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A small sperm whale (Cetacea: Odontoceti, Physeteridae) from the Miocene of Antwerp

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In the summer of 1967 during the construction of the circular highway in the city of Antwerp (Belgium) the fossil remains of a small physeterid whale were discovered. In the 1990's the remains were sold by the collector and they disappeared from sight. In 2001 the fossils turned up again and were bought by the Museum of Natural History (Natuurhistorisch Museum de Peel) in Asten, the Netherlands, where they are now exhibited. This article presents (1) a re-examination of the site of discovery and its documentation by the collector, and (2) an investigation of the fossils that reappeared in 2001. Compared to the findings *in situ*, the fossils originating from glauconitic sands of late Early to Middle Miocene Age (Antwerpen Sands) are missing a number of teeth. The remaining pieces of the whale are described and illustrated in this study. On the basis of the teeth, some parts of the skull, the main parts of the atlas and the typically fused cervical vertebrae 2-7, as well as a photograph of the periotic it is concluded that the sperm whale belongs to the family Physeteridae, subfamily Physeterinae. Assigning to generic or specific rank turned out to be more difficult. Yet an attempt is made to interpret the sperm whale find in a provisional way by comparing its skull parts and teeth with physeterine genera and species described hitherto. *Physeterula dubusii* and *Orycterocetus* sp. seem to show closest affinities. Postcranial structure of fossil sperm whales is not very well known. The numerous fragments of the specimen described here could give a more complete insight in the overall skeletal structure of these Miocene odontocetes.

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INTRODUCTION

In 1967 a new arterial road was constructed around the city centre of Antwerp. During the weekends, in the summer of the same year, Mr. and Mrs. Goossens living near the excavation in Borgerhout regularly inspected the glauconitic sands that were exposed during the works in search of fossils. In the course of that year they discovered the remains of a number of fossil whales, Mysticeti as well as Odontoceti. In a way, these discoveries seemed to be a repetition of the events in Antwerp almost a century ago. In the 1860's construction works on the fortress were carried out in the city; during the excavations a huge number of cetacean fossils were found, many of them in the same marine sands that have been named 'Antwerpen Sands' and are of late Early to Middle Miocene Age. The bulk of these cetacean remains were transported to the KBIN (Koninklijk Belgisch Instituut voor Natuurwetenschappen) in Brussels where they were stored. Neither the exact origin and connection nor the precise context in which they were found is known. Several scholars (du Bus, Van Beneden, Abel) studied the material that was thus collected. In particular Van Beneden was engaged in a considerable part of the better preserved pieces and published his findings in several atlases, presenting descriptions and drawings of many of these fossils (Van Beneden 1877). However the non-scientific (inept) way in which the material had been collected and documented hampered him and still hampers students of cetacean fossil history, especially in systematics and nomenclature of this vertebrate order. The more recent findings in 1967 from the same Antwerpen Sands would have suffered the same fate of poor documentation had it not been for Mr. and Mrs. Goossens, who were the finders. Not only were they there at the right place at the right time, but Mr. Goossens also realised the importance of a proper description of the situation in situ of the fossils he found. At the same time he and his wife were well aware of the necessity of acting quickly because of the special circumstances they encountered. The road works were at a standstill only during the weekend, and so they had only short periods of time at their disposal: not just for the unearthing of the whales or parts thereof, but also for the description of the situation and the final storage of the fossils they found each time. Especially the sperm whale BOII described in this article turned out to be a relatively complete animal; it was documented in more detail by the Goossens than several other whales (most of them not as well preserved) that were found that summer. When Mr. Goossens decided, some 15 years after the discovery, to sell the whale from his collection, a period of uncertainty for the fossils concerned began. They changed hands several times in Belgium, in Germany an finally in Holland. The odyssey ended in 2001 when the Museum of Natural History in Asten acquired this small sperm whale to exhibit it in a floor show case. Meanwhile - as our study has revealed - the fossil specimen must have 'lost' at least a number of teeth; so in its recent presentation in the museum the whale is less complete than it was at the time of its discovery. In spite of this unfortunate reduction, the fossil remains even in their present state still represent a valuable specimen and an important source of information on fossil Physeterids. The superfamily Physeteroidea includes two families: Physeteridae (sperm whales) with an ancient and diverse fossil record, but only one surviving species, *Physeter macrocephalus*, and the closely related family Kogiidae (pygmy sperm whales) with two extant species, *Kogia simus* and *Kogia breviceps*. Sperm whales are widespread in Pliocene and Miocene sediments, although species and genera based on isolated teeth can be dubious (Fordyce & Barnes 1994).

In Brussels KBIN cranial parts are preserved of the holotype of *Physeterula dubusii* as described by van Beneden (1877). Some cranial fragments from a second whale and a few postcranial fragments are also attributed to this species. All *Physeterula dubusii* remains in the KBIN probably originate from the same glauconitic Miocene Antwerpen Sands in Antwerp in which whale BOII was found in 1967, although indications for locality as well as for stratigraphy are poor. Given the rarity of physeterid fossils in general, in Western Europe in particular, and the extreme rarity of a fossil sperm whale documented in situ, we decided to start our investigation. The objectives of the study are the following: (1) To clarify and present as accurately as possible the sperm whale find in Antwerp-Borgerhout in 1967, as well as its context . (2) To reveal the adventures of the whale between the discovery in 1967 and the acquisition by the museum in Asten in 2001. (3) To give a morphological and biometrical description of those skeletal sperm whale remains, that can be identified anatomically. (4) To define - on the basis of these features - the taxonomic status of the sperm whale.

THE SPERM WHALE FIND IN 1967

Stratigrafical context

During the years 1965-1970 extensive digging works were carried out in the city of Antwerp for the 'E3-Kleine Ring'. Deposits

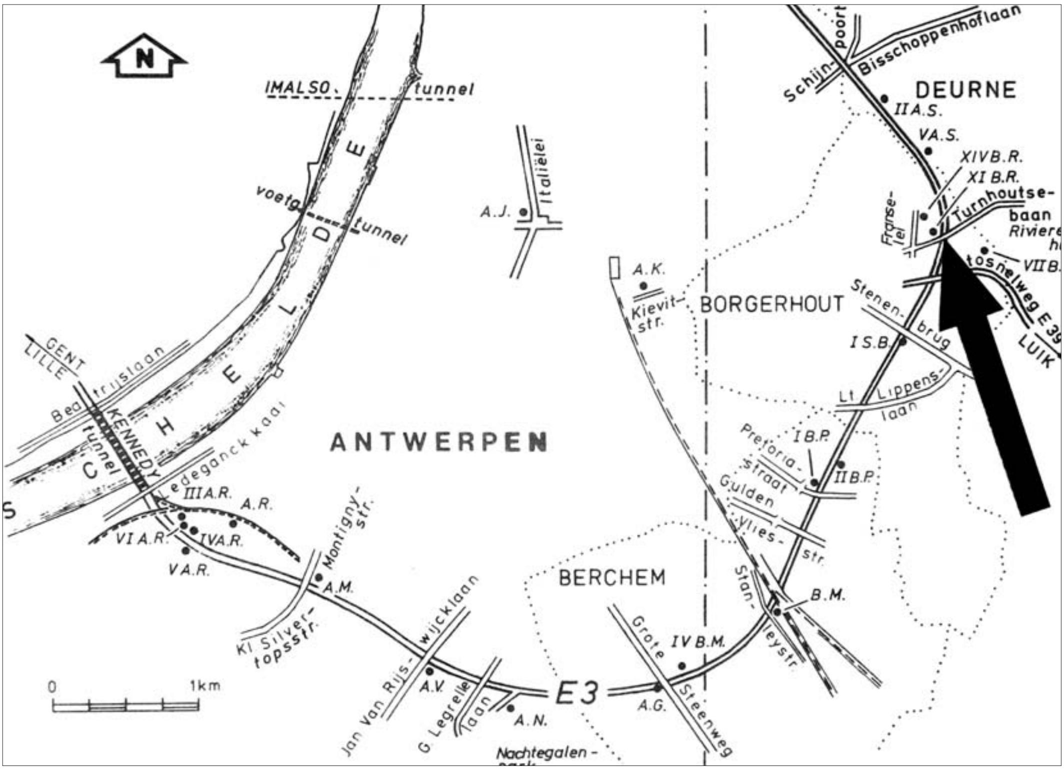

Figure 1 Antwerp city area: Localisation of sections (de Meuter *et al.* 1976) and site where sperm whale BOII was found (black arrow).

from numerous temporary exposures were studied lithostratigraphically by de Meuter *et al.* (1976). The localisation of the sections they worked out is given in Figure 1.

One of the sections they describe is the Borgerhout-Rivierenhof section (XI B.R.) which was sampled in December 1966. The localisation of this sample is quite close if not identical to the site where the sperm whale remains were found by Goossens six months later (black arrow in fig. 1) in glauconitic sands at a depth of about 6-7 meters. In section XI B.R. Antwerpen Sands were found from about 0 meter Oostende O.D. level down to a depth of more than 7 meter, the maximum depth of this section. These Antwerpen Sands are described by de Meuter et al. as: 'dark green medium fine slightly clayey fossiliferous very glauconitic sand' in which typical variable shell layers occur with the guide fossil *Pectunculus pilosus* (= *Glycymeris lunulata baldii*). The Antwerpen Sand Member is part of the Berchem Formation of late Early to Middle Miocene Age (Vinken 1988). The *Physeterula dubusii* fossils that are now stored in the KBIN collection in Brussels were found in 1863 in the same Borgerhout area in Antwerp (Van Beneden 1877; Abel 1905).

The sperm whale skeleton

The weekend of 17-18 June 1967 must have been hard work for Mr. and Mrs. Goossens in Borgerhout. In a timespan of two days a sperm whale skeleton was discovered, the findings were recorded in several sketches, photographs were taken (one with the Goossens standing alongside their whale, Fig. 2) and finally the fossils were unearthed.

The fossil skeleton was recorded by Goossens as BOII (whale number two in Borgerhout) and in his sketch he added: 'potvis, 35 tanden' (sperm whale, 35 teeth). The skeleton found in the sediment in a slightly bent burial position was not complete.

Figure 2 Mr. and mrs. Goossens next to sperm whale BOII in 1967.

At least the lower jaws and the forelimbs were missing . The absence of these parts can well be explained by a phenomenon, known to take place in the decomposition process of a whale carcass drifting around after death (Schäfer 1972). Lower jaws and forelimbs are the first parts to loose contact with the rest of the body during disintegration and could well have been lost before burial in the sediment. Other parts of the skull were found in conditions, varying from very poor and strongly deteriorated to better and well preserved in other cases. Some badly preserved fragments pulverised while being excavated (Goossens, personal communication). Teeth on the other hand were numerous and rather well preserved, but none of them was found in the jaw. Yet most of the teeth were found close to their original position in the skull. Some of them, however, had been scattered over a short distance in a backwards direction. Goossens counted a total number of 35 teeth as mentioned before. One of the numbers he used (nr. 29) in fact cannot be found in the sketch, so tooth nr. 29 is questionable. Moreover, Goossens took a picture of the teeth after their removal from the excavation site, which shows 32 teeth (two rows of 16) plus one periotic. Abel (1905) assumes there were 20 teeth on each side of the mandible as well as the maxillary in *Physeterula dubusii*. In *Orycterocetus crocodilinus* seventeen teeth in each maxillary plus three in each premaxillary were found (Kellogg 1965). We therefore think that the total number of 32 teeth (Goossens' photograph) or 34 (Goossens'sketch) could have come out of the maxilla of sperm whale BOII. One could even imagine left and right teeth in the reconstruction drawing in fig. 4. Post-cranial skeletal parts were found in the sediment more or less according to their anatomical position in the animal, including two main parts of the atlas, the fused cervical vertebrae 2-7 and a considerable number of thoracic, lumbar and two caudal vertebrae. Ribs and rib fragments were also numerous. Fig. 3 shows the overall view of the sperm whale in


Figure 3 Overall view of sperm whale BOII in situ.

situ, at a certain stage of the discovery process. As a consequence of this snapshot-character of the photograph not all parts that were finally unearthed need to be shown at this very moment.

At the rear end of the whale a small group of vertebrae can be seen that originally was considered to form part of sperm whale BOII. A closer look at the Goossens photograph, which shows these vertebrae in detail, lead us to the conclusion that they did not belong to this animal. Epiphyses and centra are still separated as is the case in young animals, while the other vertebrae of sperm whale BOII have epiphyses and centra grown together, indicating an adult animal. Moreover the centra do not show the radial surface pattern typical for odontocetes, so these vertebrae must have been part of a mysticete (personal communication K. Post). On the basis of the sketches as well as Mr. Goossens' photographs we have reconstructed the sperm whale find in a drawing that exhibits the same numbers and letters he used in 1967 (Fig. 4).

The caudal region, badly preserved and not very well documented has been left out of consideration in the drawing. On the basis of the remains that are preserved as well as Goossens' documentation we estimate the length of the skull to have been 120-130 cm. and the postcranial part (drawn in Fig. 4) between 210 and 220 cm. Assuming that the tail region will have taken about 1/3 of the animal the total length of the sperm whale must have been between 5 and 6 meter.

DESCRIPTION OF SPERM WHALE BOII

All fossil parts of the Antwerp sperm whale BOII that are left are presently stored and registrated in the Museum of Natural History 'De Peel' in Asten (the Netherlands). Of the whale's skull, relatively badly preserved, only the pieces that could effectively be traced as originating from certain parts of the cranium are described here morphologically and biometrically. To give an indication of their supposed position in the skull, photographs of the pieces are depicted on scale in the background of a drawing of a sperm whale's skull in Figure 5. This drawing from Kellogg (1965) showing a dorsal view of the skull USNM 22926 of *Orycterocetus crocodilinus* was chosen for the sake of completeness rather than suggesting a real match with BOII. Postcranial elements are described as far as they were more or less complete and can contribute to a better understanding of the skeletal anatomy and/or the taxonomic position of Miocene sperm whales.

Premaxilla fragment (Coll. nr. BOII-1)

This relatively heavy part of the cranium was found in the most anterior position of all skull fragments in situ on the right side (nr. 1 in the reconstruction drawing - Fig. 4). From the foramina in the bone it is concluded that it must be the distal end of a right premaxilla and therefore the whale carcass must have been buried in the 'normal' position of the living whale and not upside down. The massive

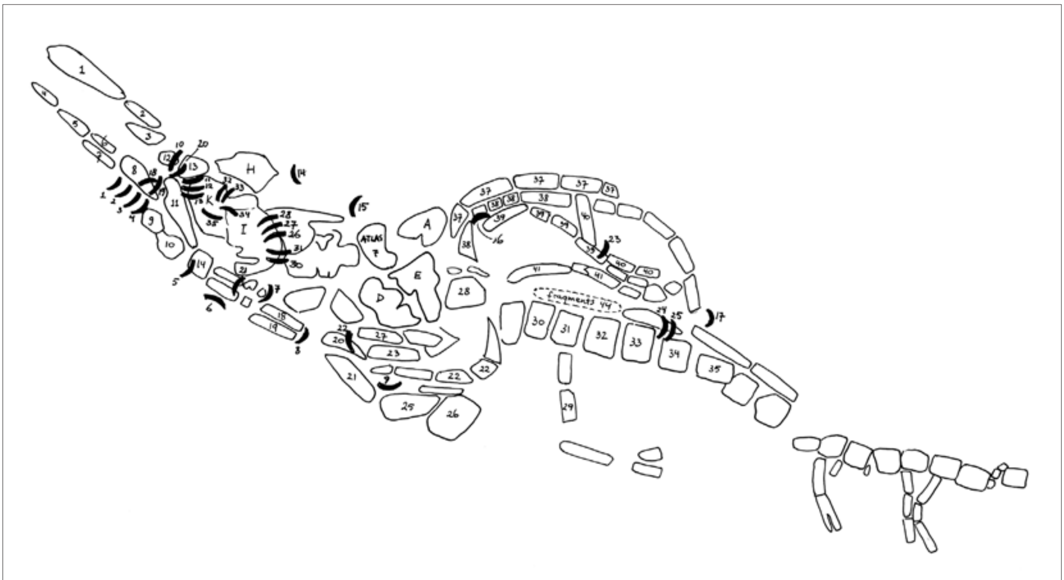

Figure 4 Reconstruction of sperm whale BOII in situ. Bony parts and teeth (in black) numbered as in Goossens sketches of 1967. [illustration Noud Peters, after sketches and photographs by Goossens]

bone (Fig. 6), slightly narrowing in posterior direction, has a convex lateral surface and a medial surface that is flattened in the dorsal region and exhibits an antero-posterior gutter in the ventral region. The front edge of the bone medially exhibits a pattern of some small undulations. The convex lateral side of the premaxilla shows four small foramina in the anterior region and one bigger foramen in the posterior part of the bone. The fragment shows no traces of alveoli in the ventral region. This could mean that in the premaxillary part of the rostrum of this sperm whale no teeth were present. Antero-posterior length of the pre-

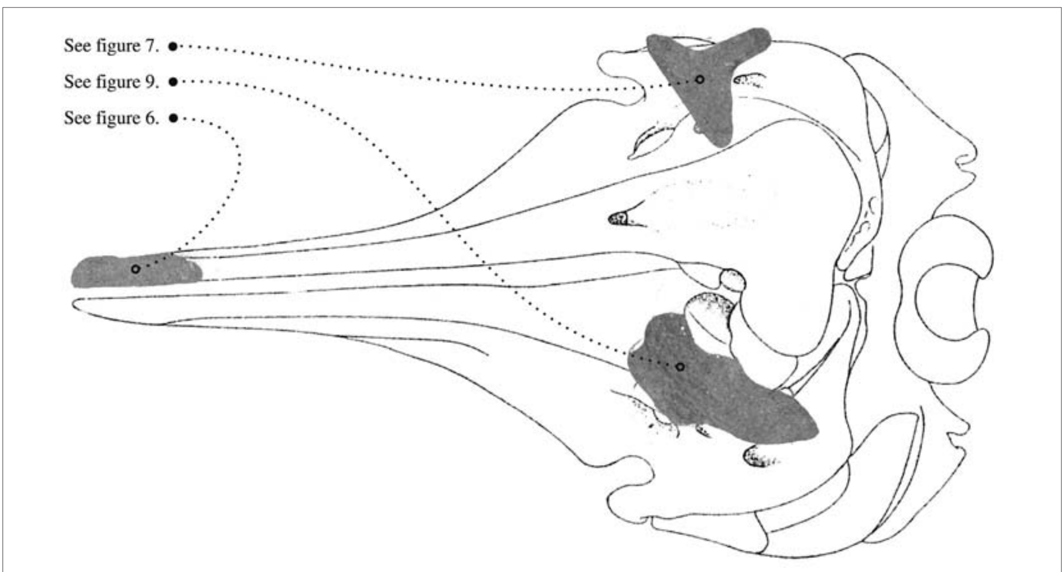

Figure 5 Supposed position of three BOII-skullfragments projected on *Orycterocetus* after Kellogg (1965).

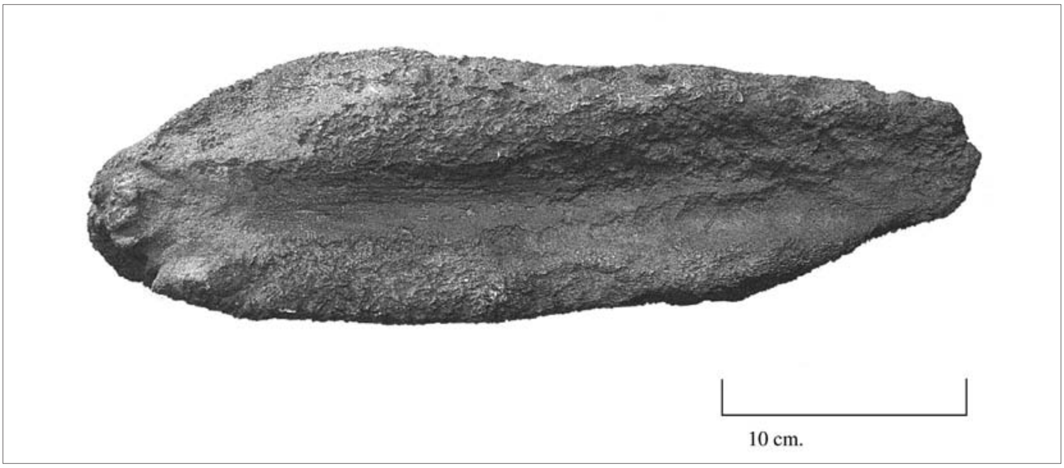

Figure 6 Anterior part of the right premaxilla, medial view.

maxilla-fragment is 362 mm, height 110 mm (maximum, at 1/3 of the length from the front) and medio-lateral thickness 70 mm (maximum, in the middle of the bone).

Supraorbital process of the frontal (Coll. nr. BOII-2)

This fragment of the frontal is the vaulted part of the bone, constituting the top of the right orbit. Medio-anteriorly this supraorbital process contacts the maxilla; just in this contact area the bone has broken off. More to the inner side of the skull the vault of the process passes into the channel of the optical nerve. Posteriorly the fossil bone ends in a tip, which is slightly curved ventrally. See Figures 7 and 8. The distance from this tip to the most forward tip of the process is 135 mm. In a medial direction the process narrows over a distance of about 180 mm. The vaulted surface of the bone is rather smooth up to its edges. Kazár (2002) in a drawing (p.159, fig. 2) compares zygomatic process of the squamosal, temporal fossa and orbital region in some physeterid species. The supraorbital process of sperm whale BOII resembles mostly *Orycterocetus crocodilinus* for this character (but the structure of this orbital region is unknown for *Physeterula dubusii*).

Fragment of the left maxilla and premaxilla (Coll. nr. BOII-4)

A rather robust skull fragment (Fig. 9) that has been preserved comprises parts of the left maxilla and premaxilla near the nasal opening. The enlarged left nasal opening is a character typical for all Physeteridae. The premaxilla fragment forms the dorsal portion of the fossil and has a flattened, more or less triangular shape. The top of the triangle is missing, but its impression on the maxilla, pointing in a posterior direction, still can be seen close to the nasal opening. The triangle's base is obliquely oriented in an anterior direction from about the foremost border of the nasal opening. The

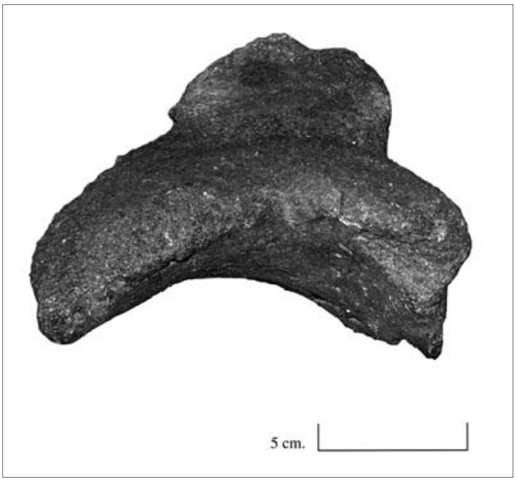

Figure 7 Supraorbital process of the frontal, lateral view.

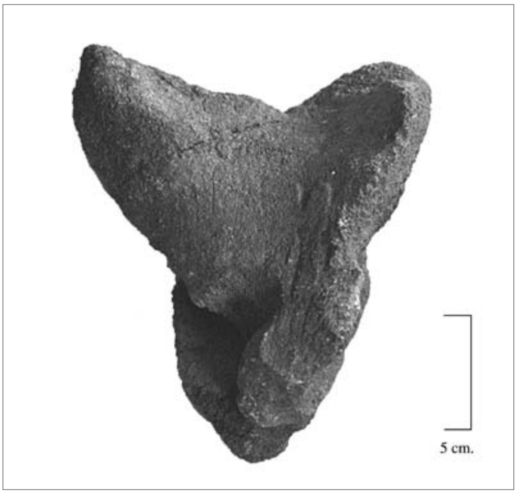

Figure 8 Supraorbital process of the frontal, ventral view.

three "sides" of the triangle (Fig. 9) measure 140 mm (the "base"), 170 mm (the lateral side) and 143 mm (the medial side near the nasal opening). The anterior part of the premaxilla fragment is about 40 mm thick tapering posteriorly into a rather flat bone of 10 mm.

From the maxilla, connected to the ventral surface of the premaxilla, a greater fragment has been preserved, measuring antero-posteriorly about 330 mm and 160 mm at its maximum width. Anteriorly near the nasal opening the piece is 90 mm thick, tapering posteriorly to 55 mm at its rear end. The nasal opening on the medial side has been only partly preserved and has an estimated diameter of 40 mm. From the opening the first part of the nasal cavity is ventrally oriented, then bending off in anterior direction, where it can be traced over a distance of about 80-90 mm. Laterally the dorsal surface of the maxilla fragment slightly curves upwards but only the lowest part of the sloping outer wall of the supracranial basin is preserved. In this area two foramina are visible, a bigger one in the posterior half of the piece exhibiting some 60% of its original size and ventrally directed, and a smaller one in the anterior part of the piece, oriented obliquely in an anterior direction. The diameter of the bigger foramen is 30 mm; the smaller one shows a funnel-shaped opening just laterally from the premaxilla and widens anteriorly into a more oval opening. Only the lower part of this opening has been preserved. On the ventral side of the maxilla considerable erosion of the surface has taken place, so that no characteristic structures can be recognised.

Teeth (Coll. nrs. BOII 70-76)

In the drawing reconstructing the sperm whale BOII find in situ in 1967 (Fig. 4) all teeth that were found have been marked as Goossens did at the time, using his numbers 1 - 35. However one of the teeth he mentioned in his drawing is missing. We could not locate his nr. 29, leaving a total of 34 instead of 35 teeth. All teeth were found loose in the sediment and after their removal were photographed by Goossens (Fig. 10). The photograph - unfortunately not very sharp - shows two rows of 16 teeth and above them one periotic, which would mean a total number of 32 teeth excavated and 2 missing, when compared with the sketch. Only 7 of these teeth have been preserved (Fig. 11). We carefully compared the available seven teeth with the Goossens picture and found out that six of the seven could be traced as relatively long teeth presumably stemming from the anterior part of the maxillae.

The teeth are rather slender and show a varying degree of (forward)bending: some being slightly bent (nr. 72), others to a greater extent (nr. 76). The crowns have no enamel, the dentine exhibiting the same brownish to almost black colour, identical to that of the roots. The

Figure 9 Fragment of the left maxilla and premaxilla, dorsal view.

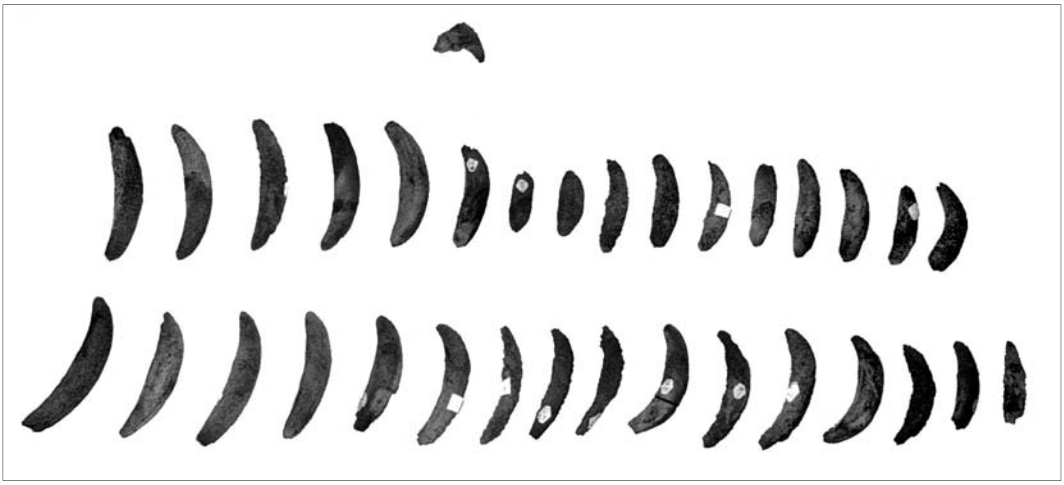

Figure 10 Sperm whale teeth in 1967 after their removal from the sediment.

surface is slightly rough by the presence of longitudinal ridges so delicate that they could as well be described as a fine lining of the surface. In some areas this surface-lining not only exhibits a longitudinal but also a circular and concentric pattern. The crowns are not pointed at the ends, resembling on the contrary obtuse cones (as in nr. 106 e.g.) and showing, at least in some teeth, clear tracks of wear and tear on the anterior side. This can possibly be considered as an indication that at least the seven teeth that we have studied could stem from the upper jaw. The teeth in the lower jaws of the Brussels specimen of *Physeterula dubusii*, a species which at least has affinities with BOII, show surface wear on the posterior side (Abel 1905). For the teeth of *Orycterocetus crocodilinus* no such tracks are mentioned by Kellogg (1965), nor can an occlusion pattern for this species be derived from his description. In most root-endings of the teeth of BOII an almost circular opening of the pulp cavity can be seen, the cavity itself being filled with glauconitic sand, which in turn prevents us from judging how deep the cavity is. The seven teeth available have been measured for the following data: TL (total length in a straight line), DAP (maximum antero-posterior diameter) and DT

Figure 11 The seven teeth of sperm whale BOII that have been left.

Table 1 Biometric data (in mm) of seven teeth of sperm whale BOII.

Tooth number	70	71	72	73	74	75	76
TL (length)	105.0	109.0	106.0	106.0	95.0	91.5	73.0
DAP (diameter antero-posterior)	20.0	21.0	21.7	23.4	20.1	22.0	18.2
DT (diameter transverse)	19.8	20.0	22.5	21.4	19.5	20.8	18.1

(maximum transverse diameter). The data are presented in Table 1.

Periotic

The periotic bone in sperm whales is a relatively small bone. At least one of the periotics of sperm whale BOII was found in 1967 as can be concluded from Figure 10. But unfortunately this periotic has been lost. The periotic above the two rows of teeth in Figure 10 is shown in a lateral view so that only the external portion, comprising the anterior and the posterior processes can be seen. The anterior process makes a right angle with the relatively long posterior process. Greatest length of the periotic is between 38.5 and 40 mm of length (in a straight line) as can be derived from its relative dimensions compared to the teeth depicted. The morphology as well as the dimensions of the periotic of sperm whale BOII look very similar to the periotics of *Orycterocetus crocodilinus* described by Kellogg (1965). No periotics have been found in association with *Physeterula dubusii* in Belgium. On the other hand several isolated sperm whale periotics have been found in Antwerp deposits that have an appearance also resembling the BOII specimen.

Vertebrae (Coll. nrs. BOII 14-35)

From the vertebral column of the sperm whale 25 more or less complete vertebrae have been preserved. The atlas as well as the the six remaining cervical vertebrae (fused) are clearly recognisable; although the thoracic and lumbar vertebrae are less complete, 16 of them are still present. The tail of the animal is not very well documented, neither in the photographs nor in the drawings Goossens sketched in 1967. In any case not many caudal vertebrae are left; we consider two vertebrae to be caudal ones.
What Goossens found and documented at the very rear end of the whale find was a group of nine typical vertebrae that have disappeared.

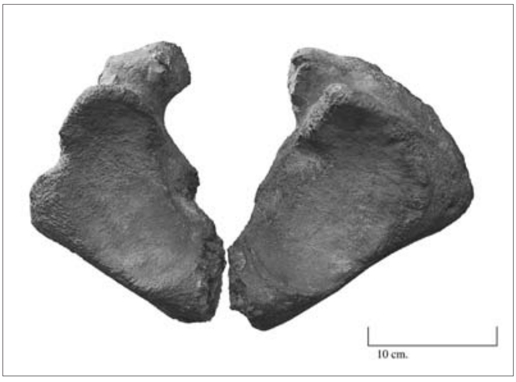

Figure 12 Atlas of sperm wale BOII, anterior view.

Figure 13 Fused cervical vertebrae of sperm whale BOII,

Figure 14 Remaining non-cervical vertebrae of sperm whale BOII, dorsal view.

He made a special photograph as well as a separate drawing of this aggregate of nine lumbar vertebrae and we guess that he considered them as belonging to sperm whale BOII. In fact, as was explained before, they must have been part of a different whale skeleton. As a consequence we let them out of the description of sperm whale BOII. In the drawing reconstructing the sperm whale find in situ in 1967 the two parts of the atlas (Fig. 12) apparently were recognised by Goossens (A and F in Figure 4). On their anterior surfaces both these parts show great concave articular facets, representing the vertebral side of the joint with the occipital condyles of the skull. Posterior to these facet surfaces each of the atlas fragments has a triangular form with rounded points laterally and ventrally, the dorsal point passing into in the vertebral arch.

The sides of these triangular atlas-halves measure about 220 mm (medially), 155 mm (dorso-laterally) and 200 mm (ventro-laterally). The articular surfaces on the anterior side are kidney-shaped (in circumference); dorso-ventrally measured they have a maximum length of 165 mm, latero-medially a maximum width of 75 mm. The neural arch has been preserved only partially: on the right side a few centimetres, on the left side just the first cm. The diameter of the arch is 55 mm. In antero-posterior direction the atlas measures about 70 mm.

Cervical vertebrae 2-7 are fused but were found in two parts: the fused centra on the one hand, the fused arches on the other (D and E respectively in Fig. 4). In Figure 13 both parts are shown in an anterior view and roughly in their anatomical position. On the right side where the fused centra are more complete than on the left side a number of sutures, where the vertebrae have grown together, can be observed. Moreover the right side clearly shows a strong narrowing of this cervical complex in antero-posterior direction. Cervical vertebra 2 (axis) must have had a width of 250-260 mm, vertebra 7 has about half that width, 130 mm. The height of the complex is about the same for all vertebrae involved, i.e. about 100 mm. Antero-posterior length of the complex is 100 mm.

The fused neural arches dorsally form a 105 mm high, pointed complex comprising the fused neural spines. There is a clear thickening in the middle of the anterior side of this complex, measuring 83 mm in the antero-posterior direction. The dimensions of the vertebral canal can approximately be derived from both the centra-complex and the arch-complex. The canal has a equilateral triangular form, with the base of the triangle, measured on the anterior side, of at least 100 mm. The first thoracic vertebra (coll. nr. B0II-18 = nr. 28 in Figure 4) that is connected to the cervical vertebrae has a centrum that is nearly intact. The neural arch on the left side is partly present, on the right side it is practically absent, only its origin being visible. From what is left it can be concluded that the base of the neural canal in this vertebra is 95 mm. For a further biometric description three measurements have been taken for the centrum of this vertebra and for all remaining vertebrae at the points where the dimensions have their maximum: DAP = antero-posterior diameter, DDV = dorso-ventral diameter, DT = transverse diameter. In Table 2 the dimensions of the remaining post-cervical vertebrae of sperm whale BOII (depicted

Table 2 Dimensions of vertebral centra of sperm whale BOII. **DAP** = antero-posterior diameter, **DDV** = dorso-ventral diameter, **DT** = transverse diameter.

Vertebra coll. nr.	DAP (mm)	DDV (mm)	DT(mm)
BOII 18 (thoracal vertebra 1)	65	100	140
BOII 19	71	101	134
BOII 20	83	102	122
BOII 21	87	104	123
BOII 22	94	117	133
BOII 23	95	112	133
BOII 24	104	121	141
BOII 25	110	?	?
BOII 26	115	120	135
BOII 27	±116	110	±143
BOII 28	?	130	139
BOII 29	114	±127	141
BOII 30	134	127	122
BOII 31	142	±111	131
BOII 32	131	122	122
BOII 33	119	112	122
BOII 34	79	110	112
BOII 35	69	68	63

in Figure 14) are presented in a sequence that is not necessarily their anatomical sequence. Because vertebrae have only a limited diagnostic value for the identification of sperm whale species or genera, we do not describe each individual vertebra morphologically.

Ribs (Coll.nrs. BOII 36-69)

There are quite a lot of rib fragments that have been preserved up to now among the fossil remains of sperm whale BOII; in the Asten Museum's collection 34 pieces are stored. Obviously there are morphological differences between the ribs (Fig. 15). Some rib fragments are relatively broad and flat: width 90 mm, thickness 32 mm which means a ratio of about 3:1 (Fig. 15 - a). By comparison with a recent *Physeter* skeleton and in view of their position in situ in 1967 we consider these broad ribs to be the foremost ones of the whale. The remaining rib fragments also illustrate differences in dimensions: some fragments having a width of 49 and a thickness of 23mm, others measuring respectively 62 and 36 for the same parameters. These ribs have a width : thickness ratio of about 2:1. (Fig. 15 - b). One rib shows a somewhat different appearance (Fig. 15 - c). It is a relatively straight piece of bone, consisting of three parts stuck together now, but found separately in situ in 1967. The cross section of this rib is nearly circular. In the in-situ-drawing (Fig. 4) this rib probably represents the last one that can be seen at the very right. Considering its position in situ, the straightness of the bone and its circular shape, we think this could well represent a floating rib of the sperm whale. The rib fragments are not described morphologically in detail here because they have a very limited diagnostic value in taxonomy.

TAXONOMIC STATUS OF SPERM WHALE BOII

Despite the damaged status of the cranium of BO II, at least two characters can be observed that allow an assignment of the fossil specimen to the superfamily Physeteroidea. The fragment of the maxillary and premaxillary clearly indicates a supracranial basin and the left nasal

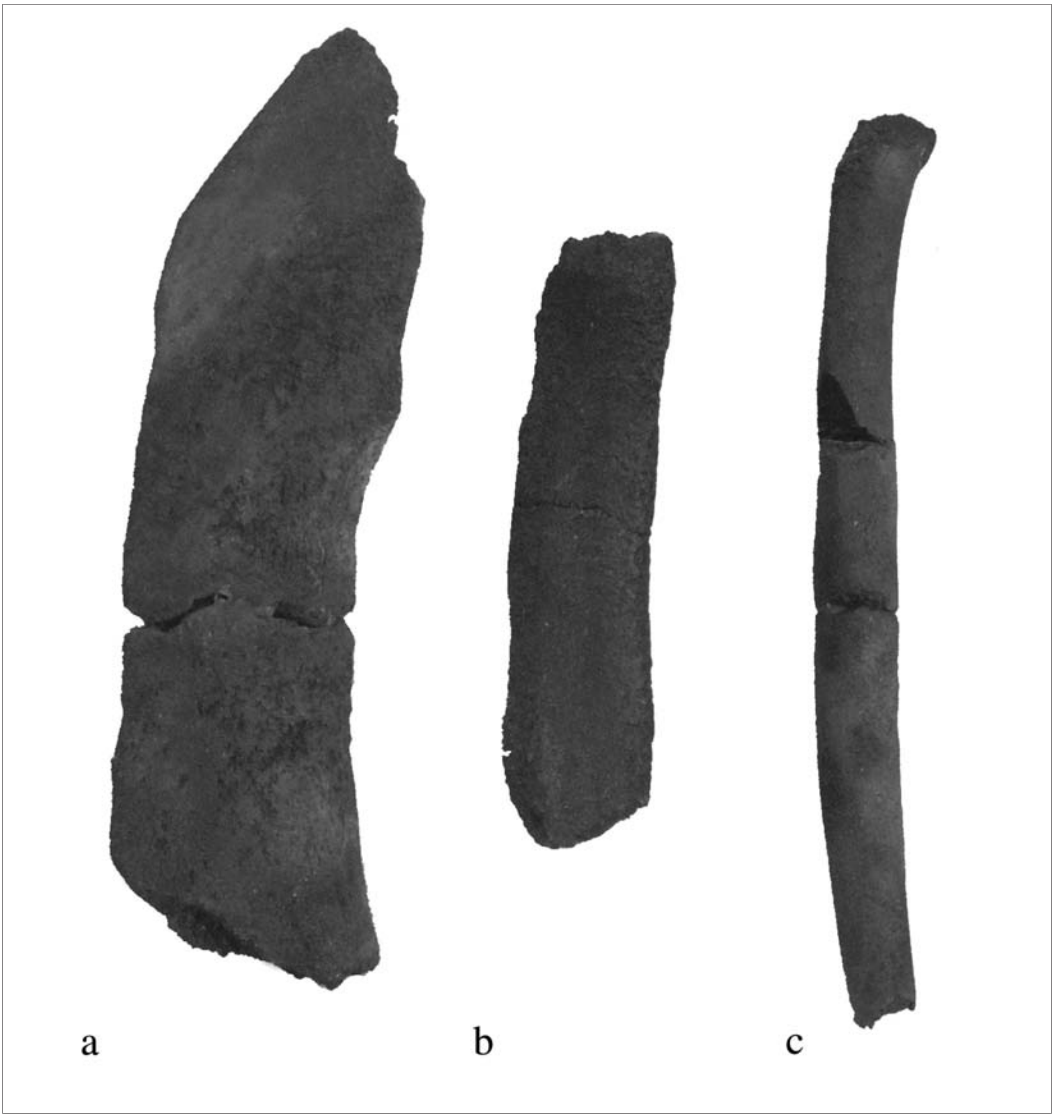

Figure 15 Ribfragments of sperm whale BOII; **a** = broad fragment of anterior rib, **b**= fragment of more posterior rib, **c** = floating rib.

opening is large. In addition the morphology of the periotic, the atlas, the fused cervical vertebrae 2-7 and count and morphology of the teeth do confirm in our opinion that BO II is a sperm whale belonging to the family Physeteridae, rather than Kogiidae. The morphology of the teeth (slender teeth without enamel) assigns BO II to the subfamily Physeterinae which includes till date the following genera and species (following Kazár 2002):

- *Physeter macrocephalus* LINNAEUS, 1758 (extant)
- *Placoziphius duboisii* VAN BENEDEN, 1869 (Miocene fossils from Belgium and Austria)
- *Physeterula dubusii* VAN BENEDEN, 1877 (Miocene fossils from Belgium)
- *Orycterocetus quadratidens* LEIDY, 1853 (Miocene fossils from USA, east coast)
- *Orycterocetus crocodilinus* COPE, 1868 (Miocene fossils from USA, east coast)
- *Idiophyseter merriami* KELLOGG, 1925 (Miocene fossils from USA, west coast)

Sperm whale BO II differs from:
- *Physeter* by its much smaller body size (< 50 %), even if it is taken into account that adult females are much smaller than adult males, the size and morphology of its periotic, the size and morphology of its teeth, including tracks of wear and tear, indicating a functional maxillary dentition.
- *Placoziphius* by the significant larger size of its cranium and vertebrae (> 40 %) and the much larger size (> 100%) of its maxillary teeth. In the holotype of *Placoziphius duboisii* no alveoli nor an alveolar groove are exhibited in the palatal surface. If present, maxillary teeth must have been lodged in the gum (Kazár, 2002). For sperm whale B0II having a functional maxillary dentition we consider the presence of alveoli in the upper jaw to be very probable.

There are very few elements of *Idiophyseter* to compare this species with BOII and therefore it is left out in this discussion. The genera *Orycterocetus* and *Physeterula* seem very similar. Kellogg (1965) noted already the similar features of the teeth and general cranial architecture, but realised that the Belgian specimina were at least 1/3 larger than *Orycterocetus*. Moreover he notes that Abel already pictured a periotic (erroneously assigned to the Eurhinodelphidae) from Antwerp, Belgium which seems very close in size and shape to the periotic of *Orycterocetus crocodilinus*. Whether the differences of *Orycterocetus* and *Physeterula* are of generic or specific nature is still to be studied and this subject falls beyond the scope of this article.

BO II differs from *Orycterocetus* by the larger size of its cranium and teeth (> 30 %). Sexual dimorphism - a feature prominently present in extant *Physeter* - as a reason for this difference as yet is not very likely because the sample of USA crania shows a remarkable similarity. BO II lacks premaxillary teeth, while *Orycterocetus* possesses premaxillary teeth. The only picture of the periotic of BO II (dorsal view) shows similarities in size and morphology with *Orycterocetus*, but the loss of the original periotic of BO II hinders further study.

Conclusion

The preserved parts of the cranium of BO II and the size and architecture of its teeth do not show essential differences if compared with the holotype cranium of *Physeterula dubusii*. Abel (1905) gives teeth lengths for *Physeterula dubusii* varying from 65 (smallest) to 130 mm (biggest). The seven BOII teeth that are preserved, vary in length from 92 to 109 mm. They certainly are among the bigger teeth of this sperm whale , so our conclusion is that the teeth of BOII are within the range of *Physeterula dubusii* (although in the holotype only the mandibular teeth are preserved). Therefore it seems prudent to identify BO II as *Physeterinae*, exhibiting closest affinity with *Physeterula dubusii*. But as yet not enough information is available to include with certainty sperm whale BOII in this genus.

For a further comparison and evaluation of the taxonomic status the following information of BOII seems to be important: (1) The presence of functional maxillary teeth (with size and shape close to the mandibular teeth). (2) The absence of premaxillary teeth. A feature which might confirm the generic differences between *Physeterula* and *Orycterocetus*. (3) The lateral view and relative size of its periotic. A periotic which seems to be of the type and size most commonly found in the Miocene of Belgium and The Netherlands. (4) The morphology of the atlas and the fused cervical vertebrae complex. (5) The size of this sperm whale. The total length of the animal is estimated between 5 and 6 meter.

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