An early seal (Mammalia, Pinnipedia) from the Middle Miocene (Langhian) of Miste (The Netherlands)

S. Schneider & K. Heissig

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Simon Schneider, Ludwig-Maximilians-Universität München, Department für Geo- und Umweltwissenschaften, Sektion Paläontologie, Richard-Wagner-Str. 10, D-80333 München, Germany (cuspidaria@web.de); Kurt Heissig, Bayerische Staatssammlung für Paläontologie und Geologie, Richard-Wagner-Str. 10, D-80333 München, Germany (k.heissig@lrz.uni-muenchen.de).

Key words — *Miophoca*, Pinnipedia, Middle Miocene, Miste, The Netherlands.
A single, upper premolar tooth of a seal from the Miste mollusc bed (Miocene, middle Langhian: The Netherlands) is determined as an upper P^3 of *Miophoca* cf. *vetusta* Zapfe. Fossils of this species and genus have to date only been reported from the Late Badenian (uppermost Langhian) of the Central Paratethys, at "Neudorf-Sandberg" (Devínská Nová Ves, Slovakia). This latter locality, however, is some two million years younger than the Miste Bed. The tooth from Miste represents the first evidence for the presence of the genus *Miophoca* in the North Sea Basin.

Contents

Introduction

Since the 19th century, the area around Winterswijk (Gelderland province) in The Netherlands has been well known for its fossil-rich marine Miocene deposits (e.g., Becks, 1843; Römer, 1853). Fossils were initially only collected at natural outcrops along the River Slinge, but, during the 1960s and 1970s, systematic examinations of sites were carried out by drilling. They were executed by the "Werkgroep voor Tertiaire en Kwartaire Geologie" (W.T.K.G.), which was founded in 1963, the "Nederlandse Jeugdbond voor Natuurstudie" and the "Rijksmuseum van Geologie en Mineralogie" (RGM). The results were published in a comprehensive geological and palaeontological overview by van den Bosch *et al.* (1975).

In 1968, the "laag van Miste" site was discovered and a preliminary report of the fossils was published by Kolstee (1969). It appeared that this locality was one of the richest and most diverse of its kind of the Miocene North Sea Basin, and several subsequent excavations examined the fauna in great detail. Miste is particularly famous for its fossil molluscs, which were the subject of several research projects (e.g., de Vogel, 1970, 1971; Nordsieck, 1972; van der Hoek, 1981; Janssen, 1984a, b). In addition, fossil remains of many other animal groups, such as Scleractinia, Bryozoa, Asteroidea (Jagt, 1991), Echinoidea, Ostheichtyes, teeth of Elasmobranchia (Bengevoord, 1973; van den

Bosch *et al*. 1975), dolphins and whales, have been recorded from this locality (Kerkhof & Wesselingh, 2004).

The discovery of the phocid tooth described herein is again due to the W.T.K.G.. On the occasion of its 40th anniversary, a great digging campaign was organized in September 2003, in which the senior author took part.

Geological overview

The locality is situated about 1500 m eastsoutheast of the village of Miste, near Winterswijk, in the province of Gelderland (Fig. 1). It was selected by the W.T.K.G. for the anniversary dig after several test boreholes had been executed in the area. In the excavation site, the fossiliferous Miocene sedimentary rocks are overlain by approximately 2 m of Pleistocene deposits (Mermuys, 2004). The Miocene layer itself also is some 2 m thick, with the upper 500 mm being less rich in fossils than the portion below. It is underlain by the Brinkheurne Member (Rupel Formation), which contains marine sedimentary rocks (clays) of Rupelian age (van den Bosch *et al*., 1975).

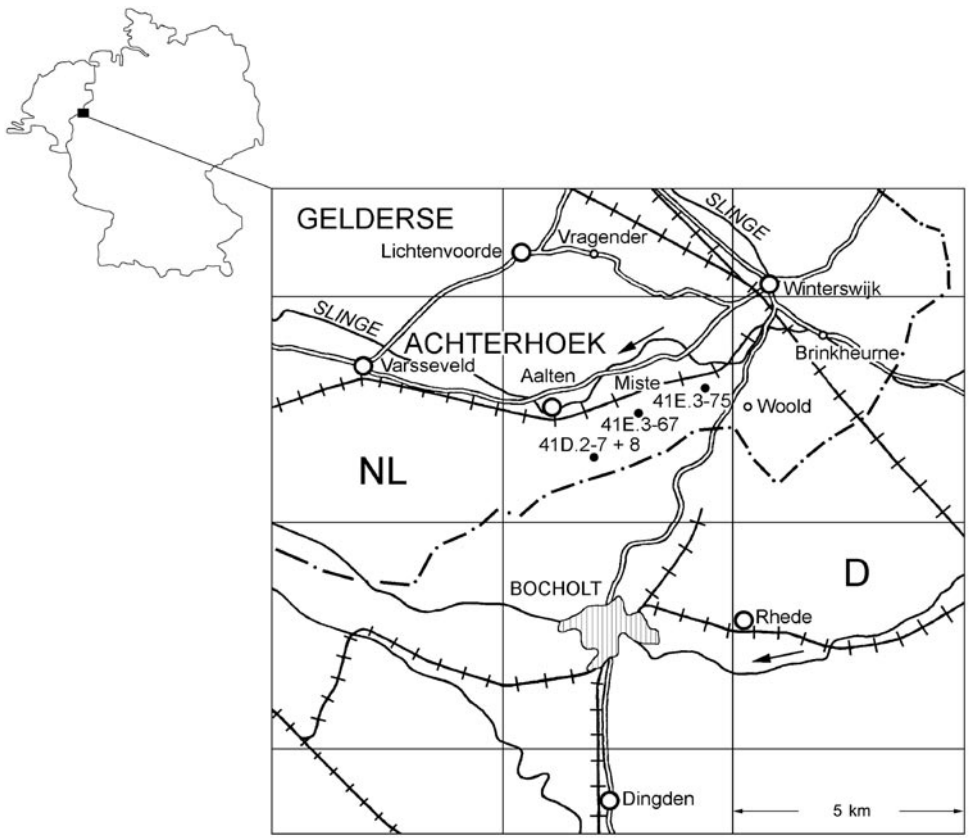

Fig. 1. Map of the Miste area. The excavation-site is located next to the drillhole marked with 41E.3-75 (after van den Bosch *et al*., 1975, fig. 1). Key: NL = The Netherlands; D = Germany.

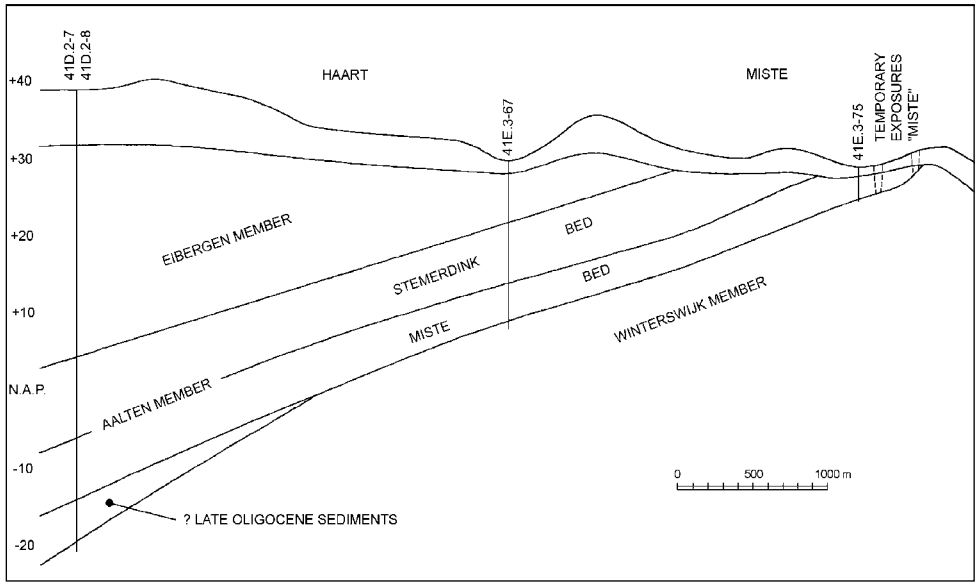

Fig. 2. Cross-section northeast (right) to southwest of the deposits at Miste. The Miste Bed is underlain by the Rupelian Winterswijk Member and cut off by Pleistocene gravels at Miste. The drillholes are marked in Figure 1 (after van den Bosch *et al*., 1975, fig. 8).

With regard to lithostratigraphy, the Miocene sedimentary rocks belong to the Miste Bed that represents the lower part of the Aalten Member, which is part of the Breda Formation (van den Bosch *et al*., 1975). The Miste Bed consists of well-sorted, fine-grained glauconitic sands, dark-brown to nearly black in colour. Especially in the lower, fossil-rich part, shapeless lumps of pyrite occur. In the Miste region, the Miste Bed is discordantly cut-off by the overlying Quarternary deposits (Fig. 2).

Unfortunately, to date no studies exist that focus on the biostratigraphy of foraminifera and other microfossils from Miste. However, the shark and mollusc faunas suggest that the lower part of the Miste Bed is Hemmoorian, whereas the upper part is Reinbekian (van den Bosch *et al*., 1975; Janssen, 1984a).

Using a counting method established by de Vogel (1970), van den Bosch *et al*. (1975) subdivided the Miste Bed into four different acme zones (according to the International Subcommission on Stratigraphic Classification, 1972) based on molluscs. These zones were defined based on the distribution maxima of significant mollusc species, but without sharply defined borders. While the fossils in the lowest zone support a Hemmoorian age, the upper three zones are placed in the Reinbekian (van den Bosch *et al*., 1975). However, these stages cannot be considered as chronostratigraphical units. Moreover, Gürs & Spiegler (2001) pointed out that no common definition exists for the boundaries of the Miocene Stages of the North Sea Basin since no appropriate type sections have ever been defined. They also showed that it is, with a few exceptions, impossible to use benthic molluscs for exact stratigraphic subdivision of the North Sea Miocene, due to their dependence on facies. In a new approach, Gürs (2002) and Wienrich (2002) presented nassariid gastropods as mostly facies-independent fossils with good stratigraphic

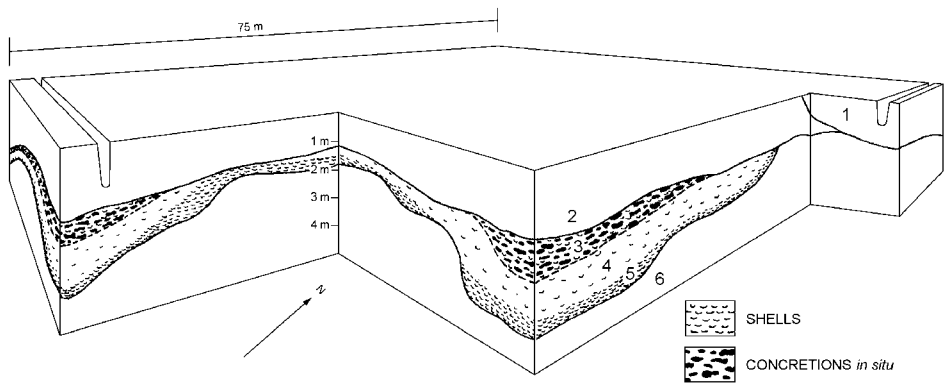

Fig. 3. Features of the geological setting at the excavation-site at Miste. Key: 1. Quarternary sands; 2. Quarternary gravels; 3. Aalten Member, Miste Bed, *Astarte radiata* acme zone, Miocene; 4. Aalten Member, Miste Bed, *Hiatella arctica* acme zone, Miocene; 5. Aalten Member, Miste Bed, *Hiatella arctica* acme zone, basal layer, Miocene; 6. Winterswijk Member, Rupelian (after Janssen, 1984a, fig. 3).

utility, especially for the Hemmoorian/Reinbekian boundary. Another stratigraphical concept for the North Sea Miocene is based on pteropods. These planktic gastropods can be regarded as completely facies-independent. The most recent refined stratigraphy for this group was compiled by Gürs & Janssen (2002).

In the excavation site at Miste, only the lower two acme zones (i.e., the *Hiatella arctica* Acme Zone and the *Astarte radiata* Acme Zone) were present in 2003 and have been sampled (Fig. 3). Since it was not possible to sample the profile precisely, the *Miophoca* tooth cannot be assigned to either one of these zones. Unfortunately, the Miste samples contain Hemmoorian as well as Reinbekian nassariids and no stratigraphically significant pteropods. According to the biostratigraphical concepts mentioned above, it is therefore not possible to date the tooth as Hemmoorian or Reinbekian.

There exist different opinions about the correlation of the Hemmoorian/Reinbekian boundary with international stages. Hinsch (2001) correlated it with the base of the Langhian (16.4 million years) by means of benthic molluscs, but this cannot be regarded as the most reliable method for exact dating as has been discussed before. The stratigraphic zonation based on *Bolboforma* (*incertae sedis*), introduced by Daniels & Spiegler (1974), seems to be more reliable since it is globally applicable. It is meanwhile correlated to calcareous nannoplankton, to palaeomagnetic zones, to *Uvigerina* zones (Spiegler, 2002) and to pteropod (Gürs & Janssen, 2002) as well as nassariid stratigraphy (Gürs, 2002). The absolute age for the Hemmoorian/Reinbekian boundary is approximately 15.6 million years, which would place it in the middle part of the Langhian stage. This corresponds to the Early Badenian in Paratethys stratigraphy. The type material of *Miophoca vetusta* Zapfe, 1937, from "Neudorf-Sandberg" (Devínska Nová Ves, Slovakia) is upper Badenian (=lower Serravallian in international stratigraphy). It is presumably less than 14 million years old; thus, the age difference between both *Miophoca* teeth is nearly two million years.

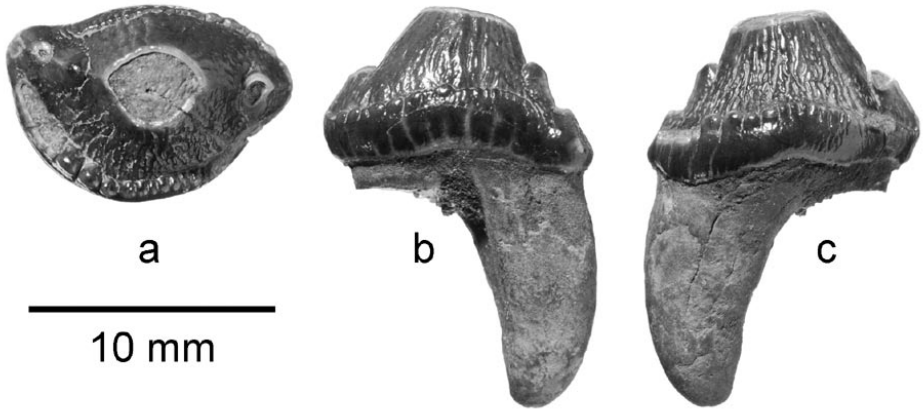

Fig. 4. Right P^3 of *Miophoca* cf. *vetusta* Zapfe, 1937, from Miste. (a) Occlusal view. (b) Labial view. (c) Lingual view.

Systematic palaeontology

Family Phocidae Gray, 1825
Subfamily Cystophorinae Gray, 1866
Genus *Miophoca* Zapfe, 1937

Type species — *Miophoca vetusta* Zapfe, 1937.

Miophoca cf. *vetusta* Zapfe, 1937
Fig. 4.

Material — Right isolated P^3. The tooth is housed at the Bayerische Staatssammlung für Paläontologie und Geologie in Munich (BSP 2003 XXIII 1). A cast of the tooth is deposited at the National Natuurhistorisch Museum in Leiden (RGM 450 228).

Description — Crown characterized by a high conical cusp with vertically wrinkled flanks surrounded by a serrated cingulum, which is thin on the labial, but robust on the lingual side. Main cusp connected by a low longitudinal ridge to a single secondary cusp in front and two cusps behind. Small front cusp rather low, but elevated above the cingulum-level, reaching about three times the height of the cingulum. Longitudinal ridge continues on front side to the cingulum. Last cusp of backside much lower and less set off the cingulum. Second cusp of backside smallest, positioned slightly higher on the longitudinal ridge than front cusp.

Outline irregularly oval with a more convex lingual and less convex labial side. Total length 12.1 mm; total width 8.3 mm. Labial side broad in front with a faint notch behind, just in front of the most distal cusp. Lingual side broadest behind, forming a

considerable cingular shelf without any trace of a lingual cusp. It possesses a small notch in front, just behind the front cusplet.

Wear facet horizontal on the main cusp. The first and last small cusps show small, lingually inclined wear surfaces. Just lingually of these cusplets even the cingulum is affected by wear, producing steeply falling facets.

Originally, the tooth possessed two roots, but only the distal is preserved. Root displays an oval section with a diagonal distolabially oriented long axis, supporting the distal cusplet and cingular shelf.

Comparisons — With the exception of a considerable difference in size, the tooth from Miste is identical in shape and contour with a P^3 (length = 9.6 mm; width = 6.7 mm) of *Miophoca vetusta* Zapfe, 1937, that was described and figured by Thenius (1952, p. 62) from "Neudorf-Sandberg" (Devínska Nová Ves, sandhill), a Late Badenian locality in Slovakia. The differences in size may be due to intraspecific variation, such as sexual dimorphism, or a slightly different geological age. They do not, however, justify establishment of a new species for the tooth from Miste. The genus identification is not affected by these differences.

Since preservation of the P^3 tooth from Miste is excellent, the weak differences to the P^4 of *M. vetusta* are clearly recognizable. In P^3, the anterior side cusplet is higher and separation of the posterior side cusplet from the posterior cingulum cusplet is more marked. Moreover, the outline of P^3 is broader and more asymmetrical than that seen in P^4.

Koretsky & Holec (2002, p. 166) recently described a skull of *Devinophoca claytoni* that demonstrates the existence of a second seal species at Neudorf. The skull was not found at the "Neudorf-Sandberg" locality, but rather a site near Neudorf called "Bonanza", which is slightly older than "Neudorf-Sandberg" (Holec *et al.*, 1987). This raises the question as to whether the isolated teeth from "Neudorf-Sandberg" and Miste may also belong to *D. claytoni*. Although the teeth of the skull are deeply worn, they still display two major differences to the isolated teeth from "Neudorf-Sandberg" and Miste. The P^3 in the skull possesses a well-marked protocone and the wear facet extends to the most lingual point of the tooth, whereas the teeth from "Neudorf-Sandberg" and Miste do not display a protocone. Moreover, wear affects the lingual cingulum near the front and rear end of the tooth.

Discussion — The isolated tooth from Miste is significant because it represents the first evidence for the occurrence on the Atlantic coast of Europe of a genus of seals that was previously known only from the Paratethys, belonging to the Mediterranean realm. Thenius (1952, p. 67) assigned *Miophoca vetusta* to the Monachinae and hence hypothesized that this taxon is directly related to the extant seals of the Mediterranean. However, the tooth from Miste shows that *Miophoca* also occurred in the North Sea. Koretsky (2001, p. 87) placed *Miophoca* in the Cystophorinae and linked the genus with the Phocidae of the open oceans. The age of the "Neudorf-Sandberg" locality (Slovakia; nearly 14 million years) corresponds to a time of widespread transgressions. This may have permitted the exchange of marine faunas between the Mediterranean and Atlantic realms. As far as the fossil record of pre-Middle Miocene seals at all permits conclusions, this view is corroborated by the discovery presented here. Since only a

few fossil remains of seals from deposits older than the Middle Miocene have been reported, *Miophoca* is regarded as one of the most primitive seals, positioned near the base of a continuous fossil record of seals and represents one of the best documented early genera. Unfortunately, van Beneden (1877) did not figure any upper teeth of his larger species and thus the possible relationships with these Pliocene seals cannot be determined. The analysis of additional seal fossils from the Miocene of the North Sea Basin, which occur in several Dutch collections (K. Post, written comm.), may lead to a better understanding of the relationships of the isolated tooth presented here.

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