

GEOLOGY AND PALAEOLOGY OF A TEMPORARY EXPOSURE OF THE LATE MIOCENE DEURNE SAND MEMBER IN ANTWERPEN (N. BELGIUM)

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(9 figures, 2 tables)

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ABSTRACT. A section of 6.10 m through the Deurne Sand Member (Diest Formation, Late Miocene) in Antwerpen (Antwerp) is described, which has been observed during the construction works of a new hospital building in the southern part of Deurne, and here called “Middelares Hospital Section” after that location. This temporary outcrop section can well be correlated with a similar one which was outcropping some 35 years ago, and was located at some 1.5 km to the NE. It was studied in detail by De Meuter *et al.* (1967), who called it the “Borgerhout-Rivierenhof VII B.R.” section. Since that section was the most relevant of the previously described sections in the Deurne Sand Member, it is here suggested to designate that section as stratotype for the member. Part of the fossil content, mainly the macrofossils (Brachiopoda, Mollusca, Ostracoda, Thoracica, Pisces, Reptilia and Mammalia) is listed. Two species of Terebratulidae (*Pliothyryna sowerbyana* (Nyst, 1843) and *Terebratula* cf. *ampulla* Brocchi, 1814) were recognized. The Mollusca are represented by 24 taxa, of which the Pectinidae are the most common. One undescribed ostracod taxon (*Thaerocythere* sp.) is restricted to the Deurne Sands and can be considered a stratigraphic marker for this member. Fossil Lepadomorpha are recorded for the first time from the Belgian Late Miocene. The *Squalus* sp. from the Deurne Sands closely resembles the *Squalus* sp. from the Gramian of Denmark. Preliminary data about a fairly complete skeleton of a Mysticete whale, probably belonging to the genus *Plesiocetus* Van Beneden (*in* Van Beneden & Gervais, 1880) are given. The recovered specimen of *Ziphirostrum* is characteristic of *Z. laevigatum* and is probably different from *Z. belgicus*. The molluscan fauna seems to point to a shallow environment with swiftly changing currents, moving sand bars and megaripples subjected to tidal currents. Palaeoclimatological data cannot be deduced from the fossils encountered.

KEY-WORDS: Deurne Sand Member, Late Miocene, Antwerpen, Cetacea, *Plesiocetus*, Brachiopoda, Mollusca, Ostracoda, Crustacea, Pisces.

1. Introduction

The Deurne Sand Member of the Diest Formation (Fm), Late Miocene, was formally described by De Meuter & Laga (1970, 1976), who also analysed its foraminiferal content. The invertebrate macrofossils were listed by Glibert & de Heinzelin de Braucourt (1955a, b). This member is found only in a very limited area to the East of the centre of the city of Antwerpen, in the districts Borgerhout and Deurne. Most of this area is now covered with buildings and this member has not

been exposed since the construction of the Main Ring Road ("Grote Ring" [Fig.1: "R1"]) around Antwerpen in the 1960s. In April 2001 the Deurne Sand member was observed in the construction pit for new hospital buildings on the Herentalsebaan in Antwerpen (Fig. 2). One of the important discoveries was a more or less complete skeleton of a mysticete whale. Besides this one, parts of other cetacean skeletons were recovered. Although the aquatic mammal fauna of the region around Antwerpen is extraordinarily rich, this is one of the few skeletal remains whose exact stratigraphy and

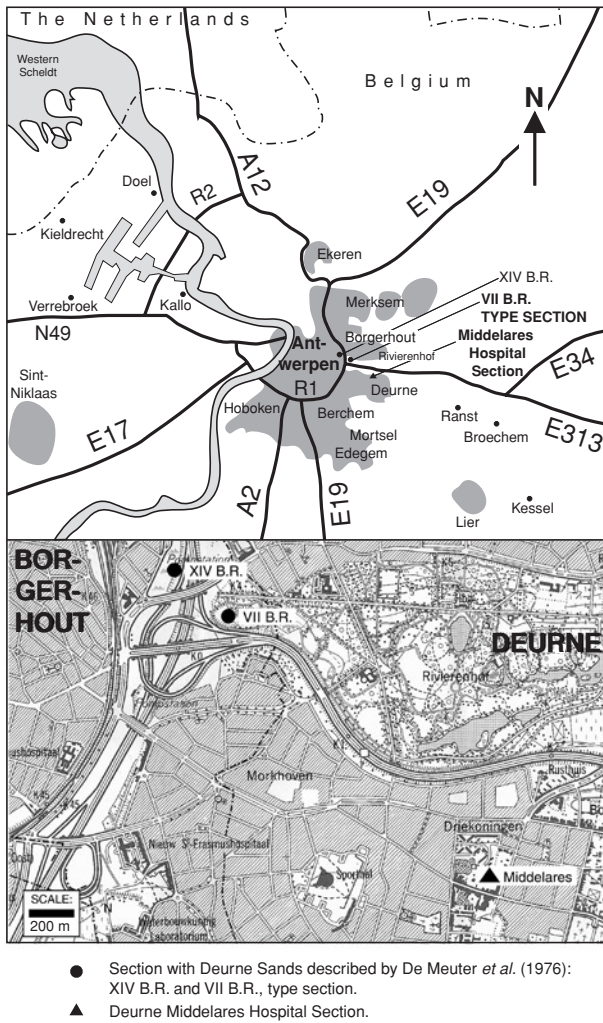


Figure 1: Location of sections with Deurne Sands.

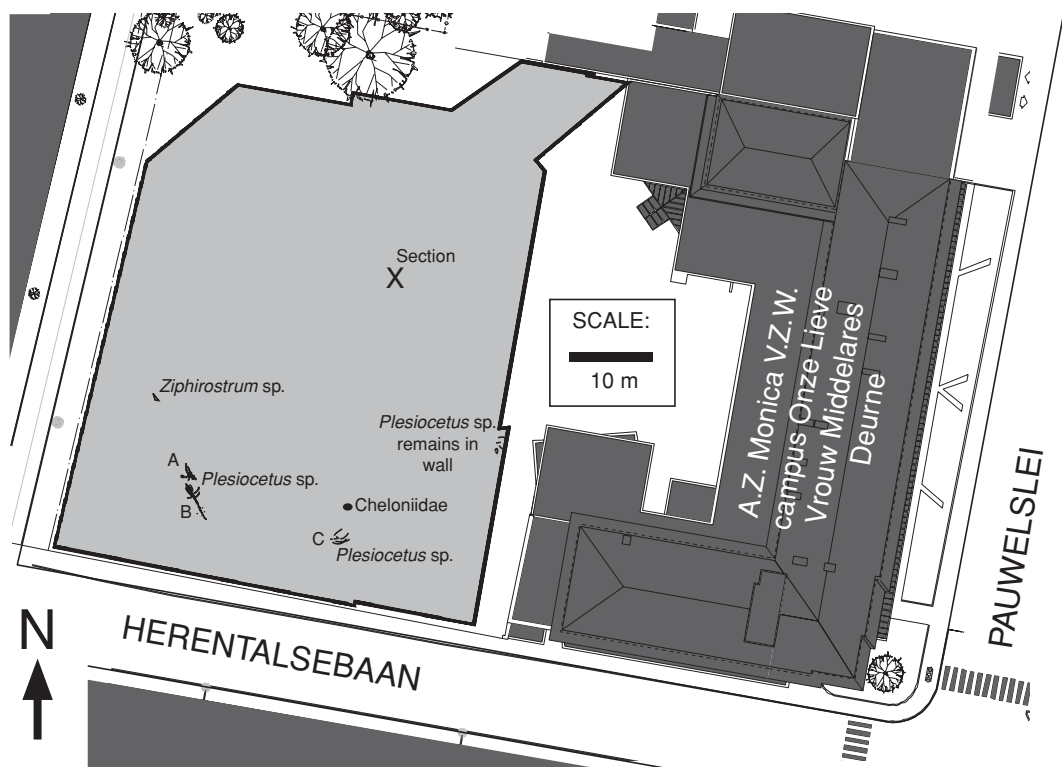


Figure 2: Location of section and vertebrate remains.

taphonomy was recorded. A preliminary report of this discovery as well as further observations on the Deurne Sand Member are presented.

The locality investigated is a building site for a new wing of the Algemeen Ziekenhuis Monica v.z.w., campus Onze Lieve Vrouw Middelares Deurne (in the present text cited as Middelares Hospital Section), on the Herentalsebaan in the district Deurne, Antwerpen (Fig. 1). The Lambert coordinates of the section are $x = 157.080$, $y = 210.700$; altitude 7.5 metres NOP (sheet Borgerhout 15/4, 1969, scale 1:10.000).

2. Material and methods

The section was measured in the eastern part of the construction pit and was completed by a boring with an Edelman auger to a depth of 10.80 m (Fig. 3). Thirty nine samples for microfossils were taken at intervals of 10 to 20 cm throughout the section, starting below the reworked Lillo Fm. downwards. Their contents of Foraminifera and of some further microfossils are to be described in following reports. Here we describe the occurrences of Brachiopoda, Mollusca, Ostracoda, Crustacea, Pisces, Reptilia and Cetacea. Large samples were taken near the top of the Deurne Sand Member and at the bottom of the construction pit at 6.80 m below surface.

The most complete whale skeleton was found at a depth of 2 m below the top of the Deurne Sand Member, in the southeastern section of the construction pit, in two clusters of bones at short distances from each other. Its

position in the sediment was recorded on drawings and photographs. The skeleton is now being cleaned and consolidated; it will be exhibited in the new hospital.

3. The section

3.1 Description

The lithological section was exposed to a depth of 6.80 m; a hand boring was performed from 6.80 m to 10.80 m. The following levels were distinguished from top to basis (Fig. 3).

- level a: 0.00 - 3.30 m Remnants of buildings.
 level b: 3.30 - 4.00 m Grey to red-brown loam without fossils.
 level c: 4.00 - 4.20 m Crag in matrix of clayey sand to clay, greyish to red coloured, with mostly broken shells and at its base derived whale bones, shark teeth and light grey sandstones; this level is variable in thickness.
 level d: 4.20 - 5.80 m Rather coarse grey-green glauconitic sand, strongly bioturbated (ichnogenus *Ophiomorpha*), containing lenticles of clay and pure glauconite as well as abundant Bryozoa, tubes of the polychaete *Ditrupa* sp., Echinoidea, Crustacea (Thoracica, Lepadomorpha), scarce otoliths, very scarce Gastropoda, more numerous Bivalvia and driftwood.
 level e: 5.80 - 6.60 m Rather coarse grey-green glauconitic sand with dispersed fossils, not bioturbated, with scattered light grey friable sandstones, and locally in its lower part concentrations of shark teeth and phosphatic nodules.
 level f: 6.60 - 6.70 m Rather coarse grey-green glauconitic sand containing lots of Brachiopoda (mainly *Pliothyrina sowerbyana* (Nyst, 1843), as described by Van Roy (1980)) and Bivalvia (mainly Pectinidae, which were dispersed in pockets), scarce shark teeth, whale bones, driftwood and scattered light grey, friable sandstones.
 level g: 6.70 - 9.30 m Rather coarse grey-green glauconitic decalcified sand.
 level h: 9.30 - 9.80 m Rather coarse grey-green glauconitic sand with dispersed gravel and phosphatic nodules.
 level i: 9.80 - 10.80 m Very fine, dark grey glauconitic sand with remains of *Glycymeris* sp.

Interpretation / Stratigraphy

- Levels a to b Pleistocene to Recent.
 Level c Reworked Kattendijk and Lillo Fms, Pliocene.
 Levels d to f Deurne Sand Member, Diest Fm., Late Miocene.
 Level g Supposedly Deurne Sand Member, Diest Fm., Late Miocene.

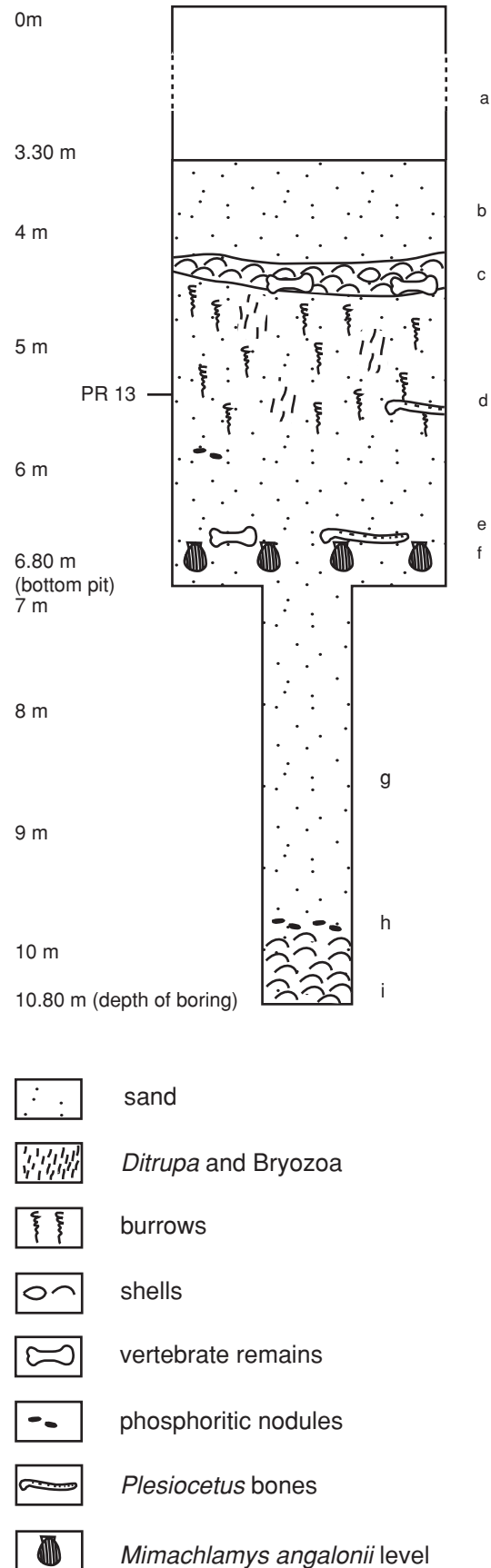


Figure 3: Section at Middelares Hospital. Upper parts: exposed in construction pit. Lower part: Edelman boring.

- Level h Supposedly base of the Deurne Sand Member, Diest Fm., Late Miocene.
 Level i Antwerpen Sand Member, Berchem Fm., Middle Miocene.

Level d is characterized by Bryozoa and concentrations of *Ditrupa* sp. Such an association is typical of the Deurne Sand Member as defined by De Meuter & Laga (1976). Moreover the assignment of levels d to f to the Deurne Sand Member is confirmed by their foraminiferal content (unpublished data). The biostratigraphic position of levels g and h could not be ascertained by micropalaeontological investigation, due to decalcification. However the sedimentation is continuous throughout the levels d to h. For this reason the latter levels are referred to the Deurne Sand Member. The placement of the *Glycymeris* sp. bed (level i) within the Antwerpen Sand Member is confirmed by the investigation of the foraminiferal content (unpublished data).

3.2 Discussion

The type locality of the Deurne Sand Member is Deurne, Antwerpen, but no real type-section has been indicated.

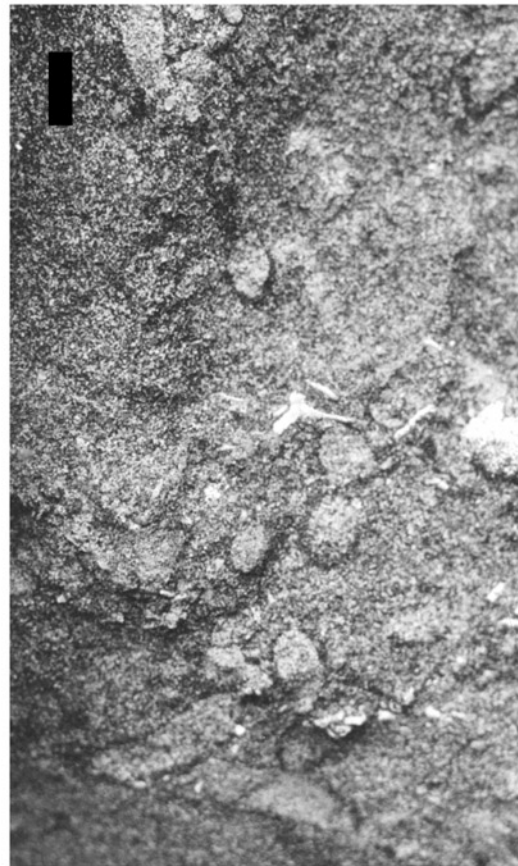
Indeed, Glibert & de Heinzelin de Braucourt (1955a, Fig. 2) only gave a composite section, based on observations of Murlon (1876) at four different locations in Borgerhout and Deurne. De Meuter & Laga (1976) mentioned “Deurne” as type-locality and “temporary exposures of shallow excavations at Deurne” as type-section. From the studied sections in the type area, the temporary exposure VII B.R. (x = 155.860; y = 211.910), figured and described by De Meuter *et al.* (1967, Fig. 2, section A), De Meuter & Laga (1970, Text-fig. 1) and De Meuter *et al.* (1976, Fig. 17), is probably the most relevant one. Therefore we designate this section as the stratotype. Thus the here described “Middelares Hospital Section” (Figs 1 – 3) is situated about 1.5 km to the SE from the stratotype section.

In their description, De Meuter *et al.* (1976) did not distinguish between the Kattendijk Fm. and the gravel at its basis. This level was observed by K. Hoedemakers and R. Marquet in temporary exposures during construction works on a new exit of the Main Ring Road in 1986. It consisted of yellowish sand with sandstones, containing *Ditrupa*, Brachiopoda, Bryozoa and Mollusca, pebbles, shells, bones and black nodules often containing steinkerns of Mollusca. Three parts consequently seemed to be present:



Photograph: J. Herman

Scale bar: 10 cm



Photograph: M. Bosselaers

Scale bar: 1 cm

Figure 4: Ophiomorpha burrows.

1) the sandstones with *Ditrupa* were probably derived from the Deurne Sand: identical sandstones were observed in the Middelaes Hospital Section;

2) the shells and part of the shark teeth and bones are autochthonous, but represent a fauna older than the Pliocene, as illustrated by the presence of *Fissidentalium floratum* (auct. non Partsch in Hörnes, 1856), which occurs in the North Sea basin only in the Langenfeldian and Syltian stages, Middle and Late Miocene of northern Germany (this taxon was not discovered in the studied section). The material of the latter is too badly preserved to allow distinction between the subspecies as defined by Janssen (1989);

3) the black nodules were found separately in a level at Broechem, to the southeast of Antwerpen city and described by Marquet (1980) as a Pliocene assemblage. This level was not observed in the Middelaes Hospital Section, but remains occurred in the basal level of the derived Pliocene crag on top of the Deurne Sand Member. This level contains typical fossils from the complete Belgian Pliocene. Vandenberghe *et al.* (1998) placed the Deurne Sands in the Late Miocene Tortonian.

In a matrix of grey-green coarse glauconitic and bioturbated sand numerous concentrations of Bryozoa and *Ditrupa* were observed in layer d (Fig. 5). This type of sedimentation, containing such an assemblage, is characteristic of the Deurne Sand Member as described by De Meuter *et al.* (1976). The Deurne Sand Member in the latter sections attained a thickness of at most one metre. The Middelaes Hospital Section however contained continuous sedimentation over 5.60 m (layers d – h), of which 2.60 m were observed in the construction pit. This part of the section is therefore entirely referred to the Deurne Sand Member. In the borehole, at a depth of 9.80 metres, a dense layer of *Glycymeris* sp. was encountered (Fig. 3, layer i). This layer is interpreted as the top of the Antwerpen Sand Member. The top of the Deurne Sand Member in the Middelaes Hospital Section was uncomformably overlain by a layer of reworked Pliocene shells (layer c).

4. The fauna

4.1 Brachiopoda (J. Herman)

In the deposit studied three species of Brachiopoda are abundant: two species of Terebratulidae (restricted to level f): *Pliothyryna sowerbyana* (Nyst, 1843) and *Terebratula* cf. *ampulla* Brocchi, 1814 and one *Lingula* sp. This association seems to be typical of the Deurne Sands.

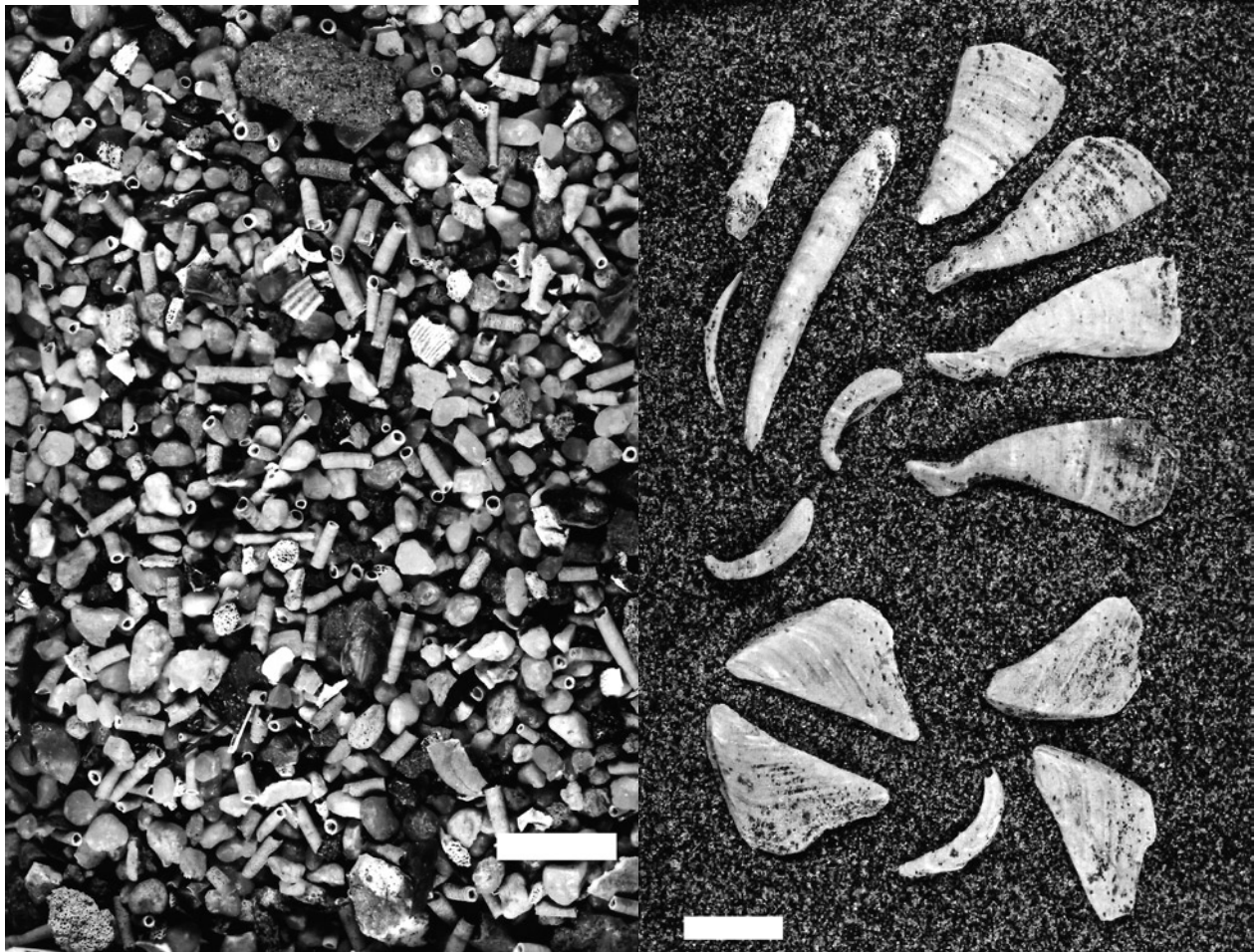
4.2 Mollusca (R. Marquet)

The mollusc fauna of the Deurne Sands at the locality discussed is scant and consists of 19 species of Bivalvia and five species of Gastropoda (Table 1). Fifteen

species are represented by one or few specimens resp. fragments, and only eight by more than ten specimens. Most common are Pectinidae, which occurred dispersed in level f (Fig. 3), often together with bones and fossil driftwood. *Mimachlamys angelonii* (de Stefani & Pantanelli, 1880) and *Pseudamussium inflexum* (Poli, 1795) are the most common species and the only ones to be found with both valves articulated. The dominance of Pectinidae in the fauna is striking, while Gastropoda are particularly scarce. Pectinidae are free swimming species, while the Gastropoda present in the section are benthic. From infaunal genera such as *Panopea* or *Venus* only eroded fragments were recovered. This seems to point to an environment with swiftly moving sand bars and little or no autochthonous fauna or flora present. The gastropod *Tornus belgicus belgicus* (Glibert, 1949) is new for the Miocene of Belgium, having been found previously only in Pliocene deposits; another subspecies however occurs in the Miocene of the Paratethys. *Goodallia laevigata* (Lehmann, 1885) is also recorded for the first time here in the Deurne Sands; at other localities it is a common species in the Antwerpen Sand Member of the Berchem Fm. Fourteen of the species recorded have previously been collected in both the Miocene and Pliocene of Belgium, nine of them (among

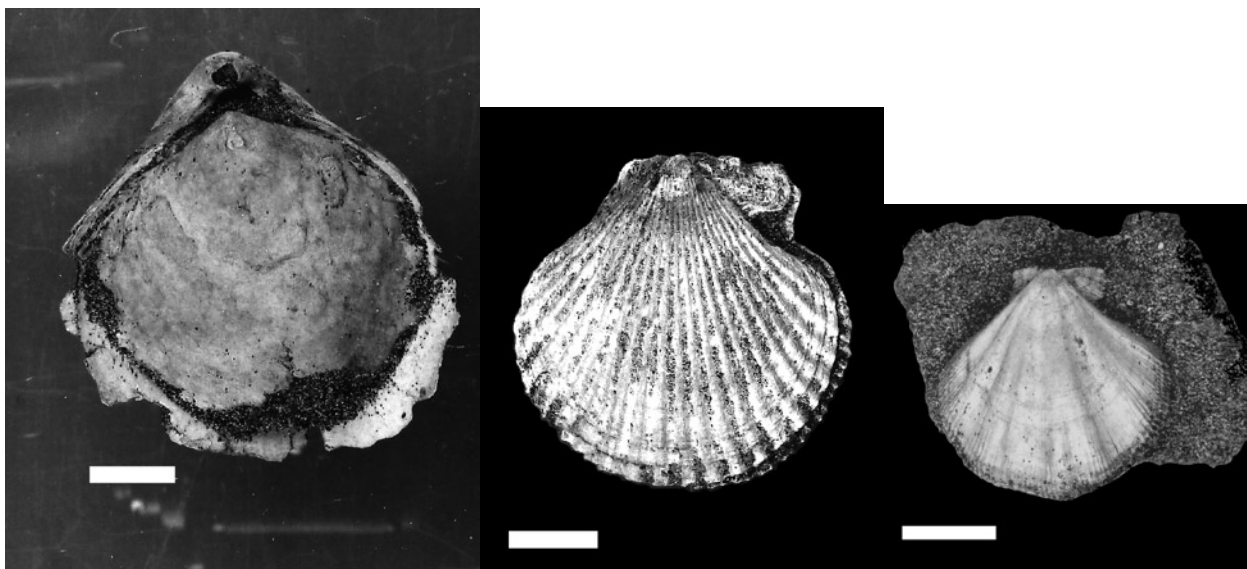
Family	Species	Occurrence
Bivalvia		
Nuculidae	<i>Nucula jeffreysi</i> Bellardi, 1875	r - M
Glycymerididae	<i>Glycymeris obovata baldii</i> Glibert & Van de Poel, 1965	r - M
Mytilidae	<i>Modiolula phaseolina</i> (Philippi, 1844)	c M/P
Pectinidae	<i>Mimachlamys angelonii</i> (de Stefani & Pantanelli, 1880)	c - M
	<i>Pseudamussium inflexum</i> (Poli, 1795)	c M/P
	<i>Pseudamussium lilli</i> (Pusch, 1837)	c M/P
	<i>Flabelliptecten duwelzi</i> (Nyst, 1861)	r - M
Anomiidae	<i>Pododesmus squamula</i> (Linnaeus, 1758)	c M/P
Limidae	<i>Limea strigillata</i> (Brocchi, 1814)	c - M
Gryphaeidae	<i>Neopycnodonte navicularis</i> (Brocchi, 1814)	c - M
Erycinidae	<i>Semierycina kautskyi</i> (Glibert, 1945)	r M/P
Lucinidae	<i>Lucinoma borealis</i> (Linnaeus, 1758)	r M/P
Astartidae	<i>Goodallia waeli</i> (Glibert, 1945)	c - M
	<i>Goodallia angulata</i> (Lehmann, 1885)	r M/? P
Veneridae	<i>Venus multilamella</i> Lamarck, 1818?	fr - M
	<i>Gouldia minima</i> (Montagu, 1803)	r M/P
Hiatellidae	<i>Panopea angusta inflata</i> (Goldfuss, 1841) ?	fr - M
	<i>Hiatella arctica</i> (Linnaeus, 1758)	fr M/P
Teredinidae	<i>Teredo</i> sp.	fr M/P
Gastropoda		
Tornidae	<i>Tornus belgicus belgicus</i> (Glibert, 1949)	r - P
Vermetidae	<i>Bivonia triquetra</i> (Bivona, 1832)	r M/P
	<i>Petalococonchus glomeratus</i> (Linnaeus, 1758)	r M/P
Epitoniidae	<i>Epitonium frondiculatum</i> (Wood, 1848)	r M/P
Pyramidellidae	<i>Odostomia</i> cf. <i>conoidea</i> (Brocchi, 1814)	fr M/P

Table 1: Mollusca recorded in the Deurne Sand Member in Deurne, fr = fragments, r = rare (less than 10 individuals), c = common (more than 10 individuals). M = exclusively recorded from Miocene deposits in Belgium, P = exclusively recorded from Pliocene deposits in Belgium (until now), M/P = present both in Mio- and Pliocene. All collection R. Marquet.



A: *Ditrupa* sp. and Bryozoa.

B: *Acroscaepellum* sp.



C: *Terebratula* cf. *ampulla*
Brocchi, 1814

D: *Mimachlamys angelonii*
(de Stefani & Pantanelli, 1880)

E: *Pseudamusium inflexum*
(Poli, 1795)

Photographs: J. Herman

Figure 5: Some typical invertebrates from the Deurne Sands at Middelares Hospital. Scale bar = 1 cm.

5a) *Ditrupa* sp. and Bryozoa; b) ? *Acroscaepellum* sp.; c) *Terebratula* cf. *ampulla* (Brocchi, 1814); d) *Mimachlamys angelonii* de Stefani & Pantanelli, 1880 e) *Pseudamusium inflexum* Poli, 1795.

them *M. angelonii*) were until now known in Miocene deposits only and one in Pliocene deposits only. There is some indication that *G. laevigata* occurs in the Pliocene; indeed, very similar specimens are present in the Oorderen Sand Member (Lillo Fm.) of Kallo and Doel (prov. Oost-Vlaanderen, Belgium), but their systematic attribution is still being studied. The molluscan fauna was identified using the publications of Glibert & de Heinzelin de Braucourt (1955 a, b), Glibert (1945, 1952) and Janssen (1984)

4.3 Ostracoda (K. Wouters)

The ostracod content of one sample (PR13), taken at the depth interval of 5.30 m – 5.40 m (Fig. 3), was studied. This sample yielded 53 valves and carapaces, belonging to 13 species. The material is well preserved. The following species were found (table 2).

Microcytherura broeckiana (Brady, 1878), three valves. This species has already been mentioned from Miocene deposits of the Antwerp Crag by Brady (1878), and was later found by Wouters (1978) as a rather common species in the Miocene and Early Pliocene of Belgium. The presence of *Callistocythere* sp. (one carapace) in the studied material is interesting, because *Callistocythere* species are extremely rare in the Belgian Miocene, and until now had never been observed in the Deurne Sand Member. *Cytheridea hoerstgenensis* Bassiouni, 1962 (one carapace) is a rather common species in the Miocene of Belgium and Germany. *Sarsicytheridea lienenklausi* (Kuiper, 1918) (11 valves, two carapaces) is a very common species in Belgium, The Netherlands (Kuiper, 1918) and Germany (Bassiouni, 1962; Uffenorde, 1981), where it is restricted to the Miocene. *Pontocythere lithodomoides* (Bosquet, 1852) (seven valves) is very common in Miocene and Pliocene deposits of the North Sea basin. The importance of this species in the evolutionary lineage *P. lithodomoides*-*P. elongata* was illustrated by Wouters (1976). The Miocene representatives of this lineage all belong to *P. lithodomoides*.

Pterygocythereis sp. (one valve) is relatively rare, occurring in the Deurne Sand Member and in the Kattendijk Fm. The species still needs to be named and described. *Muellerina latimarginata* (Speyer, 1863) (12 valves) is a very common species in the Belgian Miocene. *M. latimarginata*, originated in the Late Oligocene and is a part of the evolutionary lineage leading to the Recent Atlantic species *M. abyssicola* (Sars, 1866) (Wouters, 1979). *Muellerina*-species appear to be useful for the biostratigraphical zonation of the Pliocene of northwestern Europe, because of the rapid specific diversification in the Pliocene, as was shown by Wood & Whatley (1996, 1997). *Hermanites excancellata* (Neviani, 1928) (five valves), is a rare species in the Miocene of Belgium; it is unknown from the Pliocene. *Cletocythereis jonesi* (Wood *et al.*, 1992) (three valves) was originally described

from the Coralline Crag at Sutton Knoll, Suffolk. In Belgium it occurs in the Deurne Sand Member, in the Kattendijk Fm. and in the Luchtbal Sand Member, in the Kruisschans Sand Member and in the Merksem Sand Member. *Thaerocythere* sp. (one carapace): the presence of this (still undescribed) species in the studied material is important, it has never been observed in other deposits than in the Deurne Sand Member and is therefore considered a stratigraphic marker for this member. *Flexus* sp. (one carapace): this (undescribed) species occurs in the Deurne Sand Member, in the Kattendijk Fm. and in the Luchtbal Sand Member. Until now it has not been observed in the Neogene of the UK, The Netherlands or Germany. *Loxoconcha* sp. (two valves) is another (undescribed) species, common in the Miocene of Belgium. *Kuiperiana latissima* (Brady, 1878) (three valves), was described from the Antwerp Crag. It is a very rare species in the Antwerpen Sand Member and Deurne Sand Member (Wouters, 1978).

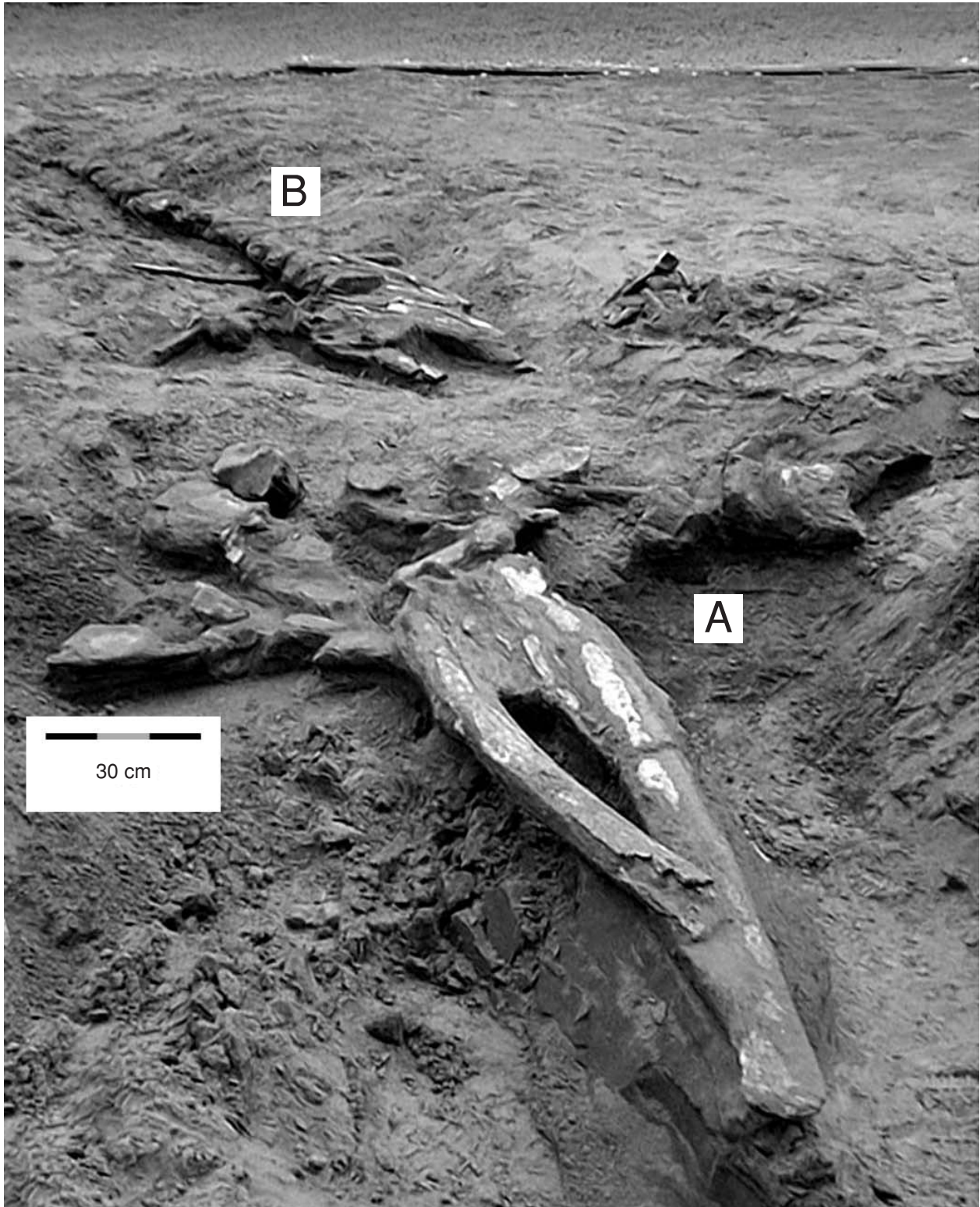
The observed species (Table 2) clearly point to the Deurne Sand Member (Diest Fm, Late Miocene). Especially the presence of *Thaerocythere* sp. is significant. When establishing a new Neogene ostracod-based biostratigraphy on the occurrences of species of the genera *Muellerina* and *Thaerocythere*, Wood & Whatley (1996, 1997) mention only three Late Miocene *Thaerocythere* species, namely *Th. vermiculata*, *Th. biformis* and *Th. woutersi*. *Thaerocythere* sp. from the Deurne Sand Member does not figure in this biostratigraphical scheme.

Species	E	H	A	Z	D	K
<i>Microcytherura broeckiana</i>	+	+	+	+	+	+
<i>Callistocythere</i> sp.					+	
<i>Cytheridea hoerstgenensis</i>	+	+	+		+	
<i>Sarsicytheridea lienenklausi</i>	+	+	+	+	+	
<i>Pontocythere lithodomoides</i>	+	+	+	+	+	+
<i>Pterygocythereis</i> sp.					+	+
<i>Muellerina latimarginata</i>	+	+	+	+	+	
<i>Hermanites excancellata</i>	+		+	+	+	+
<i>Cletocythereis jonesi</i>					+	+
<i>Thaerocythere</i> sp.					+	
<i>Flexus</i> sp.					+	+
<i>Loxoconcha</i> sp.	+	+	+	+	+	
<i>Kuiperiana latissima</i>			+		+	

Table 2: Ostracoda collected in the Deurne Middelaars Hospital Section, with their stratigraphic distribution; E = Edegem Sand Member, H = Houthaelen Sand Member, A = Antwerpen Sand Member, Z = Zonderschot Sand Member (all Berchem Fm.), D = Deurne Sand Member (Diest Fm.), K = Kattendijk Fm.

4.4 Crustacea (*Thoracica*) (J. Herman)

In a small pocket 20 cm below the *Ditrupe* level (Fig. 3: level d) the following plates of the theca of a large scaphellid cirriped were discovered, almost in



Photograph: D. Wuyts

Figure 6: Clusters "A" and "B" of the *Plesiocetus* skeleton.

connection: one very elongated carina, four scutae, four tergim, one rostral, three carinolateral and/or lower lateral plates. This unique specimen shows some affinities with species of the genus *Arcoscalpellum* Hoek, 1907 (Fig. 5B). It is the first record of a fossil Lepadomorpha in the Belgian Late Miocene.

4.5 Pisces (K. Hoedemakers)

Levels d and f of the section were extensively sampled, but yielded few fish fossils. Elasmobranch teeth were very scarce, only seven taxa could be recognised: *Isurus (Macrorhizodus) hastalis* (Agassiz, 1843), *Isurus desori*

(Agassiz, 1844), *Squalus* sp., *Squatina* sp., *Carcharias* sp., *Pristiophorus* sp. (rostral teeth), and *Raja* sp. Of these, *Squalus* sp. and *Pristiophorus* sp. have not been mentioned before from the Miocene of Belgium, although teeth of both genera have been found in Oligocene and Pliocene deposits. Moreover the *Squalus* sp. teeth of both the Deurne Sand Member and the Gram Fm. of the Gram claypit (Denmark, stratotype of the Gramian which is Late Serravallian - Tortonian; Laursen *et al.*, 1998) show identical features which differ from teeth of older and younger deposits (unpublished data).

Teleost fishes (otoliths) are represented by four taxa only: *Gadiculus irregularis* (Gaemers, 1973), *Trisopterus spectabilis* (Koken, 1891), *Gobius* sp. and *Saurida* sp., the last two taxa being new for the Deurne Sand Member. *T. spectabilis* is the most common species, all other taxa are represented by one or a few specimens only.

4.6 Reptilia (M. Bosselaers)

Near the "C" cluster of the whale skeletons, four rib fragments of a turtle (family Cheloniidae?) have been found (Fig. 2).

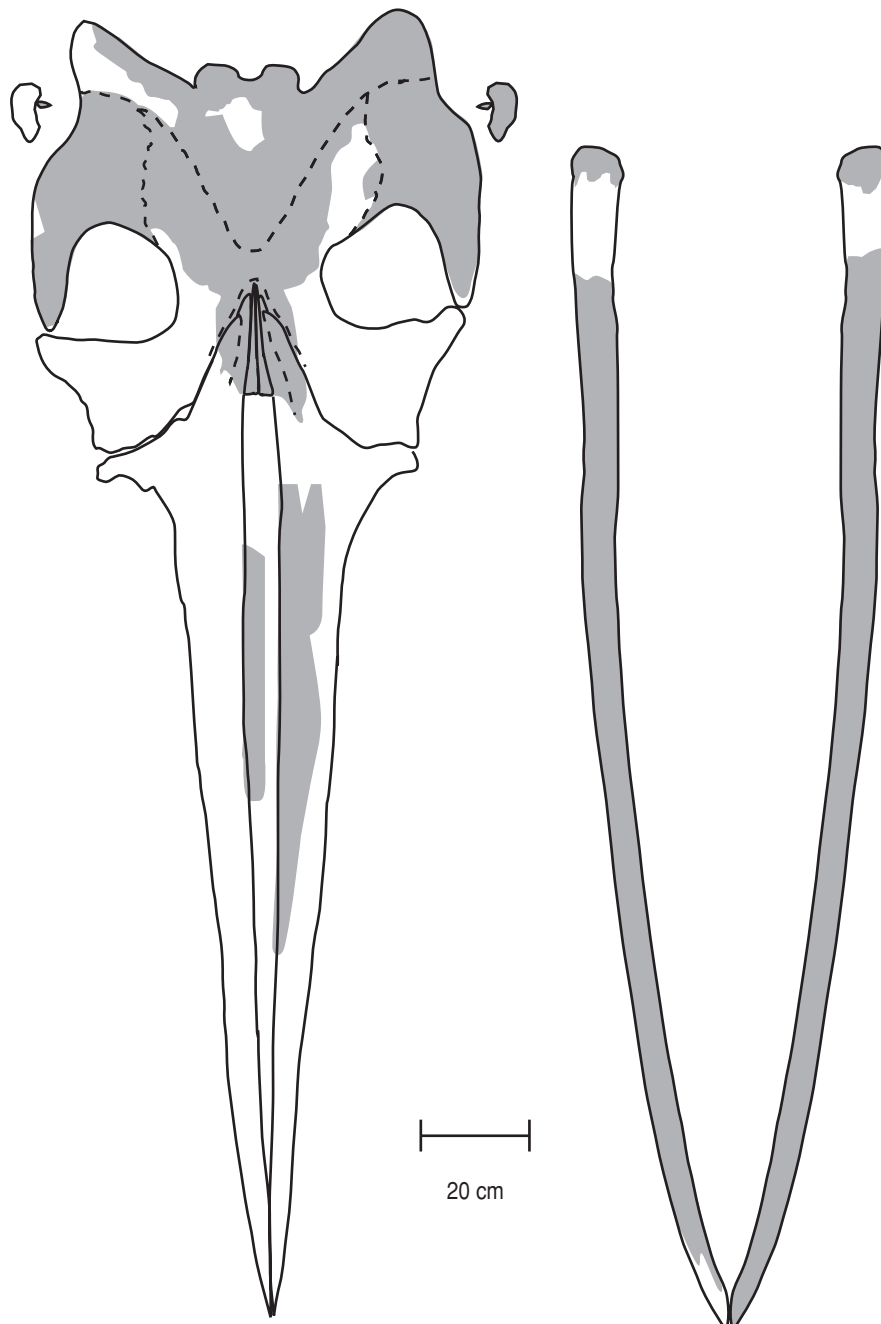


Figure 7: Outline drawing of *Plesiocetus* skull with indication of the parts (grey) recovered in the Middelares Hospital Section.



Photograph: M. Bosselaers

Figure 8: Bulla tympani of *Plesiocetus* sp. in dorsal view

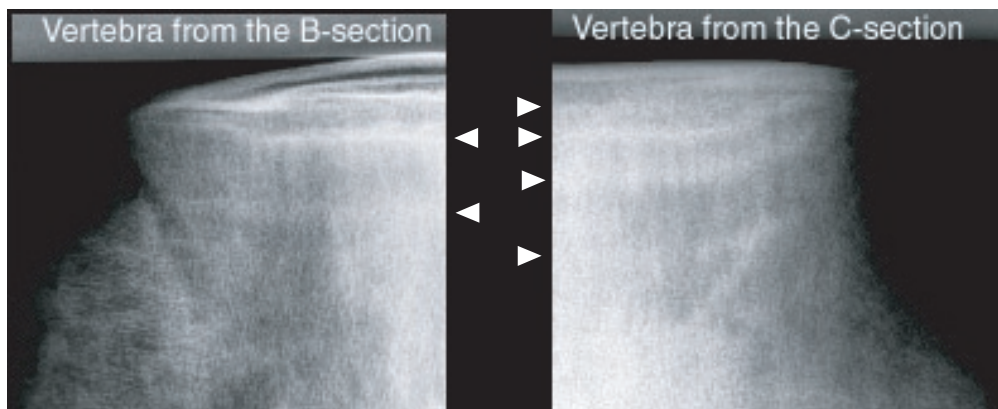
4.7 Mammalia (M. Bosselaers and O. Lambert)

4.7.1 Mysticeti

At the bottom of the construction pit at a depth between 6.20 m and 6.70 m below surface, skeletal remains of at least three baleen whales were found, respectively cluster A-B; cluster C and a specimen in the concrete wall. The most complete animal was preserved in two clusters (Figs 6 and 7): the head and shoulder part, including some remains of the flippers, all cervical and a few thoracic vertebrae and the tail part including 20 lumbar and caudal vertebrae, some of the corresponding ribs and the left tympanic bulla (Fig. 8). It is the most complete Cetotherid-like skeleton ever found in Belgium. In a third cluster the breast part of

another individual was found, containing the first six thoracic vertebrae, some of the corresponding ribs and five lumbar vertebrae. Most of the bones were found articulated, some were displaced over a few metres at most. The general state of preservation is rather poor in the sense that the bones are not well mineralised. Therefore they are extremely brittle. Many bones show a lot of fossil fractures and/or decomposition, especially at the sutures and the margins. Some bones, especially some vertebrae, have been heavily damaged during the construction works. In all over 50 vertebrae, among which the seven cervical ones, were found. Almost all neural apophyses and most other apophyses are missing. The epiphyses are completely fused with the corpora of the vertebrae, as is the vertex of the two parietal bones. This indicates that the animals reached maturity (Abel, 1931; Slijper, 1936). Other skull joints however still show sutures indicating that we are most probably dealing with young adult specimens.

In the first cluster "A" (Figs 2 and 6) several skull bones and some bones belonging to the shoulder girdle were found. The left mandibula is almost completely preserved, though the condylus is damaged and does not fit to the rest of the bone. The processus coronoideus is missing. About four fifths of the right mandibula are preserved as well, including the condylus. Some of the skull bones are preserved in between both mandibulae. These skull bones are scattered and heavily fragmented. As this part has not been cleaned and reinforced yet, we cannot ascertain which skull parts these fragments belong to. Some seem to be part of the maxillae and the premaxillae. The more caudal and dorsal skullbones were scattered over an area of a few square metres. Both the nasalia (or premaxillae ?), the caudal part of the (pre-) maxillae and the left and right parietale/supraoccipitale-complex were found articulated. The



Photograph: Alg. Ziekenhuis Monica V.Z.W. campus O.L.V. Middelaers, Deurne, X-ray departement.

Figure 9: X-ray photographs of two lumbar vertebrae: at the left from the caudal section (B); at the right from the "breast"-section (C). During growth stops denser bone is formed, visible as white bands on the X-ray photograph (marked by white triangles). As both vertebrae show a different number of growth stops, with different interspacing, they cannot belong to the same animal. The white marks at the top of the left vertebra are from "reflections" due to the high metal content of the fossil bone. Both vertebrae are shown in dorso-ventral view, the same scale.

two temporalia were isolated at some distance. The left exoccipitale was preserved as a whole, the right one was heavily fragmented and scattered over a large area. The basioccipitale is missing. All seven cervical vertebrae were found, along with six thoracic vertebrae, none of them in anatomical connection.

Scattered between the skull bones the remains of the two forelimbs were found, including parts of both scapulae (the right one being well preserved); both humeri and one ulna. So far no parts distal to the ulna have been recognised. Both radii are missing.

Cluster "B" (Figs 2 and 6) consists of the hind part of the thorax, still in anatomical connection at its "normal" position with respect to the head. Ten lumbar vertebrae were found in anatomical connection about one and a half metre behind the cranium, nineteen other (mainly caudal) vertebrae lay scattered close to these. Some of the caudal ribs lay scattered around the corresponding vertebrae. No chevron bones or pelvic bones have been found. To the right of the vertebral column, somewhere near the middle of the latter, the complete left bulla tympani has been discovered (Fig. 8). No periotic has been found so far.

About 10 metres east of the head and tail cluster, the proximal part of a thorax was found, forming the "C" cluster (Fig. 2). X-ray photographs revealed that this cluster does not belong to the specimen described above (Fig. 9). Four thoracic vertebrae, five of the corresponding ribs, and eight lumbar vertebrae have been discovered. In this area we also found a caudal vertebra. This cluster too was preserved in anatomical connection.

Apart from the big bone fragments, most of which lay in connection, hundreds of small fragments (3 to 8 cm across) have been found in the adjacent sand. These fragments have not been dealt with so far. The tympanic bulla, the cervical vertebrae, the humeri, the ulna and the right scapula of the Deurne specimen were compared to the type specimens of all Miocene baleen whales at the Royal Belgian Institute of Natural Sciences (RBINS). The Deurne specimen was preliminary identified as belonging to the genus *Plesiocetus* Van Beneden, 1859; figured in Van Beneden (1885, plates 1 - 30). This genus is considered here as valid, in the sense of Winge (1910) and True (1912); it may have a proximal maxillary nasal branch, partially covering the premaxillary. This would place *Plesiocetus* within the family Cetotheriidae Brandt, 1843 (probably a non-monophyletic clade). The whale skeleton resembles *P. dubius* (Van Beneden, 1872) at first sight, but a more thorough investigation is needed to confirm this identification and the validity of this species name. Indeed, most or all of the whale skeletons discovered during the nineteenth century construction of the Antwerp fortresses and described by Van Beneden (1859, 1861, 1872, 1880 and 1885) are composed of remains of several individuals (Abel, 1938, 1941; De Smet, 1978). Van Beneden most probably described too many species, as he based his systematics

on questionable variables such as size, which are hardly significant, in view of the high variability in osteology exhibited by Recent whales (Abel, 1938, 1941).

Furthermore, a large number of isolated bones (mainly vertebrae) of *Plesiocetus* sp. were found during the works. Among the more interesting ones are five tympanic bullae and one right temporale. In the concrete wall surrounding the construction pit the *in situ* remains of another *Plesiocetus* skull were found. Only the right tympanic bulla, the processus mastoideus of the periotic and fragments of the mandibula, the temporale and part of the vertex could be recovered; the rest of the skull was destroyed during the construction of the concrete wall.

4.7.2 Odontoceti

About 20 m west of the "A" cluster of the whale skeleton, an incomplete skull of a primitive ziphiid was uncovered (Fig. 2). The right posterior part of the brain case, including the squamosal, the posterior part of the rostrum (including a premaxilla, the posterior part of a maxilla and a proximal fragment of the palatinum, the part of the vomer, anterior to the internal nares) and four teeth were found. The specimen shows a closed mesorostral gutter, identical parts of the maxilla reabsorbed and a deep premaxillary prenasal basin which makes it referable to the genus *Ziphirostrum* (du Bus, 1868) from the Miocene of Antwerpen. Moreover its rostrum is markedly wider at the base and the median border of the right premaxilla is much less convex, which are characteristics of *Z. laevigatum* (du Bus, 1868). Abel (1905) included *Z. laevigatum* as a junior synonym of *Z. belgicus* Abel, 1905, but the former differs from the holotype of *Z. belgicus* by being less pachiostosed and having a more flattened rostrum. Therefore they could represent separate species.

Close to the thoracic cluster "C", a well preserved humerus, a few vertebrae and a typical ziphiid periotic were discovered. In spite of much effort, no other parts of the skeleton could be found. So far we have not been able to identify these remains to the genus level.

Finally, a cervical vertebra of a species belonging to the delphinoid family Kentriodontidae (Slijper, 1936) was found.

5. Conclusions

Based on the study of the fauna (Bryozoa, *Ditrupea*, Ostracoda and Mollusca) the layers d - h of the Middelares Hospital Section are referred to the Deurne Sand Member (Late Miocene). The ostracods *Calistocythere* and *Thaerocythere* sp. seem to be restricted to this member, most other invertebrates and fishes are also found in other Miocene and/or Pliocene strata. The morphology of *Squalus* sp. agrees best with the *Squalus* sp. from the Gramian (Late Serravallian - Tortonian) of Denmark.

Palaeoecological data can be deduced from the molluscan fauna mainly, the other fauna being too scanty to infer data. The paucity of Gastropoda, the infaunal Bivalvia and the dominance of Pectinidae seem to point to an environment with swiftly changing currents and moving sand bars. This points to a shallow water deposit, with megaripples subjected to tidal currents.

Palaeoclimatological conclusions are difficult to draw from the mollusk fauna encountered, because species restricted to warm or cold water were not encountered.

After comparison with the type collection at the RBINS, the recovered baleen whales (cluster A-B and the concrete wall specimen) were referred to the genus *Plesiocetus* based on the morphology of the bulla tympani, the mandibulae, the cervical vertebrae and the humeri. Remains of a third specimen (cluster C) were too fragmentary to allow identification.

The recovered *Ziphirostrum* sp. is characteristic of *Z. laevigatum*, considered a synonym of *Z. belgicus* in the revision by Abel (1905); both however probably represent separate species.

6. Acknowledgements

The authors are greatly indebted to many persons that kindly helped them, in particular J. Claes of the "A.Z. Monica V.Z.W. campus Onze Lieve Vrouw Middelaers", M. Huyghe of construction company "Jan De Nul N.V." and M. Lens, L. Luyten and D. Wuyts of "Architektenburo Luyten & Lens bvba" for their help in recovering the whale skeleton and the X-ray department of the O.L.V. Middelaers Hospital for their X-ray photographs. M. Huyghe kindly allowed us to take samples. P. Laga kindly supplied the Lambert coordinates of the section. S. Goolaerts, W. Nees, K. Post and R. Smits made their collections available for study. L. Ceulemans, S. Goolaerts, M. Grigis and W. Nees offered assistance in the field. T. Reinecke kindly supplied photographs of a *Squalus* sp. specimen of Gram and F. Roth of the Midtsønderjyllands Museum (Gram, Denmark) gave some specimens on loan. Jan Bosselaers and Annemie Price-Bosselaers corrected the English spelling. We thank the referees (T. Moorkens, N. Poulsen and D. Spiegler) for their constructive comments.

7. References

ABEL, O., 1905. Odontocètes du Boldérien (Miocène supérieur) d' Anvers. *Mémoires du Musée royal d'Histoire naturelle de Belgique*, T. III: 1-155.
 ABEL, O., 1931. Das Skelett der Eurhinodelphiden aus dem oberen Miozän von Antwerpen. *Mémoires du Musée royal d'Histoire naturelle de Belgique*, 48: 195-334.

ABEL, O., 1938. Vorläufige Mitteilung über die Revision der fossilen Mystacoceten aus dem Tertiär Belgiens. *Bulletin du Musée royal d'Histoire naturelle de Belgique*, 14 (1): 1-34.

ABEL, O., 1941. Vorläufige Mitteilung über die Revision der fossilen Mystacoceten aus dem Tertiär Belgiens (Zweiter Bericht). *Bulletin du Musée royal d'Histoire naturelle de Belgique*, 17 (32): 1-29.

BASSIOUNI, M.A.A., 1962. Ostracoden aus dem Mittelmiozän in NW-Deutschland. *Roemeriana*, 3: 1-103.

DE MEUTER, F.J. & LAGA, P. G., 1970. Coiling ratios and other variations of *Globigerina pachyderma* (Ehrenberg, 1861) and the stratigraphical significance in the Neogene deposits of the Antwerpen area (Belgium). *Bulletin de la Société belge de Géologie*, 79: 175-184.

DE MEUTER, F.J. & LAGA, P.G., 1976. Lithostratigraphy and biostratigraphy based on benthonic foraminifera of the Neogene deposits of northern Belgium. *Bulletin de la Société belge de Géologie*, 85: 133-152.

DE MEUTER, F., WOUTERS, K., RINGELÉ, A., 1976. Lithostratigraphy of Miocene sediments from temporary outcrops in the Antwerp city area. *Professional Papers*, 3: 1-19.

DE MEUTER, F.J., LAGA, P.G., RINGELÉ, A. & ROOSE, V., 1967. Compte rendu de l'excursion du samedi 29 octobre 1966, faite à Deurne, près d'Anvers. *Bulletin de la Société belge de Géologie*, 75: 392-394.

DE MUIZON, C., 1984. Les vertébrés fossiles de la Formation Pisco (Pérou). Deuxième partie: les Odontocètes (Cetacea, Mammalia) du Pliocène Inférieur de Sud-Sacaco. *Travaux de l'Institut français d'Études Andines*, 27: 1-187. Recherches sur les Civilisations, Mémoire 50, ADPF, Paris.

DE SMET, W. M. A., 1978. Beschouwingen over de fossiele Cetacea uit de omgeving van Antwerpen (België). *Mededelingen van de Werkgroep voor Tertiaire en Kwartaire Geologie*, 15(2): 37-51.

GLIBERT, M., 1945. Faune malacologique de la Belgique I. Pélécytopodes. *Mémoires du Musée royal d'Histoire naturelle*, 103 : 1-264.

GLIBERT, M., 1952. Faune malacologique de la Belgique II. Gastéropodes. *Mémoires de l'Institut royal des Sciences naturelles de Belgique*, 121 : 1-197.

GLIBERT, M. & de HEINZELIN de BRAUCOURT, J., 1955a. La faune et l'âge Miocène supérieur des Sables de Deurne. I. Descriptions. *Bulletin de l'Institut royal des Sciences naturelles de Belgique*, 30 (71): 1-27.

GLIBERT, M. & de HEINZELIN de BRAUCOURT, J., 1955b. La faune et l'âge Miocène supérieur des Sables de Deurne. II. Conclusions. *Bulletin de l'Institut royal des Sciences naturelles de Belgique*, 30 (72): 1-7.

HÖRNES, M., 1851-1870. Die fossilen Mollusken des Tertiärbeckens von Wien. *Abhandlungen der kaiserlichen-königlichen geologischen Reichsanstalt*, 3: 1-42, pl. 1-5 (1851); 43-208, pl 6-20 (1852); 209-269, pl 21-32 (1853); 297-384, pl 33-40 (1854); 385-460, pl

- 41-45 (1855); 461-736, pl 46-52 (1856); 4: 1-479, pl 1-85 (1870).
- JANSSEN, A.W., 1984. Mollusken uit het Mioceen van Winterswijk-Misten. pp. 7-451, 82 pl. KNNV/NGV/RGM.
- JANSSEN, R., 1989. Einige neue Scaphopoden aus dem Oligozän und Miozän des Nordseebeckens. *Mededelingen van de Werkgroep voor Tertiaire en Kwartaire Geologie*, 26 (3): 79-90.
- KUIPER, W.N., 1918. *Oligocäne und Miocäne Ostracoden aus den Niederlanden*. Ph.D. Thesis University of Groningen: 1-91.
- LAURSEN, G. V., POULSEN, N. E. & RASMUSSEN, L. B., 1998. Correlation of Northwest European Miocene Stages with the international stages – preliminary results. *Newsletters on Stratigraphy*, 36 (1): 55 – 61.
- MARQUET, R., 1980. De stratigrafie van Neogene afzettingen in een bouwput voor een waterreservoir te Broechem (prov. Antwerpen, België). *Mededelingen van de Werkgroep voor Tertiaire en Kwartaire Geologie*, 17 (2): 57-64.
- MOURLON, M., 1876. Sur les dépôts qui, aux environs d'Anvers, séparent les sables noirs miocènes des couches pliocènes scaldisiennes. *Bulletin de l'Académie royale de Belgique, deuxième série*, 42: 760-789.
- MOORE, R.C. (editor), 1992. *Treatise on Invertebrate Paleontology. (R) Arthropoda. Part 4 (1): Cirripedia*: 206-295.
- SLIJPER, E.J., 1936. *Die Cetaceen. Vergleichend-anatomisch und systematisch*. 590 p. Martinus Nijhoff. 's-Gravenhage.
- TRUE, F.W., 1912. The genera of fossil whalebone whales allied to *Balaenoptera*. *Smithsonian Miscellaneous Collection*, 59(6): 1-8.
- UFFENORDE, H., 1981. Ostracoden aus dem Oberoligozän und Miozän des unteren Elbe-Gebietes (Niedersachsen und Hamburg, NW-Deutsches Tertiärbecken). *Palaeontographica A*, 172: 103-198.
- VAN BENEDEN, P.J., 1859. Rapport de M. Van Beneden. *Bulletin de l'académie royale des Sciences de Belgique*, 2ème série, 8: 123-146.
- VAN BENEDEN, P.J., 1861: La côte d'Ostende et les fouilles d'Anvers. *Bulletin de l'Académie royale des Sciences de Belgique*, 2ème série, 12: 453-483.
- VAN BENEDEN, P.J., 1872: Les baleines fossiles d'Anvers. *Bulletin de l'Académie royale des Sciences de Belgique*, 2ème série, 34: 6-20.
- VAN BENEDEN, P.J., 1880: Les Mysticètes à courts fanons des sables des environs d'Anvers., *Bulletin de l'Académie royale des Sciences de Belgique*, 2ème série, 50: 11-25.
- VAN BENEDEN, P.J., 1885. Description des ossements fossiles des environs d'Anvers. Quatrième partie. Cétacés, Genre : *Plesiocetus*. *Annales du Musée royal d'Histoire naturelle de Belgique. Série Paléontologique*, 9: 1-40, pls 1 - 30.
- VAN BENEDEN, P.J. & GERVAIS, P., 1880. *Ostéographie des Cétacés vivants et fossiles comprenant la description de l'iconographie du squelette et du système dentaire des animaux ainsi que des documents relatifs à leur histoire naturelle*. 629 p. A. Durand, Paris, France.
- VANDENBERGHE, N., LAGA, P., STEURBAUT, E., HARDENBOL, J. & VAIL, P.R., 1998. Tertiary sequence stratigraphy at the southern border of the North Sea basin in Belgium. *SEPM Special Publication*, 60: 119-154.
- VAN ROY, A., 1980. *Pliothyridina*, genre terebratulide (brachiopode) nouveau du Néogène. *Bulletin de l'Institut royal des Sciences naturelles de la Belgique, Sciences de la Terre*, 52 (3): 1-9.
- WINGE, H., 1910. Om *Plesiocetus* og *Squalodon* fra Danmark. *Vidensk. Meddel. fra den Naturhist. Foren. i Kjøbenhavn for 1909*: 1-38.
- WOOD, A.M., WHATLEY, R.C., MAYBURY, C.A. & WILKINSON, I.P., 1992. Three new species of cytheracean Ostracoda from the Coralline Crag at Orford, Suffolk. *Journal of Micropalaeontology*, 11(2): 211-220.
- WOOD, A.M. & WHATLEY, R.C., 1996. A new ostracod-based biostratigraphy for the marine Pliocene of the Netherlands. *Proceedings of the 2nd European Ostracodologists Meeting*: 121-128. British Micropalaeontological Society, London.
- WOOD, A.M. & WHATLEY, R.C., 1997. The genera *Muellerina* Bassiouni, 1965 and *Thaerocythere* Hazel, 1967 from the Neogene of Northwest Europe. *Journal of Micropalaeontology*, 16: 1-18.
- WOUTERS K., 1976. *Cushmanidea lithodomoides* (Bosquet, 1852) – *C. elongata* (Brady, 1868): a case of phyletic evolution, from Oligocene to Recent in N.W. Europe (Crustacea: Ostracoda). *Bulletin de la Société belge de Géologie, de Paléontologie et d'Hydrologie*, 85(3): 107-115.
- WOUTERS, K., 1978. *Een systematische, biostratigrafische en paleobiologische studie van de Ostracoda uit Miocene afzettingen in Noord-België*. PhD thesis, K.U.Leuven, Part 1: 1-155, Part 2: 1-338, Atlas: 48 plates.
- WOUTERS, K., 1979. On the taxonomy and distribution of some European species of the genus *Muellerina* Bassiouni, 1965. *Proceedings of the 7th International Symposium on Ostracodes*, Belgrade: 223-233.

