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ELASMOBRANCHES ET STRATIGRAPHIE
Volume spécial

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TAPHONOMY OF SOME CENOZOIC SEABEDS FROM THE FLEMISH REGION, BELGIUM

by

Marcel VERVOENEN *

* M. Vervoenen, official collaborator of the Belgian Geological Survey,
Beekstraat 86a, 9300 Aalst, Belgium

Couverture: *Carcharodon carcharias* (formerly *Carcharodon rondeleti*)
Sands of Oorderen, Kallo (see p. 83)

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Jennerstraat, 13 - 1040 Brussel

SOMMAIRE

Dédicace

Les éditeurs et l'auteur s'associent pour dédier ce volume à la mémoire
de Marcel GULINCK et Robert VAN TIEGHEM
auxquels ils sont redevables
de leur initiation à la stratigraphie, à la sédimentologie et à la taphonomie des terrains
tertiaires de la Belgique et d'une approche comparative avec celles des dépots actuels.

INTRODUCTION

Place des études taphonomiques dans le cadre du Projet Elasmobranches et Stratigraphie.

Elasmobranches et Stratigraphie est la codification d'un projet national qui, initié dès 1986, avait pour but d'affiner la microstratigraphie des terrains mésozoïques et cénozoïques belges sur base des successions faunistiques d'élasmobranches.

Outre l'extension à l'odontologie comparative des microdents d'élasmobranches actuels et l'élargissement des cadres géographiques et stratigraphiques initialement prévus en 1986 (cfr. E.S. PP 1993/6 n° 264, VII), il s'est avéré de surcroît indispensable de développer la compréhension des conditions de dépôt des gisements prospectés. Si la non-contemporanéité des faunes d'élasmobranches ou d'autres groupes de vertébrés contenus dans un gravier de base d'une formation avec l'âge de celle-ci a toujours parue évidente, le doute a rarement été émis lorsque semblables faunes furent extraites d'horizons graveleux ou coquilliers situés au sein de ladite formation.
Une approche plus fine des phénomènes successifs de sédimentation de ces horizons a permis de mettre en évidence la fréquente multiplicité ainsi que la diversité des phases les ayant constitués.
Ces successions d'accidents sédimentologiques et taphonomiques suggèrent évidemment d'importantes implications paléoécologiques et microstratigraphiques.

A cette fin, les niveaux échantillonés ont fait l'objet de levés photographiques et de prises de vues détaillées exécutés par tous les collaborateurs impliqués dans ce projet. Diverses fixations sur toile de leurs coupes verticales les plus significatives ont été réalisées par D. Hovestadt et M. Hovestadt-Euler.

De chaque horizon prospecté dans le cadre du Projet Elasmobranches et Stratigraphie, ont toujours été conservés quelques échantillons bruts. Toutefois, ces témoins meubles et non-consolidés, ne dépassent guère 40cm^2 et ne permettent pas de saisir la complexité des conditions de formation de ces horizons.

Indépendamment, M. Vervoenen et ses amis ont élaboré et patiemment perfectionné une technique remarquable d'extraction, d'enlèvement et de consolidation de ces niveaux meubles permettant enfin la visualisation horizontale de la succession de toutes leurs microphases de sédimentation.
Leur procédé permet pour la première fois la description minitieuse de l'enchaînement des diverses phases de sédimentation et de bioturbation, ainsi que leurs dégradations physiques ou chimiques éventuelles.
Cette nouvelle approche du mode de constitution des pièges sédimentaires des restes d'élasmobranches, concentrés, dispersés, entiers ou fragmentaires, altérés ou non, nous a conduit à insérer ce travail dans notre programme de publication.

Explanatory note to the presentation of this article:

Except for some alternate pages with only figures, the layout is consistent: The left page is a full colour plate representing one or two preparations; the right page contains an annotated scheme of the preparation(s), an enumeration of its(their) principal species, a short comment on the particularities, some additional figures (localisation, cross section, details, other remarkable fossils of the same layer, etc.) and in the upper right corner the data concerning the **age**, the **lithostratigraphic unit** and the **locality**.

The age:
It mentions:
- the classical chronostratigraphical terms still in use in the *Guide Géologique de la Belgique* (1983), and if possible some international equivalents.
- The references to the last official legend of the Belgian Geological Map (1929). Between brackets, the official ones of (1909), i.e. the 1:40,000 Geological Map of Belgium, completed in 1913 and still the only basic reference document for both scientists and amateurs, Belgians or foreigners. These are also the only ones that can be found in the *International Stratigraphical Lexicon (Belgium, Cenozoic)*.

The lithostratigraphic unit:
The last official one with eventually reference to a former name.

The locality:
It always precizes the village, the quarry or yard, (the Geological Sheet Number), the province and the date of discovery.
The Flemish Region is presently publishing a new 1:50,000 Geological Map, of which four sheets are already available: BRUGGE (13), LOKEREN (14), LIER (16) and AARSCHOT (24).

J. Herman, july 1994.

TAPHONOMY OF SOME TERTIARY AND A LOWERMOST QUATERNARY SEABEDS FROM THE FLEMISH REGION, BELGIUM

Explanatory note to the method of preparation of sandy and silty seabed samples.

Early in the eighties the author and his friends, Freddy van Nieulande (Figs. 1 to 4) and Hans Keukelaar, tried to develop a method to dig up the very delicately conservated fossil shells of Nautilus, from the Eocene Sands of Lede at Meldert/Aalst.

The preparations were separated from the sediment with a column of their matrix, then drenched all around the block with a solution of Aceton-Velpon. After 1 or 2 hours of induration, the block could be cut off and packed for transport. The complete hardening of such a quantity of Aceton-Velpon treatment needs however minimum 24 hours.
To treat the samples with quick-gyps also took too much time, the gyps needing one hour at least to harden. Moreover, getting a find to the lab proved to be risky: more than one Nautilus arrived in pieces.

In 1984, however, the author started a quite satisfying working method, having realized that the part of sediment that has to stay undisturbed must be separated from the matrix like a block or a pillar (Fig. 1).
Explanatory note to the presentation of this article:

A roll of bandage, or Tesaband (adhesive tape on base of cloth), which permits evaporating, must be wrapped round the pillar from the bottom to the top and fixed with a pin or tape (Fig. 2).

A smooth, 3mm-thick metal plate, of which 2 sides are sharpened, is now horizontally driven through the base of the block to cut it off (Fig. 3).

Now the cut-off block can glide onto a heavy wooden pedestal; e.g. 2 wooden planks nailed together, of which the underlying one is a few cm smaller, to permit an easier hand grip (Fig. 4), and easier transport (Fig. 20).

Before starting the preparation of the sample with the Aceton-Velpon method, the block of sediment has to be dry. If not dry enough, the Velpon (glue) develops a superficial milky layer with the remnant water content and consequently the required consolidation is not obtained.
The best basic proportion is 2/3 of Aceton and 1/3 of Velpon. After stirring this mixture gently for about one minute the penetrating binding agent, which is as clear as glass, is ready. It can be kept for a long time in a beaker with an air-tight cover.
Attention: working with Aceton always needs very good ventilation!
This mixture is also very suitable for fixing small portions of a prepared fossil on its matrix of sand. It hardens almost instantaneously: the Aceton evaporates, leaving the Velpon sufficiently hard to continue work.

Once the complete surface of the sample, with all its fossils, is prepared and preliminary fixed, the whole surface can be drenched with sufficient Aceton-Velpon mixture until its saturation.

After a minimum of 24 hours of hardening (preferably 48 hours), one can start cautiously to split the artificially petrified sample from the underlying sediment. Prick carefully with spatule and thin wedges all around the sample, until it gets loose.

Now the sample has to be lifted delicately and turned to an almost vertical position, so that the underside becomes visible.

Fig. 1

Fig. 2

Fig. 3

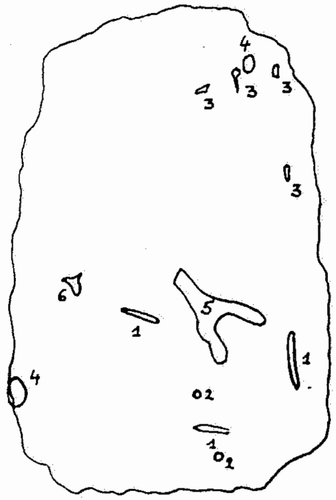
Fig. 4

The upside rim should be drenched with Aceton-Velpon, maximum twice daily, i.e. early in the morning and in and late in the afternoon.
After hardening the sample must be turned so that another rim side can be treated.
To treat the central part, the sample has to stand almost vertically. It has to be drenched with Aceton-Velpon strip by strip, until every part of it is finished. If you drench a too wide surface at once, the whole sample risks to collapse! The complete procedure of preparation and induration takes about 20 to 30 hours of work.

This method of preparation and fixing fossil sandy sea beds may induce people to remove undesirable fragments or add some more beautiful loose fossils that do not belong there. They may even be tempted to 'make' a sea bed by joining some fine fossils in a 'cake' of glued sand, in order to get a quicker and more beautiful result.
Such modus operandi should not be accepted. The Belgian Geological Survey, and domestic Museums as well as foreign ones, have qualified such procedures as genuine falsifications.

The procedure with Aceton-Velpon has to restore a pure scientifically justified fossil community. Therefore - as a kind of certificate of origin - the name of the collector-preparator should be mentioned on the preparation, together with the place of origin and other geological characteristics.

Fig. 5



Unconsolidated sample, BGS Collection (Fig. 5).

Age: Eocene - Ypresian
1929: Ypresian *Y1a* (1909: Ypresian *Yc*).
Lithostratigraphic unit: Silt of Kortemark
Locality: Egem (Sheet 53w), West Flanders, Ampe Claypit, absolute level +14.5m, January 1994.

Description:

Thin horizon of irregular thickness (0.5 to 7cm) of glauconitic silt with subangular to lightly rounded clay pebbles and derived and reconcentrated *Ditrupa*, molluscs and fish remains.

-*Ditrupa plana* partly decalcified (1).
-Teleostfish vertebra (2).
-Teleostfish bones (3).
-Fish otolith (4).
-*Striatolamia striata* juvenile functional anterior tooth (5).
-*Abdounia minutissima* (6).

This layer represents a sudden reconcentration of the fauna of the subjacent *Ditrupa* horizon with clay pebbles, phos-
phatized crustacean carapaces, bones, teeth and otoliths of Teleosts as well as elasmobranch teeth, all derived from *Ditrupa* or intermediate horizons.

This layer is the richest one for elasmobranch teeth in the Belgian Eocene. For example, 100 litres of sediment contain more than 3,000 specimens bigger than 0.5mm of more than 50 species.

The extraordinary abundance of Galeorhinid, particular Scyliorhinid, Dasyatid, Gymnurid and Rhinobatid as well as the frequent presence of *Heterodontus*, *Nebrius* and *Mustelus* suggest a tropical and undeep water environment.

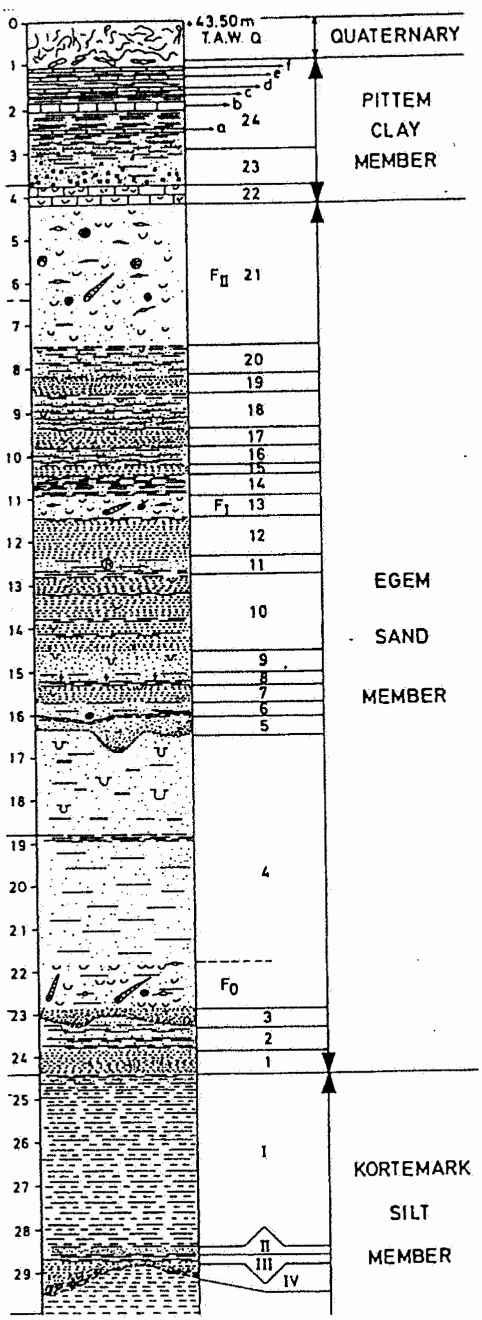
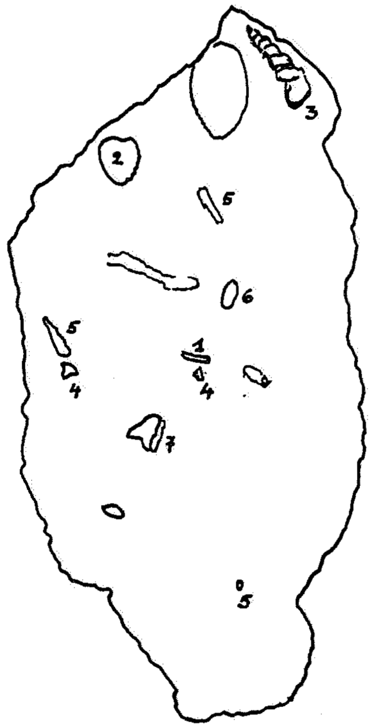


Fig. 6: Profile of the whole section of Ampe claypit. (after E. Steurbaut 1988).

Fig. 7



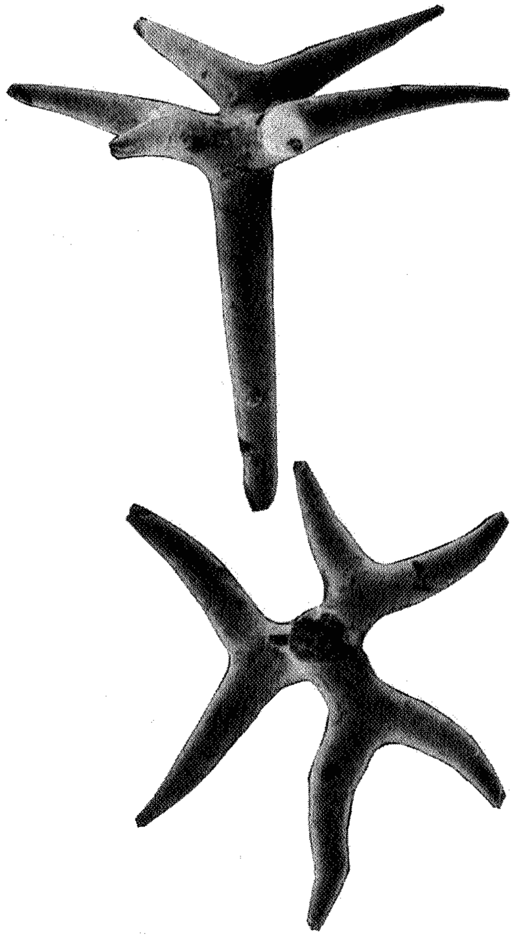


fig. 8

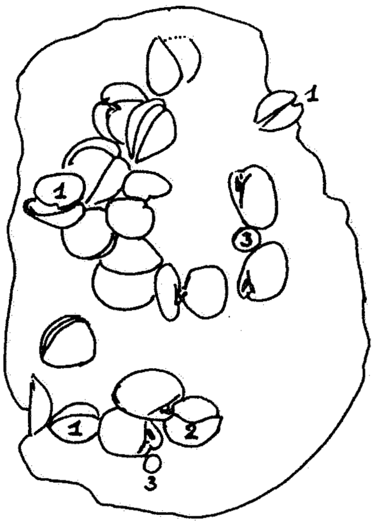
Unconsolidated sample, BGS Collection (Fig. 7).

Age: Eocene - Ypresian
1929: Ypresian *Y1a* (1909: Ypresian *Yc*).
Lithostratigraphic unit: Silt of Kortemark
Locality: Egem (Sheet 53w), West Flanders, Ampe Clay pit, absolute level +14.5m, January 1994.

Description:

Top of the same thin glauconitic silt horizon of irregular thickness; bottom view.
This horizon is extremely rich in siliceous spicules of hexactinellid sponges (Fig. 8), and contains some crustacean remains (Fig. 9: *Glyphithyreus wetherelli*).
-*Ditrupa plana* strongly decalcified (1).
-*Megacardita planicosta* juvenile damaged by the discovery act (2).
-*Turritella* sp., strongly decalcified and dama ged by the extraction (3).
-*Abdounia* tooth (4).
-Teleost bone fragment or teleost tooth (5).
-Teleost otolith (6).
-*Physogaleus secundus* (7).

Fig. 10



Preparation nr 90 (Fig. 10)

Age: Eocene - Lutetian
1929: Brusselian *B1* (1909: Paniselian *P2*).
Lithostratigraphic unit: Sands of Aalter
Locality: Aalter (Sheet 39w), West-Flanders.
New Municipal Building at Gerolflaan,
22/03/1993.

Description:
This preparation comes from -1.50m (under the surface), at the base of *Megacardita* acme horizon (Figs. 11, 12).

-Mostly bivalves, even with their ligaments fossilized (1), of *Megacardita planicosta lerichei*; a few of them in live position but slightly leaning, others are disarticulated by bioturbation. All stages of shell growth, including juveniles of some mm, are present but only as single valves.
-*Pseudoliva laudunensis*, flattened by compaction (2).
-*Vepricardium porulosum* (3).
-Different species of Venerid shells.
-Some fragments of the thick-shelled *Megacardita* suggest predation by crushing, though no trace of teeth can be found.

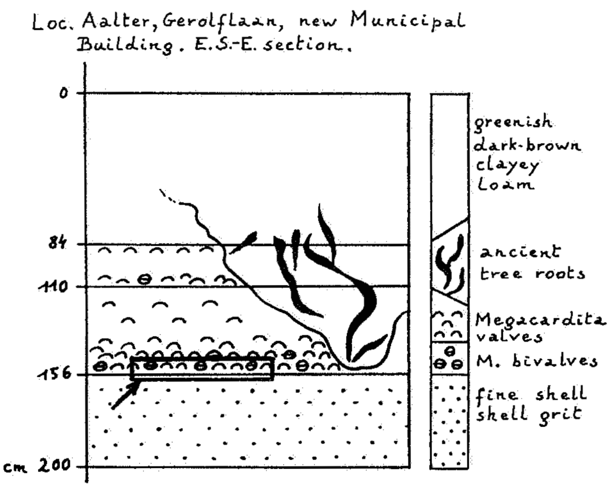
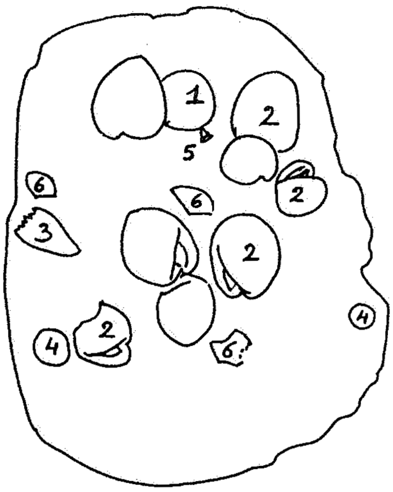


fig. 11

Fig. 13



Preparation nr 85 (Fig. 13)

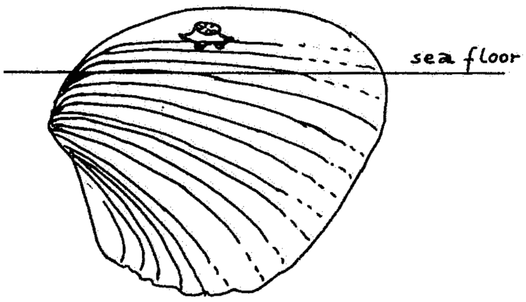
Age: Eocene - Lutetian
1929: Brusselian *B1* (1909: Paniselian *P2*).
Lithostratigraphic unit: Sands of Aalter
Locality: Aalter (Sheet 39w), West-Flanders.
New Municipal Building at Gerolflaan,
22/03/1993.

Description:
This other preparation comes from -1.53m (under the surface), at the base of *Megacardita* acme horizon (Fig. 11).

-*Megacardita planicosta lerichei* single valves and disarticulated bivalves (2). One bivalve (1) was in live position but tumbled aside by bioturbation. All stages of shell growth are present.
-A solitary coral *Balanophyllia* in live position, fixed on the upper right valve of *Megacardita* bivalve (5), (Fig. 15).
-*Vepricardium porulosum* (4).
-A fragment of Volutid gastropod (3).

The spread, disarticulated valves and some other valves not being in plane position indicate bioturbation. No displaced thanatocoenosis by sea current, nor storm wave influence are remarked. Many fragmentary shells indicate predation. Thick shell fragments of *Megacardita*, with sharply broken edges (6) suggest a powerful predator, able to crush these heavy adult shells.
The live position of the coral *Balanophyllia* (5) on this bivalve (Fig. 15), and a previously found left valve (Fig. 14) with a juvenile of the same species on the same area of the shell, suggest a not completely burrowed live position. The more heavily rusty-coloured posterior end of most bivalves give an additional suggestion that this side was above the surface of the sea floor, and perhaps overgrown by tenacious algae.

fig. 14



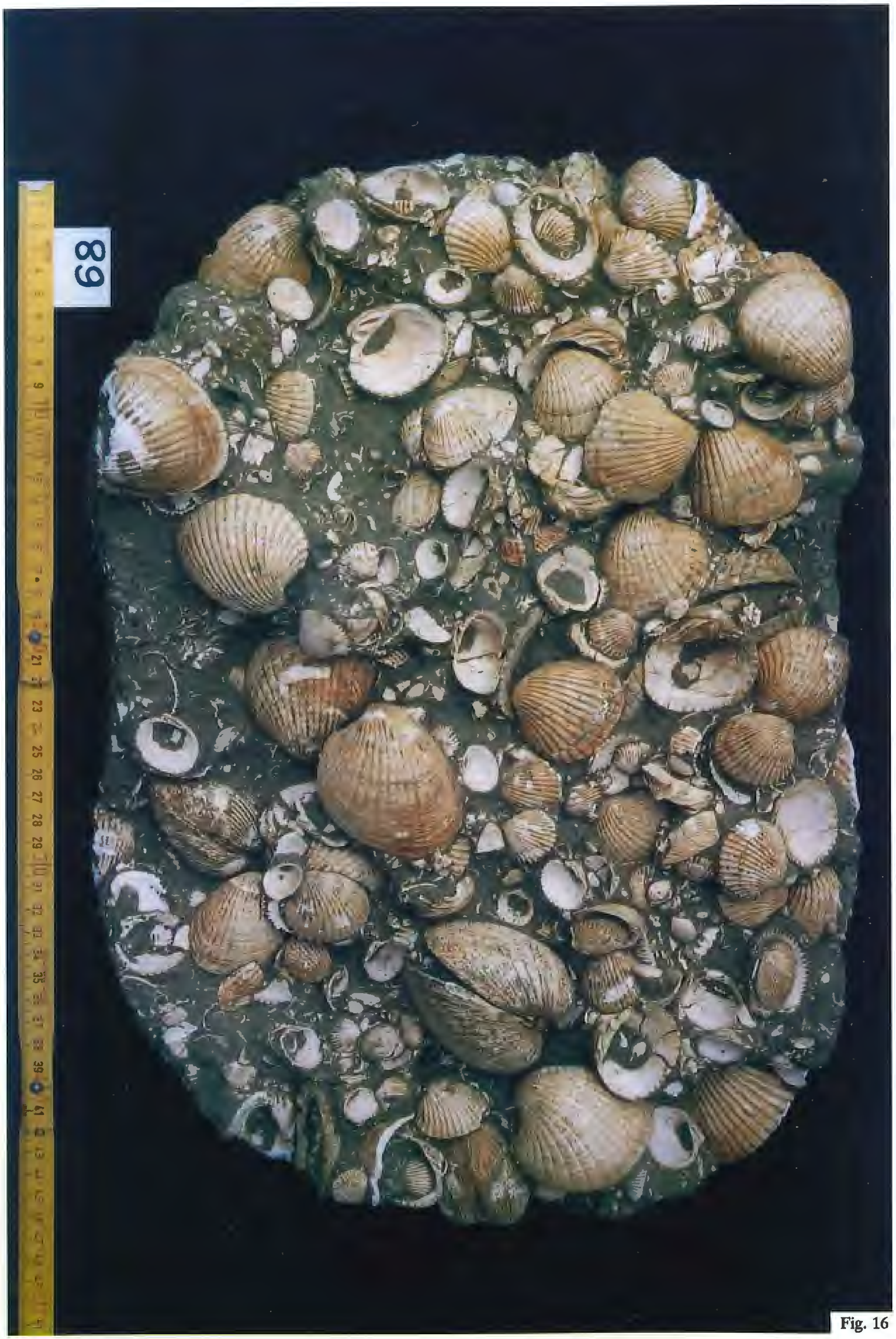
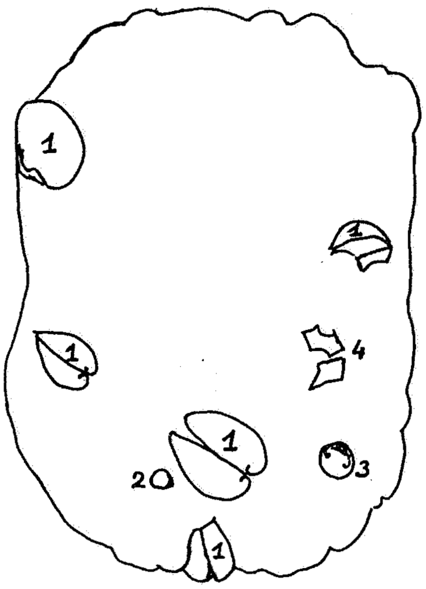


Fig. 16



Preparation nr 89 (Fig. 16)

Age: Eocene - Lutetian
1929: Brusselian *B1* (1909: Paniselian *P2*).
Lithostratigraphic unit: Sands of Aalter
Locality: Aalter (Sheet 39w), West-Flanders.
New Municipal Building at Gerolflaan,
22/03/1993.

Description:
This preparation was extracted from -1.45m (under the surface), at the base of *Megacardita* acme horizon (Fig. 17).

-*Megacardita planicosta lerichei*, single valves and even bivalves (1) with the ligament of a giant specimen still intact (Fig. 18).
-Thick sharp-edged fragments of *Megacardita* (4), suggest a powerful predator.
-*Vepricardium porulosum* (2).
-*Nemocardium* sp. (3).

The giant *Megacardita*, in live position, had the posterior end of its valves covered with incrusted sediment (a slightly pyritisized form). This allows the hypothesis that alive the animal was partly embedded in the sea floor (Fig. 14), with its posterior end possibly overgrown by algae, or just covered by its own hairy periostracum.

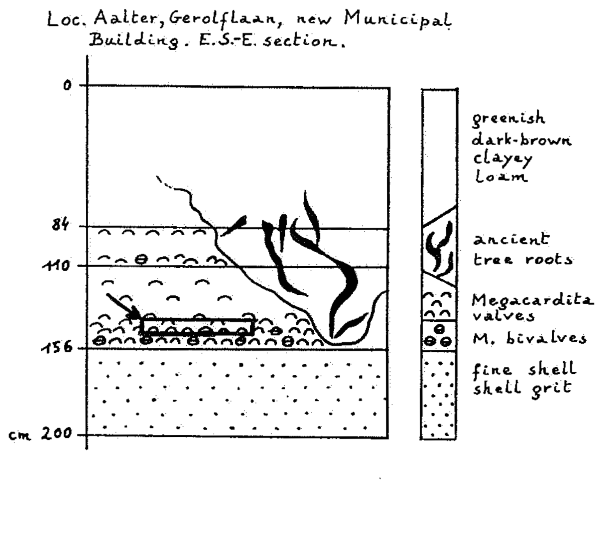
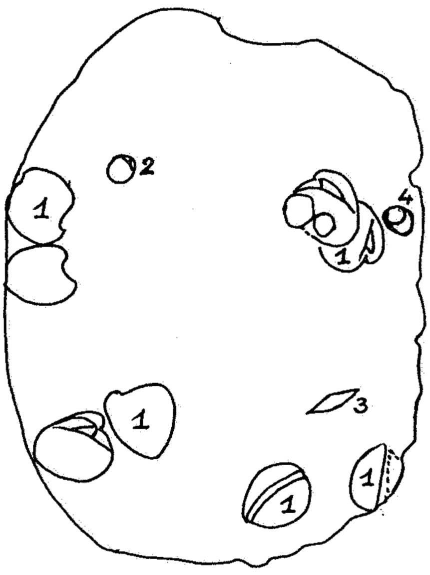


Fig. 19



Preparation nr 87 (Fig. 19)

Age: Eocene - Lutetian
1929: Brusselian *B1* (1909: Paniselian *P2*).
Lithostratigraphic unit: Sands of Aalter.
Locality: Aalter (Sheet 39w), West-Flanders.
New Municipal Building at Gerolflaan,
22/03/1993.

Description:
This sample was found at -1.45m (under the surface), at the base of *Megacardita* acme horizon (Fig. 17)

-*Megacardita planicosta lerichei*, single valves in all growth stages; many juveniles of some mm Bivalves (1) in connection are tumbled by bioturbation; others are disarticulated and disturbed by bioturbation as well. Fragments of thick shells.
-*Vepricardium porulosum* (2).
-*Volutilithes torulosus* (3).
-Fragmentary Naticid gastropod (4).
-Different Venerid shells.

Just above this horizon, at about -1,40m, 3 more sharp-edged fragments spread about 15cm from each other, in the same plane, fit together (Fig.21). Predation by a powerful unknown animal, capable of crushing such heavy shells is almost certain. On the sea floor level the pieces of the broken shell were left on the spot where the crushing occurred.
Although the strong bioturbation, no displacement by sea current, nor storm wave action are visible. This horizon provided very few, but very well preserved, selachian teeth .

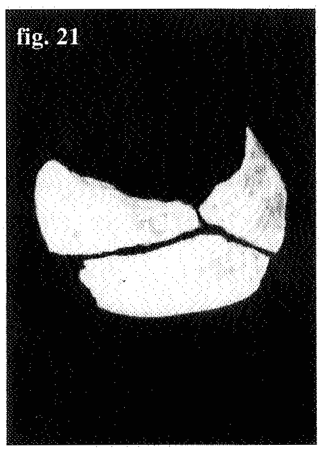


fig. 21

Fig. 22

Fig. 23

Preparation nr 100 (Figs. 22 and 23)

Age: Eocene - Middle Lutetian
1929: Ledian *Le* (1909: Ledian *Le*).
Lithostratigraphic unit: Sands of Lede.
Locality: Meldert near Aalst (Sheet 72w), East Flanders
Former Dejonge Sandpit (1982, Fig. 25), at about 0.50m below the calcareous sandstone bank (Fig.24)

Description Fig. 22:

Almost complete specimen of *Nautilus* (?) *lamarcki*, damaged at the right umbilical shoulder by the discovery act.
Phragmocone damaged by natural implosion of some empty camerae, during fossilization.
The sediment is very rich in Foraminifera, with some *Orbitolites complanatus*.
The presence of many Bryozoa species and the occurrence of otoliths of many fish species, suggest moderately deep water.
Some single valves of the oyster *Pycnodonte gryphina* are present.

Description Fig. 23:

This specimen of *Nautilus* (?) *lamarcki* was embedded in the sea floor on its unstable ventral side. This allows the presumption that post-mortem some of the camerae still contained enough gas to give some upward buoyancy to the conch during the covering with sediment.
A cluster of juvenile *Pycnodonte gryphina* colonized the posterior shell side and were buried alive as bivalves, while the *Nautilus* conch sank faster into the sea bottom, due to bioturbation.

fig. 24

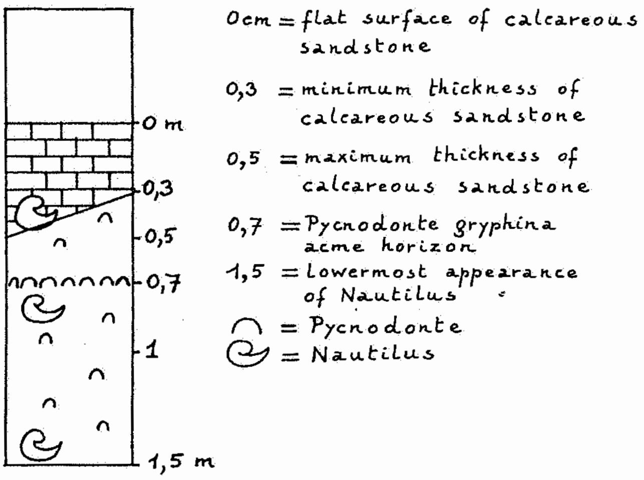


fig. 25

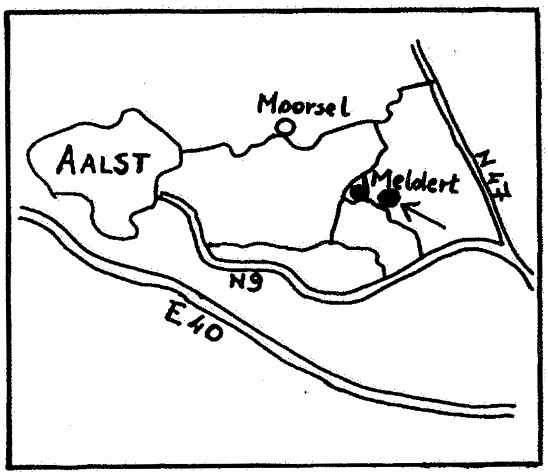


Fig. 26

Fig. 27

Preparations nr 92 and 93 (Figs.26 to 29)

Age: Eocene - Middle Lutetian
1929: Ledian *Le* (1909: Ledian *Le*).
Lithostratigraphic unit: Sands of Lede.
Locality: Meldert near Aalst (Sheet 72w), East Flanders. Former Dejonge Sandpit (1982, Fig. 25), at about 0.50m below the calcareous sandstone bank (Fig. 24).

Description: Preparation 92

Nautilus (?) *lamarcki*, dorsum of the conch damaged (discovering act); single valves of *Pycnodonte gryphina*; many Foraminifera, some *Orbitolites complanatus*; *Chlamys (Lyropecten) plebeia.*

This Nautilus conch was also embedded in the sea floor on its unstable ventral side. The entire shell was cracked, and the phragmocone damaged by implosion of empty camerae during compaction of the sediment. This specimen was surely attacked by a predator, near the sea floor. The shell fragment, nearby the conch, fits into the right body chamber wall. A fish (Fig. 28) that took shelter into the body chamber of Nautilus died inside. Its black remnants were disturbed by bioturbation.

Description: Preparation 93

Nautilus (?) *lamarcki*, margin of left body chamber wall damaged (discovery act); a bivalve *Pycnodonte gryphina*, with a drilling hole in its flat upper valve, due to a Naticid gastropod; some single valves and fragments of *Pycnodonte*; a spread bivalve of *Arcopagia rhomboides* (Fig. 29); many Foraminifera, and some *Orbitolites complanatus.*
The orange-coloured anterior border of the body chamber of *Nautilus* clearly shows a bite of two teeth. Again, this conch was embedded into the sea floor on its ventral side.
Compaction of the sediment deformed the conch by a dorsum/ventral impression, and widened the entire body chamber. The interior phragmacone was damaged by implosion of some empty camerae.
A dying fish (Fig. 29) took shelter into the body chamber of *Nautilus*. Its black remnants were disturbed by bioturbation in the body chamber (fish scales, vertebrates, 3 otoliths, jaw-bones; separately collected). The presence of dead fish in the body chamber, is a relatively frequent phenomenon in this horizon, as well as in the same horizon at Balegem (East Flanders). They all seem to be Serranidae (personal information by Dr. L. Taverne). See also Figs. 36, 37 and 38.

Fig. 30

Fig. 31

Fig. 32

Preparations nr 95 and 98 (Figs. 30 to 32)

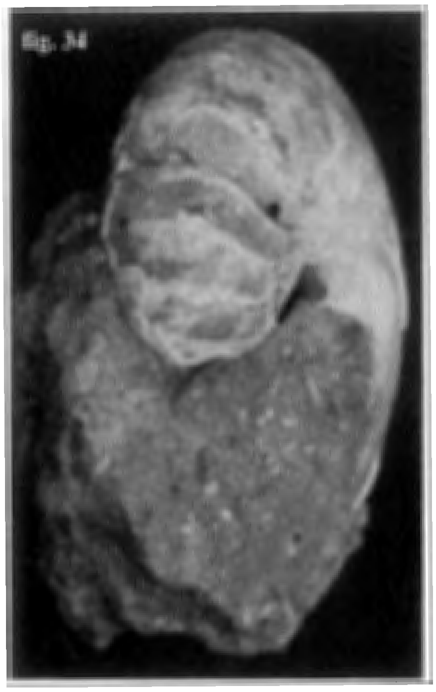
Age: Eocene - Middle Lutetian
1929: Ledian *Le* (1909: Ledian *Le*).
Lithostratigraphic unit: Sands of Lede.
Locality: Meldert near Aalst(Sheet 72w), East Flanders.
Former Dejonge Sandpit (1982, Fig. 25), at about 0.25m below the calcareous sandstone bank (Fig.24).

Description: Preparation 95:

Nautilus (?) *lamarcki*; *Pycnodonte gryphina*; many Foraminifera; some *Orbitolites complanatus*.
This Nautilus was damaged at the left umbilical shoulder (discovery act) and also at both ventrolateral shoulders of the body chambers (by a predator?). The phragmocone was almost completely damaged by implosion of some empty camerae and the conch once more embedded on its unstable ventral side. Black remnants of a fish were present in the body chamber (Fig. 31).

Description: Preparation 98:

Nautilus (?) *lamarcki* with its phragmocone damaged at the upper side (discovery act). Same type of embedding position as the above mentioned. This specimen was attacked by a predator which left two successive bite gaps on the right flank wall of the body chamber. The second one is 35mm in width, almost circular and with plenty of teeth marks on the edge. The emptied conch rested on an oyster bed of *Pycnodonte*, where it fossilized.



It is at least remarkable that Nautilus occurs abundantly at the same level as the scattered distribution of *Pycnodonte gryphina*, i.e. at about 1.5m below the flat surface of the calcareous sandstone bank. At the middle of this bank there is no longer any presence of these isolated oysters and no trace of Nautilus is found either. This could mean there is a strong relation between these two mollusc populations.
A giant adult Nautilus (F90.c Coll. M. Vervoenen, Fig. 33) was found in perfect condition at 1,5m (Fig. 24). The phragmocone is slightly damaged by implosion of empty camerae. At the place where the hood touched the phragmocone shell, rests of a lustrous orange film still occur. The occular sinus of the shell margin, which is straight on *Nautilus* (?) *lamarcki* is worn out exteriorly on both sides at the place where the hood corner touched the margin of the shell. The conch lay almost flat in the matrix sediment.

Systematic exploration of the site Meldert, gave an average population density of 1 Nautilus per cubic meter of sediment; which is unusually high.

It is possible that the Meldert site was a spawning place of these Nautilus, because of the abundant food supply of many Mollusca, Bryozoa, Foraminifera and fish.
One rhyncholite of the upper jaw was found in situ. After deposing their eggs, the expiring animals could easily be attacked, near the sea floor, by scavengers. Their empty settling conches represent surely only a small per cent of their population density. Most of the conches containing more gas in their camerae, floated away, like actual Nautilus do now.

Fig. 36

Fig. 37

Figs. 36 and 37: A fish of the family Priacanthidae (Percomorphii), burrowed in a Nautilus conch at Meldert.

Fig. 38: A Priacanthid fish in dead position with all bones in connection, found in a Nautilus conch in the sandpit Verlee at Balegem (East-Flanders) in the Sands of Lede. This unique specimen was discovered by M. René Lardinois and delicately disengaged from its sandy gangue by M. Georges Wouters.

Fig. 39

Preparation nr 66 (Fig. 39)

Age: Eocene - Middle Lutetian
1929: Ledian *Le* (1909: Ledian *Le*).
Lithostratigraphic unit: Sands of Lede.
Locality: Meldert near Aalst (Sheet 72w), East Flanders.
Former Dejonge Sandpit (1982, Fig. 25), at about 0.70m below the calcareous sandstone bank (Fig.24).

Description:

A partly petrified small horizon, with mostly bivalves in connection of *Pycnodonte gryphina*.
Many Foraminifera species; a single *Orbitolites complanatus* (Fig. 41).

The calcitic shell structure of *Pycnodonte* (Fig. 40) is well preserved. Strangely, many bivalves are in live position, others are in disorder, even upside down. This suggests a temporarily bloom of these oysters, in a rather thin layer, and a sudden complete sedimentation could have suffocated them alive. Later on, bioturbation mixed these shells. The complete deposit with *Nautilus* and *Pycnodonte* was a thanatocoenosis without any disturbance, neither by storm wave action, nor by noticeable sea current. Yet, there was heavy bioturbation of the sediment.
Fig. 42 : a common micro-sand Echinid (*Lenita patellaris*) and Fig. 43: the typical Brachiopod (*Terebratula kickxi*).

fig: 40

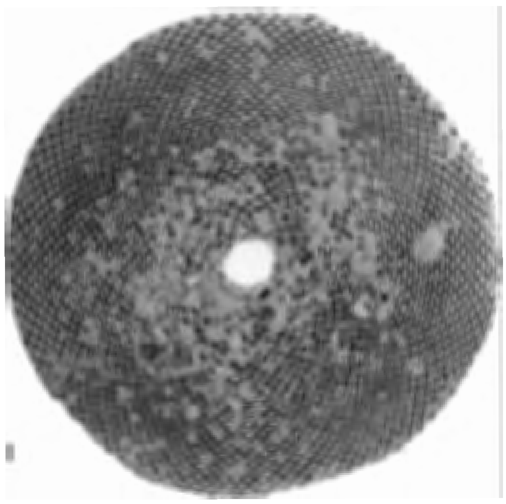


fig. 4

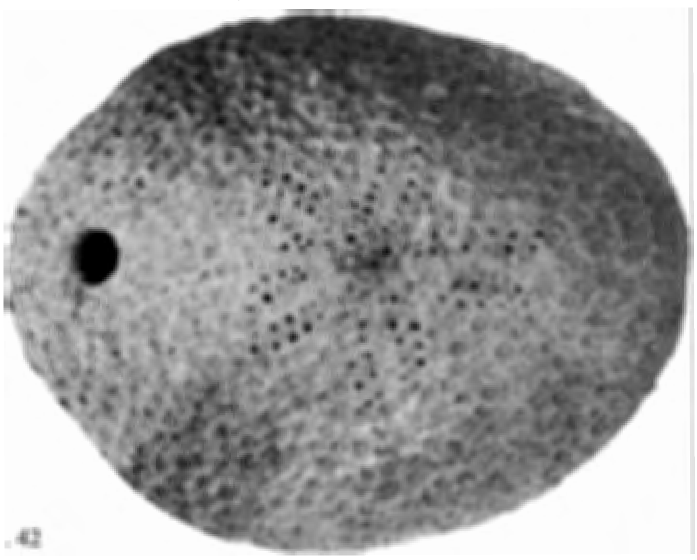
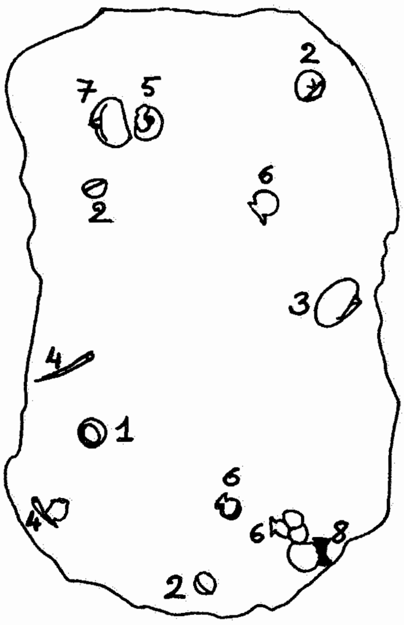


fig 42

fig. 43

Fig. 44



Preparation nr 79 (Fig. 44)

Age: Oligocene - Rupelian
1929: Rupelian *R2b* (1909: Rupelian *R1d-R2c*).
Lithostratigraphic unit: Sands of Kerniel.
Locality: Gellik, near Lanaken, (Sheet 93e), Limburg (Fig. 46)
Construction pit for widening of the Albert Canal, northside, 1991 (Figs. 45, 46).

Description:

-Some horizontal and vertical (1) tubelike ichnofossils, possibly from Pogonophorid-like animals.
-*Glycymeris obovata obovata*, some as a bivalve (2).
-*Macrocallista splendida* (3).
-*Dentalium* (4).
-*Sigatica hantoniensis* (5).
-*Chlamys hoeninghausi* (6).
-*Arctica rotundata* juvenile (7).
-A fish vertebra (8).

Bottom part of the small shell-grit lenticular concentration (Fig. 45), which from a distance looks like one continuing horizontal band.
Some lenticular formations consist of almost pure angular quartz grains, up to 5mm in size; mixed with mostly broken shells; suggesting a very strongly derived fauna, attributed to huge storm waves.
The fact that no single Elasmobranch tooth smaller than 0.8mm was found (on more than 20 tonnes of sediment), could be explained by this phenomenon.
The complete section of the Sands of Kerniel, clayey quartz sand of about 3m thick, is very strongly bioturbated by burrows of worms (Fig. 57, p. 37).

fig. 45

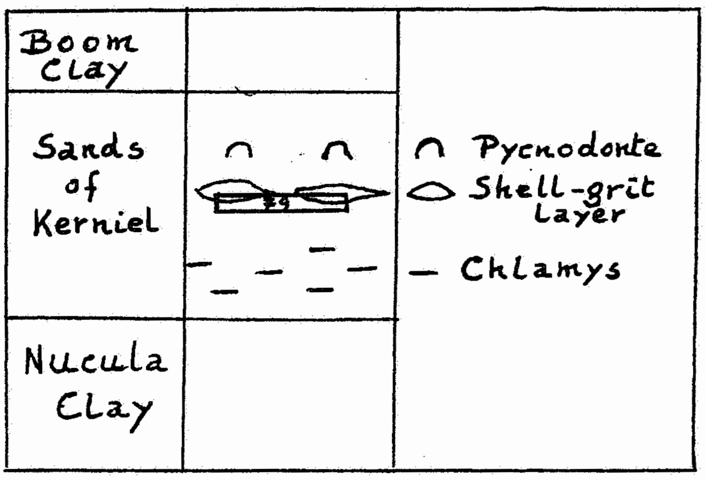


fig. 46

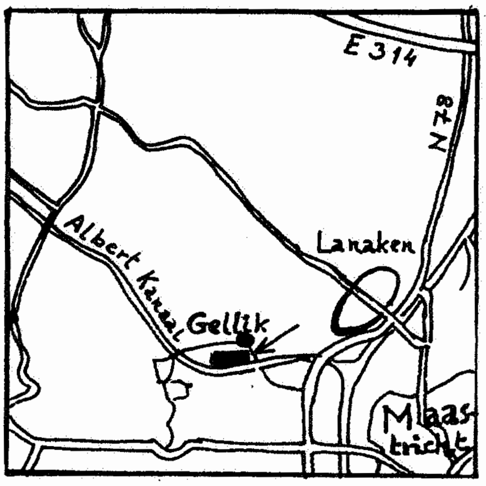
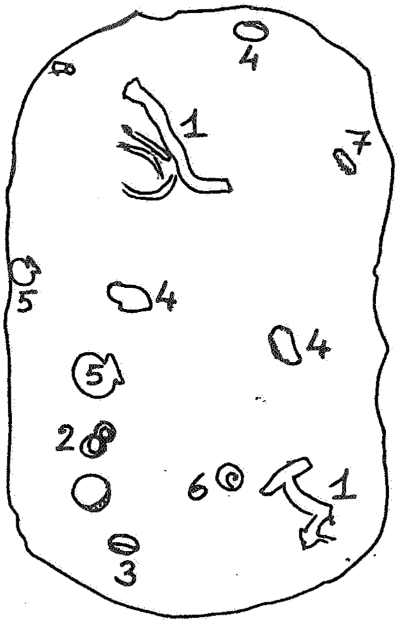


Fig. 47



Preparation nr 80 (Fig. 47)

Age: Oligocene - Rupelian
1929: Rupelian *R2b* (1909: Rupelian *R1d-R2c*).
Lithostratigraphic unit: Sands of Kerniel.
Locality: Gellik, near Lanaken, (Sheet 93e), Limburg (Fig. 46)
Construction pit for widening of the Albert Canal, northside, 1991.

Description:

-More burrows of horizontal (1, and Fig. 50) and vertical (2) ichnofossils of Pogonophorid, than in preparation nr 79.
-Many fragmentary shells.
-Many single valves of *Glycymeris obovata obovata* and a few bivalves (3).
-*Macrocallista splendida* (4).
-*Chlamys hoeninghausi* (5).
-*Tugurium* fragment (6).
-*Myliobatis* tooth (7, and Fig. 49).
Upper part of a small shell-grit lenticular concentration (Fig. 48). Somewhat more clayey quartz sand than in the underlying part (Preparation nr 79).
Notorhynchus primigenius is one of the common pelagic sharks found in this horizon (Fig. 51).

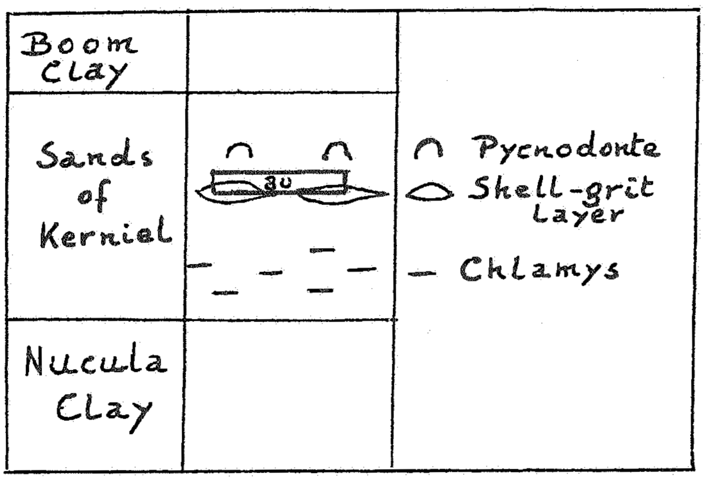


fig. 48

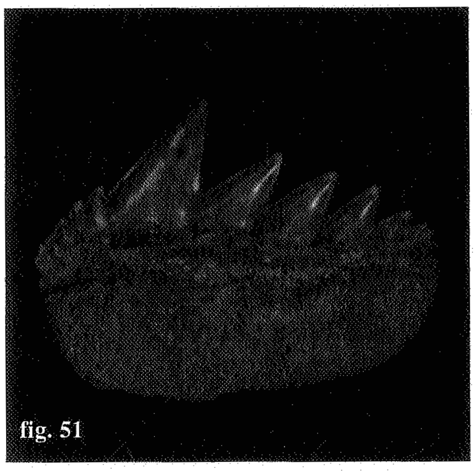
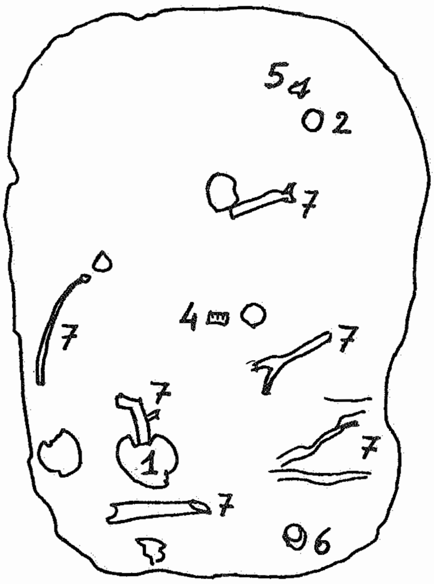


fig. 51


fig. 49


fig. 50

Fig. 52



Preparation nr 77 (Fig. 52)

Age: Oligocene - Rupelian
1929: Rupelian *R2b* (1909: Rupelian *R1d-R2c*).
Lithostratigraphic unit: Sands of Kerniel.
Locality: Gellik, near Lanaken, (Sheet 93e),Limburg (Fig. 46)
Construction pit for widening of the Albert Canal, northside, 1991.

Description:

-Some broken medium-sized *Arctica rotundata* (1).
-Some *Glycymeris obovata obovata* single valves (2).
-A single valve of *Astarte henckeliusiana* (3).
-One tooth fragment of *Myliobatis* sp.(4).
-One shark tooth of *Lamna rupeliensis* (5).
-A green-coated silex (6).

Preparation nr 77 lies at about 10cm above the shell-grit lens (Fig. 54) and shows strong bioturbation by worm burrows. These are long and tubelike, horizontal but also slanting upwards, ending almost vertically.
Slightly clayey walls, filled up with quartz sand are visible. These possible Pogonophorid traces were surely made long after the sedimentation of the sea bottom.

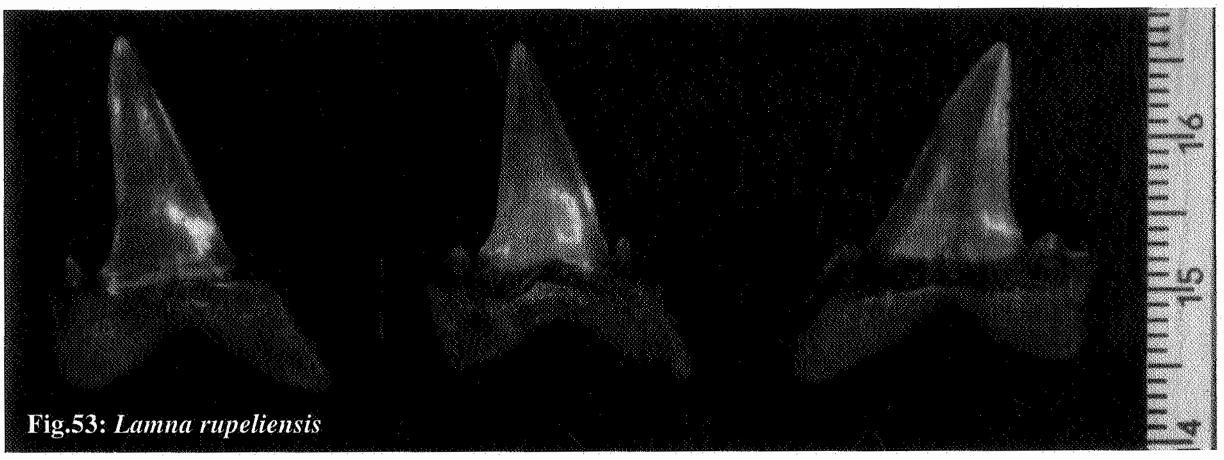


Fig.53: *Lamna rupeliensis*

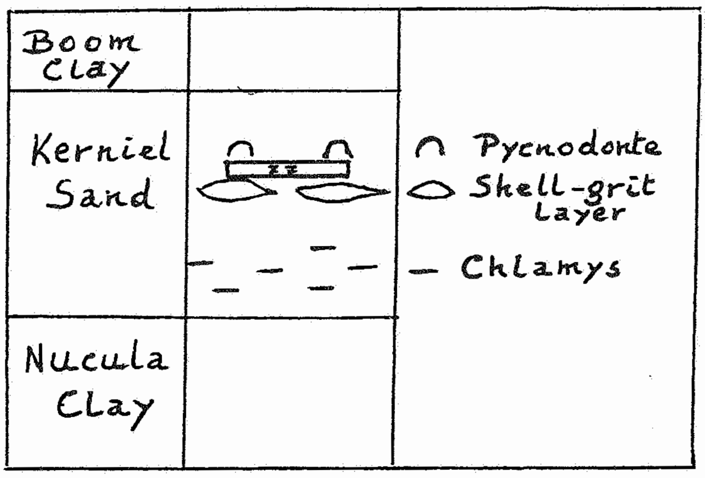
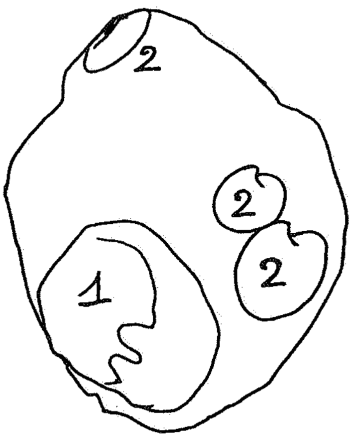


fig. 54

Fig. 55



Preparation nr 76 (Fig. 55)

Age: Oligocene - Rupelian
1929: Rupelian *R2b* (1909: Rupelian *R1d-R2c*).
Lithostratigraphic unit: Sands of Kerniel.
Locality: Gellik, near Lanaken, (Sheet 93e), Limburg (Fig.46)
Construction pit for widening of the Albert Canal, northside, 1991.

Description:

-A tumbled *Pycnodonte queteleti* valve (1).
-Three valves of *Arctica rotundata* (2).
-Remarkably very strong bioturbation by worm burrows, possibly Pogonophorids (Fig. 57).

This preparation was found at about 20cm above the shell-grit horizon (Fig. 56).
The oyster shell shows two round marks of bites from a predator (possibly a marine mammal, as e.g. a *Halitherium*) that did not succeed to eat it, for the oyster restored its shell wall, and lived at least for 5 years furtheron.

Fig. 58: Femur of Halitherium sp., plant and shell eating sea mammal, which lived in the proximity of coasts and in estuaries.

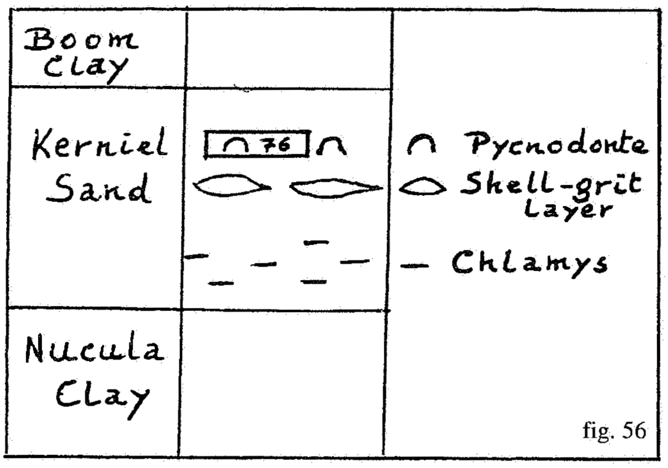


fig. 56

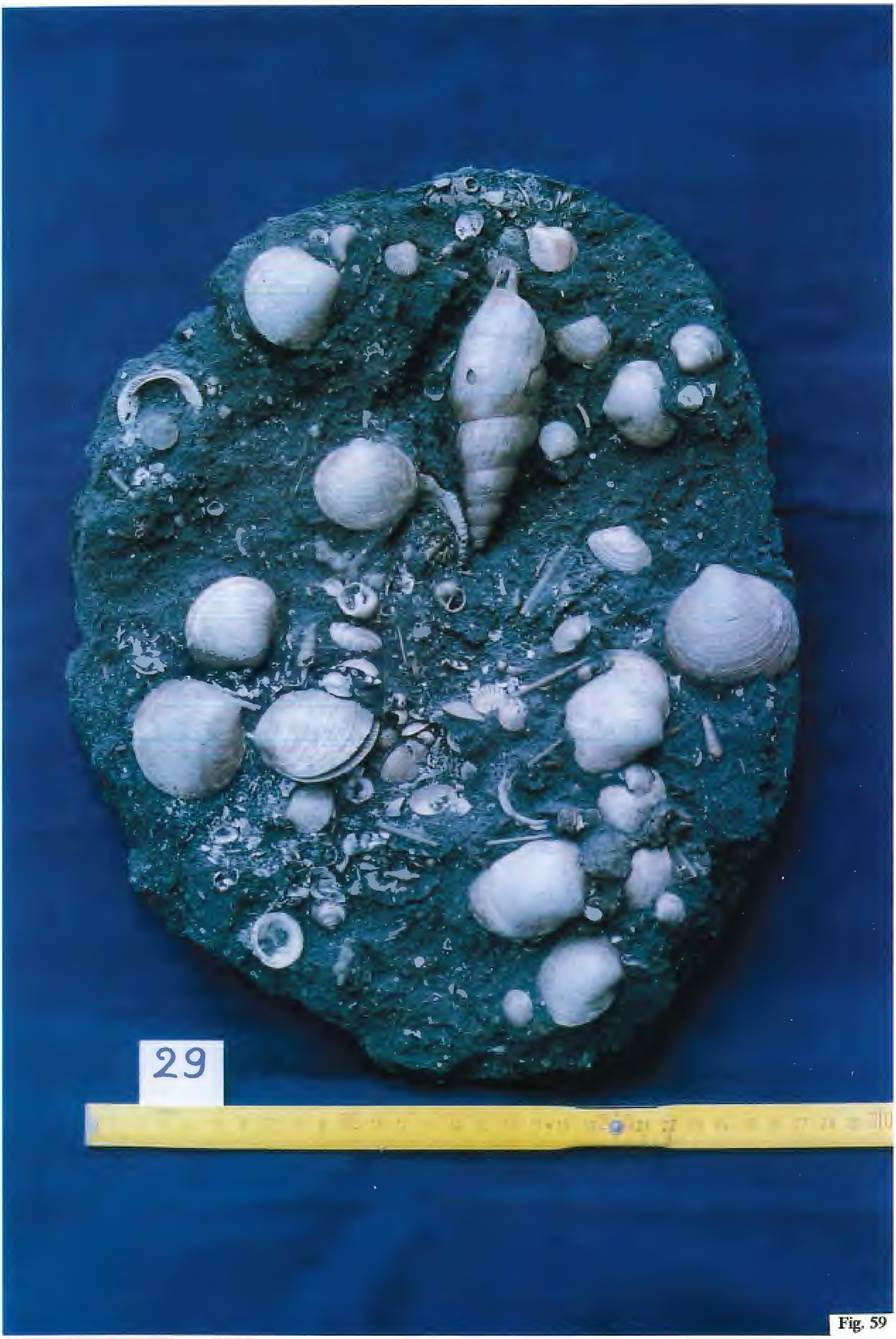
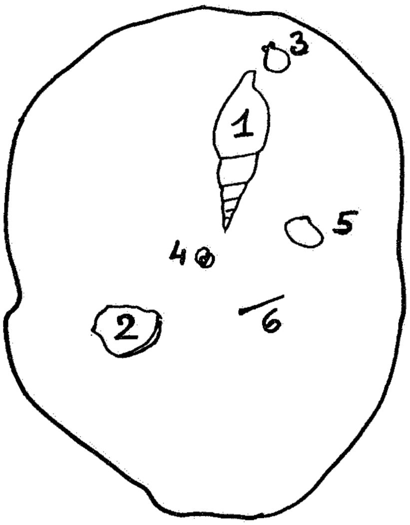


Fig. 59



Preparation nr 29 (Fig. 59).

Age: Miocene - Hemmoorian (formerly Anversian)
1929: Anversian *An* (1909: Bolderian *Bd d*).
Lithostratigraphic unit: Sands of Antwerp.
Locality: Borgerhout, near Antwerp (Sheet 28w), new access road to Motorway Ring, 1987 (Fig. 60).

Description:

This preparation shows the undermost base of a thick *Glycymeris* acme horizon (Figs. 61 & 68), split into two shell layers.

-*Scaphella bolli* (1, Fig. 62), 110mm high, damaged by predation.
-*Glycymeris obovata baldii*, single valves and one bivalve (2) in live position, though slightly inclined due to bioturbation.
-*Korobkovia woodi* (3).
-Naticidae sp. (4).
-*Angulus posterus* (5).
-Sea urchin radioles (6).

The ligament of *Glycymeris* bivalves is not very resistant, so both valves can spread easily into the surface of the sea bed, due to bioturbation by molluscs, crustaceans, worms or fishes.
This thanatocoenosis seems to be an in situ deposit. Most *Glycymeris* valves show a rusty colour pattern, particularly on the outward, younger shell border, due to a slightly pyritisized sediment. On actual living *Glycymeris* species, these shell borders usually have a thick, hairy and resistant periostracum. This should be the reason for the slight pyritization on the fossil *Glycymeris* shell borders.

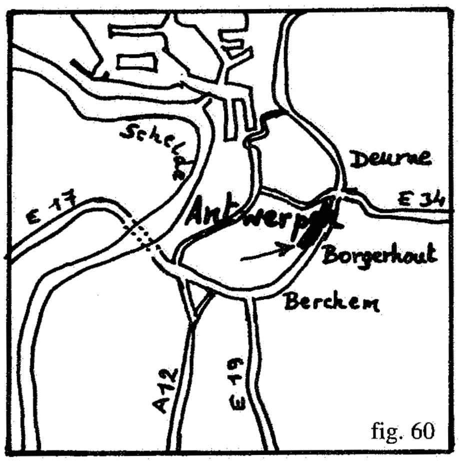
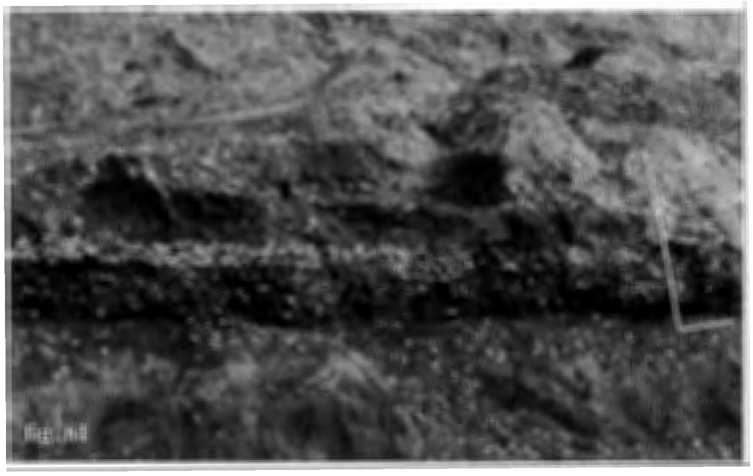


fig. 60



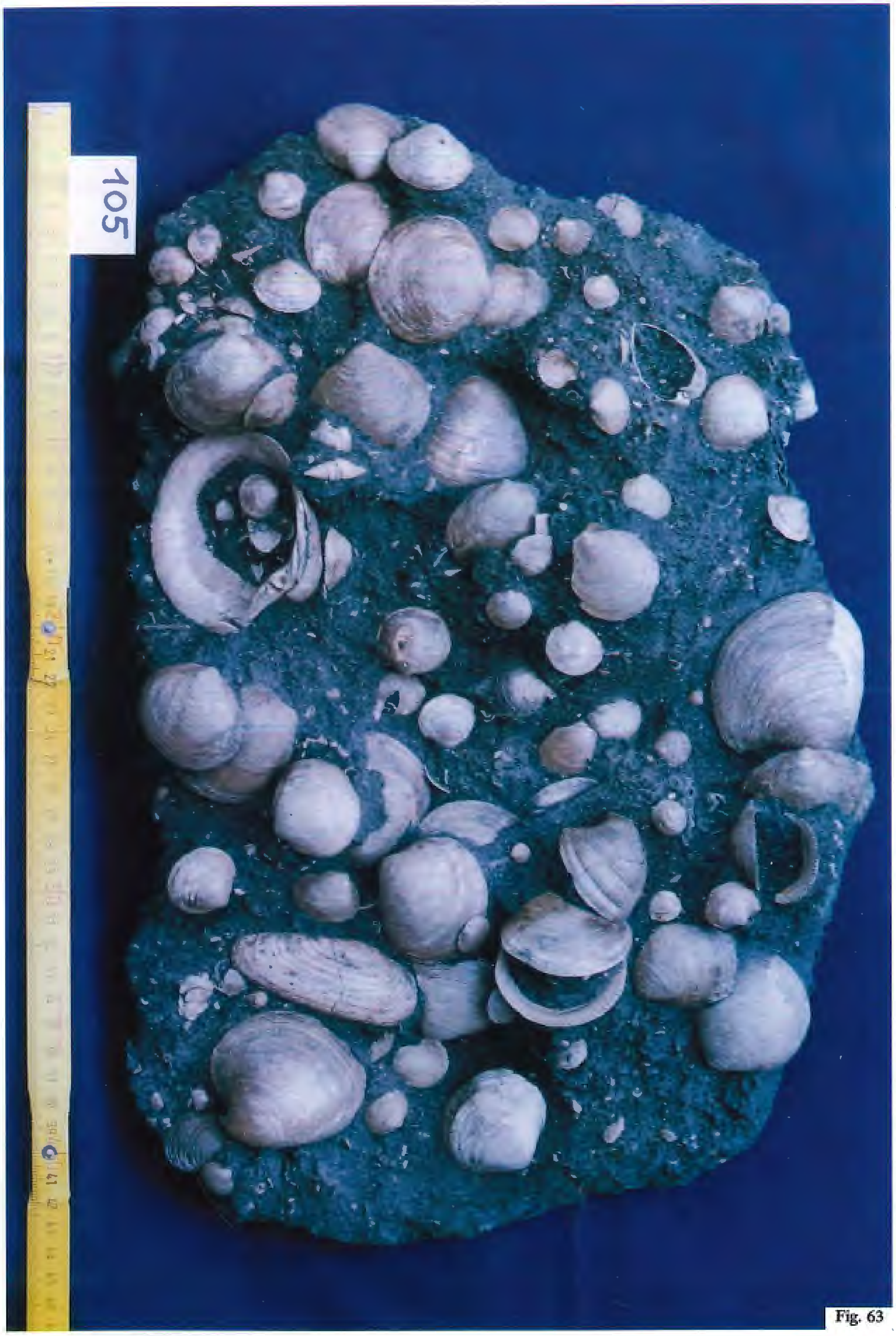
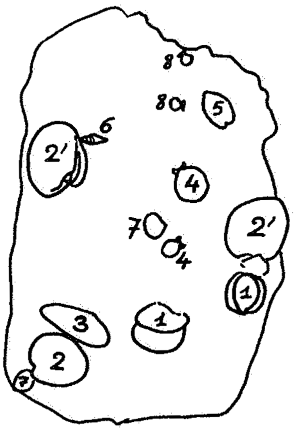


Fig. 63



Preparation nr 105 (Fig. 63).

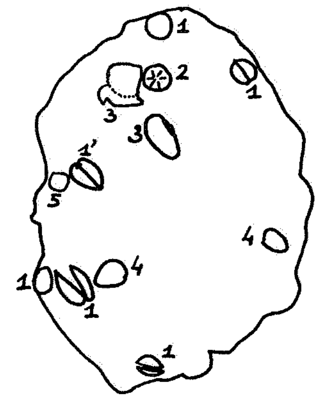
Age: Miocene - Hemmoorian (formerly Anversian)
1929: Anversian *An* (1909: Bolderian *Bd d*).
Lithostratigraphic unit: Sands of Antwerp.
Locality: Borgerhout, near Antwerp (Sheet 28w), new access road to Motorway Ring, 1987 (Fig. 60).

Description:

This preparation also shows the undermost base of a thick *Glycymeris* acme horizon, split into two layers with irregular interspace (Figs. 61 & 68).

-Mostly single valves of *Glycymeris obovata baldii*, some are bivalve (1).
-*Arctica islandica*: a small right valve (2); and two medium valves, spread on both sides of this preparation (2'), which can be attributed to the same bivalve.
-A single valve of *Cyrtodaria angusta*, 75mm long (3).
-*Korobkovia woodi* (4).
-A bivalve of *Panopea meynardi* (5) in live position, damaged by cutting off the overlying preparation nr 102.
-*Bathytoma cataphracta* (6).
-*Venus (Ventricoloidea) multilamella* (7, Fig. 64).
-*Pseudamussium lilli* (8), by comparison the two valves belong to the same animal.
-Some fragmentary shells.
The two bivalves of *Glycymeris* (1) are disturbed by bioturbation, so are the separated valves of *Arctica* (2') and *Pseudamussium* (8). This thanatocoenosis is an in situ deposit; undisturbed or displaced by any sea current or wave action.
All valves of *Glycymeris, Arctica* and *Cyrtodaria*, which are burrowers just under the sea bottom surface, look very fresh. No trace of any predation by bigger animals was found. And yet, all these molluscs, except for *Panopea*, seem to have died in situ, above the sea bed surface. Was it a disease or an algae bloom that provoked an annual mass extinction?

Fig. 65

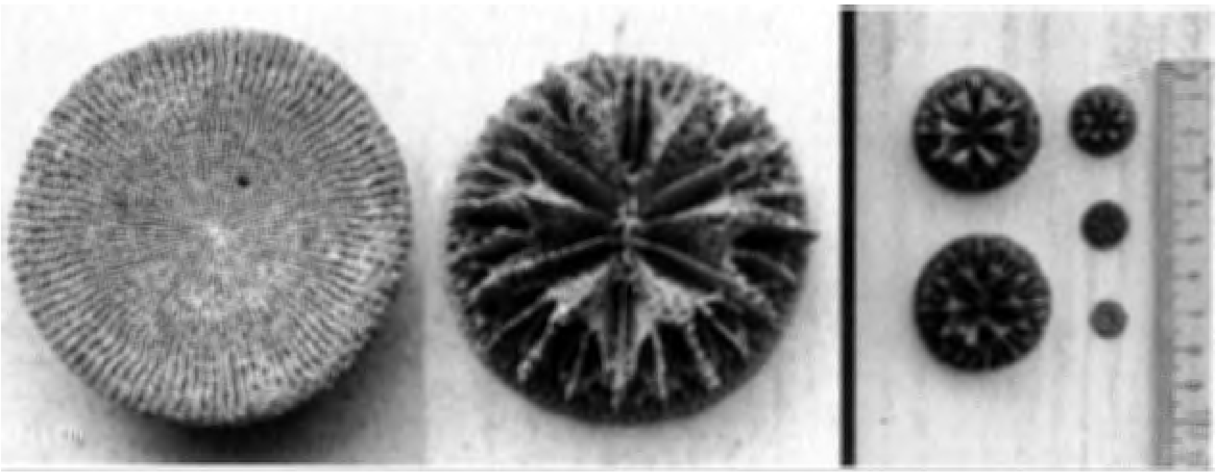


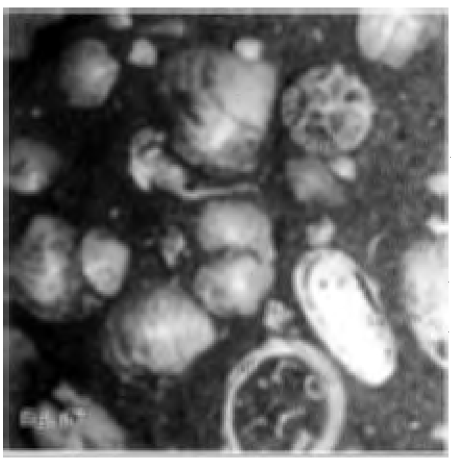
Preparation nr 102 (Fig. 65).

Age: Miocene - Hemmoorian (formerly Anversian)
1929: Anversian *An* (1909: Bolderian *Bd d*).
Lithostratigraphic unit: Sands of Antwerp.
Locality: Borgerhout, near Antwerp (Sheet 28w), new access road to Motorway Ring, 1987 (Fig. 60).

Description:

Nearly undermost part of the thick *Glycymeris* acme horizon (Figs. 61 & 68).
-Mostly single valves of *Glycymeris obovata baldii*, but also bivalves (1).
-A solitary coral *Stephanophyllia nysti* ((2, and Figs. 66 & 67) in live position.
-Two valves of *Panopea meynardi*, form a bivalve (3 & Fig. 67).
-*Venus (Ventricoloidea) multilamella* (4), and a fragment of a burrowing irregular sea urchin (5).
Most of *Glycymeris* tests show a rusty colour pattern, particularly on the outward younger shell border, due to a slight form of pyritization. This could be due to their thick hairy periostracum. Of the bivalves of *Glycymeris* only one is still in undisturbed live position (1'), the others are tumbled by bioturbation.
This thanatocoenosis shows a fauna which seems undisplaced by any sea current nor wave action.





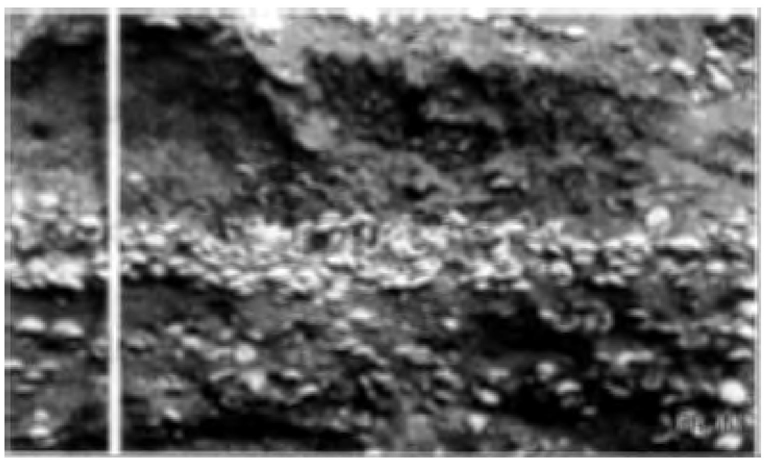


Fig. 69

Preparation nr 7 (Fig. 69).

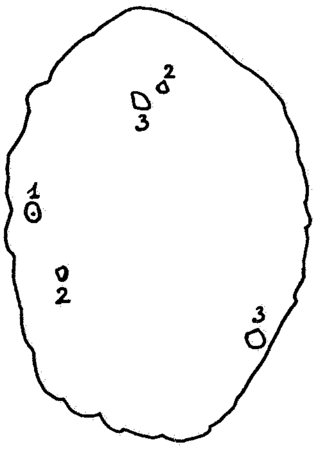
Age: Miocene - Hemmoorian (formerly Anversian)
1929: Anversian *An* (1909: Bolderian *Bd d*).
Lithostratigraphic unit: Sands of Antwerp.
Locality: Borgerhout, near Antwerp (Sheet 28w), new access road to Motorway Ring, 1987 (Fig. 60).

Description:

Nearly undermost part of the thick *Glycymeris* acme horizon (Figs. 70, 61 & 68).

-Mostly bivalves and some single valves of *Glycymeris obovata baldii*, medium size.
-Some radioles of sea urchin.
-*Calyptraea chinensis* (1).
-Some single valves and two bivalves of *Astarte radiata* (2).
-*Venus (Ventricoloidea) multilamella* (3).

Although most bivalves of *Glycymeris* are no more in live position, due to bioturbation, this thanatocoenosis seems to be an undisplaced in situ deposit. The *Glycymeris* outward shell borders show a rusty colour pattern, due to a slight form of pyritization, demonstrating presence of a thick hairy periostracum.



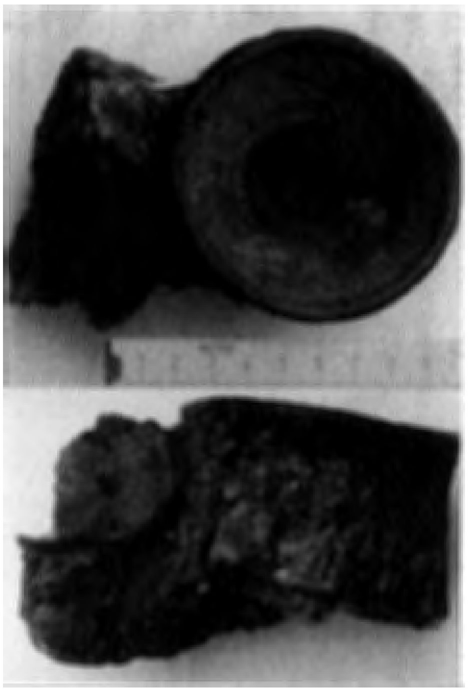


Fig. 71: Vertebra of Isuroidei (1m higher than this level). Fig. 72: *Carcharocles megalodon* tooth (Miocene, Wintham).

fig. 70

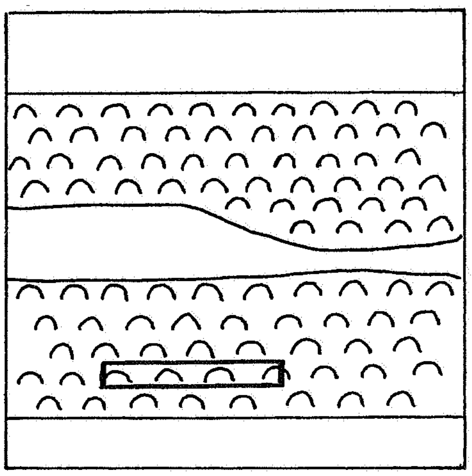
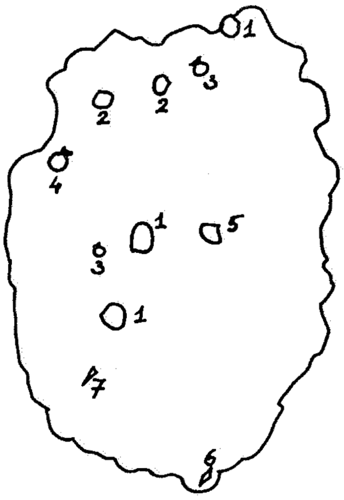


Fig. 73



Preparation nr 69 (Fig. 73).

Age: Miocene - Hemmoorian (formerly Anversian)
1929: Anversian *An* (1909: Bolderian *Bd d*).
Lithostratigraphic unit: Sands of Antwerp.
Locality: Borgerhout, near Antwerp (Sheet 28w), new access road to Motorway Ring, 1987 (Fig. 60).

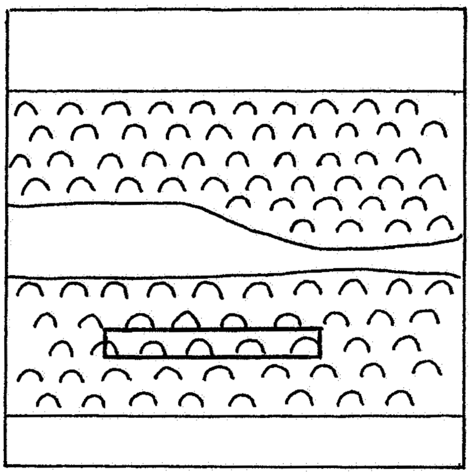
Description:

This preparation comes out of the midst of the undermost layer of *Glycymeris* acme horizon (Fig.74).

-Medium-sized and juvenile *Glycymeris obovata baldii.*
-Some *Venus (Ventricoloidea) multilamella* (1).
-Two valves of *Laevicardium subturgidum* (2).
-*Korobkovia woodi* left valve (3).
-*Korobkovia woodi* right valve (4).
-*Leionucula haesendoncki* (5, and Fig. 75).
-*Bathytoma cataphracta* (6).
-*Archimediella subangulata* (7).

Most of the *Glycymeris* tests look very fresh and their outward shell borders show a rusty colour, due to a slight form of pyritization, which indicates the place of the thick hairy periostracum. Although all these *Glycymeris* are disarticulated, this thanatocoenosis does not look like a displaced fauna. If there had been any sea current, the paper-thin *Korobkovia* would easily have flittered away with the stream.

fig. 74



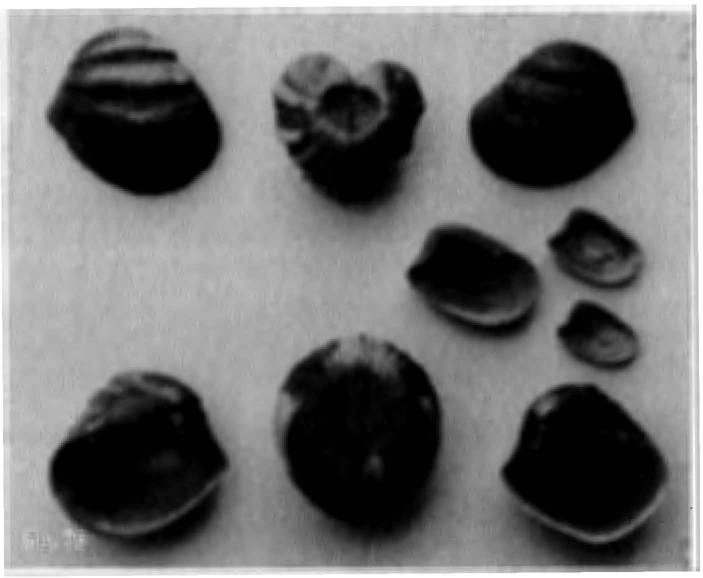
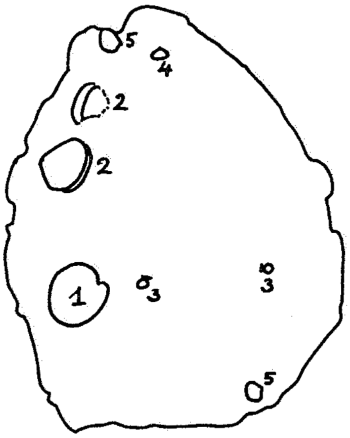


Fig. 76



Preparation nr 13 (Fig. 76).

Age: Miocene - Hemmoorian (formerly Anversian)
1929: Anversian *An* (1909: Bolderian *Bd d*).
Lithostratigraphic unit: Sands of Antwerp.
Locality: Borgerhout, near Antwerp (Sheet 28w), new access road to Motorway Ring, 1987 (Fig. 60).

Description:

From the midst of the undermost layer of the *Glycymeris* acme horizon (Fig. 77).

-*Arctica islandica* (1, Fig. 78).
-Mostly single valves, juveniles to medium-sized, of *Glycymeris obovata baldii*; two bivalves (2).
-*Pseudamussium lilli* (3).
-*Laevicardium dingdense*, syn. *L. antwerpiense*, (4).
-*Venus (Ventricoloidea) multilamella* (5).

Most valves of *Glycymeris* look very fresh. Many of them show a rusty colour pattern, on the outward younger shell border, due to a slight form of pyritization. This demonstrates the place of their thick hairy periostracum. Although this thanatocoenosis seems an in situ deposit, all of these *Glycymeris*, which were shallow burrowers, seem to have died above the sea bed surface, except for two bivalves. It may have been caused by a disease or by an annual-connected mass extinction.

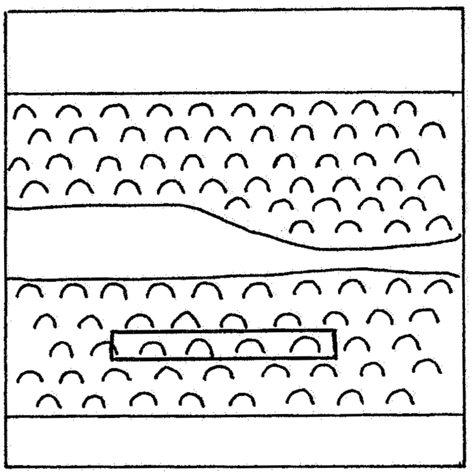
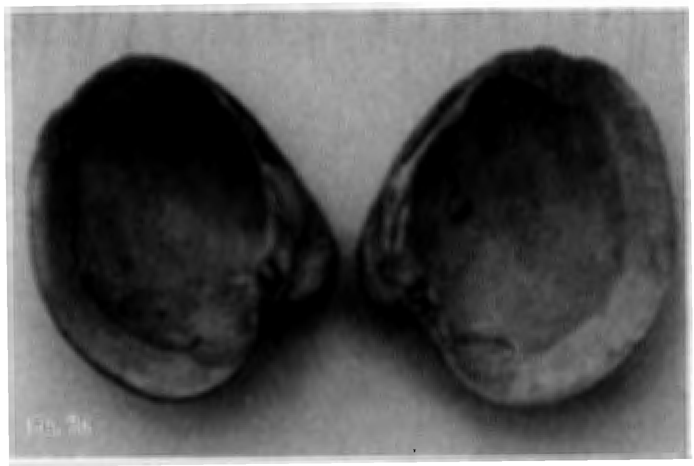


fig. 77



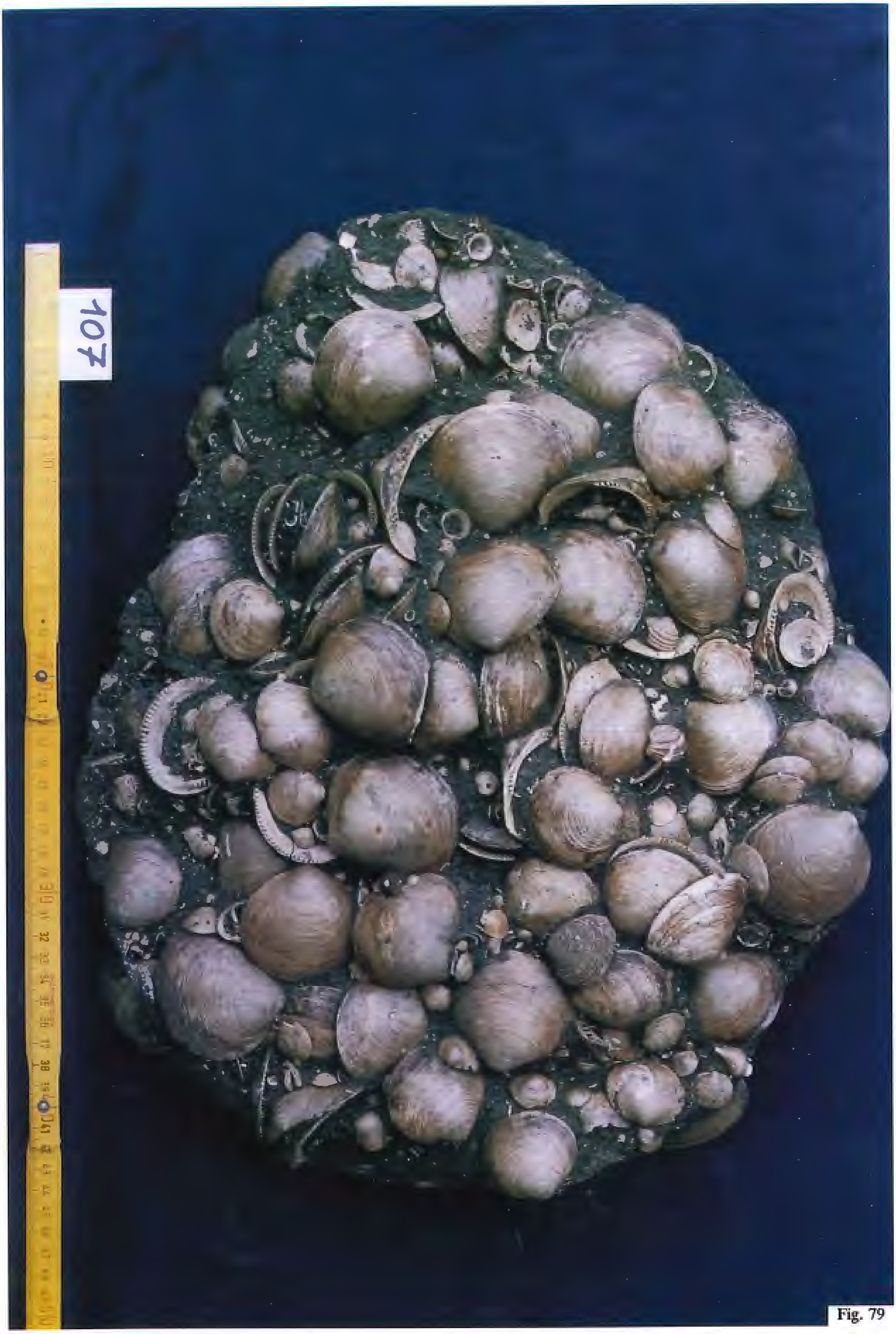
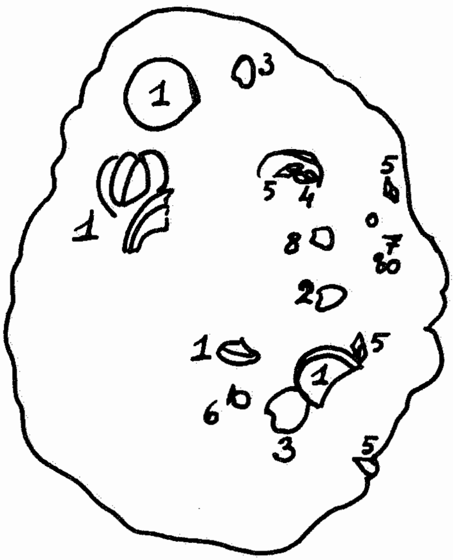


Fig. 79



Preparation nr 107 (Fig. 79).

Age: Miocene - Hemmoorian (formerly Anversian)
1929: Anversian *An* (1909: Bolderian *Bd d*).
Lithostratigraphic unit: Sands of Antwerp.
Locality: Borgerhout, near Antwerp (Sheet 28w), new access road to Motorway Ring, 1987 (Fig. 60).

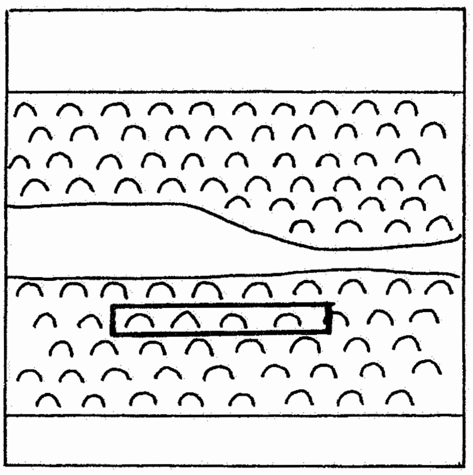
Description:

Near the top of the undermost layer of the *Glycymeris* acme horizon, which is split into two layers with irregular interspace (Fig. 80).

-Mostly single valves and many juveniles of *Glycymeris obovata baldii*, and some bivalves (1).
-*Leionucula haesendoncki* (2).
-*Venus (Ventricoloidea) multilamella* (3).
-*Ficus conditus* juvenile (4); adult (Fig. 81).
-*Acamptogenotia escheri* and fragment (5).
-Juvenile valve of *Korobkovia woodi* (6).
-Small Naticidae (7).
-Unknown bivalve (8).

More shell fragments of juvenile *Glycymeris* demonstrate predation. Most of the *Glycymeris* look fresh. This fauna seems further an in situ deposit.

fig. 80



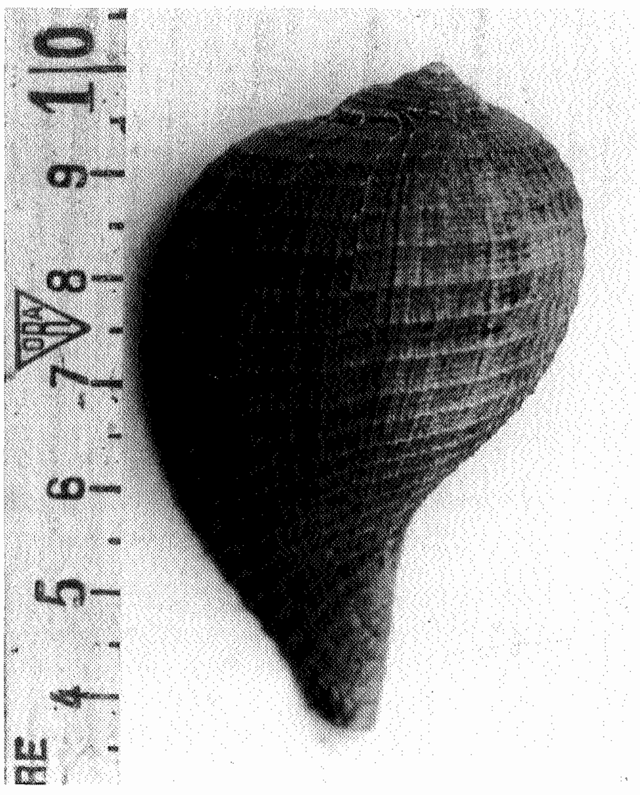
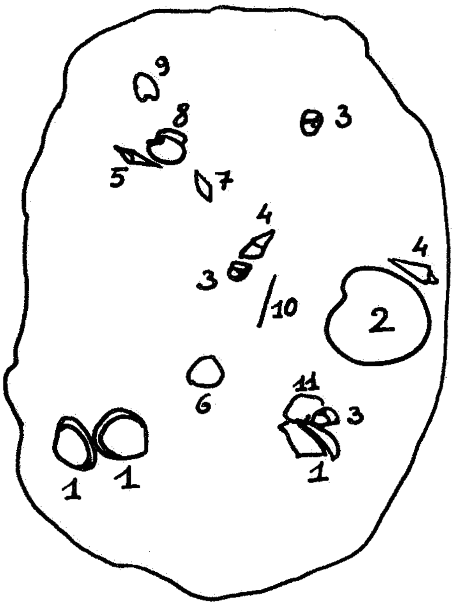


Fig. 82



Preparation nr 104 (Fig. 82).

Age: Miocene - Hemmoorian (formerly Anversian)
1929: Anversian *An* (1909: Bolderian *Bd d*).
Lithostratigraphic unit: Sands of Antwerp.
Locality: Borgerhout, near Antwerp (Sheet 28w), new access road to Motorway Ring, 1987 (Fig. 60).

Description:

Near the top of the undermost layer of the *Glycymeris* acme horizon (Fig. 83).

-Mostly single valves and juveniles of *Glycymeris obovata baldii* and three bivalves (1), disturbed by bioturbation.
-*Arctica islandica* (2).
-Naticidae (3).
-*Acamptogenotia escheri* (4). Fig. 84: other specimens; the 3rd to the right: forma *straeleni*.
-*Orthosurcula steinvorthi* (5).
-*Laevicardium dingdense*, syn. *L. antwerpiense* (6).
-*Angulus posterus* (7).
-*Venus (Ventricoloidea) multilamella* bivalve (8).
-*Leionucula haesendoncki* (9).
-Radiole of regular sea urchin (10).
-A fragment of irregular sea urchin (11).

This preparation shows again an in situ fauna deposit. Most of the *Glycymeris* valves look fresh and show a darker colour pattern, which demonstrates the place of a hairy periostracum.

fig. 83

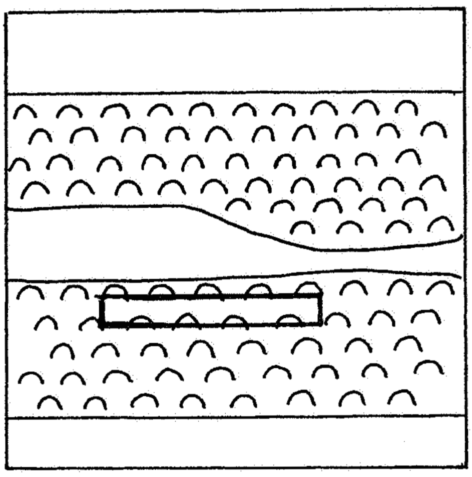
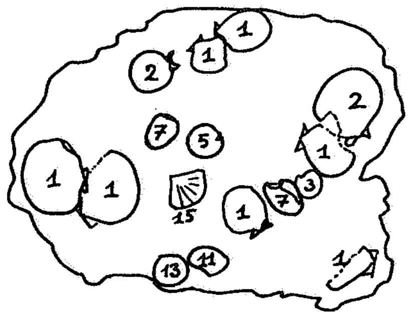
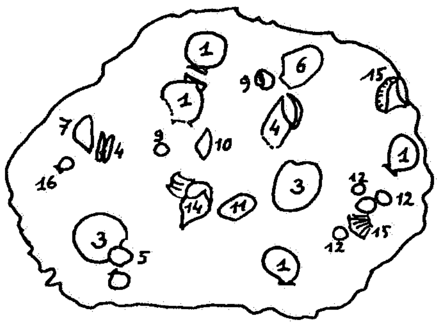


Fig. 85





Preparations nr 39 (Fig. 85 top) **and nr 26** (Fig. 85 below)

Age: Miocene - Hemmoorian (formerly Anversian)
1929: Anversian *An* (1909: Bolderian *Bd d*).
Lithostratigraphic unit: Sands of Antwerp, interspace between the two layers of the *Glycymeris* acme horizon (Fig. 86).
Locality: Borgerhout, near Antwerp (Sheet 28w), new access road to Motorway Ring, 1987 (Fig. 60).

Description:

Poorly conservated fauna, in a dark glauconitic clayey sand; shells cracked by compaction of sediment.
-*Korobkovia woodi* left valves (1).
-*Korobkovia woodi* right valves (2).
-*Venus (Ventricoloidea) multilamella* (3).
-*Panopea meynardi* in live position (4).
-*Laevicardium subturgidum* (5).
-*Thracia bivalve* damaged (6).
-*Leionucula haesendoncki* (7).
-Naticidae (8).
-*Corbula gibba*, even bivalves (9).
-*Abra antwerpiensis* (10).
-*Angulus posterus* (11).
-*Limopsis aurita*, even bivalves (12).
-Juvenile *Glycymeris obovata baldii* (13).
-*Sassia tarbelliana* with Balanidae (14).
-*Flabellum tuberculatum*, coral (15, Figs. 87 & 88).
-*Pseudamussium lilli* (16).

Although disturbed by bioturbation, this thanatocoenosis seems to be an in situ deposit. There is much fine shell grit and shell fragments, due to predation.

fig. 86

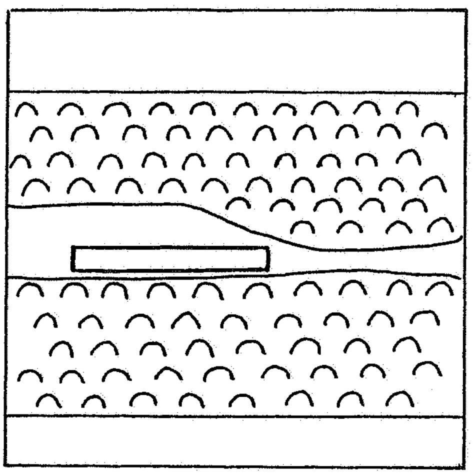
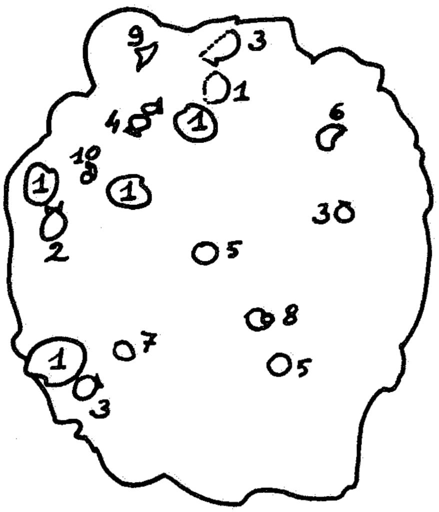


Fig. 89



Preparation nr 73 (Fig. 89).

Age: Miocene - Hemmoorian (formerly Anversian)
1929: Anversian *An* (1909: Bolderian *Bd d*).
Lithostratigraphi unit: Sands of Antwerp.
Locality: Borgerhout, near Antwerp (Sheet 28w), new access road to Motorway Ring, 1987 (Fig. 60).

Description:

Underpart of the second layer of the *Glycymeris* acme horizon (Fig. 90), which lies irregularly above the interspace (Fig. 68 top right).

-From juveniles to full-grown single valves of worn *Glycymeris obovata baldii.*
-*Venus (Ventricoloidea) multilamella* (1).
-*Korobkovia woodi* right valves (2, Fig. 91 right).
-*Korobkovia woodi* left valves(3, Fig. 91 left).
-*Pseudamussium lilli* (4).
-*Laevicardium subturgidum* (5).
-*Leionucula haesendoncki* (6).
-*Limopsis aurita* (7).
-Naticidae (8).
-*Aporrhais alata* (9).
-Solitary coral *Caryophyllia granulatus* juvenile (10).

The huge valves of *Glycymeris*, and even the juvenile ones, have a worn look, as if they had rested for a long time on the surface of the sea bed, before being covered by sediment. The presence of the paper-thin *Korobkovia* suggest no transport of any importance by sea current nor wave action. Bioturbation disturbed the position of many shells, but it seems to be still an in situ deposit.

fig. 90

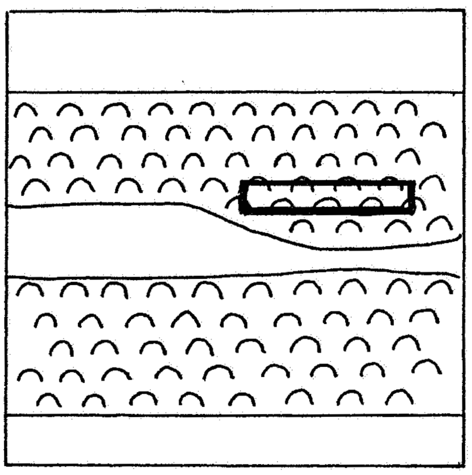
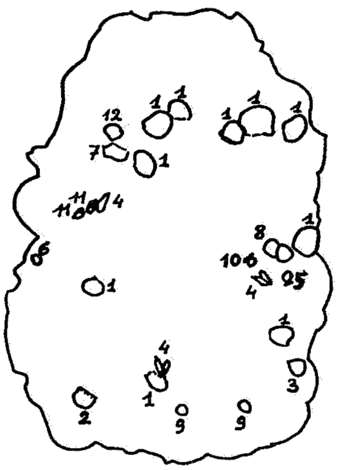


Fig. 92



Preparation nr 75 (Fig. 92).

Age: Miocene - Hemmoorian (formerly Anversian)
1929: Anversian *An* (1909: Bolderian *Bd d*).
Lithostratigraphic unit: Sands of Antwerp.
Locality: Borgerhout, near Antwerp (Sheet 28w), new access road to Motorway Ring, 1987 (Fig. 60).

Description: At 3/4 of the top of the uppermost layer of *Glycymeris* acme horizon (Fig. 93).

-Mostly worn single valves of juvenile to huge *Glycymeris obovata baldii.*
-*Venus (Ventricoloidea) multilamella* (1).
-*Anadara diluvii* (2).
-*Limopsis aurita* (3).
-*Aporrhais alata* (4).
-*Korobkovia woodi* left valve (5).
-*Leionucula haesendoncki* (6).
-*Thracia inflata* (7).
-*Laevicardium subturgidum* bivalve (8).
-*Corbula gibba* (9).
-*Pseudamussium lilli* (10).
-Juvenile solitary corals *Caryophyllia granulatus* (11).
-*Spisula subtruncata* (12).

Many small shell fragments and shell grit suggest predation. Bioturbation disturbed the position of the dead shell accumulation, in the uppermost part of the fossil sea bed surface. Otherwise, it seems to be a quite in situ deposit, just formed by accumulation of dead molluscs.

fig. 93

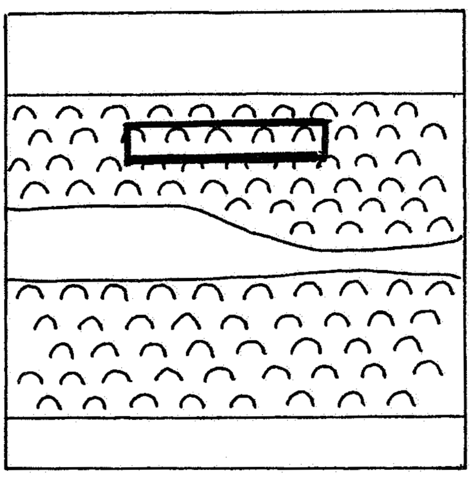
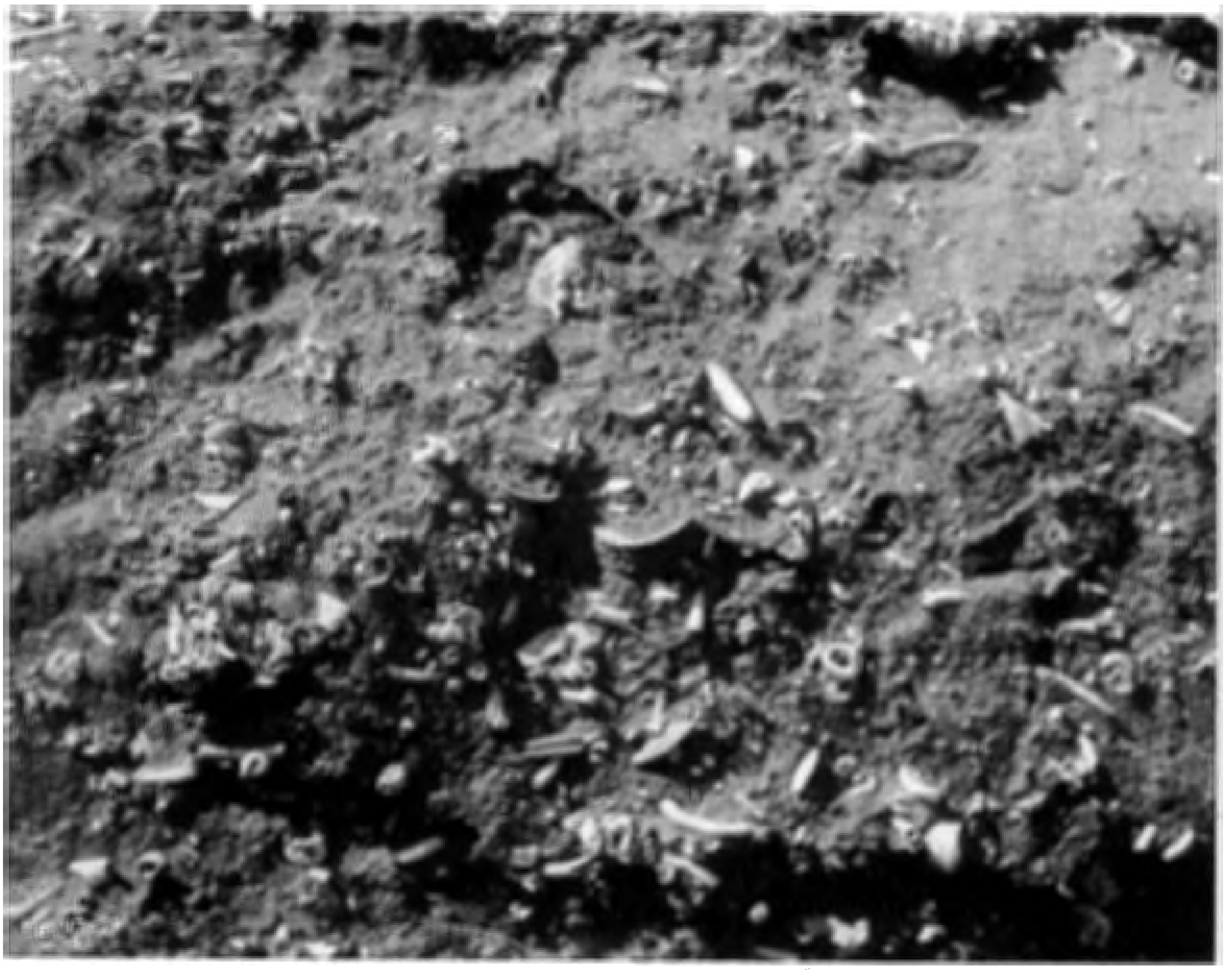



Fig. 95


Fig. 96



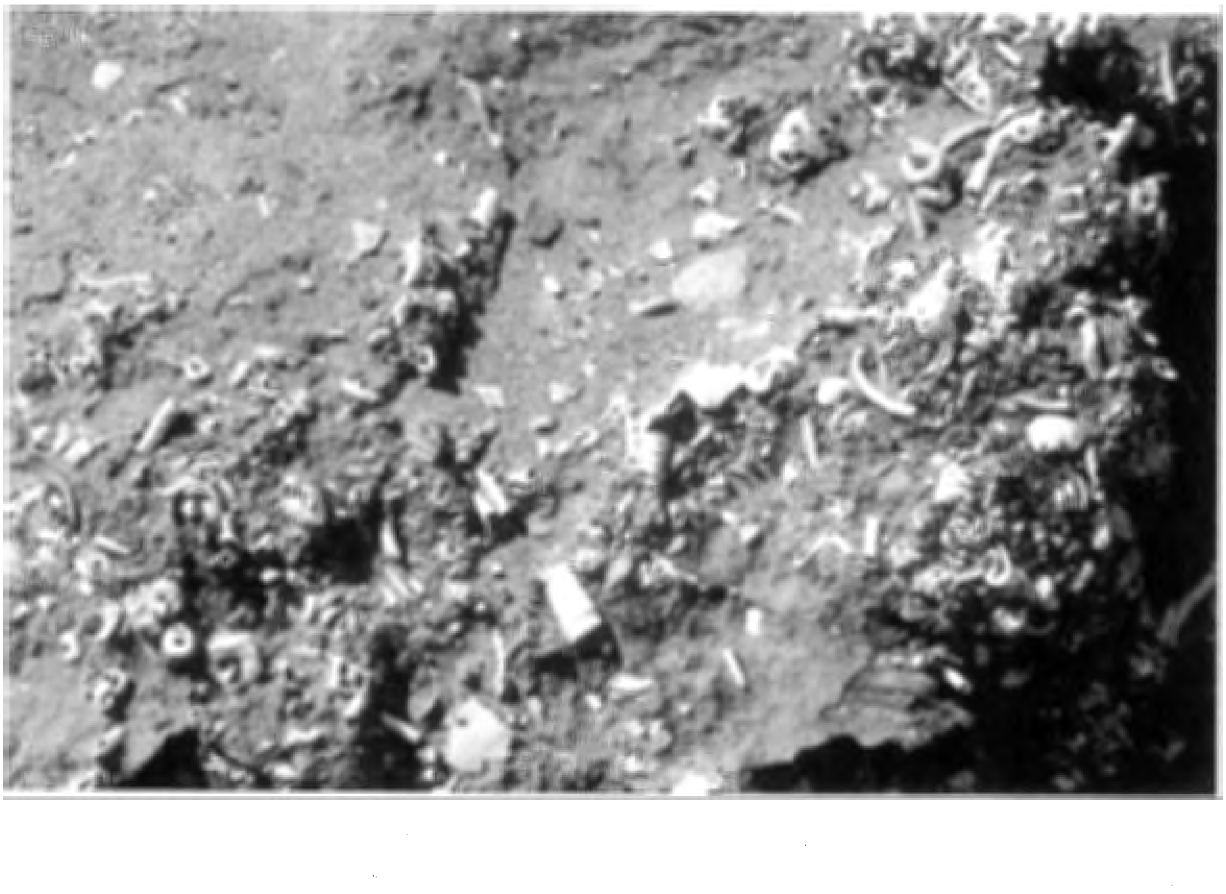


Fig. 99

Fig. 100

Preparation nr 108 (Fig. 100).

Age: Lower Pliocene - Scaldisian
1929: Scaldisian *Sc* (1909: Scaldisian *Sc*).
Lihtostratigraphic unit: Sands of Kattendijk, lower part.
Locality: Kallo, Vrasene-dock or 4th harbour dock (Sheet 27e), Antwerp, 1984 (Fig. 102).

Description: *Petaloconchus intortus* horizon (Fig. 103).

Fig. 95, p. 56, gives a general view of this very irregular layer, which is sometimes only 2cm thick, but reaches somewhere else up to more than 20cm thickness. This concentration of *Petaloconchus* (a Vermetid mollusc) seems to have benefited from a period of non-sedimentation. The individuals have grown almost one upon the other, to form a kind of reef on the sea bottom. Beside, this reef fauna provided a huge species concentration of other molluscs and brachiopods. Fish bones and otoliths are also very common. The sediment between the individuals is a more clayey fine sand. In the underlying sediment molluscs are scarce, but there are plenty of burrows, possibly made by Pogonophorid worms, of which two complete ichnofossil burrows are shown on Fig. 95 (bottom, p. 56).

Fig. 96: a detail of the *Petaloconchus* horizon.
Figs. 97 to 99: enlarged details of this horizon.
Fig. 100: a prepared and consolidated preparation (nr 108), with its wriggled mass of *Petaloconchus contortus*.
Fig. 101: *Tegulorhynchia nysti*, a 9mm high brachiopod from the *Petaloconchus* horizon.
Fig. 104: *Chlamys (Chlamys) princeps* from the undermost part of the Sands of Kattendijk.

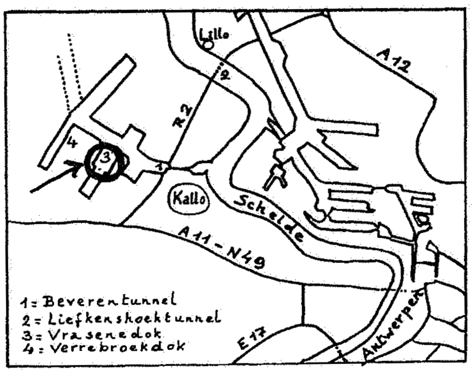


fig. 102

fig. 103

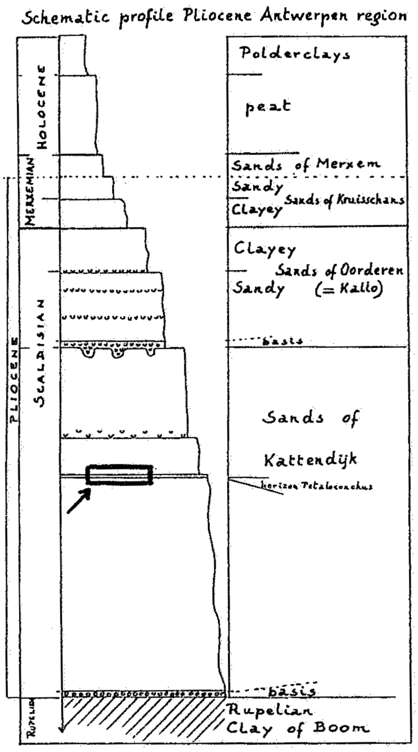


fig. 104

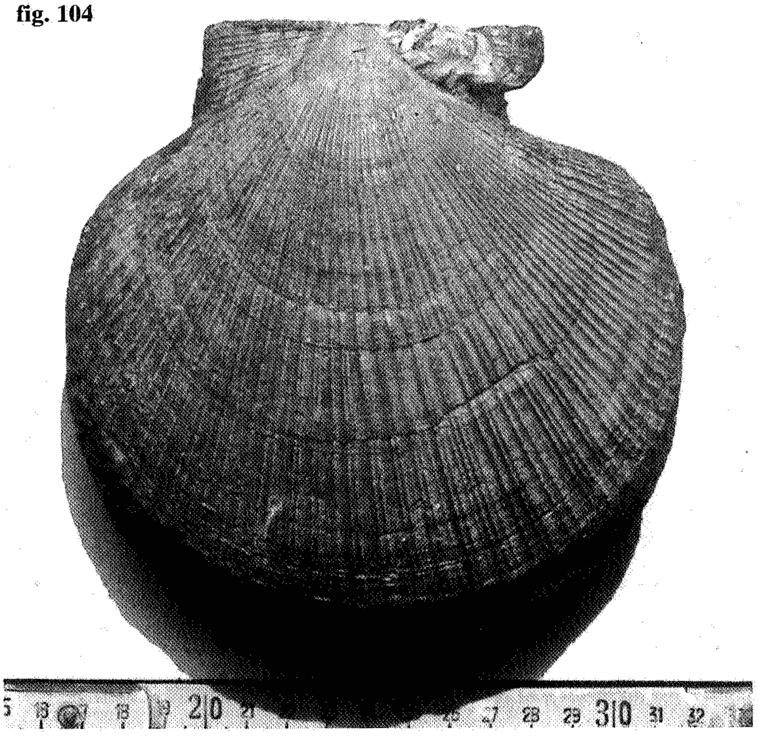
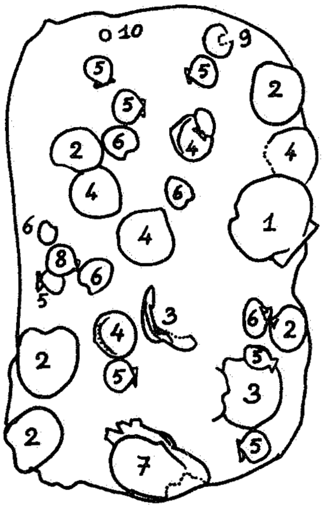


Fig. 105



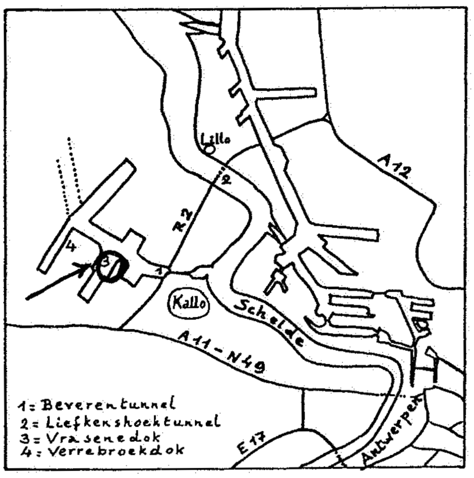
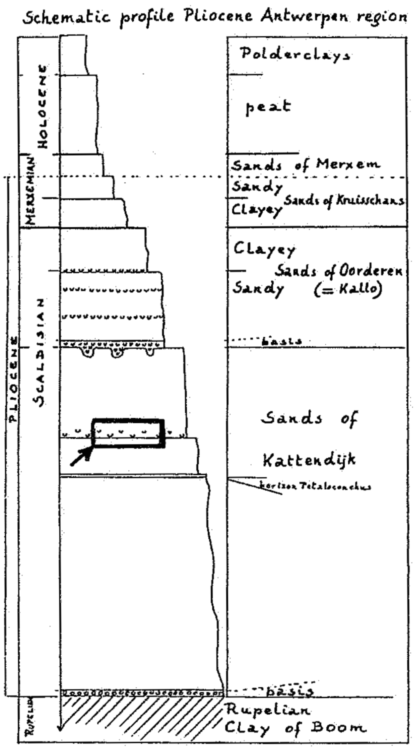


fig. 106

fig. 107



Preparation nr 62 (Fig. 105).

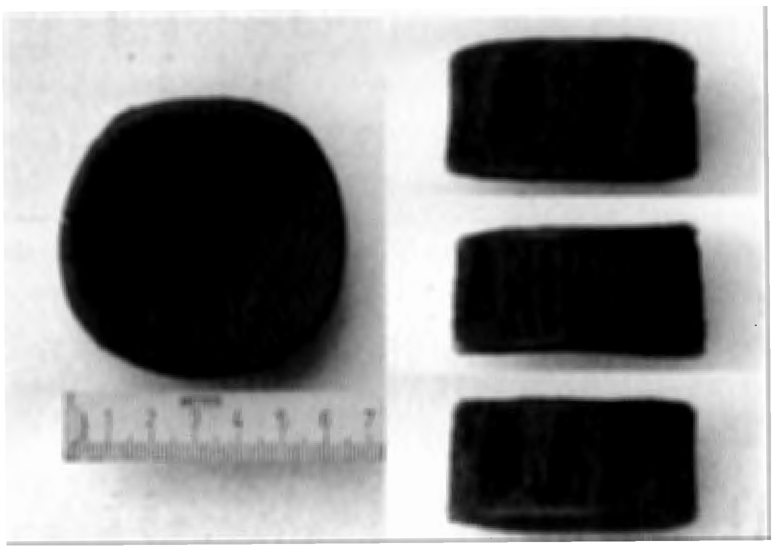
Age: Lower Pliocene - Scaldisian
1929: Scaldisian *Sc* (1909: Scaldisian *Sc*).
Lihtostratigraphic unit: Sands of Kattendijk.
Locality: Kallo, Vrasene-dock or 4th harbour dock (Sheet 27e), Antwerp, 1983 (Fig. 107).

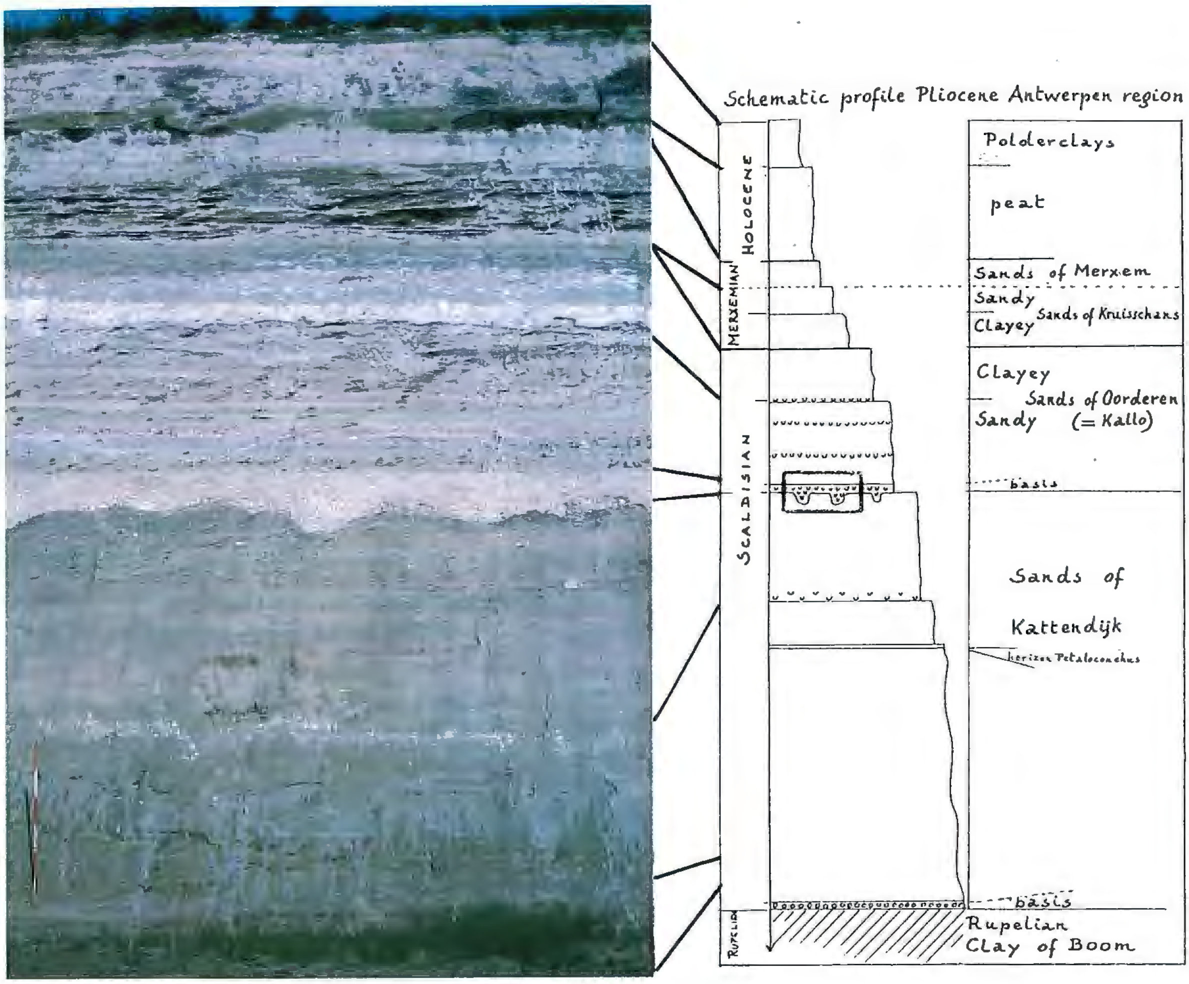
Description:

-*Pecten grandis* (1).
-*Pygocardia rustica* (2).
-*Arctica islandica* (3).
-*Glycymeris* nov. sp., in press by Moerdijk & van Nieulan-
de (4).
-*Aequipecten opercularis* (5).
-*Astarte (Isocrassina) omalii* (6).
-*Panopea faujasi* (7).
-*Palliolum tigerinum* (8).
-*Palliolum gerardi* damaged (9).
-*Lucinoma borealis* bivalve (10).
-Many derived shell fragments, due to predation.

This is a small horizon (coquina) that clearly distinguishes the lower from the upper Kattendijk Sands and contains the Elasmobranchs fauna described by J. Herman (1974).
As usual the fauna of the whole Kattendijk Sands is scarcely spread; this fauna concentration suggests a derived thanatocoenosis, due to heavy storm action, which may have washed away some metres of sea bottom sediment at once.
The only two big bivalves in connection (but tumbled): *Glycymeris* and *Panopea*, contain a slightly pyritisized sediment, which suggests the animals were alive when covered up too quickly by too much sediment at the end of the storm.

Fig. 108: Vertebra of isuroid shark from the Sands of Kattendijk, Beverentunnel.





General views of stratification which clearly show the separation of the lower, darker Kattendijk Formation and the upper bright Oorderen Sands of Lillo Formation. This contact is marked by the impressive load cast of the transgressive base of the latter.

fig. 109 - 110:
June 1984, Kallo,
Vrasene-dock,
north-west profile.

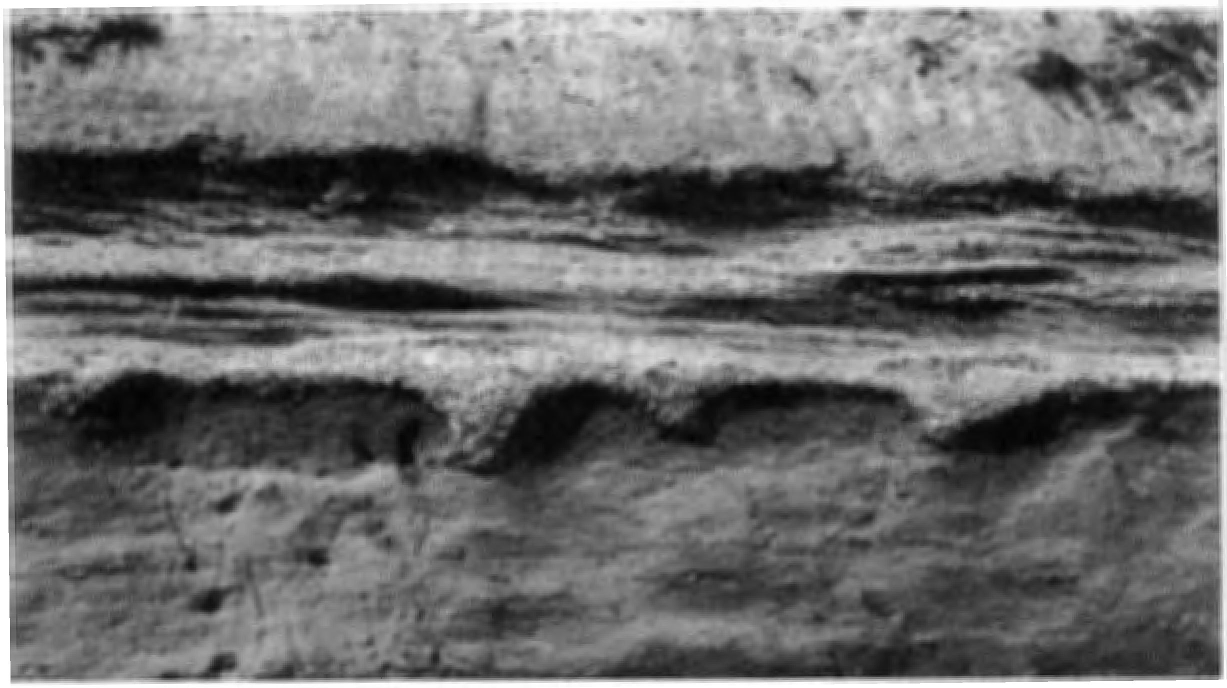


Fig. 112: May 1978, Kallo, Beveren Tunnel, northwest profile. The transgressive base of the Scaldisian - Lillo Formation - Sands of Oorderen (formerly Sands of Kallo), on the Kattendijk Formation (Sands of Kattendijk) showing a lot of impressive load casts phenomena, deep into the Sands of Kattendijk.

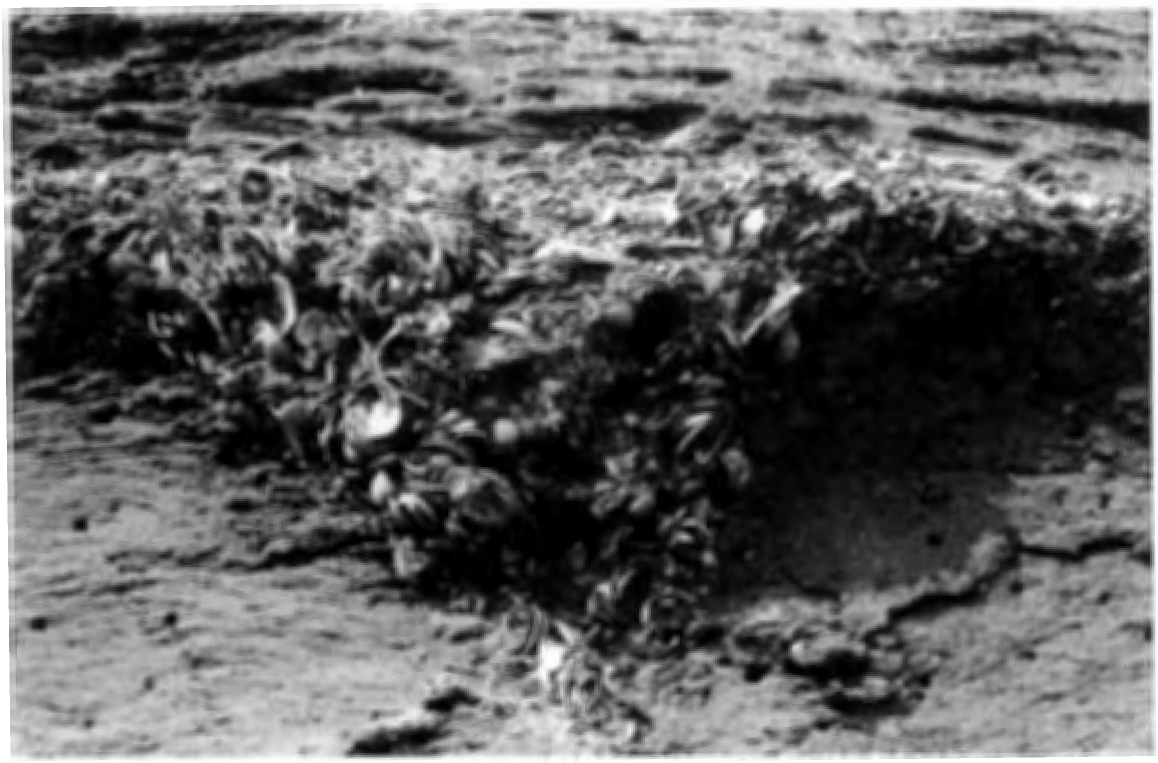
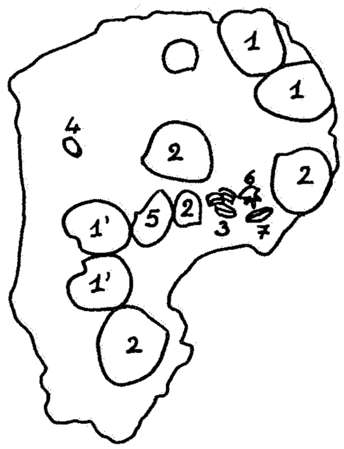


Fig. 113: May 1978, Kallo, Beveren Tunnel, northwest profile. Detail of the load cast phenomenon.
This transgression layer contains more shells and shell fragments than sediment. For this reason, the compaction cracked almost every individual shell. This layer also contains residues of the completely washed out Luchtbal Sands, which are only present in situ sporadically, at the right river bank of North Antwerp.

Fig. 114



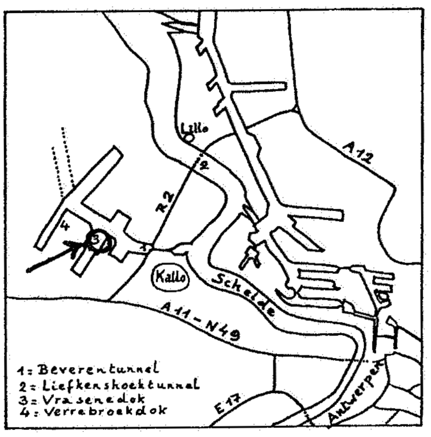
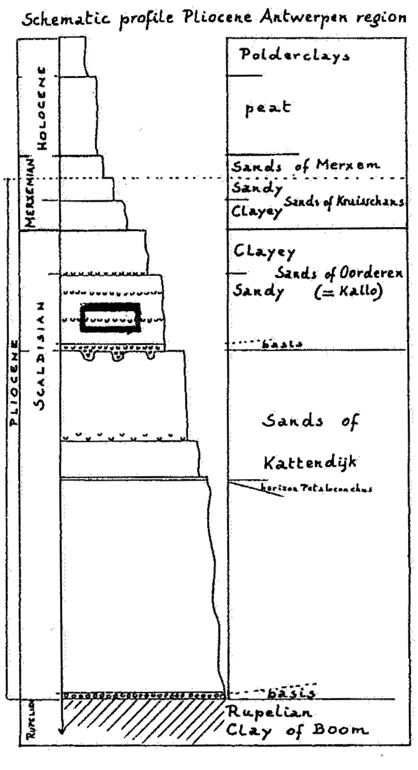


fig. 115

fig. 116



Preparation nr 55 (Fig. 114).

Age: Upper Pliocene - Scaldisian
1929: Scaldisian *Sc* (1909: Scaldisian *Sc*).
Lithostratigraphic unit: Sands of Oorderen (formerly Sands of Kallo).
Locality: Kallo, Vrasene-dock or 4th harbour dock (Sheet 27e), Antwerp, 1985 (Fig. 115).

Description:

This preparation comes from the sandy lower part of the Lillo Formation (Fig. 116).

-*Pygocardia rustica defrancei,*single valves (1) and one bivalve (1').
-*Laevicardium decorticatum* (2).
-A cluster of barnacles (3).
-*Leionucula laevigata* bivalve (4).
-*Pholadomya (Pholadomya) hesterna* (5, and Fig.117). In the Belgian Pliocene this species was only represented by a doubtful find, probably from the Kattendijk Sands. Its occur- rence in the Oorderen Sands, though as a single right valve, is new.
-*Aporrhais scaldensis* (6).
-*Cultellus cultellatus* bivalve (7).
-Many fine shell fragments due to predation.

This preparation shows a slightly derived thanato-coenosis, with some bivalves, which are not in live position. This may suggest bioturbation and displa-cement. Taking into consideration the fact that *Pholadomya* is a relatively deep burrower, and consequently often dies as a bivalve in situ, this fauna does not seem to be exactly in situ. The displacement, however, cannot have been very important, as *Pholadomya* is a very thin-shelled mollusc.

In this horizon occur sporadically large, well-preserved elasmo-
branch teeth, mainly Isuroid such as *Isurus hastalis* and *Carcharodon escheri*.

fig. 117

Fig. 118

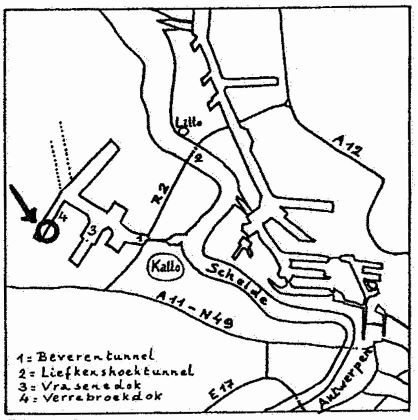
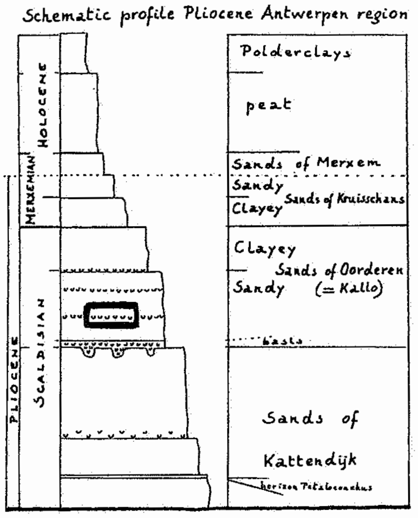


fig. 119

fig. 120



Preparation nr 34 (Fig. 118).

Age: Upper Pliocene - Scaldisian
1929: Scaldisian *Sc* (1909: Scaldisian *Sc*).
Lithostratigraphic unit: Sands of Oorderen (formerly Sands of Kallo).
Locality: Kallo, Verrebroek-dock (Sheet 27e), Antwerp, 1989 (Fig. 119).

Description:

This preparation comes from the sandy lower part of the Lillo Formation and shows a bivalve of a *Atrina* nov.sp. of 225mm length, on its top overgrown by barnacles in live position.
The large broken shells and fine shell grit indicate a derived fauna, due to a brutal storm wave action. It was clearly a living *Atrina* bivalve with its epifauna of living barnacles, which tumbled and was quickly burried under the storm sediment. Their fossilization process produced a pyritization envelopment. Even the hairy byssus turned into a pyrite concretion.
This new species of *Atrina* has unfortunately long been uncorrectly considered as a member of *Pinna* genus, and erroneously identified as *pectinata* as well.

The three drawings (Figs. 121 to 123) give the outline charac- teristics of the three distinct species: *A. pectinata, A. fragilis, A.* nov.sp., with close phyllo-genetic lineage.

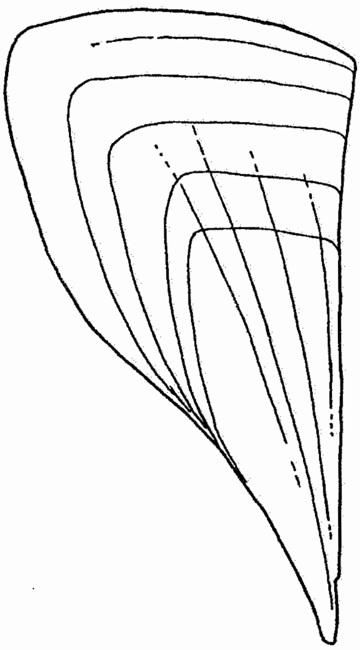


Fig. 121 Recent
Atrina pectinata
Cataluna, Spain, Mediterranean

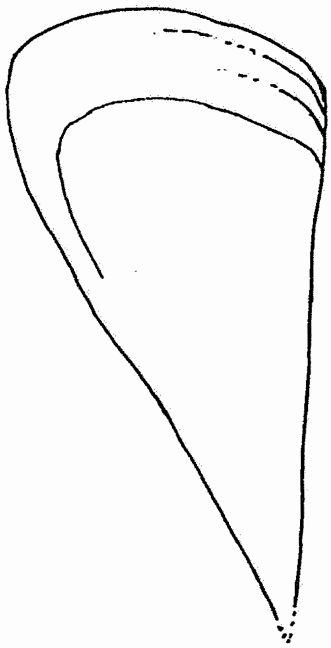


Fig. 122 Recent
Atrina fragilis
Salcombe, England, Atlantic

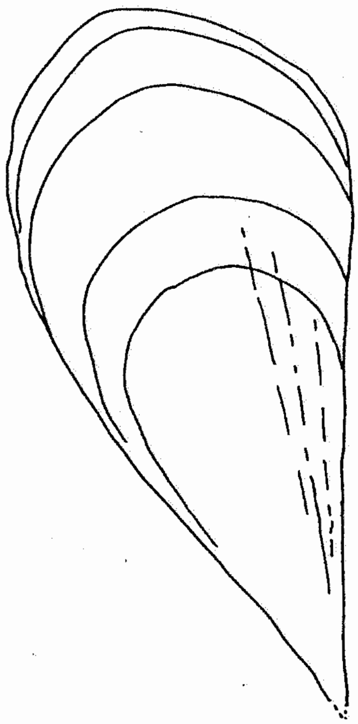
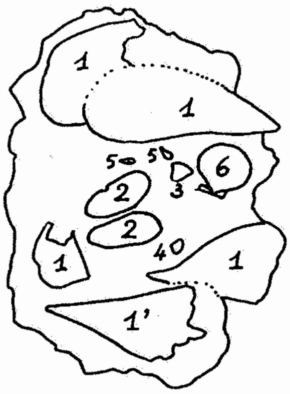


Fig. 123 Fossil
Atrina nov.sp.
Kallo, Pliocene, Belgium

Fig. 124



Preparation nr 109 (Fig. 124)

Age: Pliocene - Scaldisian
1929: Scaldisian *Sc* (1909: Scaldisian *Sc*).
Lithostratigraphic unit: Sands of Oorderen (formerly Sands of Kallo), lower part.
Locality: Kallo, Verrebroek-dock (Sheet 27e), Antwerp, 1989 (Fig. 119).

Description:
-*Atrina* nov.sp. (1).
-*Cyrtodaria angusta*, open bivalve (2).
-*Calliostoma zizyphinum simile* (3).
-*Spisula subtruncata* (4).
-*Amyclina labiosa* (5).
-*Aequipecten opercularis* (6).

Sandy sediment mixed with much very fine shell grit, ground by high kinetic wave action. Clearly a storm deposit. The opened bivalve of *Cyrtodaria* has been displaced from its burrow by heavy sea currents.

SYSTEMATIC
Observations preliminary to the publication of R. Marquet & M. Vervoenen in: "Revision of the Caenozoic Pinnidae from Belgium". Bull. 65 KBIN, in press.
MOLLUSCA
Class Bivalvia
Subclass Pteriomorphia
Order Mytiloida
Superfamily Pinnacea

Family Pinnidae
Genus *Atrina* GRAY, 1842
Atrina nov. sp.; syn.: *Pinna pectinata* non LINNAEUS, 1767

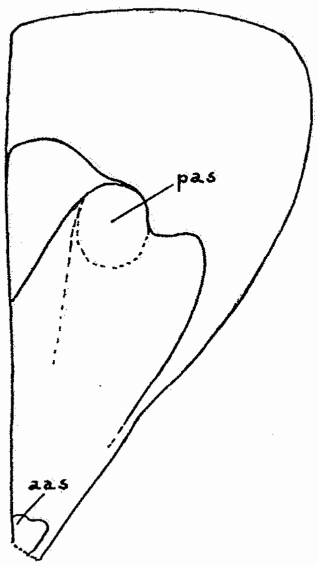
Paratype 1: Preparation nr 34 (Fig. 118, Leiden, nr: RGM 393.372) for the exterior shell.
Paratype 2: Preparation nr 109 (Fig. 124, Leiden,nr: RGM 393.373) for the interior shell, coming from the same horizon. Two additional paratypes (IRSNB, Cat. nrs: TCI 5868 & 5869) are illustrated on Figs. 188 & 189 (p. 102).

Locality: Kallo, 1989, Verrebroek-dock (Fig.), Sands of Oorderen.

The two paratypes are deposited in the National Museum of Natural History, Department Tertiary Mollusca, at Leiden, the Netherlands. The two other paratypes are at the Royal Institute of Natural Sciences, Brussels, Belgium.

The anterior adductor scar (*aas*) makes a sharp V-form in *A.* nov. sp. (Fig. 126), while in the recent *A. pectinata* it is only a smooth depression (Fig. 125); and in the recent *A. fragilis* the anterior adductor scar (*aas*) looks intermediate to the two species.
Contour of posterior shell margin of *A.* nov. sp. regularly rounded and fluently joining the dorsal ligament area (Fig. 123); in contrast to the recent *A. pectinata* whose posterior shell margin is almost straight and forms a 90° angle with the dorsal ligament margin (Fig. 121).

The recent *A. fragilis* (British Isles), has a medium position (Fig. 122) between *A. pectinata* and fossil *A.* nov. sp. The three species make a phylogenetic line, of which the recent *A. pectinata* prefers warmer Mediterranean waters; while *A. fragilis* the colder Atlantic waters.



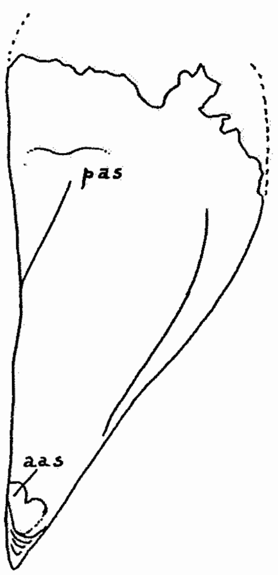
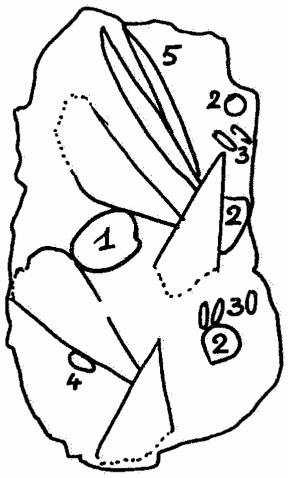


Fig. 125: Muscular imprints of *A. pectinata*, Cataluna, Spain.
Fig. 126: Muscular imprints of *A.* nov. sp., Kallo, Belgium.

Fig. 127



Preparation nr 61 (Fig. 127).

Age: Upper Pliocene - Scaldisian
1929: Scaldisian *Sc* (1909: Scaldisian *Sc*).
Lithostratigraphic unit: Sands of Oorderen (formerly Sands of Kallo).
Locality: Kallo, N.E. side of the Vrasene-dock or 4th harbour dock (Sheet 27e), Antwerp, 1985 (Fig.129).

Description:

This preparation shows the *Atrina* acme horizon in the sandy lower part of the Lillo formation.

-Mostly *Atrina* nov.sp., almost all bivalves.
-*Pygocardia rustica defrancei* (1).
-*Laevicardium decorticatum* (2).
-*Cultellus cultellatus* (3).
-*Yoldia semistriata* (4).

This thanatocoenosis consists of a dense accumulation of *Atrina* bivalves, struck by a huge storm with rolling wave action, smashed in all directions and quickly covered with after-storm-sedimentation. One *Atrina* bivalve kept a tight hold-on by its byssus anchorage (5), but could not erect anymore.
The depth of the sea bottom is estimated at about max. 20 to 30m.

fig. 128

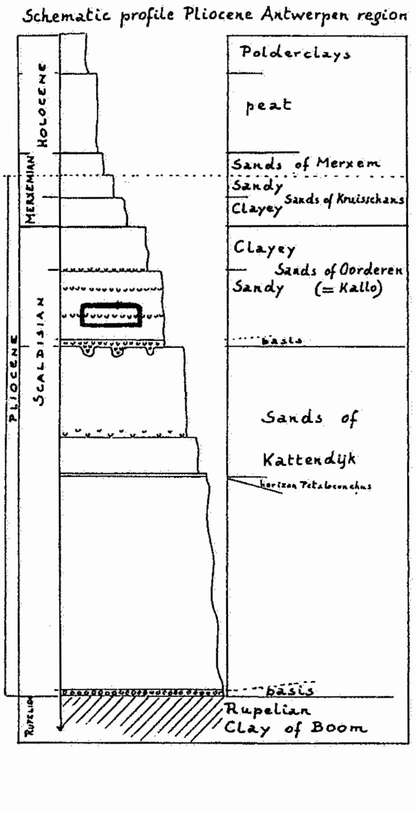


fig. 129

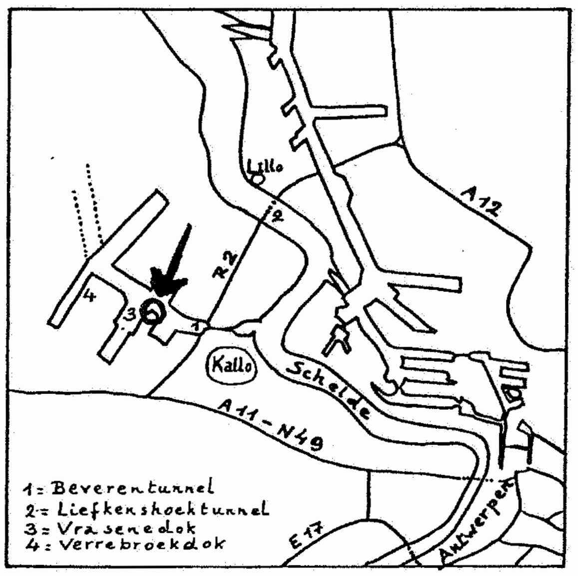


Fig. 130

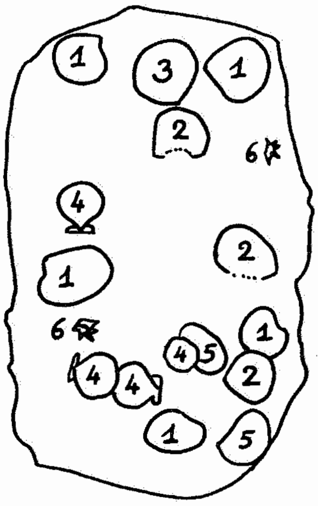
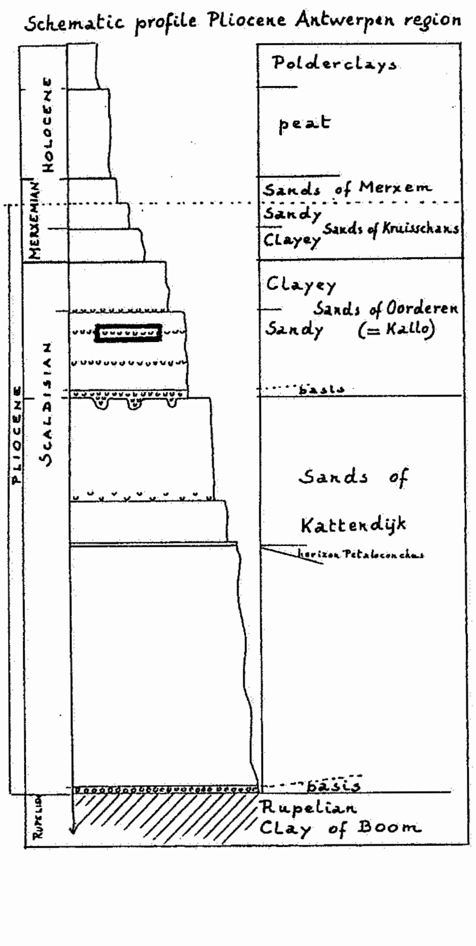


fig. 131



Preparation nr 33 (Fig. 130).

Age: Pliocene - Scaldisian
1929: Scaldisian *Sc* (1909: Scaldisian *Sc*).
Lithostratigraphic unit: Sands of Oorderen (formerly Sands of Kallo).
Locality: Kallo, Verrebroek-dock (Sheet 27e), Antwerp, 1989 (Fig.132).

Description:

This sample was located at 1.5m under the clayey upper part of the Sands of Oorderen.

-*Pygocardia rustica defrancei* (1).
-*Laevicardium decorticatum* (2).
-Single valve of *Glycymeris* nov.sp., in press by Moerdijk and van Nieulande (3).
-*Aequipecten opercularis* (4).
-*Ostrea edulis* (5).
-*Aporrhais scaldensis* (6).
-Many shell fragments especially from worn *Atrina*, but also much fine shell grit.

Glycymeris, Laevicardium and *Pygocardia* molluscs, which are burrowers, are mixed with surface dwellers of the sea bottom and a concentration of shell fragments in this small shell layer (coquina). This horizon suggests a storm deposit.

fig. 132

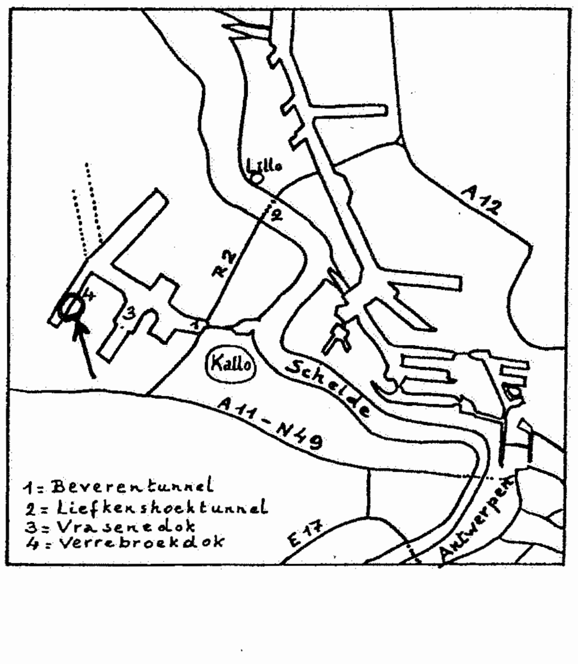
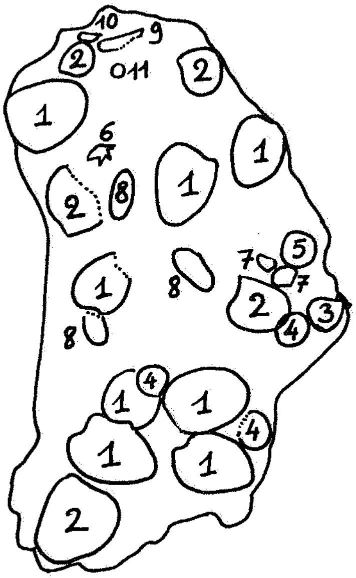


Fig. 133



Preparation nr 63 (Fig. 133).

Age: Upper Pliocene - Scaldisian
1929: Scaldisian *Sc* (1909: Scaldisian *Sc*).
Lithostratigraphic unit: Sands of Oorderen (formerly Sands of Kallo).
Locality: Kallo, Vrasene-dock or 4th harbour dock (Sheet 27e), Antwerp, 1984 (Fig. 135).

Description:

Located in the sandy lower part of the Sands of Oorderen, this preparation shows the following specimens:

-Mostly single valves of *Pygocardia rustica defrancei* (1).
-*Laevicardium decorticatum* (2).
-*Aequipecten opercularis* (3).
-*Dosinia lupinus* (4).
-*Pododesmus (Monia) patelliformis* (5).
-*Aporrhais scaldensis* (6).
-*Macoma obliqua* (7).
-*Gari (Psammobia) fervensis* (8).
-*Ensis* sp. fragment (9).
-*Amyclina labiosa* (10).
-*Polinices (Euspira) exvarians* (11).
-Many shell fragments and fine shell grit.

This preparation comes from the same shell horizon as the preparation nr. 33 (p. 70), although it contains fewer
Atrina fragments. It is a slightly derived fauna, suggesting another storm deposit.

fig. 134

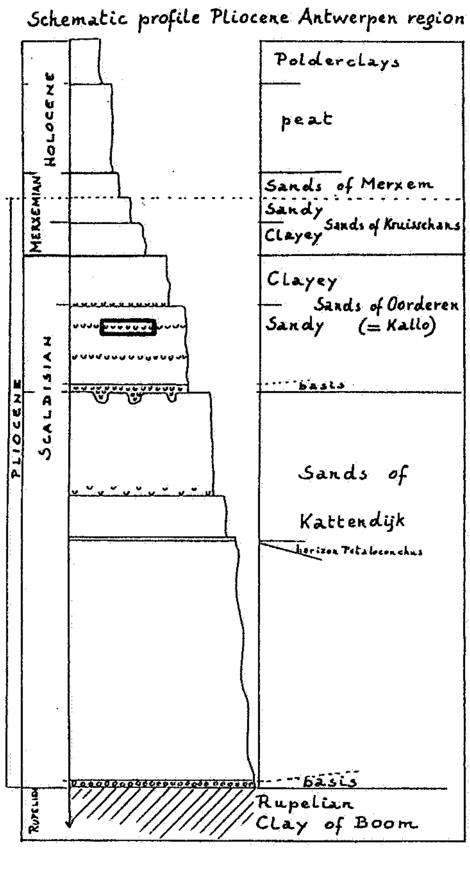


fig. 135

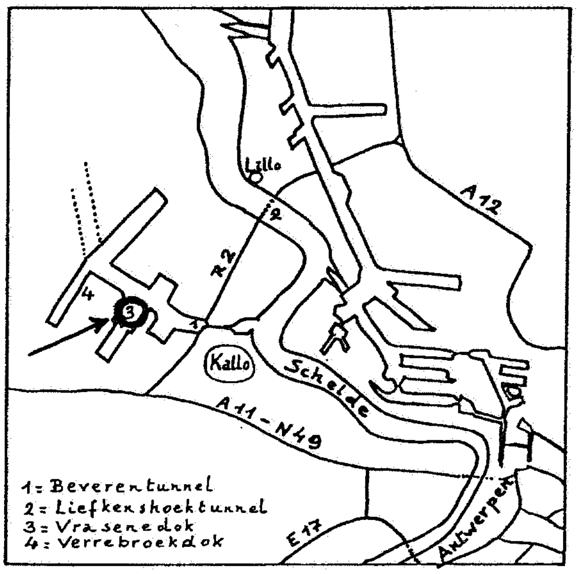
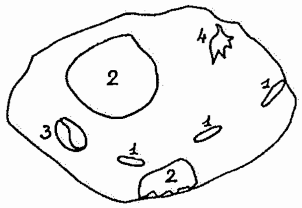


Fig. 136



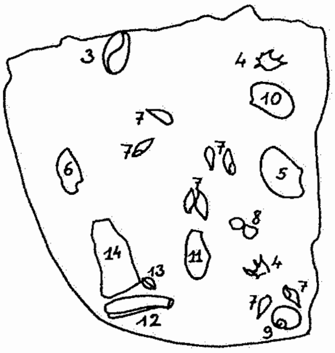
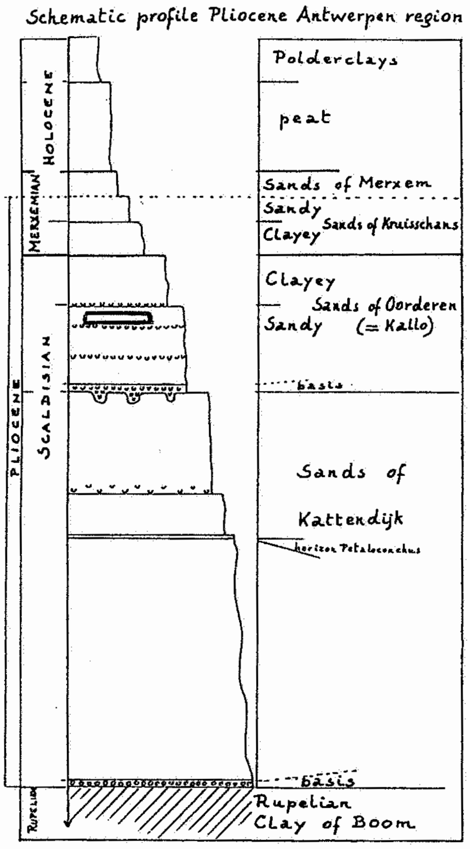


fig. 137



Preparations nr 30 and 41e (Fig. 136).

Age: Pliocene - Scaldisian
1929: Scaldisian *Sc* (1909: Scaldisian *Sc*).
Lithostratigraphic unit: Sands of Oorderen (formerly Sands of Kallo).
Locality: Kallo, Verrebroek-dock (Sheet 27e), Antwerp, 1987 (Fig.138).

Description:

These two preparations come from the lower sandy part of the Lillo Formation, at 25cm under the base of the upper clayey section.

-*Cultellus cultellatus* (1).
-*Laevicardium decorticatum* (2).
-*Scaphander lignarius* (3).
-*Aporrhais scaldensis* (4).
-*Pygocardia rustica defrancei* fragment (5).
-*Mytilus edulis* (6).
-*Amyclina labiosa* (7).
-*Corbula gibba* (8).
-*Natica multipunctata* (9).
-*Capulus unguis* (10).
-*Gari (Psammobia) fervensis* (11).
-*Ensis* sp. bivalve (12).
-*Trivia coccinelloides* (13).
-A fossil drift wood (14).
-Fine shell grit.

This thanatocoenosis seems to be a slightly derived deposit, with many sharp-edged shell fragments, and much fine, worn and rounded shell grit.

fig. 138

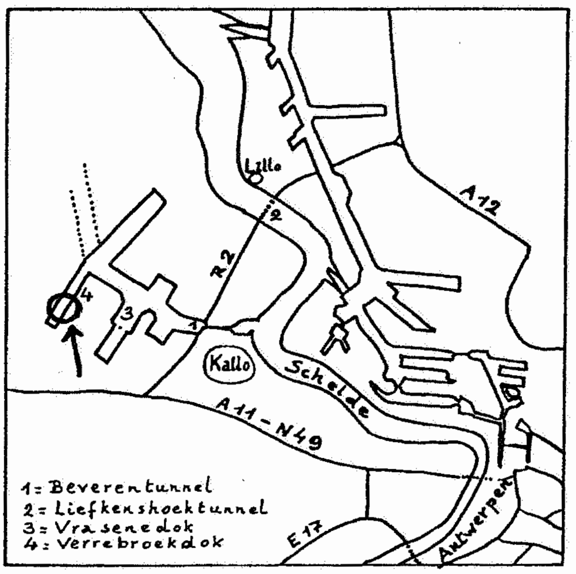
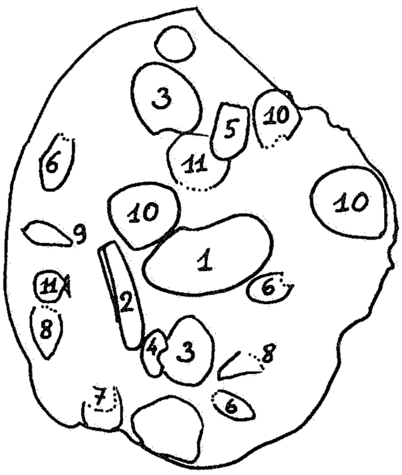


Fig. 139



Preparation nr 44 (Fig. 139).

Age: Pliocene - Scaldisian
1929: Scaldisian *Sc* (1909: Scaldisian *Sc*).
Lithostratigraphic unit: Sands of Oorderen (formerly Sands of Kallo).
Locality: Kallo, Verrebroek-dock (Sheet 27e), Antwerp, 1989 (Fig.140).

Description:

This sample was extracted from the basis of the clayey upper part of the Lillo Formation.

- *Lutraria lutraria* (1).
- Bivalve of *Ensis* sp. (2).
- *Pygocardia rustica defrancei* (3).
- *Angulus benedeni* (4).
- *Cyrtodaria angusta* fragment (5).
- *Gari (Psammobia) fervensis* (6).
- *Capulus unguis* fragment (7).
- *Mytilus edulis* (8).
- *Hinia (Uzita) reticosa* (9).
- *Laevicardium decorticatum* (10).
- *Aequipecten opercularis* (11).
- Many shell fragments and fine shell grit.

Laevicardium, Pygocardia, Cyrtodaria, Gari and *Ensis* are burrowers. The delicate bivalve *Ensis* could not resist a long transport, so this thanatocoenosis seems a slightly derived storm deposit. Compaction of the sediment cracked many shells.

In this horizon Elasmobranch teeth are extremely rare, but always of perfect preservation (Fig. 141: *Isurus hastalis*).

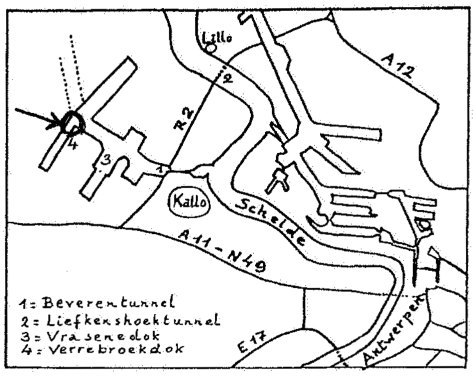


fig. 140

fig. 142

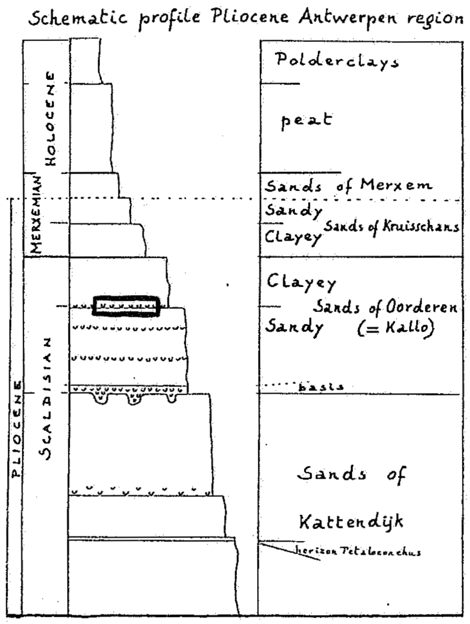


Fig. 143

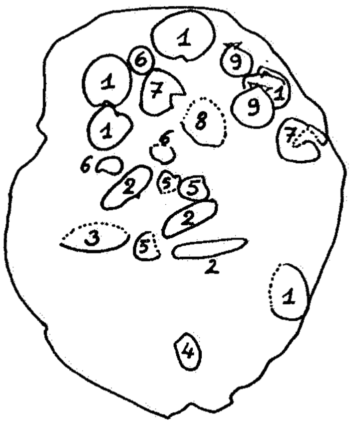
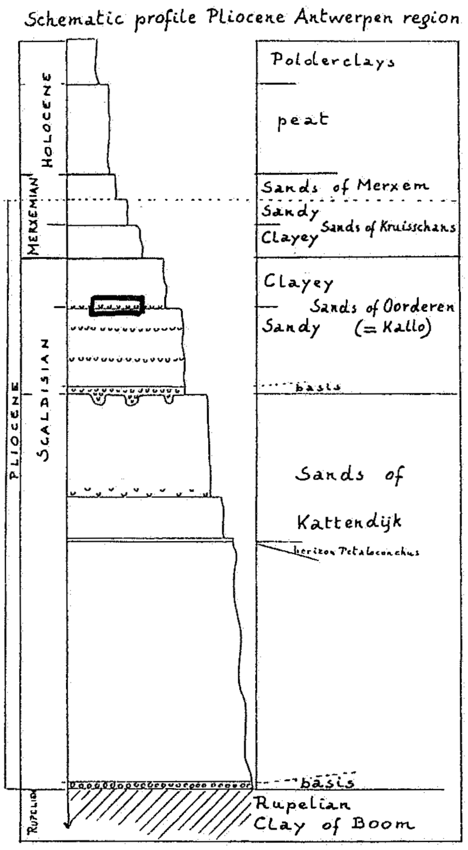


fig. 145



Preparation nr 53 (Fig. 143).

Age: Pliocene - Scaldisian
1929: Scaldisian *Sc* (1909: Scaldisian *Sc*).
Lithostratigraphic unit: Sands of Oorderen (formerly Sands of Kallo).
Locality: Kallo, Verrebroek-dock (Sheet 27e), Antwerp, 1989 (Fig.146).

Description:

This preparation comes from the basis of the clayey upper part of the Lillo Formation.

-*Pygocardia rustica defrancei* (1).
-*Cyrtodaria angusta* (2).
-*Gari (Gobraeus) depressa* right valve of 75mm length, new for the Sands of Oorderen fauna (3, detail Fig.144).
-*Venerupis (Ruditapes) rhomboides* (4).
-*Astarte (Isocrassina) fusca* (5).
-*Dosinia lupinus* (6).
-*Laevicardium decorticatum* (7).
-*Ostrea edulis* (8).
-*Aequipecten opercularis* (9).

The clayey upper part of the Sands of Oorderen starts with a new small horizon of a reworked coquina. The surface dwellers like *Ostrea* and *Aequipecten* have a dark bluish colour, indicating a rather long exposition on the sea bottom after their death. This suggests a significant sedimentation stop.
The other bivalves of a bright colour are all burrowers, but seem to be uprooted from their sediment home, and displaced by heavy water currents.

fig. 146

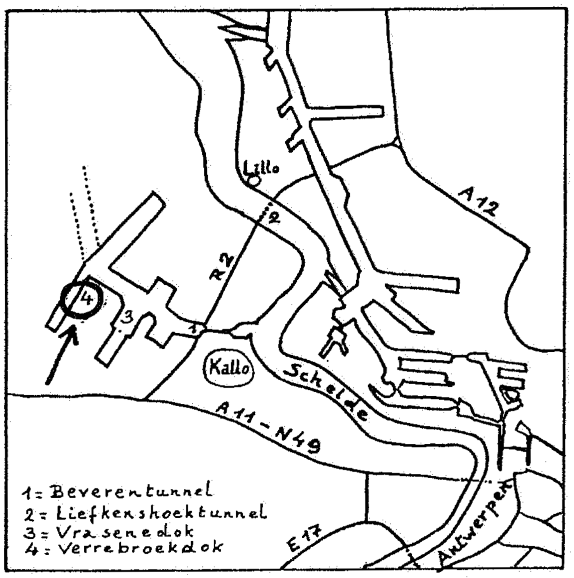
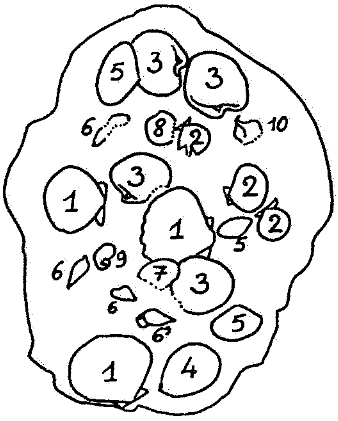


Fig. 147



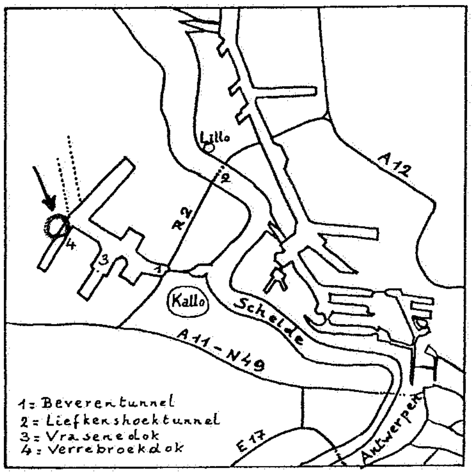
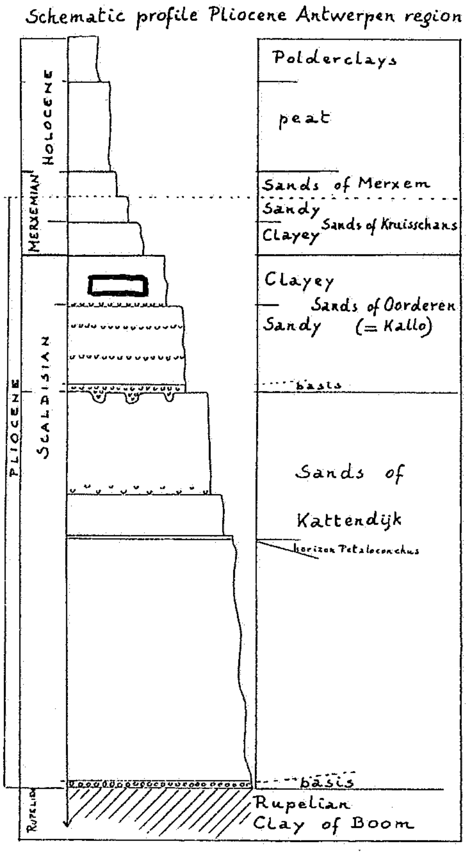


fig. 148

fig. 149



Preparation nr 48 (Fig. 147).

Age: Pliocene - Scaldisian
1929: Scaldisian *Sc* (1909: Scaldisian *Sc*).
Lithostratigraphic unit: Sands of Oorderen (formerly Sands of Kallo).
Locality: Kallo, Verrebroek-dock (Sheet 27e), Antwerp, 1987 (Fig.148).

Description:

Another preparation from the upper clayey part of the Lillo Formation.

-*Pecten complanatus* (1).
-*Aequipecten opercularis* (2).
-*Pygocardia rustica defrancei* (3).
-*Ostrea edulis* (4).
-*Angulus (Peronaea) benedeni* (5).
-*Hinia (Uzita) reticosa reticosa* (6).
-*Hinia (Uzita) reticosa costata* (1').
-*Laevicardium decorticatum* (7).
-*Dosinia lupinus* (8).
-*Polinices (Euspira) exvarians* (9).
-*Galeodea bicatenata* fragment (10).

Many sharp-edged fragments, mixed with a very fine shell grit in a clayey sand, indicate a shallow water depth with its wave action grinding debris to an always finer dimension. This kind of sea bottom seems to be cut off from the usual sea currents, so that clay particles could settle.
Compaction of the sediment cracked many shells.

Fig. 150: *Carcharodon carcharias* (formerly *rondeleti*) Vrasene-dock, Kallo.

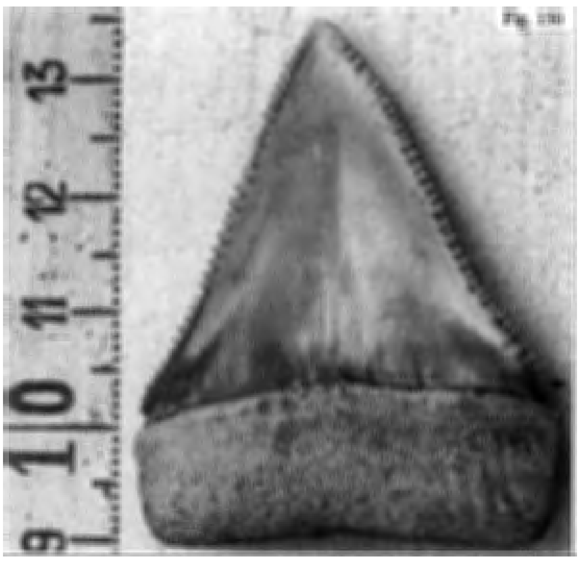
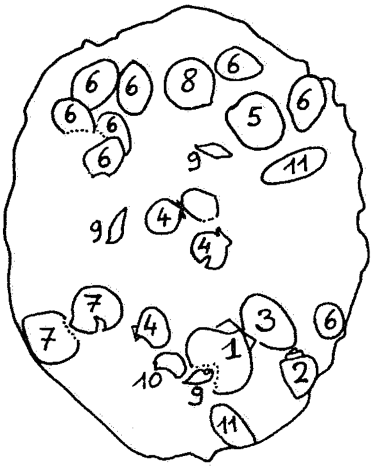


Fig. 151



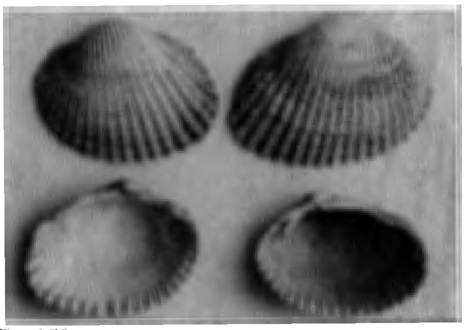
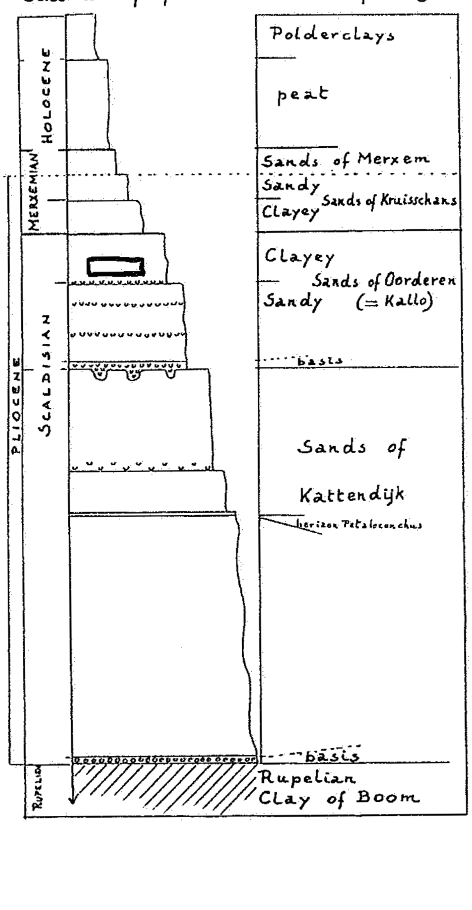


fig. 152

fig. 153

Schematic profile Pliocene Antwerpen region



Preparation nr 57 (Fig. 151)

Age: Pliocene - Scaldisian
1929: Scaldisian *Sc* (1909: Scaldisian *Sc*).
Lithostratigraphic unit: Sands of Oorderen (formerly Sands of Kallo).
Locality: Kallo, Verrebroek-dock (Sheet 27e), Antwerp, 1989 (Fig.154).

Description:

At 50cm above the base of the upper clayey part of the Sands of Oorderen (Lillo Formation), the following sample was extracted:

-*Pecten complanatus* (1).
-*Galeodea bicatenata* (2).
-*Spisula arcuata* (3).
-*Aequipecten opercularis* (4).
-*Pygocardia rustica defrancei* (5).
-*Angulus (Peronaea) benedeni* (6).
-*Laevicardium decorticatum* (7).
-*Glycymeris (Glycymeris) variabilis* (8).
-*Hinia reticosa concinna* (9).
-*Cerastoderma edule hostiei* (10, and Fig. 152).
-*Cyrtodaria angusta* (11).

Many sharp-edged fragments, but also very fine shell grit in a clayey sand, indicates a shallow depth of water, within reach of wave action. This horizon contains a displaced fauna, suggesting a storm deposit, for some of the *Hinia* gastropods did not have the time to fill up with shifting sediment. Later compaction cracked almost all of the shells, and the empty *Hinia* collapsed.

fig. 154

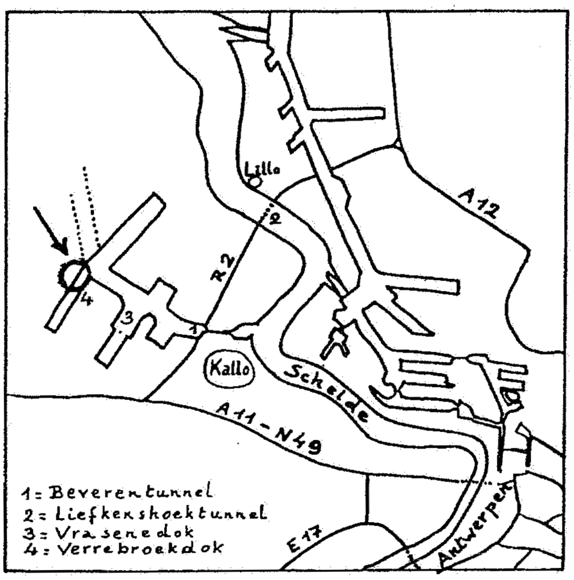
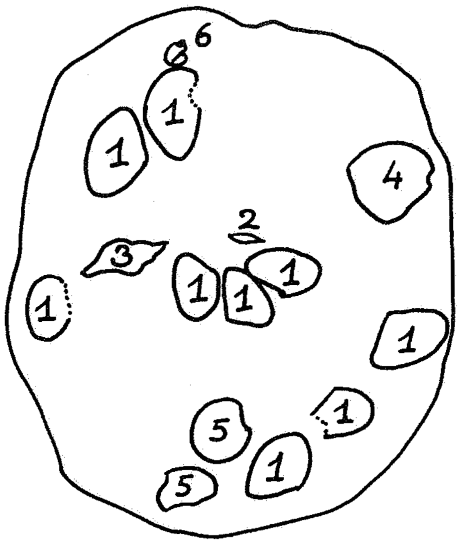


Fig. 155



Preparation nr 42 (Fig. 155).

Age: Pliocene - Scaldisian
1929: Scaldisian *Sc* (1909: Scaldisian *Sc*).
Lithostratigraphic unit: Sands of Oorderen (formerly Sands of Kallo).
Locality: Kallo, Verrebroek-dock (Sheet 27e), Antwerp, 1989 (Fig.158).

Description:

Another association of molluscs from the upper clayey part of the Sands of Oorderen (Lillo Formation).

-Mostly single valves of *Angulus (Peronaea) benedeni* (1).
-*Amyclina labiosa* (2).
-*Colus curtus* (3).
-*Laevicardium decorticatum* (4).
-*Dosinia lupinus* (5).
-*Polinices (Euspira) exvarians* (6).

Many sharp-edged fragments, but also fine shell grit are mixed. The *Colus* conch was not quite filled up with sediment, which suggests this tiny shell horizon is once more a displaced fauna, due to wave action or storm deposit. Cetecean bones are quite common in this horizon

fig. 156

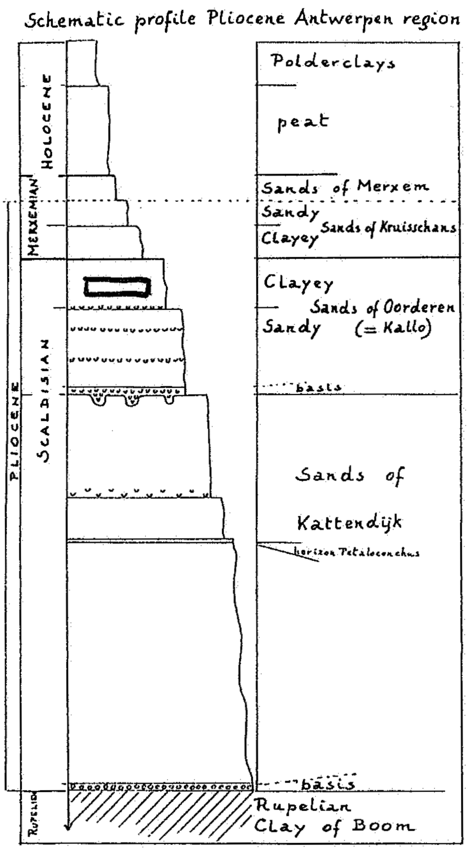


fig. 157: Tympanic delphinid bone.

fig. 158

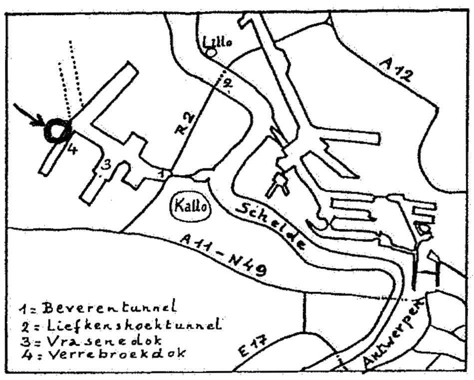
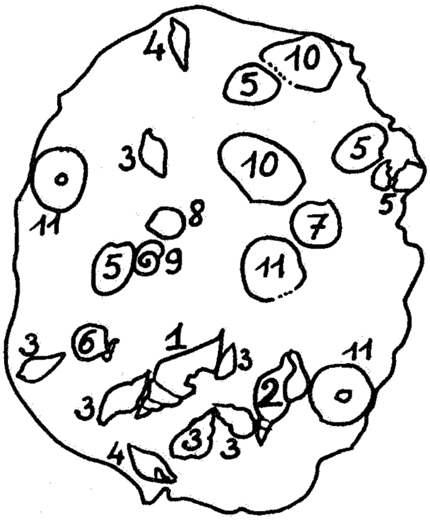


Fig. 159



Preparation nr 59 (Fig. 159).

Age: Lower Pleistocene - Merxemian.
1929: Scaldisian *Sc* (1909: Scaldisian *Sc*).
Lithostratigraphic unit: Sands of Kruisschans.
Locality: Kallo, Verrebroek-dock (Sheet 27e), Antwerp, 1989 (Fig. 162).

Description:

This sample comes from the clayey lower part of the Sands of Kruisschans at 1m above its basis (Fig.161).

-*Neptunea antiqua despecta* (1).
-*Neptunea contraria* (2).
-*Hinia reticosa* (3).
-*Colus curtus* (4).
-*Venerupis (Ruditapes) rhomboides* (5).
-*Aequipecten opercularis* (6).
-*Dosinia lupinus* (7).
-*Natica multipunctata* (8).
-*Calliostoma zizyphinum* (9).
-*Mya arenaria* (10).
-*Tasselia ordamensis* (11), ichnofossil.
-Abundant single valves and bivalves of *Corbula gibba.*

Many shell fragments, and very fine shell grit, clayey sand fragments (derived) mixed with nests of sand and shell grit, suggest a very displaced fauna, due to a high kinetic energy deposit. Most of the gastropods did not have the time to fill up, as they were so quickly covered with shifting sediment.
Later compaction cracked almost all the shells.
Prospection by a common sieving procedure only shows shell fragments and big worn elasmobranch teeth.

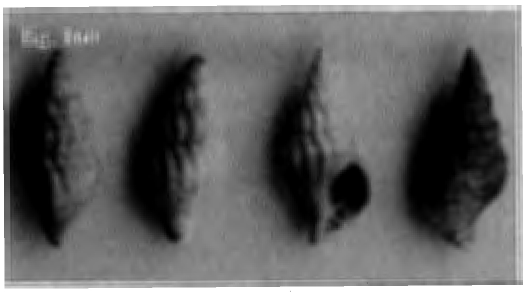
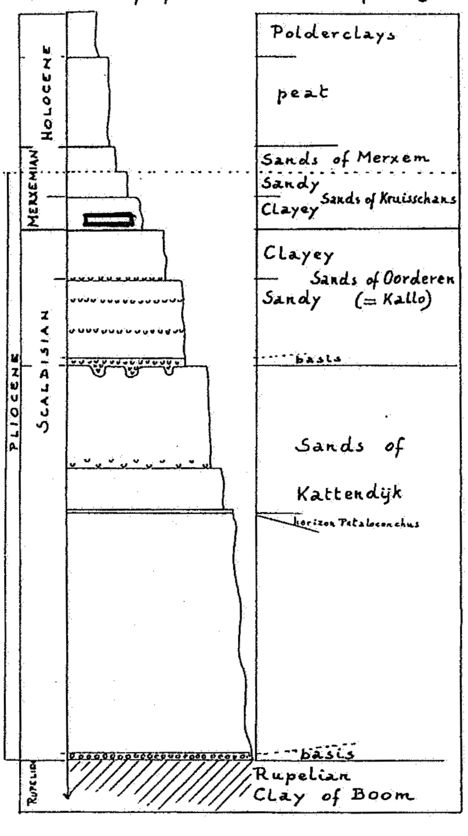


Fig. 160: *Trophonopsis (Pirgos) alveolatus*, a rare gastropod from the same horizon and locality.

fig. 161

Schematic profile Pliocene Antwerpen region



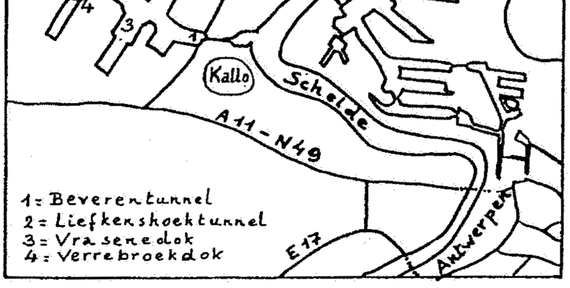
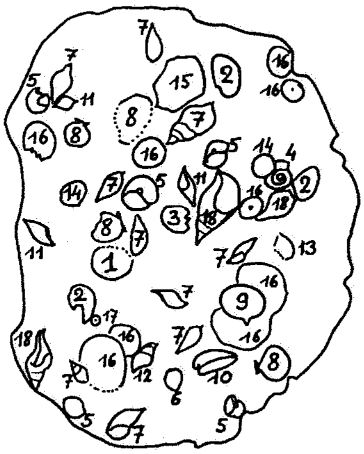


Fig. 163



Preparation nr 38 (Fig. 163).

Age: Lower Pleistocene - Merxemian.
1929: Scaldisian *Sc* (1909: Scaldisian *Sc*).
Lithostratigraphic unit: Sands of Kruisschans.
Locality: Kallo, Verrebroek-dock (Sheet 27e), Antwerp, 1989 (Fig. 164).

Description:

This clayey sample from the lower part of the Sands of Kruisschans, was taken at 2.6m above its basis.

-*Mya arenaria* half hidden (1).
-*Venerupis (Ruditapes) rhomboides* (2).
-*Spisula arcuata* (3).
-*Calliostoma zizyphinum simile* (4).
-*Polinices (Euspira) catenoides* (5).
-*Natica multipunctata* (6).
-*Hinia reticosa* (7).
-*Aequipecten opercularis* (8).
-*Capulus ungaricus* (9).
-*Capulus unguis* (10).
-*Colus curtus* (11).
-*Liomesus dalei* with barnacles (12).
-*Buccinum undatum* (13).
-*Laevicardium (Dinocardium) parkinsoni* (14).
-*Panopea* fragment (15).
-*Tasselia ordamensis* (16).
-Fish vertebra (17).
-*Neptunea contraria* (18).

Many shell fragments and very fine shell grit, mixed with clayey sand fragments, demonstrate a storm deposit. Most of the gastropods were quickly covered with sediment after a storm, but not filled up with it. Later compaction of the sediment cracked many gastropods.

fig. 164

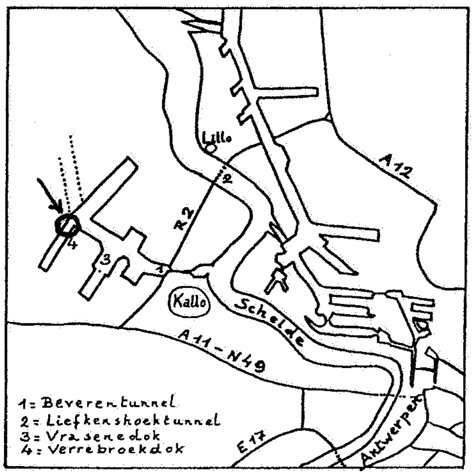


Fig. 165: East wall of Verrebroek-dock, August 1987.

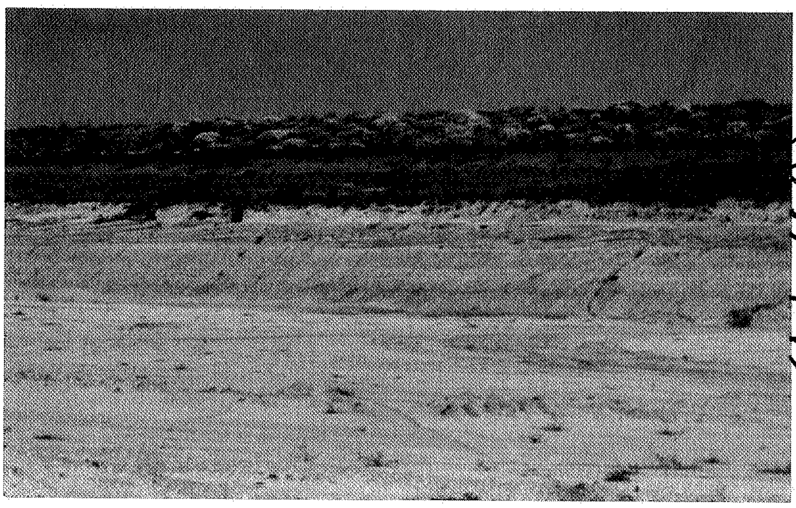


fig. 166

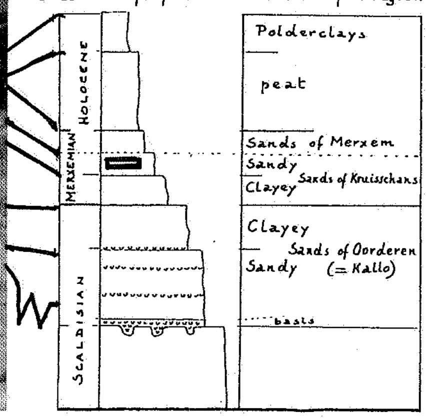


Fig. 167

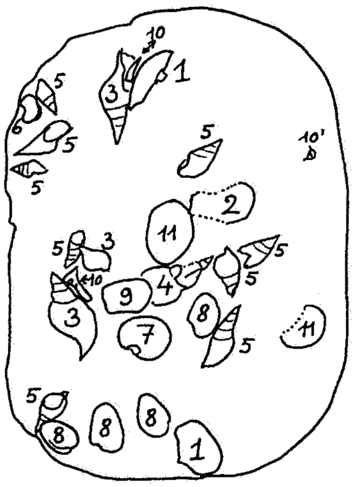
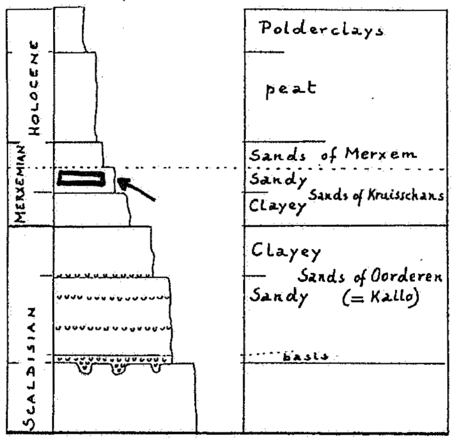


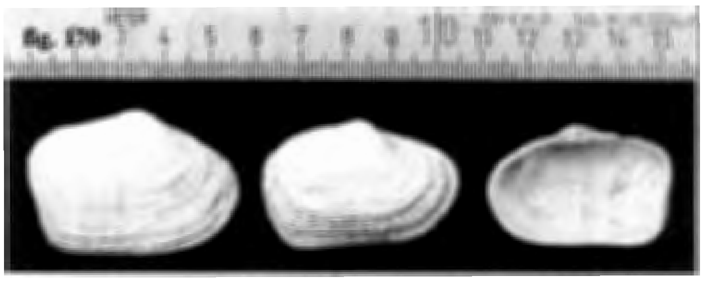
fig. 169

Schematic profile Pliocene Antwerpen region



Preparation nr 36 (Fig. 167 and 168).

Age: Lower Pleistocene, Merxemian.
1929: Scaldisian *Sc* (1909: *Sc*).
Lithostratigraphic unit: Sands of Kruisschans.
Locality: Kallo, Verrebroek-dock (Sheet 27e), Antwerp, 1989 (Fig. 171).



Description:

This preparation comes from 2.70m above the basis of the clayey lower part of the Sands of Kruisschans.

- *Mya arenaria* (1).
- *Mya truncata* (2).
- *Neptunea contraria* (3).
- *Neptunea antiqua despecta* damaged (4).
- *Hinia reticosa* (5).
- *Calliostoma zizyphinum* (6).
- *Polinices (Euspira) catenoides* 54mm large (7).
- *Venerupis (Ruditapes) rhomboides* (8).
- *Panomya trapezoidis* (9 and Fig. 170).
- Fish bones (10) and vertebra (10').
- *Tasselia ordamensis* ichnofossil (11).
- Many *Corbula gibba*, even bivalves.

Many shell fragments and very fine shell grit indicate a storm deposit in a sublittoral environment. Many shells were cracked by compaction of the sediment.

fig. 171

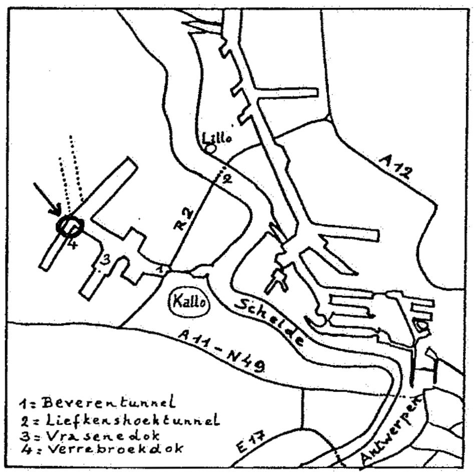
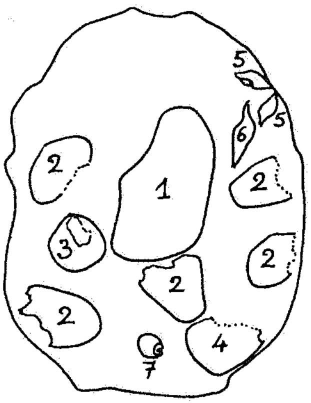


Fig. 172



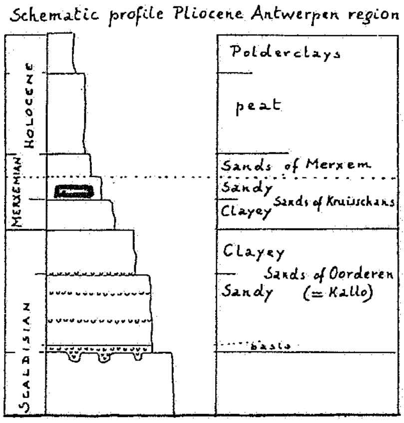


fig. 173

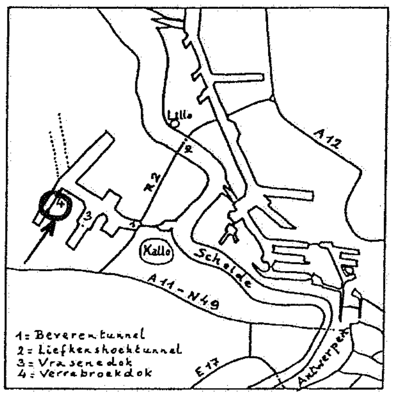


fig. 174

Preparation nr 49 (Fig. 172).

Age: Lower Pleistocene - Merxemian.
1929: Scaldisian *Sc* (1909: Scaldisian *Sc*).
Lithostratigraphic unit: Sands of Kruisschans.
Locality: Kallo, Verrebroek-dock (Sheet 27e), Antwerp, 1987 (Fig. 174).

Description:

This preparation belongs to the basis of the sandy upper part of the Sands of Kruisschans.

-*Panopea faujasi* (1).
-*Mya arenaria*, some are only fragments (2).
-*Laevicardium (Dinocardium) parkinsoni* (3).
-*Spisula arcuata* (4).
-*Hinia reticosa* (5).
-*Colus curtus* (6).
-*Natica multipunctata* (7).
-Many *Corbula gibba*.

This small sandy layer with plenty of molluscs is again a storm deposit with a displaced fauna. It lies on a 3cm thick horizon of compact heavy sea clay, which is surely here at Verrebroek-dock the top layer of the clayey lower section of the Sands of Kruisschans.
Mya arenaria and *Spisula arcuata*, eventually *Dinocardium parkinsoni* are sublittoral burrowers, suggesting a nearby coast.
In this same horizon other sublittoral molluscs, like *Littorina suboperta* and *Nucella lapillus incrassata* are present too.

Fig. 175: Bones of the Gadidae fish: *Melanogrammus conjunctus* of the same locality.

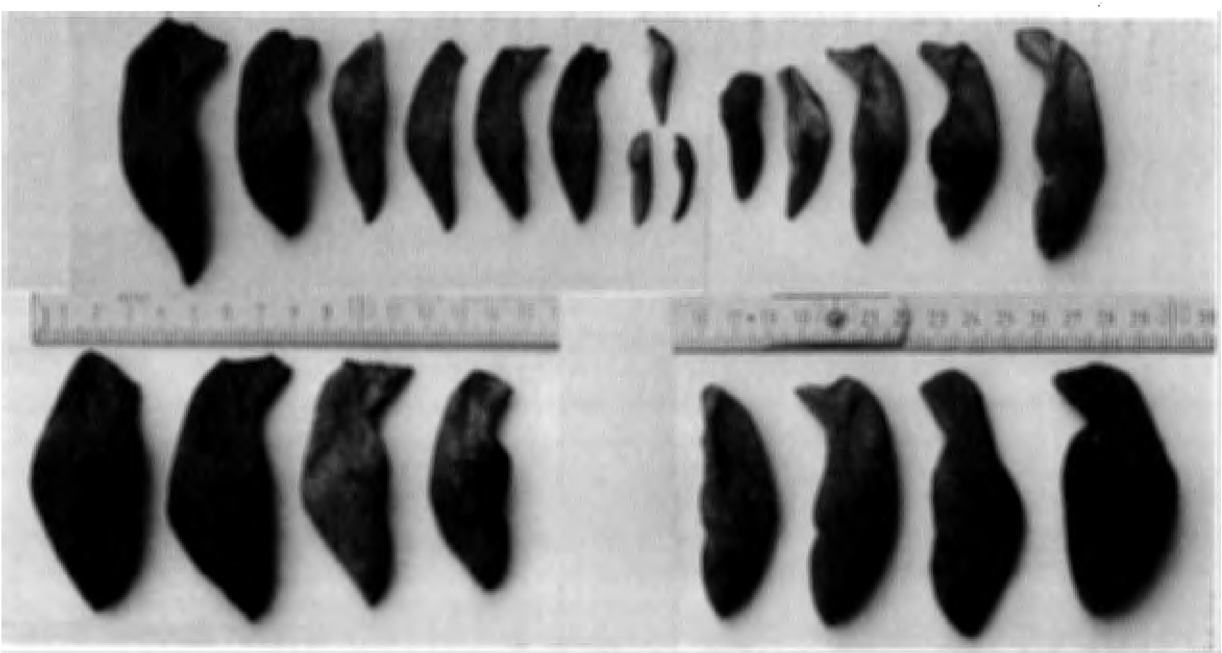
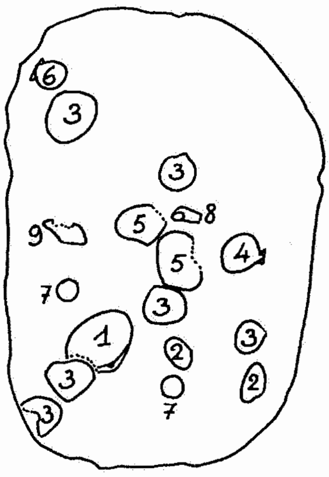


Fig. 176



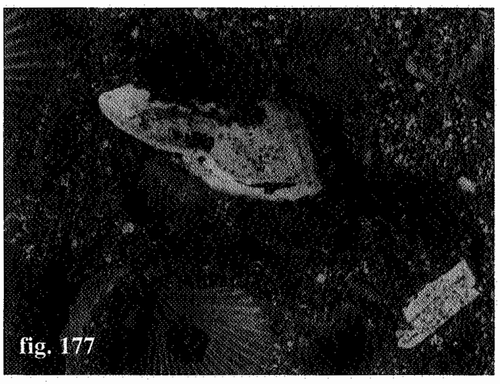


fig. 177

Preparation nr 60 (Fig. 176).

Age: Lower Pleistocene - Merxemian.
1929: Scaldisian *Sc* (1909: Scaldisian *Sc*).
Lithostratigraphic unit: Sands of Merxem.
Locality: Lillo, entrance of the Liefkenshoektunnel (Sheet 15w), at a depth of 6m, 1988 (Fig. 179).

Description:

-*Arctica islandica* (1).
-*Venerupis (Ruditapes) rhomboides* (2).
-*Laevicardium (Dinocardium) parkinsoni* (3).
-Mostly *Aequipecten opercularis* (4).
-*Spisula arcuata* (5).
-Juvenile *Pecten complanatus* (6).
-*Tasselia ordamensis* ichnofossil concretions (7).
-*Turritella* cf. *incrassata* (8).
-*Zirfaea crispata* new to the Belgian Lower Pleistocene fauna (8 and Fig. 177).

Intertidal zonation deposit, with fine shell grit sediment due to ebb and flood kinetic energy and shifting sediment.

fig. 178

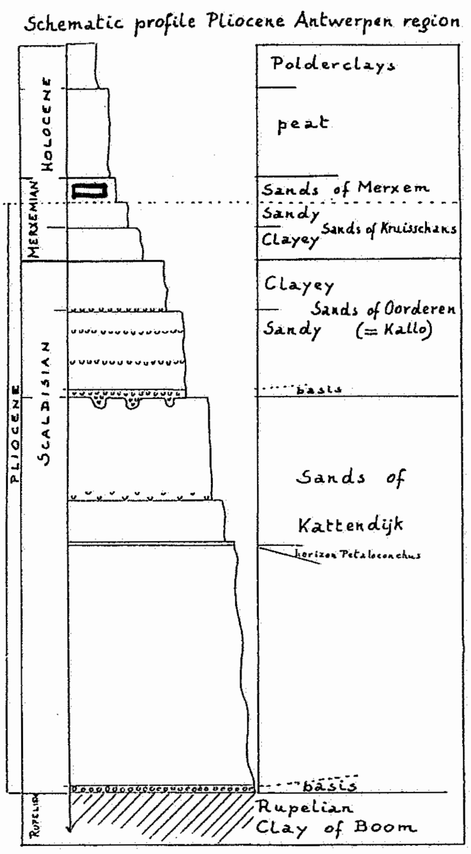


fig. 179

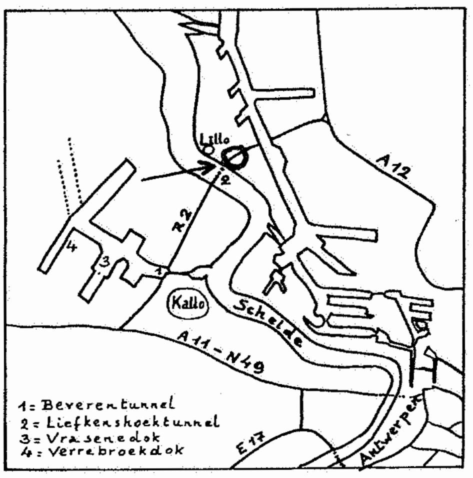


Fig. 180

fig. 183

Preparation nr 50 (Fig. 180).

Age: Lower Pleistocene - Merxemian.
1929: Scaldisian *Sc* (1909: Scaldisian *Sc*).
Lithostratigraphic unit: Sands of Merxem.
Locality: Lillo, entrance of the Liefkenshoektunnel (Sheet 15w), 1988 (Fig. 181).

Description:

-Mostly medium-sized *Aequipecten opercularis*.
-Some *Venerupis (Ruditapes) rhomboides*.

An intertidal zonation deposit with fine shell grit, due to tidal currents. Sedimentation built up in about 2mm layers of fine shell grit and coarse sand, clearly separated by a film of clay; demonstrating tidal currents that washed back and forth four times a day. A high sedimentation growth of 4mm a day is shown on this and following preparation nr 51.
Pogonophorid ichnofossil
Fig. 183: *Tasselia ordamensis*, Berendrecht.
Fig. 184: *Tasselia ordamensis*, Lillo.

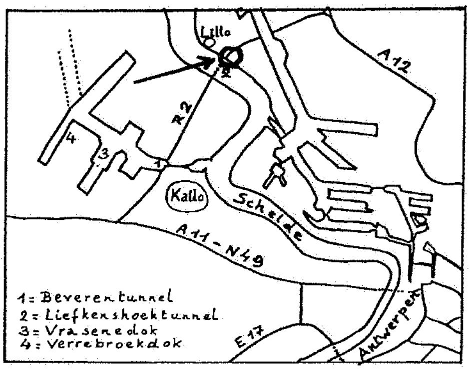
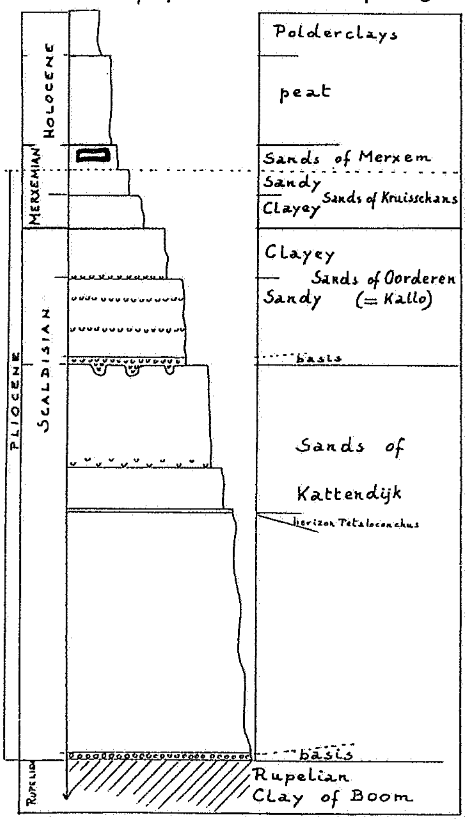


fig. 181

fig. 182

Schematic profile Pliocene Antwerpen region



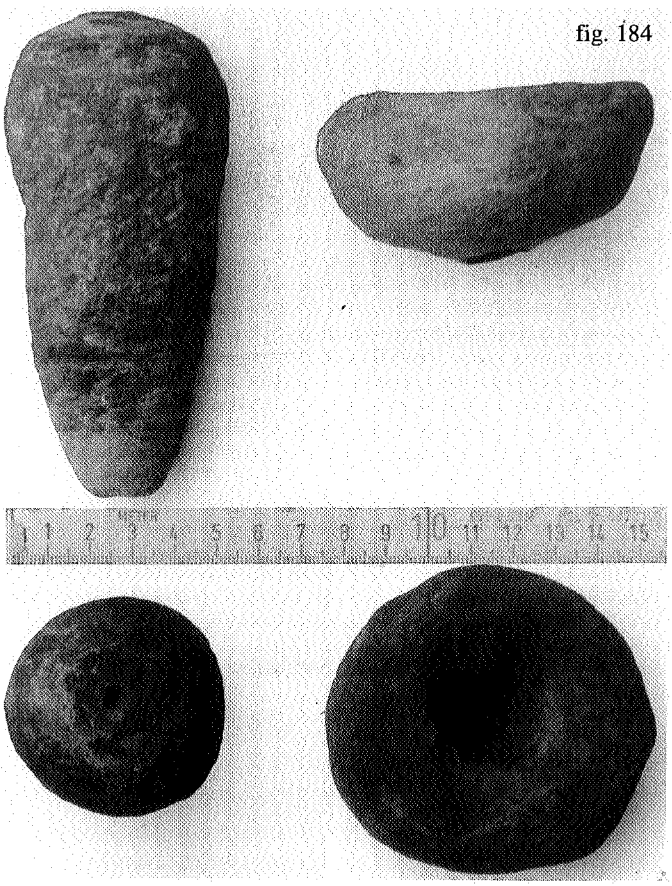


fig. 184

Fig. 185

Preparation nr 51 (Fig. 185).

Age: Lower Pleistocene - Merxemian.
1929: Scaldisian *Sc* (1909: Scaldisian *Sc*).
Lithostratigraphic unit: Sands of Merxem.
Locality: Lillo, entrance of the Liefkenshoektunnel (Sheet 15w), 1988 (Fig. 187).

Description:

-Mostly medium-sized *Aequipecten opercularis*.
-A bivalve *Mya truncata* in live position.

An intertidal zonation deposit, not far away from the seashore. The same remarks as for the preceding preparation nr 50, p. 99.

fig. 186

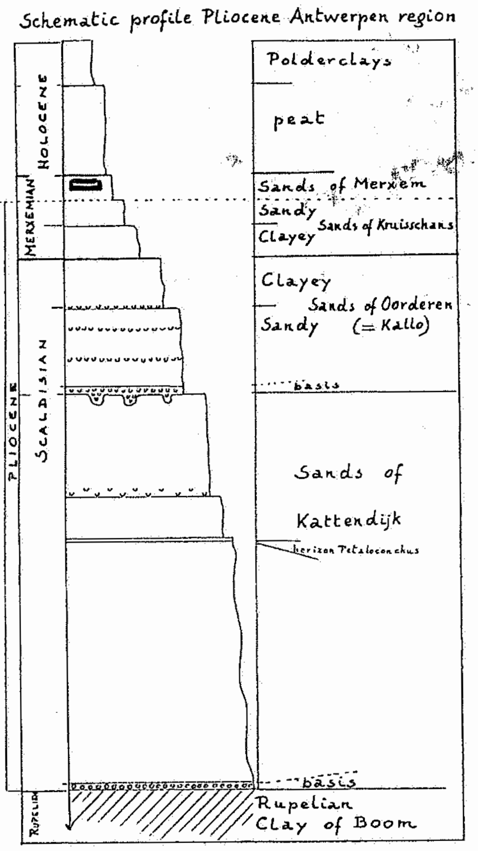


fig. 187

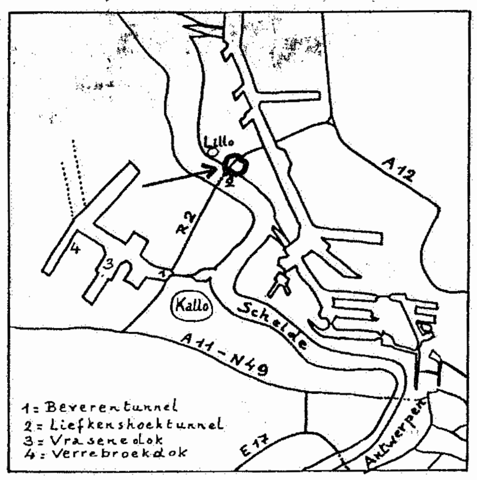
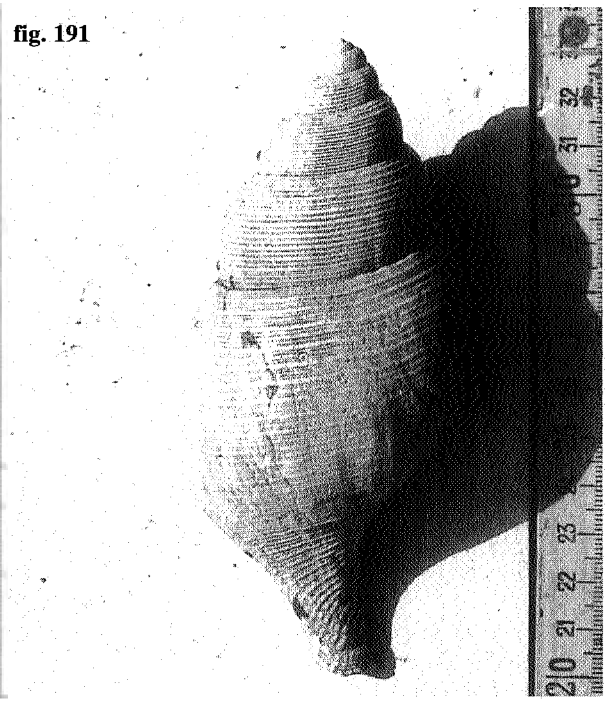


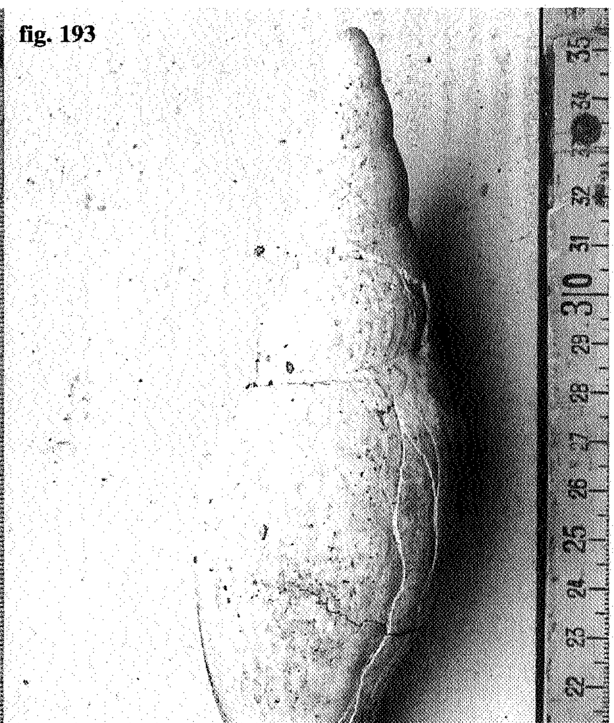
fig. 188

Atrina nov. sp. in press (Marquet and Vervoenen), paratype nr. TCI 5868 (Fig. 188), and paratype nr. TCI 5869 KBIN Collection Brussels, from the sluice entrance at Kallo, same horizon as the three preparations nrs 34, 109 and 61 (p. 66-71). Preparation J. Herman.

fig. 189



Figs. 190 and 191: *Atractodon elegans*, a rare Buccinid from the Sands of Oorderen, Kallo.
Figs. 192 and 193: *Scaphella lamberti*, a very slender specimen from the Sands of Kattendijk, Kallo.



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Systematic Index.

*: not yet specified subgenus

Index of the localities

CONCLUSIONS

Implications for the use of Elasmobranch remains as stratigraphical or paleoecological tool.

All the observations and deductions presented below are geographically (8 localities) or stratigraphically (9 horizons) very punctual. They permit, however, to propose a new interpretative approach of the fine succession of the different taphocoenosis phases which have contributed to the formation of some of the the so-called "shell banks" or "coquilliers" (in French). This has important implications concerning the relative contemporaneity of the vertebrate remains (Elasmobranches or other groups), concentrated in these shelly horizons and formerly considered as homogeneous population communities.
Exceptionally, they may represent a pure biocoenosis, but generally, they were mixed with other remains, derived from older thanatocoenosis of one or more levels.

1. EGEM (53 W), West-Flanders, Lower Eocene, Ypresian, Silt of Kortemark (lower part).

After a calm and quite pure clayey sedimentation phasis (circa 14m a.l.) an eroding channel network of submetric to suprametric scale is observable. These little channels seem to have been quickly filled by light glauconitic silty-sandy material with plenty of *Ditrupa* tubes. It contains an interesting Elasmobranch fauna with possible estuarian influences.

A short new clayey phasis succeeded this first disturbating event and was followed by a more brutal one. *Ditrupa* channel elements were mixed with remains from other shelly layers, and centimetric to decimetric still subangular clay pebbles. This horizon contains the richest Belgian eocene fauna of Elasmobranches.

The dispersion of the shells (esp. those of the bivalves), the fragmentation of all the delicate Teleost bones, and the volume of the clay pebbles suggest a high kinetic event. The quality of the preservation of the otoliths and the Elasmobranch teeth, as well as the relative non-selective sorting of these teeth (1l of sediment contains more than 100 teeth between 0.3 and 50mm), permit to suppose that the duration of the transport was very short. This must also have happened in a very shallow environment. Tidal crustacean carapaces are quite common. The shells of the top of this level are affected by an intense decalcification of unprecised age.

2. AALTER (39 W), West-Flanders, Middle Eocene, Lower Lutetian, Sands of Aalter (upper part).

The sudden appearance of a horizon with *Megacardita*, in such a high density, lying on a thick layer of fine shell-grit with a matrix of fine clayey sands, marks an important ecological change of the environment. The preparation process revealed the live position of these *Megacardita*, and allowed a hypothesis as to the cause of death of the majority of them. It seems their mortality and fragmentation can only be explained by the activity of powerful, but unknown, shell crushing predators.

The sea bottom was so calm during a short period that some little solitary corals could grow on empty *Megacardita* shells. Rare, but perfectly preserved Elasmobranch teeth, mainly of Dasyatids or Myliobatids (Batomorphii) were found in this horizon. The relative scarcity of large Myliobatid teeth make it difficult to sustain the hypothesis that they were the principal shell-crushing predators. Only the adults of big species could have been able to pick up such heavy shells and their methodical crushing would have left obvious scars.

When large quantities of shark teeth, generally rolled and altered, and associated with some silicified tree remains (*Palmoxylon*), are mixed with isolated valves of *Megacardita*, it seems logical to suppose that both molluscs and elasmobranchs are derived from different horizons.

3. MELDERT (72 W) and BALEGEM (70 E), West-Flanders, Middle Eocene, Upper Lutetian, Sands of Lede.

The sampling method of blocks of matrix sediment revealed two new aspects of the taphonomy of the *Nautilus* horizon: possible predation near the surface of the seabed and the frequent occurrence of an almost vertical embedding of the conches, logically due to gas left in some camerae. Observing the abundance of various species in this sediment, which is allied to sunlight, the water must have been shallow. An annual sea trek to this possible spawning place, or an upwelling phenomenon, may have caused the death of the exhausted animals, not being protected by the darkness of their usual deepwater habitat. Although the 5 actual *Nautilus* species lay their eggs in bathyal regions, a nightly trek to the foraging place, as e.g. Meldert or Balegem, was not excluded by the horizontal distance that separated their bathyal habitat from these localities.

The extraordinary high frequency (circa 70%) of the elasmobranch teeth of *Isistius* is also abnormal. The collected teeth (more than 500 specimens) of this "deepwater" little shark are perfectly preserved. They include all the positions of the lower jaws, at all the growing stages, but none of the upper jaws. It is well known that living *Isistius* redigest their own deciduous upper teeth, due to their inward position. If lower teeth in all growing stages are found in the sediment, this means that they come from dead animals and that the upper teeth were originally associated with these. After sieving more than 5 cubic metres of sediment on 0.25mm mesh, this phenomenon could only be explained by the fact that the very fine acuminated teeth of the upper jaws were naturally dispersed further away. The frequency of this deep to mid-deep water shark may only be explained by physico-climatic troubles, such as upwellings.
Another surprising phenomenon is the frequent discovery of dead priacanthid fishes (more than 40 specimens are known, with bones in connection) in conches of the *Nautilus*, at Meldert ... as well as at Balegem (more than 30km from each other).

The following successive conditions may be proposed:
-A rich environment with plenty of foraminifera, pennatulids, bryozoans, crustaceans, echinids and molluscs (esp. ostreids) of undeep waters. The elasmobranch teeth are perfectly preserved but very rare and with a majority of batoids and a few of the common pelagic sharks of the Belgian eocene.
-Abnormal concentration of dying or dead *Nautilus* (circa 1/m^2), mostly adults (only 1 juvenile of 5cm in diameter is known), generally subvertically embedded and associated with plenty of teeth of the "deepwater" shark *Isistius*, and very few other pelagic elasmobranch teeth.
-The *Nautilus* conches were incrusted by ostreid and bryozoan. Considering the growing stages of the ostreids it is difficult to suppose that this phasis lasted more than a few years.
-The empty conches progressively embedded by different bioturbating animals constituted ideal resting and/or nesting places for priacanthid fishes (2 or 3 species, personal communication L. Taverne).
Suddenly they died and their bodies remained, mostly with bones in connection. The discovery of vertebrae, articulated dorsal fin spines, squamosae, fin skeletons etc. is quite common. This means that they were so quickly buried that even all the necrophageous animals had no time to disturb their skeletons completely.
-All this was definitely covered by a relatively fine sandy sediment of shallow water with plenty of molluscs, and small sands echinids.
-A silicification phasis followed, affecting first the covering sediment and progressively the upper part of the *Nautilus* horizon.

4. GELLIK (93 E), Limburg, Oligocene, Rupelian, Sands of Kerniel.

The Sands of Kerniel preparations give a horizontal view of these lenticular shell-grit concentrations. Most of the bivalve shells lie on their unstable curved side, which may be the result of a huge storm.

The following succession is observable:
-On the top of the clayey sands deposit without any evidence of stratification (so bioturbated?) a shell-grit lenticular concentration level appeared.
-At the basis an intense reconcentration of all the small pectinids, principal constituent of the precedent biocoenosis, is observed. This level provides a very poorly diversified fauna of elasmobranch (mainly *Squalus* teeth and very rare Dasyatid teeth). They are progressively more and more mixed with other isolated valves of pelecypods, which suggests a high kinetic environment. So that in the upper part of this shell bank a high quantity of elasmobranch teeth was concentrated (material is comprised between 3 and 70mm). Little sugar plums like flintstone pebble and rare sea mammal bones are associated.
-The environment goes through a calmer period with a quite rapid sedimentation. It presents millions of bioturbation traces, which means they were covered sufficiently quickly by additional sediment, so that they could not be destructed by their producers. Here and there lie dispersed valves of pelecypods including large *Pycnodonte*. One of these demontrates by its bite scars the presence of seacow-like mammals (*Halitherium*), allowing to suppose an undeep environment and possible proximity of large seaweed meadows.

5. BORGERHOUT (28 W), Antwerp, Miocene, Hemmoorian, Sands of Antwerp.

In these preparations most of the bivalve shells lie with their convex face upward, a mechanically more stable position. This may be due only to common bioturbation. The "in situ" character of this thanatocoenosis has been demonstrated by this new preparation method. Also the gradual faunistic change from the lower to the upper part of these *Glycymeris* beds could be shown as to predation on the smaller shell fauna.

Once more it is only in the quite undisturbed microlevels of these *Glycymeris* accumulations that small or larger teeth of perfectly preserved elasmobranch teeth were found. Whole skeletons of sea mammals and extremely rare skeletons of sharks lay just below these accumulations when the sedimentation was intensive in a calm environment.

6. KALLO (27 E), Antwerp, Pliocene, Scaldisian, Sands of Kattendijk to Sands of Oorderen.

Throughout the Belgian Pliocene in the Antwerp Basin, a successive change of fauna has been observed; from the shallow deepwater *Petaloconchus* horizon and the other shelly levels of the Kattendijk sands to a gradual fill-up by a changing sediment type of the whole Pliocene sea, showing a progressive cooling of sea water as well as an increasingly tidal environment.
-The *Petaloconchus* horizon contains an extremely poor density of Elasmobranch teeth: only two native batoids and some pelagic sharks.
-The elasmobranch fauna of the other horizons of the Sands of Kattendijk is quite diversified and includes some interesting squaloids, such as *Somniosus* and *Oxynotus*, and the last representatives of Belgian *Pristiophorus*.
-The Sands of Oorderen contain a very poorly diversified elasmobranch fauna, dominated by a *Raja*, closely related to the *R. clavata*, still living in the North Sea. Occasionally some large pelagic shark teeth of *Isurus*, *Odontaspis* or *Carcharodon* are found.
A rapid sedimentation could explain the perfect fossilization of many cetaceans' or seals' skeletons, such as occasional discovery of pilgrim sharks (teeth vertebrae and branchial elements quite undisturbed).

7.LILLO (15W), Antwerp, Lower Pleistocene, Merxemian, Sands of Kruisschans.

This preparation method demonstrates that the Sands of Kruisschans' deposits considered as shell-grit horizons, in fact result from heavy storm deposits. The mollusc fauna was displaced, but remained intact. It was the later compaction of the sediment that cracked the empty shells. Conventional sieving methods, showing only fragments of shells, led to the misinterpretation of these level as shell-grit.
The extreme scarcity of elasmobranch remains in these levels confirms the hypothesis of the rapidity at which they were formed.

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