	15
22	90	10	89	11	91	9
21	*26*	*7*	*28*	*5*	*26*	*7*
20	*8*	*1*	*9*	*0*	*9*	*0*
19	*30*	*19*	*42*	*7*	*41*	*8*
18	18	82	58	42	71	29
17	6	94	41	59	66	34
16	4	96	48	52	68	32
15	8	92	48	52	71	29
14	4	96	53	47	70	30
13	1	99	40	60	68	32
12	5	95	47	53	65	35
11	9	91	49	51	70	30
10	2	98	50	50	61	39
9	3	97	58	42	76	24
8	3	97	42	58	74	26
7	4	96	50	50	73	27

Text-figure 2: VARIATIONS of *GLOBIGERINA PACHYDERMA* in the NEOGENE DEPOSITS of the RIVIERENHOF section near DEURNE, ANTWERPEN area.
Countings on 100 specimens. In italics: less than 100 specimens.

specimens were counted in the Kattendijk Sands, the Luchtbal Sands, the Kallo Sands and the Merksem Sands. Although the planktonic fauna decreases gradually upwards, the same trends were still observed. The *G. bulloides* character of the sinistrally coiling forms

of the Kattendijk Sands persists in the upperlying Members as shown in text-figure 3. Also a loamy shell band at the top of the Rivierenhof section contains a mixed fauna probably derived from various Members well developed North of Antwerpen.

Members	S	D	4	4½-5	N L	R L
Merksem Sands	92	8	92	8	90	10
Kallo Sands	85	15	97	3	93	7
Luchtbal Sands	100	0	91	9	96	4
Kattendijk Sands	97	3	85	15	89	11

Text-figure 3 Variations of *G. pachyderma* in the Plio-Pleistocene deposits of the Antwerpen area. Countings of 100 specimens. [symbols: see text-figure 2]

3. *The Mio-Pliocene boundary in the Neogene deposits of the Antwerpen area.*

After the introduction of the "Anversian stage" by COGELS (in VAN ERTBORN, 1879), the Miocene age of this stage (containing the Antwerpen Sands and the Edegem Sands) was generally accepted. The "Diestian stage" was officially considered of Pliocene age; following the legend of the Geological Map of Belgium of 1929 the Diestian contains the "sable glauconifère à *Terebratula perforata* (= Sands of Diest), the "sable à Hétérocètes et *Terebratula perforata*" (= Sands of Deurne) and the "sable à *Isocardia cor*" (= Sands of Kattendijk). Several authors had already assumed a Miocene age for the Lower Diestian, but it was LAGAAIJ (1952) who finally decided on the Upper Miocene age of the Lower Diestian (= zone à *Terebratula perforata*) according to the bryozoan fauna it contains. GLIBERT and DE HEINZELIN (1955) also decide, after the study of the complete fossil content of these controversial Sands of Deurne — now called Deurnian and no longer Diestian —, on the Upper Miocene age of this Member, and on the Pliocene age of the Sands of Kattendijk (the former Upper Diestian). This opinion has been confirmed in the resolutions of the Symposium on the Stratigraphy of the Northern Neogene in Gent 1961 (1963).

The stratigraphical level of the stated change in the dominantly coiling direction of *G. pachyderma* coincides with the recently admitted Mio-Pliocene boundary. It seems important to continue our investigations in the other Neogene marine deposits of the North Sea basin. At this stage following remarks can be given. BOEKSCHOTEN (1969) studied the faunas of Oligo-Miocene deposits in borings of NW Germany. The presence of dextrally coiled specimens of *G. pachyderma* confirms the stratigraphical relationship between the Deurne Sands and the German upper Miocene deposits. Also countings which we have done in the same way on the planktonic forms in Coralline and Red Crag sediments of East-

Anglia (England) correspond with the Belgian results.

Our results can be compared with the description and distribution of recent forms by KENNETT (1968). The variations in the *G. pachyderma* of the Deurne Sands show clear relations with the *subtropical forms* of this author, except for the higher percentage of 5-chambered specimens in our material. Moreover, the variations in the forms from the Kattendijk Sands and the upperlying Members have affinities with his *subantarctic forms*, except for the dominating 4-chambered individuals in our deposits. The *antarctic forms* were not found in the Neogene Antwerpen sediments.

4. *Systematics*

Globigerina pachyderma (EHRENBERG, 1861)
Pl. 1, figs. 1-6.

Selected synonymy:

1861 *Aristerospira pachyderma* - EHRENBERG, p. 303; [1873] pl. 1, fig. 4.
1941 *Globigerina bulloides* D'ORBIGNY-TEN DAM and REINHOLD, p. 60.
1950 *Globigerina bulloides* D'ORBIGNY-VAN VOORTHUYSEN, p. 66.
1958 *Globigerina bulloides* D'ORBIGNY-VAN VOORTHUYSEN, p. 22.
1968 *Globigerina pachyderma* (EHRENBERG)-KENNETT, p. 316; pl. 1, figs. 1-32.
1969 *Globigerina pachyderma* (EHRENBERG)-BOEKSCHOTEN, p. 42; pl. 2, figs. 3a-4c.
1969 *Globigerina bulloides* D'ORBIGNY-VAN VOORTHUYSEN and TOERING, p. 101; pl. 3, fig. 12.

Type: EHRENBERG, 1861, p. 303; [1873] pl. 1, fig. 4.

Description: see KENNETT 1968, p. 309-316.

Remarks: The specimens from the Deurne Sands are dominantly dextrally coiled with 4 or 4 1/2 to 5 chambers in the last whorl and with an umbilical-extraumbilical aperture. About one third of the individuals possesses a smaller final chamber, sometimes reduced to a plate or a broad lip. Rarely are the chambers closely coiled, more inflated and have the specimens a quadrate umbilicus; they show affinities with the *G. ciperoensis* group. When the chambers increase very quickly in size as added, the chambers are still more inflated and there are morphological affinities with the *G. bulloides* group. Finally, *Globorotalia* characters are present, when closely coiled specimens possess a more extraumbilically situated aperture.

In the Kattendijk Sands and the upperlying Plio-Pleistocene deposits, the percentages of the mentioned features are clearly different. The dominantly sinistrally coiled forms mostly have 4 chambers in the last whorl (umbilical view) and an umbilical aperture. The more inflated, thick-walled chambers show a *G. bulloides* character. The last chambers are rarely reduced.

Distribution: The species, originally described from the recent sediments of the Greenland basin, is distributed in the oceans of both the Northern and Southern Hemispheres. According to KENNETT (1968) there are records from the Upper Miocene to the Recent. In the North Sea basin the species has been identified by some authors as *G. bulloides* from Plio-Pleistocene deposits in Belgium and the Netherlands. Only BOEKSCHOTEN (1969) mentioned dextrally coiled *G. pachyderma* species in some of the deepborings he studied in NW Germany.

Occurrence: Deurne Sands: very abundant in all the samples of the Rivierenhof section.

Kattendijk, Luchtbal, Kallo en Merksem Sands: rare specimens in nearly all the samples of the studied sections of the Antwerpen area.

Acknowledgments

These are due to Mr. M. GULINCK, President of the Société belge de Géologie, de Paléontologie et d'Hydrologie, who kindly proposed to have our paper published in the same

Bulletin of this Society, as the one containing the papers read at the Colloquium on the Northern Neogene held in East Anglia in March-April 1970.

The authors are greatly indebted to the "Komitee voor Elektronenmikroskopie, Katholieke Universiteit Leuven" who so liberally enabled them to make the photographs of the specimens.

Finally, our sincere thanks also go to Prof. W.P. VAN LECKWIJCK for reading the manuscript and offering constructive criticism.

BIBLIOGRAPHY

BANDY, O.L., (1968). Paleoclimatology and Neogene planktonic foraminiferal zonation. (Committee on Mediterranean Neogene, Internat. Congr., 4th, Bologna-Giornale di Geologica, serie 2a, vol. 35, fasc. 2, 1967, p. 277-290).

BOEKSCHOTEN, G.J., (1969). Fossilführung und Stratigraphie des Oligo-Miozäns von fünf norddeutsche Bohrungen. (Meyniana, vol. 19, p. 1-77).

DAM, A. TEN and REINHOLD, T., (1941). Die stratigraphische Gliederung des niederländischen Oligo-Miozäns nach Foraminiferen (mit Ausnahme von Süd-Limburg). (Med. Geol. St., C-V, nr. 1).

EHRENBERG, C.G., (1861). Ueber die Tiefgrund-Verhältnisse des Oceans am Eingange der Davisstrasse und bei Island. (K. Preuss. Akad. Wiss. Berlin, Monatsber., Jahr 1861 (1862), p. 275-315 - fide ELLIS & MESSINA).

EHRENBERG, C.G., (1873). Mikrogeologische Studien über das kleinste Leben der Meeres-Tiefgründe aller Zonen und dessen geologischen Einfluss. (K. Akad. Wiss. Berlin Abh., Jahr 1872, p. 131-397, pl. 1-12 - fide ELLIS & MESSINA).

ERTBORN, O. VAN, (1879). Notes sur les formations géologiques des environs d'Anvers. (Bull. Soc. géogr. d'Anvers, vol. 3, p. 346-350).

GLIBERT, M. and HEINZELIN, J. DE, (1955). La faune et l'âge Miocène supérieur des sables de Deurne. (Bull. Inst. roy. Sci. nat. de Belgique, vol. 31, nr. 71, p. 1-27, nr. 72, p. 1-12).

KENNETT, J.P, (1968). Latitudinal variation in *Globigerina pachyderma* (EHRENBERG) in surface sediments of the southwest Pacific Ocean. (Micropal., vol. 14, nr. 3, july 1968, p. 305-318; text-figs. 1-9; pl. 1).

LAGAAIJ, R., (1952). The Pliocene Bryozoa of the Low Countries and their bearing on the marine stratigraphy of the North Sea basin. (Med. Geol. St., C-V, nr. 5, p. 1-233).

MEUTER, F. DE, LAGA, P., RINGELÉ, A., ROOSE, V., (1967). Compte rendu de l'excursion du samedi 29 octobre 1966, faite à Deurne, près d'Anvers. (Bull. Soc. belge de Géol., de Paléont. et d'Hydrol., vol. 75, p. 392-394).

Symposium, (1963). Résolutions du 2e Symposium sur la stratigraphique du Néogène de la mer du Nord. (Mém. Soc. belge de Géol., de Paléont. et d'Hydrol., série in-8°, nr. 6, p. 168-175).

VOORTHUYSEN, J.H. VAN, (1950). The quantitative distribution of the Pleistocene, Pliocene and Miocene Foraminifera of boring Zaandam (Netherlands). (Med. Geol. St., N.S., nr. 4, p. 51-72).

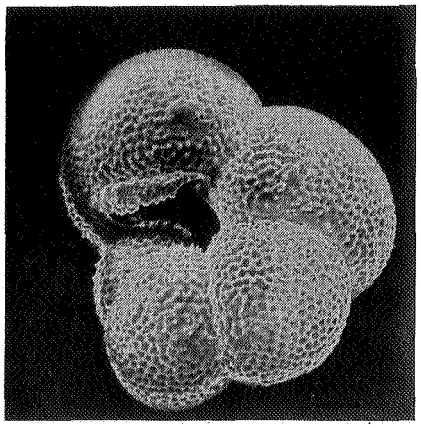
VOORTHUYSEN, J.H. VAN, (1958). Les Foraminifères Mio-Pliocènes et Quaternaires du Kruisschans. (Mém. Inst. roy. Sci. nat. de Belgique, nr. 142).

VOORTHUYSEN, J.H. VAN and TOERING, K., (1969). Distribution quantitative des foraminifères néogènes et quaternaires aux environs d'Anvers. (Med. Rijks Geol. Dienst, N.S., vol. 20, p. 93-123).

PLATE 1: *Globigerina pachyderma* (EHRENBERG, 1861)

symbols: D or S: dextrally or sinistrally coiled.
4 or 5: number of chambers in the last whorl.
NL or RL: normal or reduced last chamber.

Fig. 1: D, 5, NL; umbilical view; ×100 — Deurne Sands, Rivierenhof section, near Deurne.
Fig. 2: D, 5, RL; umbilical view; ×120 — id.
Fig. 3: D, 4, NL; spiral view; ×115 — id.
Fig. 4: D, 4, RL; umbilical view; ×155 — id.
Fig. 5: S, 4, NL; umbilical view; ×80 — id.
Fig. 6: S, 4, NL; umbilical view; ×125 — Kattendijk Sands, Prolongation Fifth Dock section, Antwerpen.



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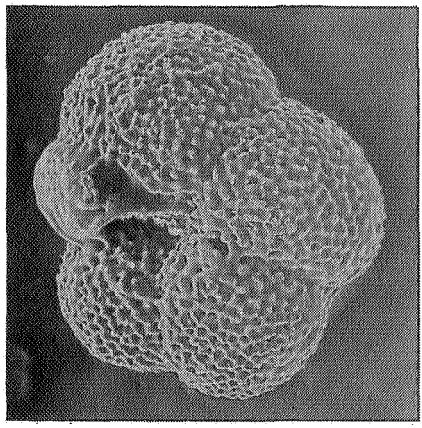

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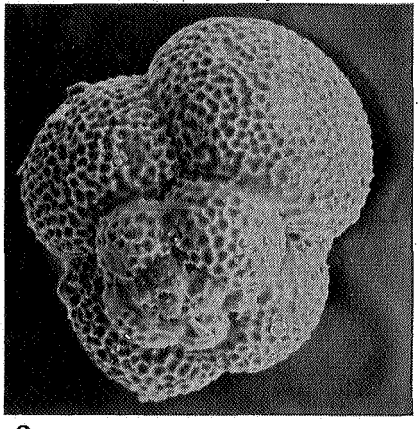

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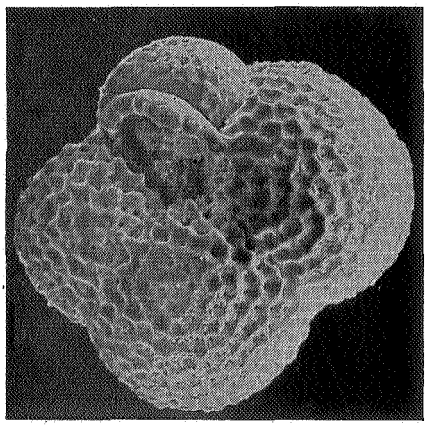

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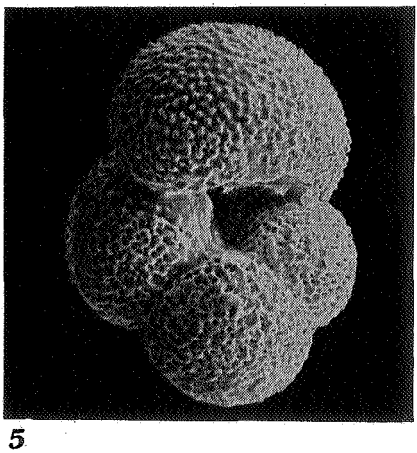

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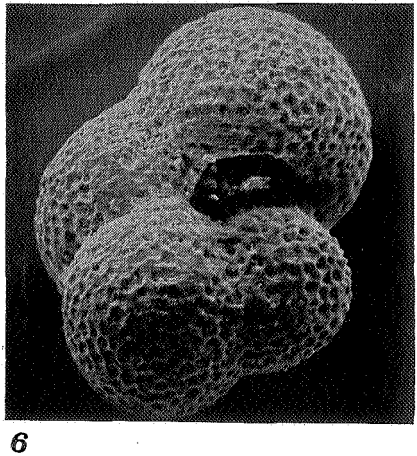

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