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PLIOCENE GASTROPOD FAUNAS FROM KALLO (OOST-VLAANDEREN, BELGIUM) — PART 1. INTRODUCTION AND ARCHAEOGASTROPODA

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Archaeogastropods from Pliocene strata exposed at Kallo, province of Oost-Vlaanderen (Belgium) are revised, and their stratigraphical and geographical occurrence discussed. Six taxa have not been described previously from the Pliocene of Belgium, *viz. Emarginula rosea* Bell, 1824, *E. crassa crassalta* Wood, 1874, *Calliostoma (C.)* aff. *noduliferens* (Wood, 1872), *Gibbula (Colliculus) crassistriata* (Bell *in* Wood, 1882), *Skenea (Lissospira) basistriata* (Jeffreys, 1877) and *Dikoleps pusilla* (Jeffreys, 1847). *Calliostoma (C.) kickxii* (Nyst, 1835) is considered distinct from *Calliostoma (C.) zizyphinum* (Linné, 1758). *Gibbula (Colliculus) petala* is described as new. Sections of the Kallo (temporary) exposures and their geographical setting are described in detail and discussed.

Key words — Gastropoda, Archaeogastropoda, Pliocene, North Sea Basin, taxonomy, stratigraphy, new species.

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CONTENTS

INTRODUCTION

For over twenty years, collecting from the harbour construction works at Kallo (near Antwerp) has yielded an enormous amount of excellently preserved and palaeontologically important biota. Various groups represented in this fossil fauna (*e.g.* shark teeth, foraminifera, echinoids, and molluscs from the Kattendijk Formation and the Kruisschans Member [Lillo Formation]) have been described in the literature by a number of authors. In the present paper, an attempt is made to provide a synthesis of the entire Pliocene molluscan faunas, all representatives of which appear to occur at Kallo. Quite a number of species are here recorded for the first time from the Pliocene of Belgium.

As early as the 1840-50s fossils were collected in the study area from sandpits exploited at Kallo and Doel, amongst others by Dewael (1853), who published a species list and by Nyst, who also collected at Doel sandpit.

Van den Broeck (1874) and van den Broeck *in* Nyst (1881) combined faunal lists for both localities. From Kallo, 73 and 71 species, respectively, were mentioned, from Doel 70. Unfortunately, none of the 19th century palaeontological collections are stratigraphically well documented. From these faunal lists, however, it appears that not all species could have originated from the same bed. At Kallo, the following species were collected: the bivalves *Spisula inaequilaterata* (Nyst, 1843) (typical for Merksem Member), *Pecten complanatus* (J. Sowerby, 1822), *Laevicardium parkinsoni* (J. Sowerby, 1818), *Arenomya arenaria* (Linné, 1758), the gastropods *Littorina suboperta* (J. Sowerby, 1813), *Eulimene terebellata* (Nyst, 1835) (Kruisschans Member), and the bivalves *Cerastoderma belgica hostiei* (Chavan, 1941) (top Oorderen Member), *Laevicardium decorticatum* (Wood, 1840), *Lajonkairea rupestris lupinoides* (Nyst, 1836), and *Solecurtus scopula* (Turton, 1822) (Oorderen Member). Species restricted to the Kattendijk Formation were not recorded, which holds true also for the distinctive subspecies of the bivalve genus *Atrina* from the Oorderen

Member. Apparently, the Kallo outcrop did not extend below the *Cultellus* bed of the Oorderen Member. The species list for Doel yields the same, 'mixed' impression: recorded are the bivalve *Spisula inaequi-laterata* and the gastropod *Potamides tricinctus* (Brocchi, 1814) (Merksem Member) and the bivalves *Laevicardium parkinsoni*, *Lentidium complanatum* (J. Sowerby, 1822) and gastropods *Nucella incrassata* (J. Sowerby, 1823), *Admete viridula* (Fabricius, 1780) (Kruisschans Member), the bivalve *Clausinella imbricata* (J. de C. Sowerby, 1826) and the gastropods *Epitonium foliaceum* (J. de C. Sowerby, 1825), *Cirsotrema f. fimbriosum* (Wood, 1848) and *Mitrella scaldensis* (van Regteren Altena, 1956) (Oorderen Member) are mentioned together.

Unfortunately, the mixed character of these samples was not recognised timely, and part of the Belgian Pliocene (or former 'Scaldisian') was consequently collectively known as the 'Sables de Callo' (Dumont, 1839) or 'Sables de Kallo' (de Heinzelin, 1955; Glibert, 1957, 1958a, b, 1959, 1960). Because of the ambiguity of these stratigraphical terms, de Meuter & Laga (1976) rightly proposed the Oorderen Member (Lillo Formation) for the middle Pliocene of Belgium.

In the early 1970s the extensive works for the construction of the Antwerp Left Bank harbour started, and they continue to the present day. First, a new sea lock was constructed to connect the new harbour with the Scheldt River, to be followed by the first dock, the Waasland Kanaaldok. Simultaneously, a tunnel was built under this dock.

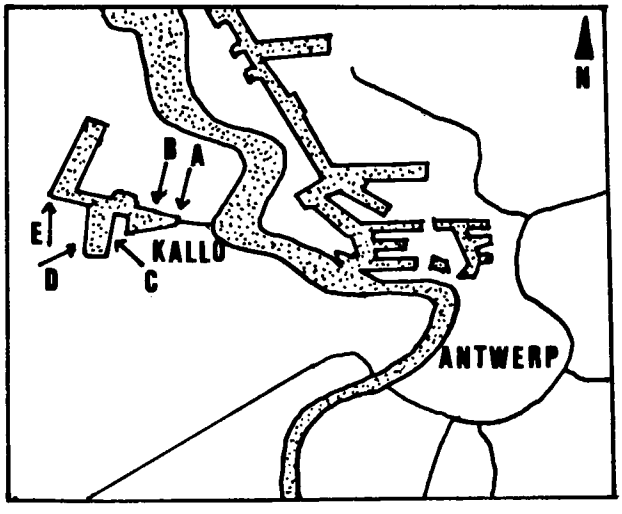

Fig. 1. Map showing location of the various docks and exposures in the Kallo area, with indication of the sections.

From 1974 onwards followed the construction of the Vrasenedok or Vierde Havendok. The last stage of the works started about 1986 and comprised the construction of the Liefkenshoektunnel under the Scheldt.

A large pit was dug for the construction of the separate portions for this tunnel, which were only later assembled on the river bed. Portions for the Piet Heyntunnel at Amsterdam (The Netherlands) were constructed there as well. This pit will later be incorporated into the Verrebroekdok, the construction of which will probably start in 1995. In Fig. 1 the location of the various docks is shown.

The first paper describing the stratigraphy and faunas of strata exposed in the modern Kallo works is by Marquet (1972), who provided a stratigraphical section and a list of molluscs, comprising only 74 species, to be followed by Gaemers & Janssen (1972), containing a section with interpretation, of the sea lock exposure. A detailed section of the Kanaaldok pit was provided by Janssen (1974), while Gaemers (1975a, b) presented a palaeoecological discussion of this section. In the same period appeared a paper by Herman (1974), describing a number of species of shark from the Kattendijk Formation, new for the Pliocene of Belgium. Geys & Marquet (1979a) described a well-preserved specimen of the echinoid *Strongylocentrotus pallidus* (G.O. Sars, 1871), which record served to illustrate the excellent preservation. Molluscs from Kallo were described by Marquet (1984, 1986).

Microfossils from Kallo were described by Nuyts (1984, 1990), who studied foraminifera from the Vrasenedok (Vierde Havendok) and the biozonation of the Rupel Formation (Oligocene) to Lillo Formation (Oorderen Member).

Hoedemakers & Marquet (1992) published a new section from the works in the Liefkenshoektunnel elements construction pit, paying particular attention to the presence of the Kruisschans Member at Kallo. Marquet (1993) studied in detail the molluscan faunas from that unit, and described a new gastropod species. A new bivalve subspecies from Kallo has recently been described by Marquet & Vervoenen *in* Marquet (1995). Vervoenen (1995) discussed the taphonomy of the various shell beds as exposed at Kallo.

The North Sea Basin Pliocene

During the Pliocene, parts of Holland, England and Belgium were inundated by the North Sea. Probably, a warm temperate to subtropical climate prevailed in the North Sea Basin during the Pliocene, comparable with that found nowadays between Lisbon and Agadir, with winter water temperatures between 14 and 16°C and summer water temperatures between 20 and 22°C (Lozouet, 1986).

FORMATION	MEMBERS	PLIOCENE	Kallo
Lillo	**Merksem/Poederlee**		present
	Kruisschans	late	present
	- lower: Amerika-dokgravel		absent
	Oorderen (= Kallo)		
	- upper: *Angulus benedeni* (= Austruweel)	middle	present
	- middle: *Cultellus* and *Atrina*		present
	- lower: basal bed		present
	Luchtbal		remanié
Kattendijk	**Kattendijk**	early	
	- upper: *Ditrupa*		remanié
	- middle: *Petaloconchus*		present
	- lower: basal gravel		present

Table 1. Lithostratigraphical units of the Belgian Pliocene.

Pliocene strata are known from borehole cores from all over The Netherlands, mostly at great depths. Only at the 'de Kauter' quarry (Nieuw Namen, Zeeuwsch Vlaanderen) do Pliocene strata outcrop.

The gastropod faunas recovered from the above-mentioned boreholes were studied by Tesch (1912), who provided a species list only, and by Beets (1946), who described and illustrated his specimens. Their material included taxa of Pleistocene age, and both works lack subdivision into stratigraphical units. Of the gastropod faunas described by Beets (1946) about 105 species may be considered to be typically Pliocene. The fossil fauna, found washed ashore on Dutch beaches, in particular that from the Scheldt estuary in the province of Zeeland, but also those from the Wadden, was studied by van Regteren Altena (1937) and by van Regteren Altena *et al.* (1965). This material comprised Pliocene as well as Pleistocene forms, and cannot be assigned to specific stratigraphical units. A total of about 160 gastropod species could have originated from Pliocene deposits. Quite a large material is known from the Scheldt estuary, dredged up and brought ashore at Ellewoutsdijk (formerly) and Yerseke (now) (province of Zeeland). These faunas comprise Pliocene and Pleistocene forms. The present description of the *in situ* molluscan faunas from Kallo may be helpful in seeing this material in its proper stratigraphical context.

Spaink (1975) divided the Dutch Pliocene and Pleistocene into five molluscan zones and two subzones. His MOL A and B zones are of Pleistocene age. Zone MOL C, with the gastropod *Nassarius propinquus* (J. de C. Sowerby, 1825) and the bivalve *Lentidium complanatum*, undoubtedly corresponds with the Kruisschans and Merksem members of the Lillo Formation, although Spaink (1975) correlated that zone with the Oorderen Member of the same formation. The Oorderen Member appears to be the equivalent of Spaink's subzone D1, although the species listed for that subzone are not characteristic of a particular horizon. Zones D2 and E correspond, at least in part, to the Kattendijk Formation, but it is not clear where the Luchtbal Member should be placed, since none of the typical molluscan species of that unit were recorded by Spaink (1975).

In Great Britain (mainly East Anglia) many highly fossiliferous deposits outcrop. A tiny spot at St Erth (Cornwall) has also yielded an important Pliocene molluscan fauna, but that locality was situated outside the North Sea Basin, with the Channel still closed. The British Pliocene gastropod faunas were first studied in detail by Wood (1839, 1842, 1848, 1856, 1872-74, 1879, 1882), although earlier authors had already described a large number of species. Wood's papers record a total of 345 Pliocene and Pleistocene species. Harmer's (1914-18, 1920-25) monumental work is a revision of Wood's papers, but includes also the St Erth fauna. An astonishing number of 766 species is listed by Harmer. Of these,

53 species are terrestrial, and can be excluded when comparing this with the Kallo fauna. The number of the remaining species is greatly exaggerated: Harmer was an inveterate 'splitter'. Many unidentifiable fragments were assigned by him to fossil or modern species, or described as new. Harmer's papers are in need of a modern revision.

In France, comparable faunas of possible Pliocene age are to found in Brittany, where they are assigned to the so-called Rédonien. However, which of these faunas is Miocene and which Pliocene cannot be decided at present. On gadid otolith evidence, Gaemers (1988) assigned the Rédonien to his Zone 17, corresponding with the Kattendijk Formation, but the molluscan faunas do not appear to support such an assignment of the entire Rédonien. Gastropod faunas from this unit were described by Brébion (1964), but a formal publication has not yet come out.

In Germany, marine Pliocene which corresponds to the upper part of the Lillo Formation, was encountered in a borehole at Nütterden near Kleve and described by Oppenheim (1915). On the basis of heavy mineral analyses, Burger (1986) considered part of the Morsum Cliff section on the Isle of Sylt (northern Germany) to be of early Pliocene age, although it is mostly considered to be of a late Miocene date (*e.g.* Gaemers, 1983). In the 'Geschiebe' (boulders) in northern Germany, no Pliocene faunas have so far been recognised.

In Scandinavia Pliocene strata are unknown. In northern Iceland, however, indurated Pliocene deposits occur at Tjörnes. The molluscan faunas from these deposits, with 103 gastropod taxa, were described by Schlesch (1924). A few species occur also in the Pliocene of Belgium.

On Belgian territory, the Pliocene North Sea extended into the province of Antwerp. In the Antwerp city area, the succession of Pliocene deposits is the most complete, and often (temporarily) exposed in harbour construction pits. Table 1 lists the lithostratigraphical units currently employed in the Belgian Pliocene. East, west and south of the city, Pliocene deposits become thinner: at Tielrode (west of Antwerp), Broechem (east) and Boechout (southeast), the Pliocene is essentially developed as a grey or reddish basal gravel, of 1 or 2 m thickness, comprising elements from the entire middle Pliocene, often mixed with Pleistocene terrestrial elements. To the east, these deposits are underlain by black sand and gravel, in which molluscs occur as moulds in nodules only. This unit could belong to the Kattendijk Formation. Further east, in the Campine area, a reddish sandstone is found around Kasterlee and Poederlee, which contains only internal moulds of shells. This Poederlee Member may be correlatable with the Merksem Member.

STRATIGRAPHY

Five temporary sections at Kallo are illustrated in Fig. 2: those at the sea lock (Gaemers & Janssen, 1972), at the Waasland Kanaaldok (Janssen, 1974), at the fourth harbour dock (Vrasenedok) (Nuyts, 1984 and Janssen [unpubl. 1984]), and at the Verrebroekdok (tunnel elements) (Hoedemakers & Marquet, 1992).

The original ground level of all sections are calibrated at the same depth. In the course of the harbour works, sands from the construction pits were scooped up over the entire area. This means that this original zero-level is now situated at a depth of *c.* 5 m, as is seen in the most recent section, published by Hoedemakers & Marquet (1992).

The deepest part of the section, as published by Janssen (1974) and Nuyts (1984) exposed a dark grey clay, clay R with septaria, of the upper part of the Boom Member (Rupel Formation, middle Oligocene). Seven metres at the most of this formation were exposed, the underlying unit not having been reached. An interesting fauna, characterised by the bivalve *Yoldia deshayesiana* (Nyst, 1835) and the nautilid cephalopod *Aturia aturi* (Basterot, 1825) was collected from this unit.

The basal gravel **[Kb]**, assigned to the Kattendijk Formation and observed resting directly on Rupel Clay, consisted of greyish, rather coarse sand with black, eroded phosphorites and other pebbles. Reworked fragments of septaria were also common, which evidences that part of the Rupel Formation was eroded. Strata of late Oligocene (Chattian) and Miocene age are absent. A few fossils of Miocene age are found in the basal gravel. The occasionally well-preserved carapaces of the crab *Coeloma rupeliensis* Stainier, 1887, occurring in small, septaria-like concretions, are undoubtedly of Oligocene age. Vertebrate remains are abundant in the basal gravel deposit, especially shark teeth, and whale and seal bones. On account of its excellent preservation, part of this vertebrate fauna must be autochthonous; a large part, however, is reworked from Miocene strata. Internal moulds of a typically Miocene bivalve (*Panopea inflata* Goldfuss, 1841) occur at this level at Kallo, a species known exclusively from the Miocene in Belgium. Other molluscan species in shell preservation are undoubtedly autochthonous elements.

The main body of the Kattendijk Formation comprises rather coarse, dark gray, glauconitic sand, with various shell beds. The lowest part consists of strongly bioturbated sands, which contain gravel with phosphorites. Gravel is absent from the higher parts of the formation. Beds with different types of burrows are separated by horizontal 'clefts', which probably represent erosion levels.

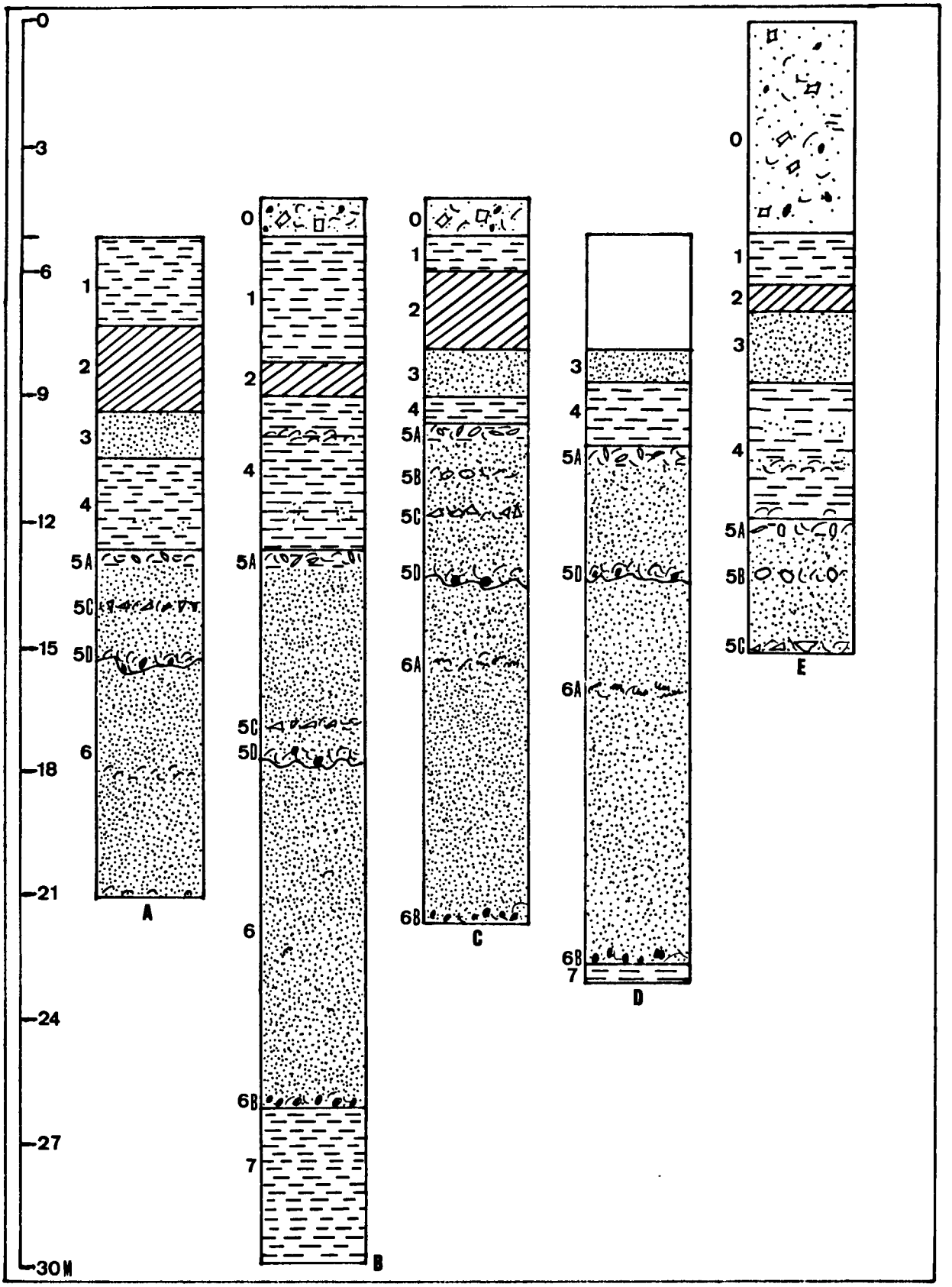

Fig. 2. Stratigraphy of temporary sections at Kallo; A - after Gaemers & Janssen (1972); B - after Janssen (1974); C - after Janssen (1984, unpubl.); D - after Nuyts (1984) and E - after Hoedemakers & Marquet (1992).

	K	Kb	KP	O	Ob	OAt	OC	OAn	Kr	M
Diodora graeca	x									
Emarginula cancellata										
E. fissura f. *reticulata*			x			x	x		x	
E. rosea			x							
E. punctura			x							
E. c. crassa						x	x		x	
E. c. crassalta			x							
Anatoma crispata			x							
Scurria compressiuscula										
Cocculina miocaenica										
Lepeta (L.) scaldensis					x	x	x			
Margarites trochoides	x		x							
M. belli										
Solariella maculata	x		x			x				
Calliostoma zizyphinum	x		x						x	
C. simile					x	x	x	x	x	
C. occidentale			x							
C. kickxii			x							
C. aff. *noduliferens*				x						
C. multigranum										
Gibbula solarium				x						
G. gelriana										
G. cineroides										
G. octosulcata			x		x	x	x		x	
G. beetsi						x	x		x	
G. o. forma *obconica*			x							
G. o. forma *nehalenniae*						x	x			
G. crassistriata						x				
G. petala			x							
G. woodi										
Skenea basistriata			x	x						
Dikoleps pusilla						x	x			

Table 2. Stratigraphical distribution of all species of archaeogastropod from the Belgian Pliocene (Kallo sections) known to date.

Abbreviations: **K** - Kattendijk Formation (unspecified); **Kb** - Kattendijk Formation base; **KP** - Kattendijk Formation, *Petaloconchus* bed; **O** - Oorderen Member (unspecified); **Ob** - Oorderen Member base; **OAt** - Oorderen Member, *Atrina* bed; **OC** - Oorderen Member, *Cultellus* bed; **OAn** - Oorderen Member, *Angulus benedeni* bed; **Kr** - Kruisschans Member; **M** - Merksem Member.

E-W oriented gullies, most of them comparatively small (10-15 cm deep and 1,2 m wide), but some reaching in certain places a considerable width and depth (to 3 m depth). The evolution of these gullies are the cause of different kinds of sedimentation structures, such as oblique bedding and parallel laminations. The larger gullies may contain two types of burrows: *c.* 1 cm wide, vertical fugichnia, which point to deposition of large quantities of sediment over a short time period, and 2-3 mm wide, mostly horizontal burrows. These burrows are mostly slightly indurated and prepared free by the wind. These sedimentary structures indicate interrupted deposition, strong erosion and the influence of currents (Gaemers, 1975a, b).

The lowest part of the formation yields many large foraminifera, eroded shells and a few otoliths. Higher in the section, large forams become rarer, otoliths are commoner and shells better preserved, often still articulated. The larger shells are generally not concentrated; at about 17 m a bed with larger bivalves and at 18 m a bed with Pectinidae may occur. Scattered throughout the formation are found vertebrate bones, whales in particular

being well represented. Several skeletons were seen in the temporary sections, but due to the rapid advance of the works (and contractors objecting to collecting) these could rarely be recovered. However, a number of skulls of toothed and baleen whales have been excavated almost intact. Shark teeth are splendidly preserved and comprise many species.

The most important bed as far as molluscan faunas are concerned is without doubt the *Petaloconchus* bed **[KP]**, which was discovered at a depth of 12-13 m, slightly above the middle of the Kattendijk Formation. The lower part of this bed consists of a 10 cm thick, reef-like network of tubes of the gastropod *Petaloconchus intortus* (Lamarck, 1818). Amongst these tubes lived a highly remarkable molluscan association, described by Marquet (1984), amongst which fissurellids and chitons are of note, which are otherwise characteristic of a rocky substrate. About 10 cm above this level occurs a concentration of vertical *Ophiomorpha* crustacean burrows, of about 3 cm wide and 15 cm long. Many of these burrows contain numerous minute fish bones, occasionally found in anatomical connection. Between the burrows, a molluscan fauna is found which differs from the underlying *Petaloconchus* bed, and which is characterised by the small bivalve *Similipecten similis* (Laskey, 1811). It is striking how small most molluscs remain in the *Petaloconchus* bed at Kallo. This holds especially true for the bivalve *Neopycnodonte cochlear* (Poli, 1795), which at Kallo grows to a maximum size of 3 cm at the most. Specimens from the same level, dredged from the Westerscheldt and brought ashore at Ellewoutsdijk (formerly) and Yerseke (now), are much larger and reach 10 cm. Large-scale collecting and analysis of the molluscs from this level has increased our knowledge of Pliocene molluscan faunas from the Antwerp area considerably.

Resting discordantly upon the Kattendijk Formation is the basal shell bed **[Ob]** of the Oorderen Member (Lillo Formation). The contact between both formations is abrupt and the basal bed is strongly undulate. The basal depressions in this bed were interpreted as load casts by Gaemers (1975b), being the result of unequal distribution of weight on the sea floor. The basal layer consists of a rather compact crag, which may contain rock fragments and whale bones. During deposition of this bed, part of the Kattendijk Formation was eroded and redeposited. This follows from the presence of numerous, internally slightly indurated articulated specimens of the typical Kattendijk Glycymerididae. The bivalve *Glossus humanus* (Linné, 1758), one of the most important index fossils of the Kattendijk Formation, is found mostly in this basal layer at Kallo. This proves, that the shell bed with *Glycymeris*, *Glossus* and the serpulid *Ditrupa*, typical of the upper part of the Kattendijk Formation at *e.g.* Noordkasteel and the Schijnpoort underground station at Antwerp, was eroded at Kallo. The overlying Luchtbal Member is also missing at Kallo. Its former presence is proved by the occurrence in the basal crag of many lumps of eroded, yellow sandstone, containing the bivalve *Palliolum gerardi* (Nyst, 1835). This sandstone has also yielded small regular echinoids, and often show bivalve borings. Other shells in the basal crag are autochthonous; whale bones and shark teeth are common. Higher in the Oorderen Member, vertebrates become much rarer.

The *Atrina* level **[OAt]** consists of rather coarse, occasionally slightly indurated yellowish grey sand, with many articulated specimens of *Atrina pectinata kalloensis* Marquet & Vervoenen *in* Marquet, 1995. These shells were observed in (upright) life position in the sea lock construction pit (Gaemers & Janssen, 1972), but at the other localities they were only found lying flat. Many other molluscan species occur in this bed as well, as do regular echinoids (*Strongylocentrotus pallidus*), which may even preserve spines and lantern (E. Huysmans Collection). This level consists mainly of shallow gullies and oblique layers, which may run in all directions, giving a rather chaotic outlook. This horizon is capped by an erosion surface and an overlying coquina. The lithology changes considerably at this erosion surface: the sediment becomes red, it is much finer than that of the underlying horizon and often slightly indurated. The basal layer is characterised mainly by large, often articulated specimens of the bivalve *Pygocardia rustica rustica* (J. Sowerby, 1818). Higher up, this species becomes less common and the shells are not packed as densely as in the basal bed. Extremely fragile species, such as the bivalve *Cultellus cultellatus* (Wood *in* Sowerby, 1844) and *Ensis hausmanni* (Goldfuss, 1841) are common. This level is referred to as 'OC' in Table 2; it contains few sedimentary structures.

The Oorderen Member terminates with a bed of clayey sand **[OAn]**, the base of which is a compact shell bed, which yields mainly articulated specimens of the bivalve *Angulus benedeni benedeni* (Nyst & Westendorp, 1839), a species occurring also in the underlying parts of the same member, but more rarely. These shells often preserve traces of colour. The other shells at this level are mostly rather eroded and occasionally crushed. Gaemers & Janssen (1972) assumed this bed to have formed in a tidal area. A gastropod species which at Kallo occurs most frequently at this level, is *Ellobium pyramidale* (J. Sowerby, 1822), which at other localities is considered typical of the Austruweel Member. At Kallo, this horizon is possibly the lateral equivalent of that member.

Resting upon the Oorderen Member is the Kruisschans Member **[Kr]**. This unit consists of fat, dark grey clay, which follows without clear boundary on the *Angulus* bed. Intercalated in this clay are nests of rather

coarse, yellowish sand with clay pebbles. Specimens of the bivalve *Laevicardium parkinsoni*, the most important index fossil of this member, occur in this unit. The horizontal basal layer of the Kruisschans Member consists of a bed with remanié shell material. The upper part of this member may show a dip of 5 to 15°, and consists of a number of gullies and oblique layers. The complete set suggests a shallow open sea (depth less than 10 m) environment. The larger shells in the sand lenses are often broken, and occasionally crushed under the load of the overlying clay. Larger gastropods are often empty, and not filled with sand, which increases their fragility. This could point to very rapid sedimentation. The fauna of this unit is much more diverse than previously assumed. Some species appear to suggest climatic cooling (Marquet, 1993).

Overlying the Kruisschans Member is the Merksem Member 'M' of the Lillo Formation. At Kallo, this unit is rather thin, especially in comparison with its thickness on the Scheldt right bank. It is a light green, clayey unit, with a poor fauna, composed almost entirely of articulated specimens of the bivalve *Corbula gibba gibba* Olivi, 1792.

Deposits resting on the latter unit are of Holocene age. The peat layer may attain a respectable thickness and contains many semi-carbonized tree trunks. Generally, few animal remains occur. At one locality in the Kanaaldok a gully was discovered in this unit which was filled by fresh water deposits, rich in terrestrial shell material, and with vertebrate remains. The youngest *in situ* deposit at Kallo is the polder clay, a grey clay, deposited in brackish water, and containing many of but a few species, mostly the bivalves *Scrobicularia plana* (da Costa, 1778) and *Cerastoderma glaucum* (Poiret, 1789).

MATERIAL

The present study is primarily based on personal collecting and observations, between 1971 and 1994, in the various sections exposed during the Kallo harbour works. Material was handpicked from all levels encountered, and sediment samples were sieved on 1 mm and 5 mm meshes. The *Petaloconchus*, *Atrina* and *Cultellus* beds and the Kruisschans Member in particular were sampled extensively. From each of these beds, a residue sample of at least 50 kg was handpicked. Smaller samples were taken from the Kattendijk Formation basal gravel, the Oorderen Member basal bed, the *Angulus benedeni* level and the Merksem Member. Faunas from these levels are as a consequence less well represented, but the low diversity of their molluscan faunas follows firstly from a genuine impoverishment of the fauna, with the exception of the Oorderen Member basal bed, which is really underrepresented.

The smallest species were not found, not even in the 1 mm mesh residue samples. For that reason, unsieved sand was sorted under a binocular microscope. Random samples contained only few of the smallest gastropod species. But, large shells, such as *Scaphella* or *Galeodea*, may yield remarkably preserved faunules of small and often extremely fragile species. Being protected against abrasion, these species were better preserved inside these larger gastropods shells.

The material collected is contained in the collections of the author. The illustrated specimens are deposited in the type collection of the Koninklijk Belgisch Instituut voor Natuurwetenschappen (Brussels). Material from a number of private collections is also covered in the present paper, as are specimens from the *Petaloconchus* bed in the collections of the Nationaal Natuurhistorisch Museum (Leiden).

SYSTEMATIC DESCRIPTIONS

Abbreviations are as follows: KBIN - Koninklijk Belgisch Instituut voor Natuurwetenschappen/Institut royal des Sciences naturelles de Belgique, Brussels; NNM - Nationaal Natuurhistorisch Museum, Leiden.

Superorder	Archaeogastropoda Thiele, 1925
Order	Vetigastropoda Salvini-Plawen & Haszprunar, 1987
Superfamily	Fissurelloidea Fleming, 1822
Family	Fissurellidae Fleming, 1822
Subfamily	Diodorinae Odhner, 1932
Genus	*Diodora* Gray, 1821

Diodora graeca (Linné, 1758)
Pl. 2, Fig. 1

1758 *Patella graeca* Linné, p. 784.
1848 *Fissurella graeca* Linn. — Wood, p. 168, pl. 18, fig. 4.
1872 *Fissurella costaria* Wood, p. 90, pl. 7, fig. 29.
1878 *Fissurella graeca*, Lin. — Nyst, pl. 2, fig. 2.
1881 *Fissurella graeca*, Lin. — Nyst, pp. 111, 112.
1923 *Fissurella italica*, Defrance — Harmer, p. 771, pl. 61, fig. 17.
1923 *Fissurella graeca* (Linné) — Harmer, p. 770, pl. 61, fig. 18.
1965 *Diodora apertura* (Montagu, 1803) — van Regteren Altena *et al.*, p. 8, pl. 1, fig. 7.

1957 *Diodora apertura dorsata* Monterosato, sp. 1875 — Glibert, p. 7.
1988 *Diodora graeca* (Linné, 1758) — Graham, p. 70, fig. 17.

Dimensions — Height 15 mm, width 40 mm.
Description — Patelliform, medium-sized shell, lacking slit, but with apical hole at about one third of shell length from the anterior end. Apical hole oval, thickened on the shell's interior. Ornament consisting of numerous radial and slightly weaker concentric ribs. The radials are occasionally equal in strength, some specimens have one or more secondary ribs between primary ones.
Discussion — *Diodora apertura* (Montagu, 1803) is considered by most neontologists to be synonymous with *Diodora graeca* (Graham, 1988; Poppe & Goto, 1991). The Kallo specimens are larger than most Recent shells, and thus approach the Mediterranean species *Diodora italica* (Defrance, 1820), but differ in showing a more convex posterior side and more concave anterior side. At Kallo, the present species occurs more frequently in the Kattendijk Formation. From the Kruisschans Member, a single fragment was collected. Miocene North Sea Basin material belong to another species (Janssen, 1984). *Diodora graeca* is at present found in Mediterranean, Arctic and Atlantic waters, from the littoral zone to 250 m depth, on rocks or shells (Graham, 1988).

Subfamily Emarginulinae Gray, 1834
Genus *Emarginula* Lamarck, 1801

Emarginula rosea Bell, 1824
Pl. 1, Fig. 2

1824 *Emarginula rosea* Bell, p. 52, pl. 4, figs 1, 2.
1923 *Emarginula rosea*, T. Bell — Harmer, p. 779, pl. 62, fig. 10 (*partim*).
1965 *Emarginula conica* Lamarck, 1801 — van Regteren Altena *et al.*, p. 7, pl. 1, fig. 3.
1988 *Emarginula conica* Lamarck, 1801 — Graham, p. 66, fig. 15b.

Dimensions — Height 4 mm, width 5,5 mm.
Description — Small, patelliform shell, with the apex near or over the posterior edge, below the highest point of the shell. A slit occurs in the anterior margin and continues as a groove to the apex. The ornament consists of radial and concentric ribs, with *c.* 16-18 strong primary ribs, and in between, a single slightly weaker secondary rib. The concentric ribs (about 20) are as strong as the secondary radials, and continue into the groove.
Discussion — This species is recorded here for the first time from the Pliocene of Belgium. It is slightly less common in the *Petaloconchus* bed than the following species, which it resembles closely. There is much confusion about the proper name to apply to this species. Graham (1988) used *Emarginula conica* Lamarck, 1801 and considered *E. rosea* to be a synonym. Sabelli *et al.* (1990) and Poppe & Goto (1991), however, preferred Bell's name and considered *E. conica* to be a synonym of *E. fissura* (Linné, 1758). Lamarck's (1801) original description of *E. conica*, however, refers explicitly to '*Patella fissura* L.', for which it appears to be a new name. Recent North Sea specimens and fossils from the Eemian ('Assise d'Oostende') of the Belgian coast are larger than the Kallo shells, while their secondary and primary ribs are more equally developed, especially when the shells are not completely fresh. The ornament inside the groove is more pronounced. Recent specimens are found from the British Isles to the Mediterranean, from the sublittoral to depths of 30 m (Graham, 1988).

Emarginula punctura Wood, 1848
Pl. 1, Fig. 1

1842 *Emarginula punctura* Wood, p. 528.
1848 *Emarginula fissura* var. *punctura* Wood, p. 164, pl. 18, fig. 3b.
1872 *Emarginula fissura* var. *punctura* Wood — Wood, p. 90, pl. 7, fig. 24.
1923 *Emarginula rosea*, T. Bell — Harmer, p. 779, pl. 62, fig. 10 (*partim*).
1957 *Emarginula punctura* Wood, 1848 — Glibert, p. 5, pl. 1, fig. 1.

Dimensions — Height 4 mm, width 5,4 mm.
Description — The shell form of this species closely resembles that of the previous species. The ornament consists of about 17 strong primary radial ribs; in between, 3-4 much weaker secondary ribs occur. Concentric ribs are absent. Between the radials, a fine granulation is seen.
Discussion — Wood (1842) only listed the species name but did not provide a description nor a figure (*nomen nudum*). Wood's (1848) illustration is not too good, but his 1872 figure is unambiguous. In Great Britain, this species is known from the Coralline Crag. In Belgium, it occurs in Kattendijk Formation as well as in the Luchtbal Member. It seems to be an endemic North Sea Basin species. Specimens from the Luchtbal Member (KBIN collections, illustrated by Glibert, 1957) are larger and the apex is situated further from the posterior edge in *Petaloconchus* bed specimens from Kallo.

Emarginula fissura forma **reticulata** J. Sowerby, 1813
Pl. 1, Fig. 3

1813 *Emarginula reticulata* J. Sowerby, p. 74, pl. 33 (*partim*).
1848 *Emarginula fissura* Linn. — Wood, p. 164, pl. 18, fig. 3a.
1878 *Emarginula fissura*, Lin. — Nyst, pl. 7, fig. 9.
1881 *Emarginula fissura*, Lin. — Nyst, p. 114.
1923 *Emarginula fissura*, Linné — Harmer, p. 776, pl. 62, fig. 7.
1923 *Emarginula fissura* var. *depressa* Harmer, p. 777, pl. 62, fig. 8.
1946 *Emarginula (Emarginula) reticulata* Sowerby, 1813 — Beets, p. 22.
1965 *Emarginula reticulata* J. Sowerby, 1813 — van Regteren Altena *et al.*, p. 7, pl. 1, fig. 2.
1957 *Emarginula reticulata* Sowerby, 1813 — Glibert, p. 4.

Dimensions — Height 7 mm, width 10 mm.
Description — Rather small, patelliform shell, with the apex about one third of shell width from the posterior margin. The anterior margin shows a slit, which continues as a groove to near the apex. The groove shows ridges which run parallel to the shell margin. The ornament consists of about 30 strong primary radial ribs, with a single weaker secondary in between. There are about 20 concentric ribs, which are as strong as the secondary radials.
Discussion — This species differs clearly from both previous species in the position of its apex, in being larger and in having a different ornament. It is rare in the Kattendijk Formation, slightly more common in the Oorderen Member, and again very rare in the Kruisschans Member. Differences between the Recent species *Emarginula fissura* (Linné, 1758) and the present Pliocene specimens are slight. Their ornament is identical and the apices are found in the same position. Many authors, *e.g.* Graham (1988) and Sabelli *et al.* (1990) consider these species identical. There is only a slight difference in size, the Pliocene specimens being slightly larger (up to 14 mm), while Recent ones only rarely reach 10 mm in length. Also, the height/width ratio seems to be slightly larger in Pliocene specimens, especially in those from the English Red Crag and Belgian Oorderen Member. This was also observed by Harmer (1923), who separated more typical, flatter specimens from the Coralline Crag as var. *depressa* Harmer, and by Glibert (1957). High, conical specimens, however, appear to occur also in Recent faunas from the Mediterranean (d'Angelo & Garguillo, 1978, p. 79 fig.). The Kallo *Petaloconchus* bed specimens are high, but comparatively small. The name *reticulata* might be reserved for larger, higher, conical shells, as found mainly in the Red Crag and Oorderen Member. It is here interpreted as a forma rather than as a subspecies.

Emarginula crassa crassa J. Sowerby, 1813
Pl. 2, Fig. 2

1813 *Emarginula crassa* J. Sowerby, p. 73, pl. 33 (upper figure).
1843 *Emarginula crassa* Sow. — Nyst, p. 532, pl. 36, fig. 3.
1848 *Emarginula crassa* J. Sow. — Wood, p. 165, pl. 18, fig. 2a, b, d (non c).
1878 *Emarginula crassa*, J. Sowerby — Nyst, pl. 7, fig. 8.
1881 *Emarginula crassa*, J. Sowerby — Nyst, p. 113.
1923 *Emarginula crassa*, J. Sowerby — Harmer, p. 775, pl. 62, figs 1-3.
1923 *Emarginula crassalta*, S.V. Wood — Harmer, p. 775, pl. 62, figs 4, 5.
1926 *Emarginula anassa* Dean, p. 21, pl. 1, fig. 7.
1946 *Emarginula crassa* Sowerby, 1813 — Beets, p. 22, pl. 1, figs 1, 2.
1957 *Emarginula crassa* Sowerby, 1813 — Glibert, p. 6.
1965 *Emarginula crassa* J. Sowerby, 1813 — van Regteren Altena *et al.*, p. 7, pl. 1, fig. 5.
1979b *Emarginula crassa* Sowerby, 1813 — Geys & Marquet, p. 66, pl. 26, fig. 4.
1988 *Emarginula crassa* Sowerby, 1813 — Graham, p. 66, fig. 15c.

Dimensions — Height 25 mm, width 55 mm.
Description — Medium-sized patelliform shell, with the apex between the centre of the shell and the posterior end. Anterior margin with slit, which continues as a striated groove to near the apex. Ornament consists of numerous radial ribs, mostly composed of three to four smaller ridges. The grooves between the ribs show pits.
Discussion — This is a typical subspecies of the Oorderen Member; in the Kruisschans Member only fragments were collected. At present, it seems to be a northern species, being most common between Norway and Iceland (Graham, 1988). There seems to be little or no reason to distinguish Recent specimens as a separate species, as Dean (1926) did.

Emarginula crassa crassalta Wood, 1874
Pl. 2, Fig. 3

1848 *Emarginula crassa* J. Sow. — Wood, p. 165, pl. 18, fig. 2c (non a, b, d).
1874 *Emarginula crassalta* Wood, p. 90.
1923 *Emarginula crassalta* var. *conica* (S.V. Wood) —

Harmer, p. 776, pl. 62, fig. 6 (non 4, 5).

Dimensions — Height 11 mm, width 12 mm.
Description — Shell closely resembling that of the previous subspecies, but smaller. In comparison with *E. c. crassa* of the same size it is markedly higher. In addition, the apex is situated closer to the posterior margin.
Discussion — Wood's (1874) name *Emarginula crassalta* was based on Coralline Crag specimens, which show the same differences from Red Crag specimens as do specimens from the Kattendijk Formation from those of the Oorderen Member. A subspecific distinction seems appropriate. Harmer (1923) also applied the name *E. crassalta* to specimens of Red Crag age, but Wood's original description cannot be applied to these. They rather belong to Wood's (1848) forma *conica*. Harmer appears to have confused the proper application of the names *E. crassalta* and *E. conica*. The present forma is confined to the Kattendijk Formation in Belgium and to the Coralline Crag of Great Britain.

Superfamily	Scissurelloidea Gray, 1847
Family	Scissurellidae Gray, 1847
Genus	*Anatoma* Woodward, 1859

Anatoma crispata (Fleming, 1828)
Pl. 2, Fig. 4

1828 *Scissurella crispata* Fleming, p. 366.
1848 *Scissurella crispata* Flem. — Wood, p. 163, pl. 15, fig. 13.
1984 *Scissurella (Anatoma) crispata* Fleming, 1828 — Marquet, p. 338, pl. 3, fig. 2.
1988 *Scissurella crispata* Fleming, 1828 — Graham, p. 60, fig. 13.
1992 *Anatoma crispata* (Fleming, 1828) — Cavallo & Repetto, p. 34, fig. 16.
1994 *Anatoma crispata* (Fleming, 1828) — Gianuzzi-Savelli *et al.*, p. 50, fig. 92.

Dimensions — Height 1 mm, width 2 mm.
Description — Minute, cyrtoconoid shell, with wide, deep umbilicus. Numerous prosocline radial costae occur, with many fine spiral ribs between them. The most characteristic feature is the slit in the outer lip, which continues up the spire as a closed slit-band.
Discussion — So far this species has only been found in the *Petaloconchus* bed at Kallo. In Great Britain it is known from the Coralline Crag. Recent specimens are found between depths of 8 to 2,000 m; southern records are from deeper water (Graham, 1988).

Superfamily	Patellacea Rafinesque, 1815
Family	Lepetidae Dall, 1869
Genus	*Lepeta* Gray, 1847

Lepeta (Lepeta) scaldensis van Regteren Altena, 1954
Pl. 2, Fig. 5

1843 *Patella aequalis* Sow. — Nyst, p. 349, pl. 35, fig. 5.
1848 *Tectura virginea* Müll. — Wood, p. 161, pl. 18, fig. 6.
1878 *Tectura virginea* ? Müll. — Nyst, pl. 7, fig. 12 (*partim*).
1881 *Lepeta caeca*, Müller — Nyst, p. 119.
1925 *Lepeta fulva* (Müller) — Harmer, p. 878, pl. 65, fig. 36 (*partim*).
1946 *Lepeta (Lepeta) caeca* (Müller, 1776) — Beets, p. 23, pl. 1, figs 3, 4.
1946 *Pilidium fulvus* (Müller, 1773) — Beets, p. 23 (*partim*).
1954 *Lepeta scaldensis* van Regteren Altena, p. 45.
1957 *Lepeta scaldensis* Regteren-Altena, 1954 — Glibert, p. 9.
1965 *Lepeta scaldensis* Van Regteren Altena, 1954 — van Regteren Altena *et al.*, p. 8, pl. 2, fig. 9.
1979b *Lepeta scaldensis* Regteren-Altena, 1954 — Geys & Marquet, p. 60, pl. 26, fig. 3.

Dimensions — Height 9 mm, width 19 mm.
Description — Medium-sized, patelliform shell, its colour invariably being yellow, and lacking a slit. The protoconch is smooth, brilliant, tumid and sharply delimited from the teleoconch. Juvenile specimens show numerous, granular radial ribs and less pronounced concentric lines; in mature specimens this ornament becomes obsolete. On the shell's interior, a clearly delimited muscle impression is seen.
Discussion — In lacking a slit and showing the distinctive yellow colour, this species is easily distinguished from all other patelliform gastropods. It is a typical and common element in the Oorderen Member faunas, and appears to be endemic to middle Pliocene of the North Sea Basin.

Superfamily	Trochoidea Rafinesque, 1815
Family	Trochidae Rafinesque, 1815
Subfamily	Margaritinae Stolizcka, 1868
Genus and subgenus	*Margarites* Gray, 1847

Margarites (Margarites) trochoides (Wood, 1842)
Pl. 3, Fig. 4

1842 *Margarita trochoidea* Wood, p. 530.
1848 *Margarita trochoidea* S. Wood — Wood, p. 136, pl. 15, fig. 2.
1923 *Eumargarita trochoidea* (S.V. Wood) — Harmer, p. 752, pl. 55, fig. 14.
1957 *Margarites trochoidea* Wood, 1842 — Glibert, p. 9, pl. 1, fig. 3.

Dimensions — Height 2 mm, width 4 mm.
Description — Small, flattened, turbiniform shell with five slightly tumid whorls and wide open umbilicus. Ornament is almost absent; only on the upper part of the whorls and around the umbilicus can very faint spiral lines be seen. With the upper shell layer partially peeled off, as is often the case, nacre becomes visible.
Discussion — This is a rather rare species, with but a single specimen known from the *Petaloconchus* bed of the Kattendijk Formation; it becomes less rare higher up in this formation. They differ from Glibert's (1957) specimens in having spirals, but in this respect they coincide more closely with Wood's (1848) illustration. *Margarites trochoides* is a local North Sea Basin early Pliocene species.

Subfamily Solariellinae Powell, 1951
Genus *Solariella* Wood, 1842

Solariella maculata Wood, 1842
Pl. 3, Fig. 1

1835 *Turbo moniliferus* Lam. — Nyst, p. 27.
1842 *Solariella maculata* Wood, p. 531, pl. 5, figs 7, 10.
1843 *Solarium turbinoides* Nyst, p. 370, pl. 36, fig. 7.
1848 *Margarita* (?) *maculata* S. Wood — Wood, p. 135, pl. 15, fig. 3.
1878 *Trochus turbinoides*, Nyst — Nyst, pl. 10, fig. 24.
1881 *Trochus turbinoides*, Nyst — Nyst, p. 98.
1923 *Solariella maculata*, S.V. Wood — Harmer, p. 744, pl. 60, fig. 1.
1918 *Eumargarita (Solariella) antwerpiensis* Cossmann, p. 259, pl. 8, figs 64, 65.
1957 *Solariella maculata* Wood, 1842 — Glibert, p. 10, pl. 1, fig. 5.
1965 *Solariella maculata* S.V. Wood, 1842 — van Regteren Altena *et al.*, p. 9, pl. 2, fig. 12.
1979b *Solariella maculata* Wood, 1842 — Geys & Marquet, p. 68, pl. 27, fig. 5.

Dimensions — Height 9 mm, width 9,5 mm.
Description — Medium-sized, turbiniform shell, with about six tumid teleoconch whorls and a wide open umbilicus. The protoconch comprises a single smooth, glossy whorl, which is sharply delineated from the teleoconch. The teleoconch ornament starts with about 30 radial ribs on the first whorl. On the second whorl, radials are still the most important elements of ornament, but two spirals begin to appear, which start as an upper and a lower keel. Thereafter the radials lose in strength and remain as tubercles on the spiral ribs. Half a whorl later, the subsutural area above the upper keel is completely free of radial ornament. Two secondary spirals with tubercles begin to appear below the adapical primary spiral. The tubercles become more obsolete towards the aperture. The ornament consists of about 9 strong spirals on the last whorl, which continue also on the shell base. In the umbilicus, up to the first spiral, radial ribs occur. Nacre can be seen there where the upper shell layer is missing. Some specimens show traces of their original colour pattern (see Geys & Marquet, 1979b, pl. 27, fig. 5).
Discussion — This species is common in the *Similipecten* bed immediately above the *Petaloconchus* bed, but is rare in the other units at Kallo. A few specimens have been collected from the *Atrina* level (Oorderen Member). It is an endemic North Sea Basin species of early and middle Pliocene age. Katttendijk Formation specimens are narrower and relatively higher than those from the Luchtbal Member from other localities and than those from the Oorderen Member at Kallo.

Subfamily Calliostomatinae Thiele, 1924
Genus and subgenus *Calliostoma* Swainson, 1840

Calliostoma (Calliostoma) zizyphinum (Linné, 1758)
Pl. 3, Fig. 2

1758 *Trochus zizyphinus* Linné, p. 759.
1835 *Trochus laevigatus* Sow. — Nyst, p. 26.
1839 *Trochus sedgwicki* Nyst & Westendorp, p. 18.
1843 *Trochus laevigatus* Nyst, p. 379, pl. 36, fig. 2.
1843 *Trochus sedgwicki* N. & W. — Nyst, p. 32, pl. 35, fig. 20.
1848 *Trochus zizyphinus* Linn. — Wood, p. 124, pl. 13, fig. 9a-h.
1878 *Trochus conulus* ? L. — Nyst, pl. 6, fig. 26.
1878 *Trochus zizyphinus*, L. — Nyst, pl. 6, fig. 25.
1879 *Trochus zizyphinus* Linn. — Wood, p. 34, pl. 4, fig. 20.
1881 *Trochus conulus* ? L., var. — Nyst, p. 101.
1881 *Trochus zizyphinus*, L. — Nyst, p. 99.
1918 *Calliostoma antwerpense* Cossmann, p. 289, pl. 9, figs 50, 51.

1923 *Trochus (Calliostoma) zizyphinus* (Linné) — Harmer, p. 708, pl. 52, figs 1-6.
1923 *Trochus (Calliostoma) conulus* (Linné) — Harmer, p. 716, pl. 58, fig. 6.
1946 *Trochus (Calliostoma)* cf. *zizyphinus* (Linné, 1758) — Beets, p. 24.
1946 *Trochus (Calliostoma) zizyphinus* (Linné) var. *conuloides* (Lamarck, 1822) — Beets, p. 25 (*partim*).
1957 *Calliostoma (Calliostoma) zizyphinum* Linné, 1758 — Glibert, p. 11, pl. 1, fig. 6.
1965 *Calliostoma zizyphinum zizyphinum* (Linnaeus, 1758) — van Regteren Altena *et al.*, p. 9, pl. 2, fig. 13b.
1979b *Calliostoma zizyphinum* (Linné, 1758) — Geys & Marquet, p. 68, pl. 27, fig. 3.
1988 *Calliostoma zizyphinum* (Linné, 1758) — Graham, p. 124, fig. 41.
1993 *Calliostoma zizyphinum* (Linné, 1758) — Marquet, p. 89.
1994 *Calliostoma (Calliostoma) zizyphinum* (Linné, 1758) — Gianuzzi-Savelli *et al.*, p. 66, figs 158-168.

Dimensions — Height 39 mm, width 38 mm; height 35 mm, width 31 mm.
Description — Medium-sized, rectilinear-conical shell, lacking umbilicus. Shell slightly keeled at the periphery by the presence of a thick spiral band, which often remains visible above the suture on older whorls. A much lower keel occasionally occurs just below the suture. Ornament may either be entirely absent or consist of about 20 very weak spirals, or of a low number of much more conspicuous spirals, as in most Recent specimens.
Discussion — The species is typical for the Kattendijk Formation, but is not more common in the *Petaloconchus* bed than it is in the other portions of this formation. In the Oorderen Member at Kallo, it is replaced by the next species, from which it differs by its usually relatively higher shell, more conspicuous keel and much less prominent spiral ornament. It reappears in the Kruisschans Member. The specimen from the Antwerp Pliocene illustrated by Harmer (1923, pl. 58, fig. 6) under the name *Trochus (Calliostoma) conulus*, might represent a small specimen of *C. zizyphinum*, but the ornament is not figured clearly enough to be certain. Recent specimens occur from the Lofoten to the Mediterranean; they mostly differ from Pliocene shells in possessing 6-9 much better-developed spiral ribs, but the variation in ornament is wide in Recent shells (well illustrated by Gianuzzi-Savelli *et al.*, 1994, figs 158-168) as it is in fossil material. There seems to be little or no need to separate the present Pliocene shells as a subspecies, although the names *antwerpense* Cossmann, 1918 and *sedgwicki* Nyst & Westendorp, 1839 are available.

Calliostoma (Calliostoma) simile (J. Sowerby, 1816)
Pl. 3, Fig. 3

1816 *Trochus similis* J. Sowerby, p. 179, pl. 81, fig. 35.
1843 *Trochus similis* Sow. — Nyst, p. 377, pl. 35, fig. 19.
1843 *Trochus dekenii* Nyst, p. 378, pl. 36, fig. 10.
1848 *Trochus papillosus* var. *similis* Sow. — Wood, p. 126, pl. 13, fig. 6c (non a, b).
1878 *Trochus noduliferens*, S. Wood — Nyst, pl. 6, fig. 27.
1878 *Trochus occidentalis*, Migh. et Adams — Nyst, pl. 6, fig. 29.
1918 *Oxystele nysti* Cossmann, p. 214, pl. 7, fig. 26.
1923 *Trochus (Calliostoma) conuloides* (Lamarck) — Harmer, p. 706, pl. 57, figs 8, 9.
1923 *Trochus (Calliostoma) granulatus* (Born) — Harmer, p. 711, pl. 57, figs 11, 12.
1923 *Trochus (Calliostoma) similis* (J. Sowerby) — Harmer, p. 713, pl. 57, fig. 16.
1946 *Calliostoma (Calliostoma) zizyphinum* (Linné) var. *conuloides* (Lamarck, 1822) — Beets, p. 25 (*partim*).
1957 *Calliostoma (Calliostoma) simile* Sowerby, sp. 1818 — Glibert, p. 13, pl. 1, fig. 1.
1965 *Calliostoma zizyphinum simile* (J. Sowerby, 1818) — van Regteren Altena *et al.*, p. 59, pl. 2, fig. 13a.
1979b *Calliostoma simile* (Sowerby, 1818) — Geys & Marquet, p. 68, pl. 27, fig. 2.
1993 *Calliostoma simile* (J. Sowerby, 1818) — Marquet, p. 89.

Dimensions — Height 29 mm, width 26 mm; height 20 mm, width 21 mm.
Description — Medium-sized, rectilinear-conical shell, lacking umbilicus. The protoconch consists of half a whorl bearing a reticulate ornament, and separated from the teleoconch by a ridge. The shell is often slightly keeled by the presence of a thick spiral band, visible above the suture. The aperture is rounded-quadrangular. Teleoconch ornament is always prominent, and consists of about 8 spirals on the last whorl. These spirals may bear granules, especially near the suture. Shell base shows spirals, which may become obsolete halfway to the centre.
Discussion — *Calliostoma subexcavata* (Wood, 1846) from the British Crags, considered to be a synonym by Glibert (1957), is clearly a distinct species, with a higher shell and much coarser and more strongly granulate spirals. *Calliostoma simile* occurs in the Oorderen and Kruisschans members. Only in the latter does it co-occur with *C. zizyphinum*. Shell height is very variable, but the mean height/width ratio seems to be lower than that in the previous species. These species are easily distinguished on details of ornament. *Calliostoma simile* is confined to the middle Pliocene of the North Sea Basin.

Calliostoma (Calliostoma) kickxii (Nyst, 1835)
Pl. 4, Fig. 2

1835 *Trochus Kickxii* Nyst, p. 26, pl. 4, fig. 19.
1835 *Trochus Robynsii* Nyst, p. 26, pl. 5, fig. 20.
1843 *Trochus Kickxii* Nyst — Nyst, p. 381, pl. 38, fig. 2.
1843 *Trochus Robynsii* Nyst — Nyst, p. 26, pl. 382, fig. 3.
1878 *Trochus Kickxii*, Nyst — Nyst, pl. 6, fig. 31.
1878 *Trochus Robynsii*, Nyst — Nyst, pl. 7, fig. 2.
1923 *Trochus (Gibbula) Kickxii* (Nyst) — Harmer, p. 737, pl. 59, fig. 15.
1923 *Trochus (Gibbula) Robynsii* (Nyst) — Harmer, p. 737, pl. 59, fig. 16.
*non*1836 *Trochus Kickxii* Nyst — Nyst, p. 28.
*non*1848 *Trochus Kickxii* Nyst — Wood, p. 130, pl. 14, fig. 5.

Dimensions — Height 9 mm (incomplete), width 10 mm.
Description — Medium-sized, cyrtoconoid conical shell, with slightly tumid whorls. Periphery slightly keeled. Umbilicus absent. Aperture more or less quadrangular. Ornament consists of a single spiral rib just above the suture on the older whorls and just above the keel in the youngest one. The spirals closest to the top may bear small tubercles. On the basal shell part, 2-4 clearly delimited spirals may be seen.
Discussion — Glibert (1957) considered this species to be a junior synonym of *Calliostoma zizyphinum*. However, there appear to be a few constant differences between juveniles of that species and the present taxon. The former is invariably wider and neatly conical. If ornament is present on the shell basis, it occurs near the periphery or over the entire surface. *Calliostoma kickxii* on the other hand is narrower and the whorls are tumid. The presence of spirals near the centre of the shell base is also typical. *Trochus robynsii* Nyst, 1835 is considered synonymous with *C. kickxii*. Differences between both are well within the range of individual variation of the latter species.

Calliostoma kickxii is a rather rare species, which appears to be typical for the Kattendijk Formation, having been collected from the *Ditrupa* bed in this formation at Antwerp (Borgerhout and Noordkasteel, Marquet Collection). This bed is absent in the Kallo exposures. The sole specimen known from Kallo (van Nieulande Collection) came from the base of the Oorderen Member and may have been reworked from the underlying Kattendijk Formation. The species is also known from the British Red Crag. Wood (1848) illustrated under this name a specimen with many spiral ribs, which however should rather be referred to one of the species of the genus *Gibbula*. Harmer's (1923) figures correspond with *Calliostoma kickxii* Nyst's (1836) specimen from the Oligocene of Kleine Spouwen (province of Limburg, Belgium) should obviously be assigned to another species. *Calliostoma kickxii* thus appears to be restricted to the North Sea Basin early and middle Pliocene.

Calliostoma (Calliostoma) aff. **noduliferens**
(Wood, 1872)
Pl. 4, Fig. 1

1848 *Trochus papillosus* ? Da Costa — Wood, p. 126, pl. 13, fig. 6a, b (non c).
1872 *Trochus noduliferens* Wood, p. 81.
1874 *Trochus noduliferens* Wood — Wood, p. 210.
1923 *Trochus (Calliostoma) noduliferens* (S.V. Wood) — Harmer, p. 718, pl. 58, figs 8, 9.
1965 *Calliostoma noduliferens* (S.V. Wood, 1872) — van Regteren Altena *et al.*, p. 9, pl. 2, fig. 14.

Dimensions — Height 4,5 mm (top not preserved), width 5,5 mm.
Description — Small, near-recticonical shell with slightly tumid whorls and rather deep sutur s d.e, comprising to about 6 teleoconch whorls. The ornament consists of 5 spiral rows of small tubercles, which are only very slightly interconnected. There is no radial ornament. The shell base is completely covered with 9-10 continuous spiral ribs. Much weaker radial growth lines are also conspicuous on the base. The aperture is more or less quadrangular. There is no umbilicus.
Discussion — This species has not been recorded previously from the Belgian Pliocene. Only a handful of incomplete specimens have been collected from the Oorderen Member by F. van Nieulande, but without specification of horizon. The species differs from juvenile specimens of the congeners at Kallo by showing slightly tumid whorls, ornament consisting of rows of tubercles and presence of spirals over the entire shell base. It differs from *Calliostoma multigranus* (Wood, 1848), which also occurs in the Belgian Pliocene, but not at Kallo, in being wider and in lacking tubercles on the basal spirals. The species is known from the British Red Crag and St Erth Beds and from Dutch beach material; it appears to be confined to the Pliocene of the North Sea Basin and the Atlantic.

Subgenus *Eucasta* Dall, 1898

Calliostoma (Eucasta) occidentale
(Mighels & Adams, 1842)
Pl. 4, Fig. 3

1842 *Trochus quadricinctus* Wood, p. 531 (*nomen nudum*).
1842 *Trochus occidentalis* Mighels & Adams, p. 47, pl. 4, fig. 16.
1848 *Trochus formosus* Wood, p. 125, pl. 13, fig. 2.
1878 *Trochus occidentalis*, Migh. et Adams — Nyst, pl. 7, fig. 5.
1923 *Trochus (Calliostoma) occidentalis* (Mighels and Adams) — Harmer, p. 721, pl. 58, figs 14, 15.
1957 *Calliostoma (Eucasta) occidentale* Mighels, sp. 1842 — Glibert, p. 14, pl. 1, fig. 8.
1965 *Calliostoma occidentale* (Mighels, 1842) — van Regteren Altena *et al.*, p. 9, pl. 3, fig. 16.
1988 *Calliostoma occidentale* (Mighels & Adams, 1842) — Graham, p. 128, fig. 43.

Dimensions — Height 14 mm, width 14 mm; height 11 mm, width 14 mm; height 2,8 mm, width 2,8 mm.
Description — Medium-sized, rectilinear, keeled (Pl. 4, Fig. 3a, b) to slightly concave (Fig. 3c) conical shell, lacking umbilicus. The protoconch consists of about one whorl, which is very tumid and bears a reticulate ornament. The aperture is rounded. The teleoconch ornament starts with two spirals and a number of radial ribs, which are of near-equal strength. The radials gradually efface, in comparison with the spirals, and on the third teleoconch whorl they are limited to tubercles on the spirals. The ornament of the youngest whorls consists of 3-5 very prominent spirals above the peripheral keel, which may bear tubercles, especially near the suture. The shell base is either weakly ribbed with about 15 spirals, especially near the centre, or almost smooth.
Discussion — This species is easily distinguished from all congeners in remaining constantly smaller and in having more clearly delimited and stronger spiral ornament. It is typical especially for the bed with crustacean burrows immediately above the *Petaloconchus* bed. It is rare elsewhere in the Kattendijk Formation and absent from all younger strata at Kallo. It is a modern northern species, found in Britain, Scandinavia, Iceland and eastern North America, between depths of 19 and 1,000 m (Graham, 1988).

Subfamily Gibbulinae Stoliczka, 1868
Genus and subgenus *Gibbula* Risso, 1826

Gibbula (Gibbula) solarium (Nyst, 1835)
Pl. 4, Fig. 4

1835 *Trochus solarium* Nyst, p. 26, pl. 5, fig. 21.
1843 *Trochus solarium* Nyst — Nyst, p. 383, pl. 38, fig. 4.
1872 *Solarium vagum* Wood, p. 85, pl. 7, fig. 29.
1878 *Trochus solarium*, Nyst — Nyst, pl. 6, fig. 32.
1881 *Trochus solarium*, Nyst — Nyst, p. 106.
1923 *Solarium solarium* (Nyst) — Harmer, p. 852, pl. 64, figs 41, 42.
1946 *Gibbula (Steromphala) solarium* (Nyst, 1835) — Beets, p. 30, pl. 1, figs 24-27.
1957 *Gibbula solarium* Nyst, sp. 1835 — Glibert, p. 15, pl. 1, fig. 10.

Dimensions — Height 4 mm, width 7,5 mm; Kruisschans Member specimen: height 13 mm, width 18 mm.
Description — Fairly large, flattened, near-recticonical shell with a marked carina. The whorls become progressively more concave. The teleoconch ornament at first consists of two, then 5-7 spiral ribs, which may bear tubercles; these are however almost completely obliterated by erosion in the available specimens. The tubercles are most pronounced near the adapical suture; the lowest spiral, which runs on the carina, is smooth. On the shell base, 7-8 spirals occur, which become stronger and more tuberculate towards the umbilicus. The aperture is circular, and pointed in its upper part. The umbilicus is deep, half closed and marked by strong radial growth lines.
Discussion — This species differs markedly from all other trochids at Kallo on account of shell shape, base and umbilicus. But a single very incomplete specimen has been collected at Kallo (Sea Lock) by A. Janse from the Oorderen Member (*Angulus benedeni* bed ?); it preserves the typical umbilicus. A better preserved specimen from Antwerp is here illustrated. So far, the present species was known especially from the Austruweel Member and rarely from the Kruisschans Member (Marquet, 1993). In Great Britain, it occurs in the Red Crag.

Subgenus *Steromphala* Gray, 1847

Gibbula (Steromphala) octosulcata (Nyst, 1835)
Pl. 6, Fig. 1

1835 *Trochus octosulcatus* Nyst, p. 26, pl. 4, fig. 18.
1843 *Trochus octosulcatus* Nyst — Nyst, p. 323, pl. 38, fig. 1.
1848 *Trochus Adansoni* Payr. — Wood, p. 129, pl. 14, fig. 3.
1878 *Trochus octosulcatus*, Nyst — Nyst, pl. 7, fig. 1.
1881 *Trochus octosulcatus*, Nyst — Nyst, p. 107.
1923 *Trochus octosulcatus* (Nyst) — Harmer, p. 727, pl. 58, fig. 19.
1923 *Trochus Adansoni* (Payraudeau) — Harmer, p. 732,

pl. 59, fig. 8.
1946 *Gibbula octosulcata* (Nyst, 1835) — Beets, p. 25.
1957 *Gibbula (Steromphala) octosulcata* Nyst, sp. 1835 — Glibert, p. 17, pl. 1, fig. 13.
1965 *Gibbula octosulcata* (Nyst, 1835) — van Regteren Altena *et al.*, p. 10, pl. 3, fig. 19.
1979b *Gibbula octosulcata* (Nyst, 1835) — Geys & Marquet, p. 66, pl. 26, fig. 6.

Dimensions — Height 14 mm, width 13 mm; height 12 mm, width 12 mm; height 9 mm, width 12 mm.
Description — Medium-sized, cyrtoconoid conical shell, with rather flattened whorls. The umbilicus is mostly closed, but occasionally a narrow cleft remains. The height/width ratio is very variable. Spiral ornament is present on the whorls as well as on the shell base, and consists of 6-8 primary spirals and 3-5 weak secondary spirals in between. The primary ribs bear small granules.
Discussion — Distinctive features of this species are its size and ornament, which is much finer than in most congeners occurring at Kallo. It is very common in the Oorderen Member, but rare in the Kattendijk Formation and in the Kruisschans Member. The species is restricted to the North Sea Basin Pliocene.

Subgenus *Colliculus* Monterosato, 1888

Gibbula (Colliculus) beetsi van Regteren Altena, 1954
Pl. 5, Fig. 1

1923 *Trochus (Gibbula) philberti* (Récluz) — Harmer, p. 739, pl. 69, fig. 20.
1946 *Gibbula philberti* (Récluz, 1843) — Beets, p. 26.
1946 *Gibbula* spec. 2 — Beets, p. 31, pl. 1, figs 32, 33
1946 *Gibbula* spec. 3 — Beets, p. 31, pl. 1, figs 34, 35.
1954 *Gibbula beetsi* van Regteren Altena, p. 46.
1957 *Gibbula (Steromphala) beetsi* Regteren-Altena, 1954 — Glibert, p. 18, pl. 1, fig. 14.
1965 *Gibbula beetsi* Van Regteren Altena, 1954 — van Regteren Altena *et al.*, p. 10, pl. 3, fig. 20.
1993 *Gibbula* aff. *beetsi* van Regteren Altena, 1954 — Marquet, p. 89.

Dimensions — Height 5,5 mm, width 6 mm.
Description— Rather small, thick-shelled, cyrtoconoid conical shell, with closed umbilicus and rounded whorls. The aperture is rounded-squarish, with occasionally a very inconspicuous columellar tubercle. The ornament consists of strong spiral ribs, separated by deep grooves. About 5-7 spirals occur on the last whorl above the periphery, and about 8 below. The distance between them is variable. The adapical spiral delimits a subsutural depression. Weaker secondary spirals may occur between the primary ones. The spiral ribs are crossed by close-set oblique radial striae, which give the spirals a granulate or scaly appearance. The primary spirals often preserve their purple or red colour, the secondary ones in between are invariably white.
Discussion — *Gibbula beetsi* belongs to a group of species which are difficult to separate. It may be distinguished on account of its stronger and fewer ribs and often also of preservation of colour pattern. It is restricted to the Oorderen Member, in which it is rarer than *G. obconica*, and to the Kruisschans Member. The species is endemic to the Pliocene of the North Sea Basin, and differs from *G. obconica* in having a more rounded last whorl, a closed umbilicus and coarser, fewer spiral ribs.

Gibbula (Colliculus) obconica forma **obconica**
(Wood, 1842)
Pl. 5, Fig. 3

1842 *Trochus obconicus* Wood, p. 532.
1848 *Trochus obconicus* S. Wood — Wood, p. 133, pl. 14, fig. 10.
1923 *Trochus (Gibbula) obconicus* (S.V. Wood) — Harmer, p. 740, pl. 59, fig. 22.
1946 *Gibbula spastica* Beets, p. 26, pl. 1, figs 8-12.
1957 *Gibbula (Steromphala) obconica* Wood, sp. 1842 forme *obconica* s.s. — Glibert, p. 19, pl. 1, fig. 16a (*partim*).
1965 *Gibbula nehalenniae* Van Regteren Altena, 1954 — van Regteren Altena *et al.*, p. 10, pl. 3, fig. 21 (*partim*).

Dimensions — Height 6,5 mm, width 5,5 mm.
Description — Rather small, cyrtoconoid conical shell, with almost completely closed umbilicus. The general shape is the same as that of the following subspecies. The ornament consists of about 20 fine spiral ribs above the keel, 15-18 below, which are interconnected by only slightly weaker radial ornament. On the points of intersection, small granules develop.
Discussion — At Kallo, this forma is known exclusively from the *Petaloconchus* bed. It differs from *G. obconica* forma *nehalenniae* in having granules on the spiral ornament. Topotypical specimens housed in the KBIN collections possess the same ornament, if well preserved. In *G. spastica* Beets, 1946 the '[...] spirals are somewhat granulous on account of numerous growth-lines ...' (Beets, 1946, p. 26), which corresponds with the type of ornament shown by Kattendijk Formation specimens. According to Beets his new species differed from *G. obconica* in having less convex whorls, but this is a very variable character in the present material and does not warrant separation on the specific level.

Gibbula (Colliculus) obconica forma **nehalenniae**
van Regteren Altena, 1954
Pl. 5, Fig. 2

1878 *Trochus obconicus*, S. Wood — Nyst, pl. 7, fig. 4.
1881 *Trochus obconicus*, S. Wood — Nyst, p. 110.
1946 *Gibbula (Colliculus) pennanti* (Philippi, 1851) — Beets, p. 27.
1946 *Gibbula* spec. 1 — Beets, p. 31, pl. 1, figs 28-31
1954 *Gibbula nehalenniae* van Regteren Altena, p. 47.
1957 *Gibbula (Steromphala) obconica* forme *obconica* Wood, sp. 1842 — Glibert, p. 19, pl. 1, fig. 16a (*partim*).
1957 *Gibbula (Steromphala) obconica* Wood, sp. 1842 forme *nehalenniae* Regteren-Altena, 1954 — Glibert, p. 19, pl. 1, fig. 16b.
1965 *Gibbula nehalenniae* Van Regteren Altena — van Regteren Altena *et al.*, p. 10, pl. 3, fig. 21 (*partim*).
1979 *Gibbula obconica* (Wood, 1842) — Geys & Marquet, p. 66, pl. 26, fig. 5.

Dimensions — Height 7 mm, width 6 mm; height 6 mm, width 5 mm.
Description — Rather small, cyrtoconoid conical shell, with nearly completely closed umbilicus. The suture is deep and the flat-sided whorls have a stepwise form. The last whorl has a rounded-keeled periphery. The aperture is squarish, with often a very slight tubercle on the columellar side. The ornament consists of 12-20 unequal, fine spiral ribs above the keel, and 18 below. Occasionally fine radial ornament is seen between the spiral ribs. Some specimens retain their original colour pattern, consisting of small reddish spots, while others have fewer (about 7) and coarser ribs and a lower spire. For specimens such as these van Regteren Altena (1954) coined the name *G. nehalenniae*.
Discussion — Glibert (1957) is here followed in not considering *G. nehalenniae* as a separate species, but only as a forma with extremely low spire and coarse ribs. *Gibbula obconica* forma *obconica* is clearly different and never found to co-occur with *G. o.* forma *nehalenniae*. As early and middle Pliocene specimens need to be distinguished, the oldest available synonym, *G. nehalenniae*, is here used for the forma occurring in the Oorderen Member. At Kallo it is most common in the *Atrina* bed and much rarer in the *Cultellus* bed.

Gibbula (Colliculus) crassistriata
(Bell *in* Wood, 1882)
Pl. 5, Fig. 4

1882 *Margarita crassi-striata* Bell *in* Wood, p. 10, pl. 1, fig. 15.
1923 *Margarites crassistriata* (R.G. Bell) — Harmer, p. 749, pl. 60, fig. 8.
1965 *Margarites crassistriata* (R. Bell in S.V. Wood, 1882) — van Regteren Altena *et al.*, p. 8, pl. 2, fig. 11.

Dimensions — Height 6 mm, width 6 mm.
Description — Rather small, solid, cyrtoconoid shell, consisting of about five tumid, slightly angular whorls, with a deep suture. The umbilicus is nearly closed. The aperture is near-quadrangular and possesses a very weak columellar tooth. Older whorls have three strong, clearly delimited spiral ribs, which are about as broad as one third of the intercostal areas. On the last whorl, two additional weaker spiral ribs appear; one runs near the base, the other on the adapical part of the whorl, where it causes a narrow subsutural depression to develop. On the shell base, 8 weaker spirals occur, which are about as broad as the intercostal areas. None of the spirals bear tubercles, but brown colour spots may be seen on them. Numerous fine, radial striae are present between the spirals on the dorsal part of the shell, but not on the shell base. They are prosocline, less so in the subsutural depression than more abapically.
Discussion — This species is here recorded for the first time from the Belgian Pliocene. At Kallo, it is extremely rare in the Oorderen Member. So far it was known only from the British Boyton and Red Crags. Dutch beach specimens, housed in the NNM collections, differ from Kallo material in having on the last whorl the five spiral ribs become equally strong. All available specimens are thick shelled and not nacreous, as one could expect of a species of the genus *Margarites*, to which taxon it has previously been assigned.

Gibbula (Colliculus) petala n. sp.
Pl. 5, Fig. 5

Diagnosis — A species of the subgenus *Colliculus* with ornament consisting of about 7-10 spiral rows of weakly interconnected tubercles, with radial sculpture in between.
Dimensions — Height 5,5 mm, width 5,5 mm.
Type — Holotype, KBIN/IRScNB no. IST 5881; 10 paratypes (Marquet Collection).
Locus typicus — Vrasenedok, Kallo, municipality of Beveren, province of Oost-Vlaanderen, Belgium; co-ordinates (sheet 7/5-6): x = 140,850, y = 216,700 (see Hoedemakers & Marquet, 1992).
Stratum typicum — Kattendijk Formation, *Petaloconchus* bed (early Pliocene).
Derivatio nominis — Alluding to *Petaloconchus*.
Description — Rather small, relatively high, cyrtoconoid shell, consisting of about 6 rather flat-sided and stepwise whorls with deep suture. The aperture is rounded to

slightly squarish. The umbilicus is nearly closed. On the older whorls, 6 closely set rows of interconnected tubercles occur, crossed by nearly equally strong radial striae. The last whorl has an angular, but not keeled, periphery. Above the periphery, 7-10 close-set rows of tubercles occur; the tubercles are only weakly interconnected. The spiral rows of tubercles are nearly as wide as the intercostal areas. Between these spiral rows, fine radial lines are present, which become more or less obsolete near the periphery. Eleven continuous spiral ribs without tubercles are seen on the shell base, below the periphery. They are joined by radial lines in between.
Discussion — This species differs from *G. obconica* f. *obconica* in having coarser tubercles, which form discontinuous spirals above the periphery; in addition, the new species has fewer spirals. *Gibbula obconica* forma *nehalenniae* has a better-developed and finer spiral, non-tuberculate ornament. The new species differs from *G. beetsi* in having less rounded whorls, less deeply incised intercostal areas, more numerous spirals and coarser tubercles. *Gibbula (Colliculus) woodi* (Harmer, 1923) is nearly smooth, flat-sided and has a very shallow suture. Of *'Trochus (Calliostoma) incertus'* Harmer, 1923 but a single fragment is known from the St Erth Beds; it shows a comparable ornament, but is larger, with the umbilicus apparently absent, the suture probably shallow, and with flat-sided whorls. So long as no better-preserved is available, this name is better treated as a *nomen dubium.*
Remarks — The present species is confined to the *Petaloconchus* bed (Kattendijk Formation) at Kallo, in which it is much rarer than *G. obconica* forma *obconica.*

Family Skeneidae Clark, 1851
Genus *Skenea* Fleming, 1825
Subgenus *Lissospira* Bush, 1897

Skenea (Lissospira) basistriata (Jeffreys, 1877)
Pl. 6, Fig. 2

1877 *Margarita basistriata* Jeffreys, p. 17.
1923 *Cyclostrema basistriatum*, Jeffreys, MS. — Harmer, p. 753, pl. 60, fig. 17.
1988 *Skenea basistriata* (Jeffreys, 1877) — Graham, p 138, fig. 47.
1991 *Skenea basistriata* (Jeffreys, 1877) — Warén, p. 64, fig. 5a, b, e, f, h; 7a, c.
1993 *Skenea basistriata* (Jeffreys, 1877) — Warén, p. 176, fig. 16.

Dimensions — Height 0,8 mm, width 0,8 mm.
Description — Minute, turbiniform shell, with relatively high spire, tumid whorls, deep open umbilicus and oval, near-circular aperture, pointed at the apical end. Ornament consists of about 9 spiral ridges, which are most pronounced around the umbilicus and continue to the shell's periphery.
Discussion — This species is extremely rare in the *Petaloconchus* bed and in the Oorderen Member. Only few specimens have been collected (NNM, A. Janse and F. van Nieulande Collections). It has not been previously recorded from the Belgian Pliocene. In the British Pliocene, it was found at St Erth. Modern records of this species are known from Spain to Norway, where, according to Graham (1988) and Warén (1991, 1993), it occurs mostly in deep waters (90-2,400 mm).

The ornament of the Kallo specimens falls within the wide range of variation characterising the species, as illustrated by Warén (1993).

Genus *Dikoleps* Hoisaeter, 1968

Dikoleps pusilla (Jeffreys, 1847)
Pl. 6, Fig. 3

1847 *Margarita pusilla* Jeffreys, p. 17.
1923 *Cyclostrema nitens* (Philippi) — Harmer, p. 755, pl. 60, fig. 19.
1984 *Dikoleps pusilla* (Jeffreys, 1847) — van Aartsen *et al.*, p. 12, fig. 39.
1988 *Skenea nitens* (Philippi, 1844) — Graham, p. 136, fig. 46.
1991 *Dikoleps pusilla* (Jeffreys, 1847) — Warén, p. 56, pl. 2, fig. 2.
1993 *Dikoleps pusilla* (Jeffreys, 1847) — Warén, p. 179, fig. 12f.
1994 *Dikoleps pusilla* (Jeffreys, 1847) — Gianuzzi-Savelli *et al.*, p. 106, fig. 355.

Dimensions — Height 1 mm, width 1 mm.
Description — Minute, turbiniform shell, with relatively low spire and tumid whorls. The umbilicus is narrow and partially closed by an extension of the inner lip of the aperture. The outer apertural lip has a basal and a peripheral bay. Surface smooth, except for growth lines.
Discussion — This species differs from the previous in lacking ornament, in having the umbilicus partially closed and a lower spire. It too is new for the Belgian Pliocene, having been first discovered at Kallo by Y. Butaye, where it is extremely rare in the *Atrina* bed (Oorderen Member). Other records include the Pliocene of St Erth. According to Graham (1988) this is a species of rather shallow water. Most modern authors, *e.g.* Warén (1991, 1993) and van Aartsen *et al.* (1984), consider *Dikoleps pusilla*, an Atlantic-Mediterranean species, distinct from *D. nitens* (Philippi, 1844), from the Mediterranean. The latter may be distinguished in showing ornament on the

lower part of the shell, around the umbilicus.

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PLATE 1

Fig. 1. *Emarginula punctura* Wood, 1848, Kallo (Vrasenedok), Kattendijk Formation (*Petaloconchus* bed), x 14,5 (a) and x 17,5 (b). KBIN collections, no. IRScNB IST 5872.

Fig. 2. *Emarginula rosea* Bell, 1824, Kallo (Vrasenedok), Kattendijk Formation (*Petaloconchus* bed), x 14,8 (a) and x 15,5 (b). KBIN collections, no. IRScNB IST 5873.

Fig. 3. *Emarginula fissura* forma *reticulata* J. Sowerby, 1813, Kallo (Vrasenedok), Lillo Formation (Oorderen Member, *Atrina* level), x 8,2 (a) and x 5,7 (b). Marquet Collection.

PLATE 1

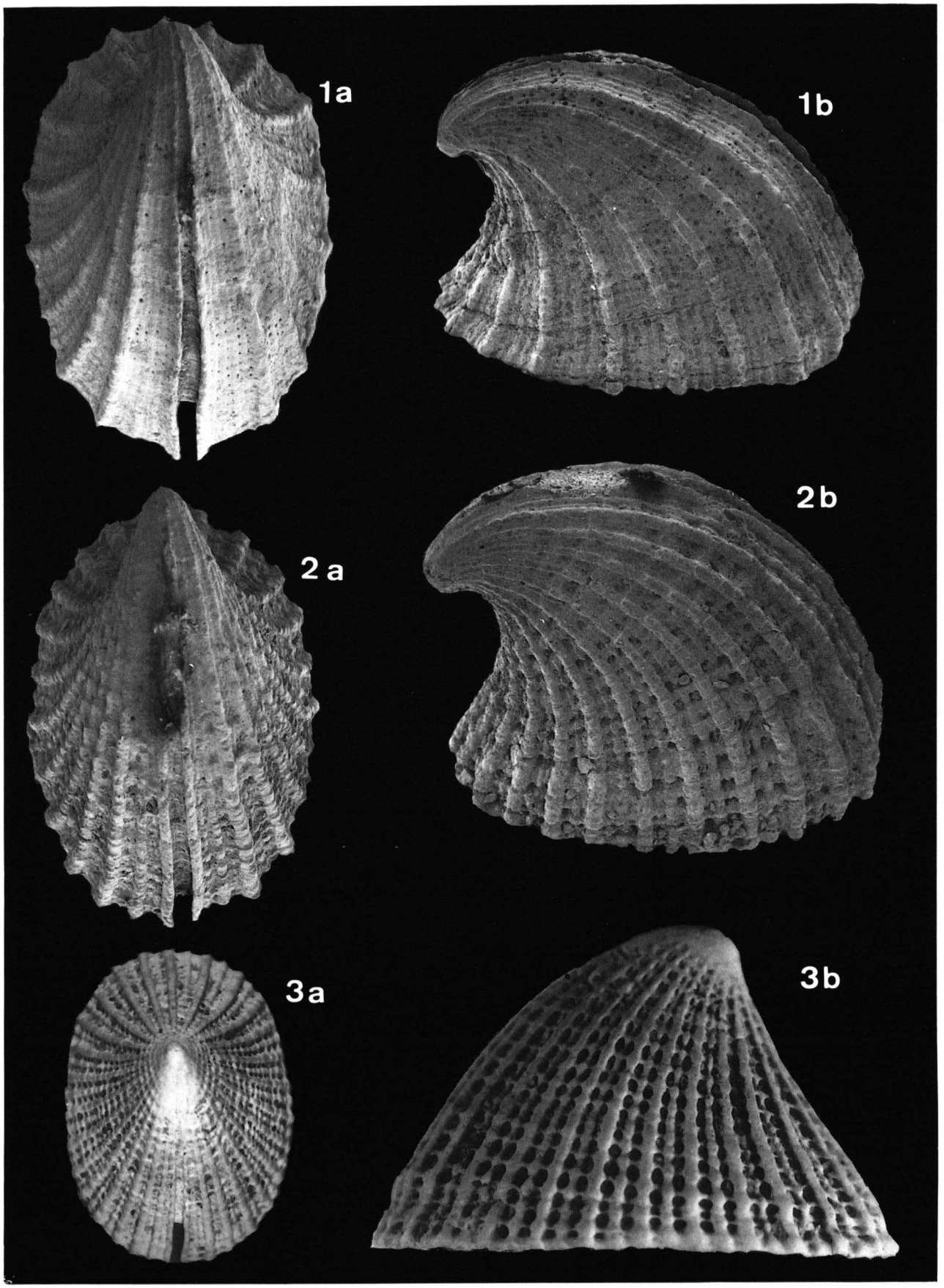

PLATE 2

Fig. 1. *Diodora graeca* (Linné, 1758), Kallo (Vrasenedok), Kattendijk Formation, x 1,9 (a), x 2,2 (b) and x 1,3 (c). Marquet Collection.

Fig. 2. *Emarginula crassa crassa* J. Sowerby, 1813, Kallo (Vrasenedok), Lillo Formation (Oorderen Member, *Atrina* level), x 0,8 (a) and x 0,72 (b). Marquet Collection.

Fig. 3. *Emarginula crassa crassalta* Wood, 1874, Kallo (Vrasenedok), Kattendijk Formation (*Petaloconchus* bed), x 2,5 (a) and x 3,2 (b). Marquet Collection.

Fig. 4. *Anatoma crispata* (Fleming, 1828), Kallo (Vrasenedok), Kattendijk Formation (*Petaloconchus* bed), x 23,5. KBIN collections, no. IRScNB IST 5874.

Fig. 5. *Lepeta (Lepeta) scaldensis* van Regteren Altena, 1954, Kallo (Verrebroekdok), Lillo Formation (Oorderen Member, *Atrina* level), x 3,8 (a) and x 3,8 (b). Marquet Collection.

PLATE 2

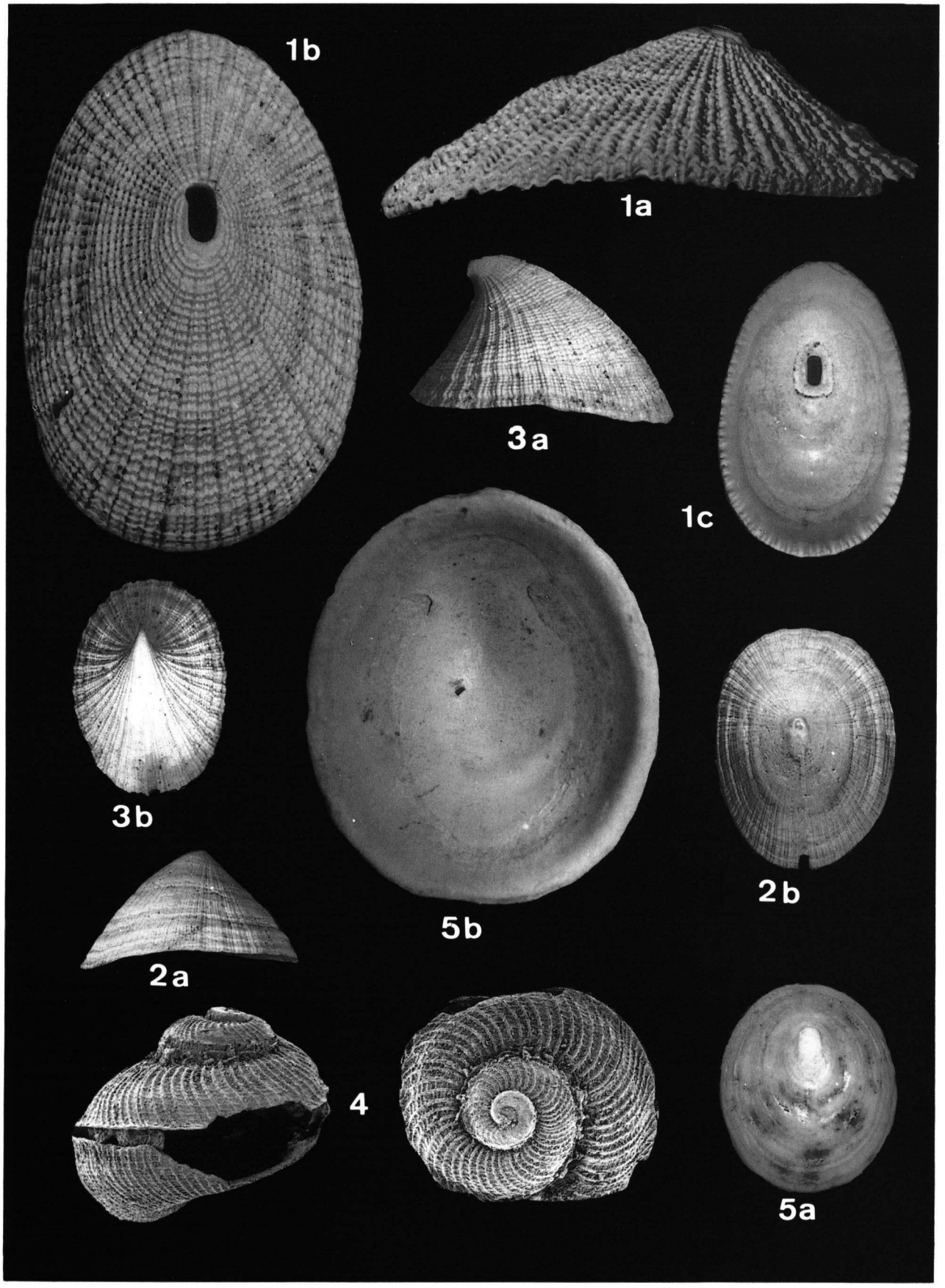

PLATE 3

Fig. 1. *Solariella maculata* Wood, 1842, Kallo (Vrasenedok), Kattendijk Formation (*Similipecten* bed), x 5,4 (a) and x 6,4 (b). Marquet Collection.

Fig. 2. *Calliostoma (C.) zizyphinum* (Linné, 1758), Kallo (Vrasenedok), Kattendijk Formation, x 2,1 (a), x 1,2 (b), x 1 (c) and x 1,2 (d). Marquet Collection.

Fig. 3. *Calliostoma (C.) simile* (J. Sowerby, 1816), Kallo (Vrasenedok), Lillo Formation (Oorderen Member, *Atrina* level), x 1,4 (a), x 1,4 (b), x 1,5 (c) and x 1,9 (d). Marquet Collection; e, f - juvenile specimen, Kallo (Vrasenedok), Lillo Formation (Oorderen Member, *Cultellus* level), x 120 and x 60, respectively. KBIN collections, no. IRScNB IST 5875.

Fig. 4. *Margarites (Margarites) trochoides* (Wood, 1842), Kallo (tunnel), Kattendijk Formation, x 12,2. Van Nieulande Collection.

PLATE 3

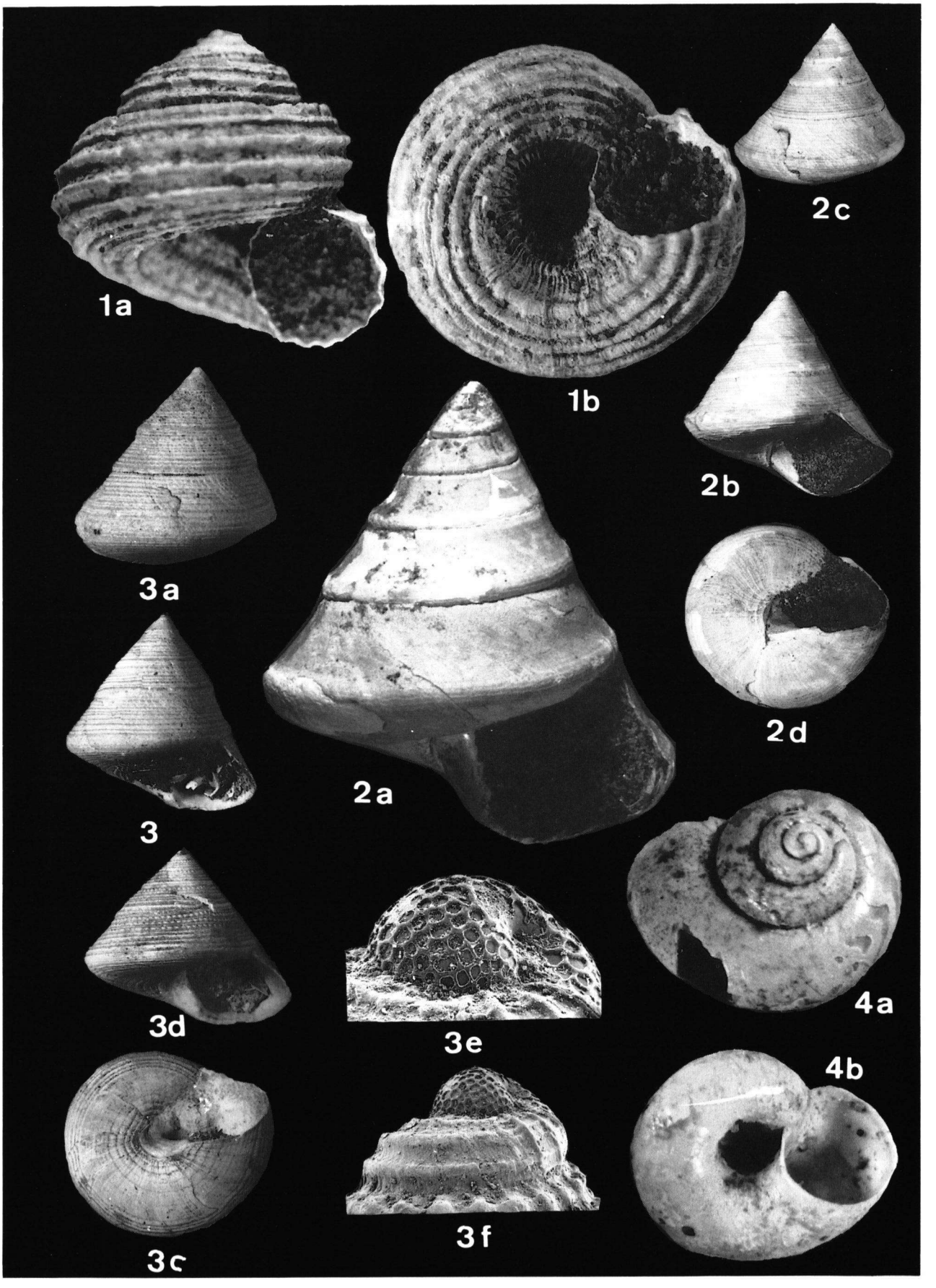

PLATE 4

Fig. 1. *Calliostoma (C.)* aff. *noduliferens* (Wood, 1872), Kallo (Zeesluis), Lillo Formation (Oorderen Member), x 8,2 (a) and x 9,1 (b). KBIN collections, no. IRScNB IST 5876.

Fig. 2. *Calliostoma (C.) kickxii* (Nyst, 1835), Kallo (tunnel), Lillo Formation (Oorderen Member, basal crag), x 5 (a), x 4,4 (b) and x 6,2 (c). Van Nieulande Collection.

Fig. 3. *Calliostoma (Eucasta) occidentale* (Mighels & Adams, 1842), Kallo (Vrasenedok), Kattendijk Formation (*Similipecten* bed), x 2,5 (a, b). Marquet Collection; c - same locality and level, x 2,5. Marquet Collection; d, e - juvenile specimen, same locality and level, x 16 and x 60, respectively. KBIN collections, no. IRScNB IST 5877.

Fig. 4. *Gibbula (Gibbula) solarium* (Nyst, 1835), Antwerp (Zevende Havendok), Lillo Formation (Kruisschans Member), x 2,6 (a), x 2,7 (b) and x 2,3 (c). Marquet Collection.

PLATE 4

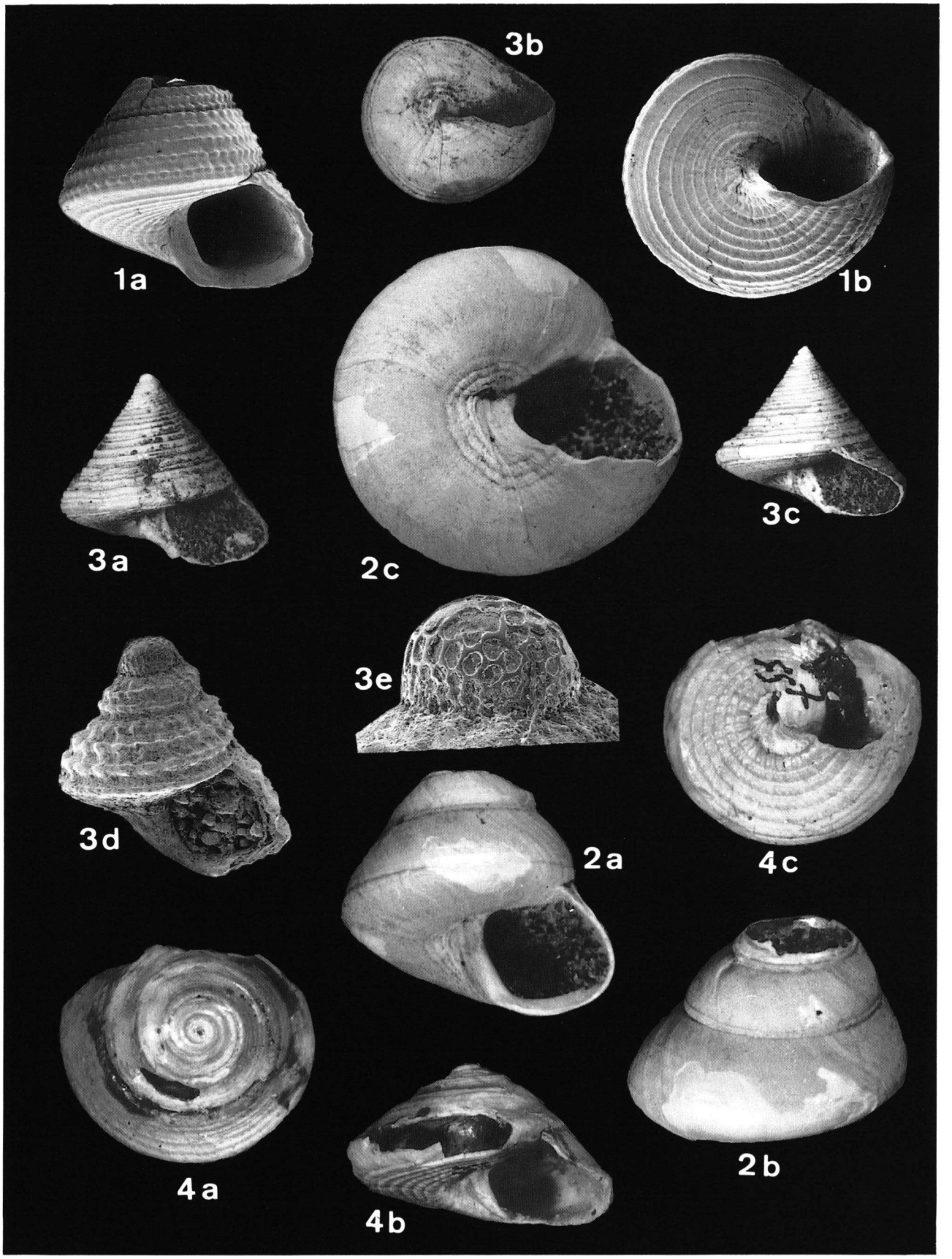

PLATE 5

Fig. 1. *Gibbula (Colliculus) beetsi* van Regteren Altena, 1954, Kallo (Verrebroekdok), Lillo Formation (Oorderen Member, *Atrina* level), x 8 (a, b) and x 7,5 (c). Marquet Collection.

Fig. 2. *Gibbula (Colliculus) obconica* forma *nehalenniae* van Regteren Altena, 1954, Kallo (Verrebroekdok), Lillo Formation (Oorderen Member, *Atrina* level), x 6 (a) and x 35 (b). KBIN collections, no. IRScNB IST 5878; c - Kallo (Vrasenedok), Lillo Formation (Oorderen Member, *Atrina* level), x 10,8. Marquet Collection.

Fig. 3. *Gibbula (Colliculus) obconica* forma *obconica* (Wood, 1842), Kallo (Vrasenedok), Kattendijk Formation (*Petaloconchus* bed), x 8. KBIN collections, no. IRScNB IST 5879.

Fig. 4. *Gibbula (Colliculus) crassistriata* (Bell *in* Wood, 1882), Kallo (Verrebroekdok), Lillo Formation (Oorderen Member, *Atrina* level), x 9 (a), x 8 (b) and x 30 (c). KBIN collections, no. IRScNB IST 5880.

Fig. 5. *Gibbula (Colliculus) petala* n. sp., Kallo (Vrasenedok), Kattendijk Formation (*Petaloconchus* bed), x 8,7 (a), x 8,9 (b) and x 35 (c). KBIN collections, no. IRScNB IST 5881 (**holotype**).

PLATE 5

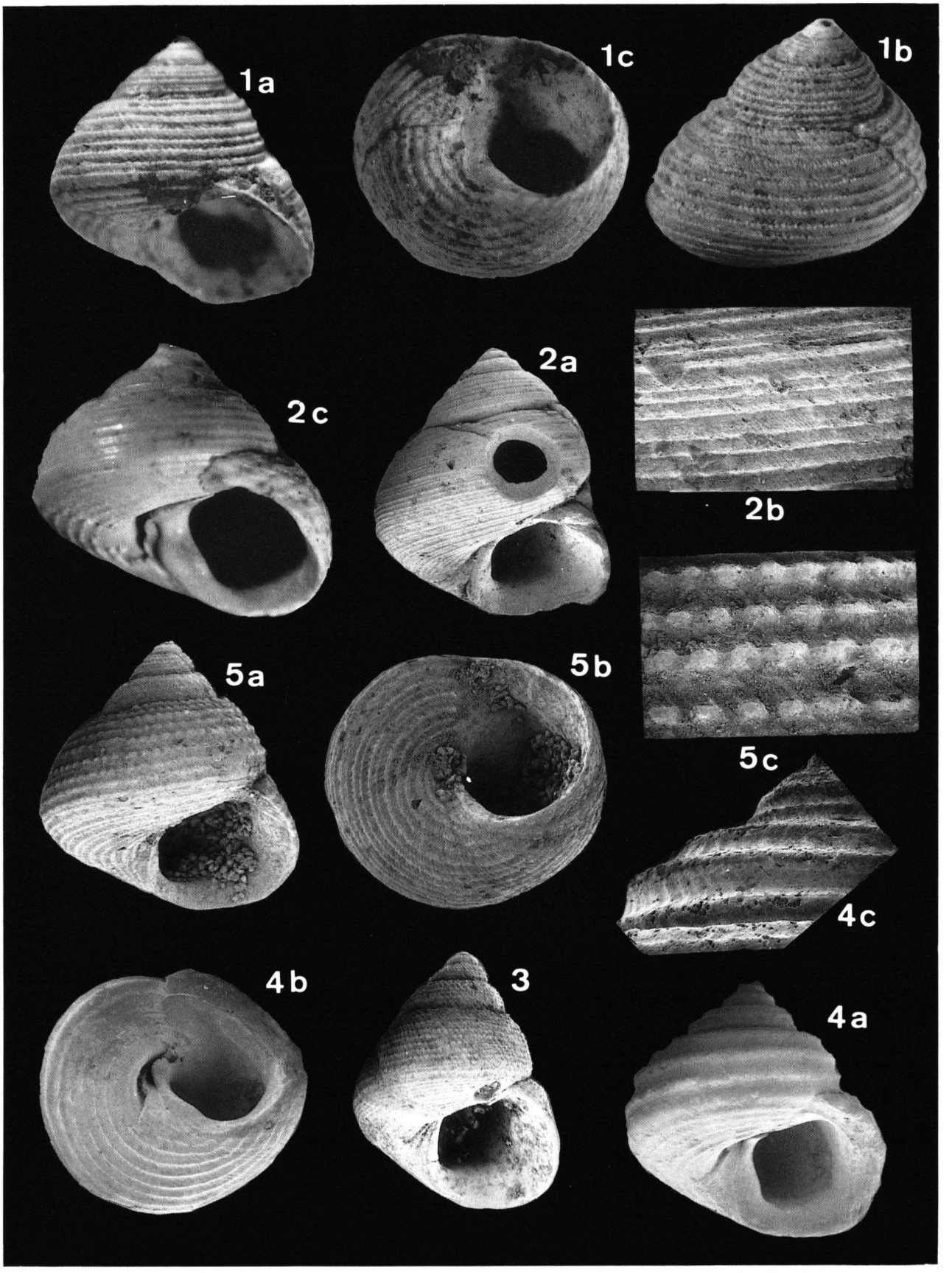

PLATE 6

Fig. 1. *Gibbula (Steromphala) octosulcata* (Nyst, 1835), Kallo (Verrebroekdok), Lillo Formation (Oorderen Member, *Atrina* level), x 4,8 (a), x 5,4 (b) and x 5,3 (c). Marquet Collection.

Fig. 2. *Skenea (Lissospira) basistriata* (Jeffreys, 1877), Kallo (Vrasenedok), Kattendijk Formation (*Petaloconchus* bed), x 100 and x 84, respectively. KBIN collections, no. IRScNB IST 5882.

Fig. 3. *Dikoleps pusilla* (Jeffreys, 1847), Kallo (Verrebroekdok), Lillo Formation (Oorderen Member, *Atrina* level), x 53, x 55, and x 58, respectively. KBIN collections, no. IRScNB IST 5883.

PLATE 6