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New records of giant campanilid gastropods (Mollusca) from the southern North Sea Basin: implications for Eocene and Quaternary palaeogeography•

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Abstract

Three specimens of the large-sized Eocene campanilid gastropod genus *Campanile* have been dredged from the modern sea floor in the Bruine Bank area (North Sea, Dutch sector). The material is identified here as *Campanile parisiense rarinodosum*, a subspecies hitherto unknown from the North Sea Basin. All three shells are strongly abraded, reflecting their secondary derivation. The new finds suggest that fossiliferous strata of probably late Lutetian (middle Eocene) age are represented in the southern North Sea Basin, situated most likely in the southeastern part of the UK sector. The present material of *Campanile* must have been reworked into the Dutch sector via Quaternary rivers. The occurrence of *Campanile parisiense rarinodosum* would indicate close biogeographic ties between the North Sea and the western French Atlantic basins during the late Lutetian. These new records thus shed light on the palaeogeography of the area during two widely separated geological time slices.

Keywords: *Campanile*, landscape evolution, Lutetian, North Sea Basin, palaeogeography

Introduction

During the past century, the bottom of the North Sea has become renowned for the rich fossil faunas that have been brought ashore by trawlers. In general, these involve Quaternary mammals, such as woolly mammoth (e.g. Mol & Post, 2010). However, older vertebrate and invertebrate material, of early Quaternary, Neogene, Paleogene and even Mesozoic age, is known from dredged shell accumulations in the southern North Sea (Buffetaut & Post, 2001; Moerdijk et al., 2010). Despite this, the record of several dredged specimens of the genus *Campanile*, one of the largest known fossil snails, came as some surprise. *Campanile* is indicative of the tropical character and highly diverse nature of the early and middle Eocene of western Europe. In our subsequent search for the identity and stratigraphic origin of this material, we also assessed internal moulds of *Campanile* from Lutetian deposits of northwest Belgium and northern France. The Bruine Bank specimens, all in the Fossil Mollusc collections of Naturalis Biodiversity Center (abbreviation RGM), turned out to represent a new taxon for the North Sea Basin. Here we document these new occurrences, refer the material to *Campanile parisiense rarinodosum* and discuss biogeographic implications and aspects of Neogene-Quaternary evolution of the southern North Sea Basin.

Systematic palaeontology

Class Gastropoda Cuvier, 1795
Family Campanilidae Douvillé, 1904
Genus Campanile *Bayle* in *Fischer, 1884*

Type species

Cerithium laeve Quoy & Gaimard, 1834 (non Perry, 1811) (= *Cerithium symbolicum* Iredale, 1917), Recent, Western Australia; by subsequent designation of Crosse (1888). This designation follows arguments provided by Darragh (2002).

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Campanile parisiense rarinodosum *Cossmann, 1907*

Fig. 1A-G.

1907 *Campanile rarinodosum* Cossmann, p. 254, fig. 4.
1912 *Campanile parisiense rarinodosum*; Boussac, p. 26, pl. 8, figs 4, 7a.
1913 *Cerithium* (*Campanile*) *parisiense* var. *rarinodosa*; Cossmann, p. 164.

Material

RGM 608.182 (leg. K. Post), a damaged shell from a sea floor depression, at ca 30 m water depth, between 0 and 10 miles (0-16 km) west of the Bruine Bank ('Brown Ridge'), collected by trawler G041 in January 2003; RGM 608.183 (leg. A. Hoekman), a heavily abraded, fragmentary shell from an unspecified locality, presumably near the Bruine Bank; RGM 608.184 (leg. K. Tanis), a damaged specimen from the Bruine Bank area (coordinates 52°36'50" N, 3°20'50" E) at 43 m water depth, recovered by trawler G04, on September 16, 2009.

Description

RGM 608.182 (Fig. 1A-D) measures 18.6 × 7.9 cm, with about 7.7 whorls preserved. Although abraded, the brownish white shell is relatively well preserved; the apical whorls have broken off, while the canal is plugged. The shell surface is somewhat shiny and punctured by clionid sponge borings as well as other types of irregular borings; boring intensity is strongest on one side of the shell, encompassing the youngest two to three whorls. The first teleoconch whorl, as preserved, shows only spiral elements, i.e., two basal spiral ribs, with a broader third rib above; the latter has poorly developed, low knobs. The upper half of the whorl is smooth, except for very low, regularly spaced knobs. On the first whorls, the growth lines are prosocyrt (inversed C-shaped). On later whorls knobs develop; on the second whorl, the knobs (15 per whorl) are situated in the upper half of the whorl and form a very subtle subsutural ridge. The knobs become increasingly elongate in the second and third whorls and are opisthocline. The number of knobs decreases to about 8 on the ultimate whorl. Axial ribs progressively are closer to mid-whorl and become more massive. The numerous fine growth lines eventually become opisthocline and tend to be sigmoidal. On the upper whorl half there are many, very fine and slightly irregular spiral ribs. The whorls are almost adnate, the suture being very shallow. The aperture is damaged; the type of scissor-like damage patterns (similarly worn as the remainder of the shell) suggests predation by a large decapod crustacean. The columella has a single, very strong basal fold which is both robust and acute. This lower fold is located entirely at the base of the columella towards the base of the aperture, delimiting a siphonal canal. Halfway the columellar lip, a second very low median spiral fold is present. In previous whorls (visible through the puncture), the upper fold is a narrow, well-defined rib.

RGM 608.183 (Fig. 1E) is a badly damaged, beige-coloured specimen of approximately three whorls, 9.3 cm in length and 5.9 cm wide. The surface is strongly encrusted, presumably by calcareous algae, with subsequent deep and intensive boring by clionid sponges and worms. The apex is missing; the canal plugged. The lower part of the shell is broken. More or less evenly spaced, low spiral ribs are observed on the base of the penultimate and ultimate whorls. This subadult specimen reveals a very low median columellar fold. Just behind the aperture the basal fold is visible, which is still very low in this subadult specimen and located almost at the base of the aperture.

RGM 608.184 (Fig. 1F, G) is another heavily damaged shell of approximately three whorls, 8.7 cm in length. The shell surface is corroded, light brown and intensely bored by clionid sponges and worms. Eight or nine low, slightly opisthocline, knobs are present on the shell. The median fold is thin, yet comparatively well defined. The basal columellar fold is very low and, similar to RGM 608.183, situated almost at the base of the aperture.

Differentiation and stratigraphic derivation

The Bruine Bank material shows a certain resemblance to a number of Eocene species of *Campanile* from southern England and western France. The newly collected specimens differ strongly from *C. giganteum* (De Lamarck, 1804) from the Lutetian of northwest Europe (Fig. 2) in ornament and in the absence of a strongly developed shoulder on later teleoconch whorls. Internal moulds of *C. giganteum* are not uncommon in the Lede Formation (middle Lutetian) of the Mont Cassel area in northern France. A few of such specimens have been collected from this unit in Belgium (Vlaanderen), inclusive of a single, near-complete specimen here illustrated in Fig. 1H. Even in these internal moulds, the characteristic strong shoulder is well preserved, a feature missing in the reconstructed mould of *C. parisiense rarinodosum* (Fig. 1D). In addition, the whorls in the reconstructed mould of the latter are lower as well. A single internal mould of *C. giganteum* is also known from the Vlaamse Banken area, offshore the northern Belgium coast (F.A.D. van Nieulande, pers. obs.).

Shell profile in *Campanile benechi* Bayan, 1870, from the Lutetian of the Paris Basin (see e.g. Boussac, 1912, pl. 1, fig. 2, 2a; pl. 4, fig. 3), is closely similar to that of *C. parisiense rarinodosum*. The knobs are lower (i.e., appearing as low folds), but as in the Bruine Bank specimens, they become restricted towards the centre of later whorls. There is some variation in the number of axial ribs/knobs in the French specimens, but the Bruine Bank material falls within the range of variation. However, the opisthocline character of the Bruine Bank knobs is different; in the French material the knobs are more orthocline. In addition, the median columellar fold is situated higher on the columellar lip in the latter and the whorls are lower.

Campanile parisiense parisiense Deshayes, 1864, from the Lutetian of the Paris Basin (see e.g. Boussac, 1912, pl. 1, fig. 4) has a higher spire, while the whorls are slightly lower and more

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Fig. 1A-G. Campanile parisiense rarinodosum *Cossmann, 1907, all dredged from around the Bruine Bank (Dutch sector, North Sea). For specimen details, see text. A-D. RGM 608.182, 18.6 cm in length, in rear and frontal views, detail of apical whorls, and reconstruction of the shell cast of this specimen based on X-ray images (similar magnification as Fig. 1H), respectively. E. RGM 608.183, 9.3 cm in length. F, G. RGM 608.184, 8.7 cm in length, in rear and frontal views, respectively. H.* Campanile giganteum *(Lamarck, 1804), specimen from the Lede Formation (middle Lutetian) of the Balegem area in Oost-Vlaanderen (Belgium; collector unknown), 42 cm in length.*

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tightly packed and a third upper columellar spiral rib appears to be present. Furthermore, the axial knobs are more closely spaced.

Campanile elongatum Boussac, 1912, from the Bartonian of the Paris Basin (see e.g. Boussac, 1912, pl. 6, fig. 3) has a slightly higher spire, although the specimen from Coulombs, illustrated in pl. 14, fig. 8 of that paper, is very plump and broad. The knobs are less pronounced, yet their opisthocline character is similar to that of the North Sea specimens.

Campanile rarinodosum Cossmann, 1907, from late Lutetian-early Bartonian deposits of the Lower Loire region, France (see e.g. Boussac, 1912, pl. 8, fig. 4, 4a; pl. 9, fig. 7), would appear to match the Bruine Bank specimens. The French material shows some variation in height/width ratio; the North Sea material falls well within this range of variation. Ribbing is identical, as are the columellar plicae.

Boussac (1912) postulated that *C. p. rarinodosum* was the stratigraphic successor of *C. p. parisiense*. The latter is found in middle Lutetian deposits of the Paris Basin, the former apparently restricted to the locality of Bois Gouët in the French Atlantic region. The age of the Bois Gouët fauna is most likely late Lutetian on ostracod, chlorophycaean and foraminiferal evidence (Margerel, 1968; Blondeau, 1971, 1972; Génot, 1987), although an early Bartonian date, on otolith evidence, cannot be completely ruled out (Nolf & Lapierre, 1977). As such, the new North Sea specimens would appear to be either of late Lutetian or early Bartonian age.

Discussion

Until now, *Campanile parisiense rarinodosum* had been recorded exclusively from Bois Gouët near Nantes, in the French Atlantic Basin (Fig. 2). This subspecies appears to be absent from Eocene deposits of Cotentin and of the Paris and Hampshire basins, despite the fact that fossiliferous upper Lutetian-lower Bartonian strata are known in these areas. We are uncertain as to the biogeographic significance of this subspecies in common between the North Sea and French Atlantic Eocene. However, we consider it possible that this is a truly Atlantic species that may have been absent from the Paris Basin and Channel basins which were situated further inland (Fig. 2). However, the presence of *C. giganteum* in the middle Lutetian of Vlaanderen and adjoining French territory, inclusive of the Paris Basin, does document close biogeographic ties between these basins just prior to the late Lutetian.

The provenance of the Bruine Bank specimens of *Campanile* is far from straightforward. Eocene deposits in the area are found at least a few hundred metres below the present-day sea floor, making local derivation impossible. There are various accounts of macrofossil taxa that have been reworked by Quaternary glaciers and rivers from areas up to a few hundreds of kilometres away in the North Sea Basin. For instance, there are records of Mesozoic dinosaur remains (Buffetaut & Post, 2001), Jurassic echinoderms (Jagt & Reumer, 2010) and Oligocene and Miocene

Fig. 2. Localities discussed in the present paper; the approximate distribution of more or less continuous Eocene deposits in the various basins is indicated by red lines.

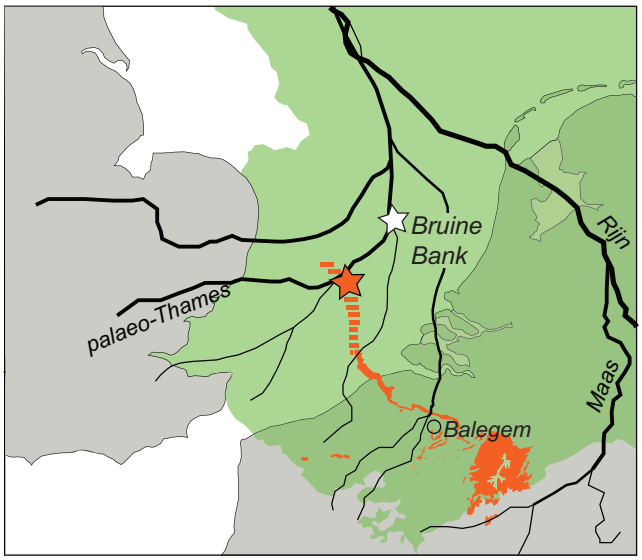

Fig. 3. Distribution of Eocene strata (green) and fossiliferous Lutetian-Bartonian deposits at the surface or at the sea floor (orange) in the southern North Sea Basin (after Maréchal, 1993; Du Four et al., 2006; Cameron et al., 1992). The new Campanile *material was dredged from the Bruine Bank area, its most likely source area within the southeastern UK sector of the North Sea being indicated by an orange star. Courses of Quaternary rivers are conjectural.*

molluscs (Janssen, 1978; Ter Poorten, 2003; Cadée & Cadée, 2011). To the north and east, i.e., the Netherlands and adjacent German territories, there are no known records of (remnants of) of fossiliferous Eocene deposits; as source area of the present specimens of *Campanile* they can be excluded. This leaves only the possibility of a southerly or westerly origin.

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Fossiliferous Eocene deposits are widespread near and at the surface in Vlaanderen and the adjoining Belgian sector of the North Sea (Du Four et al., 2006). However, no late Lutetian or early Bartonian shell-bearing deposits are known from that region, other than poorly fossiliferous clays (Maldegem Formation) with decalcified, soft-bottom marine molluscs. In view of the rare presence of other Bartonian (and, by implication, late Lutetian) fossils in suppleted material from the North Sea offshore Zeeland (Janse, 2010; Rijken, 2010), the former presence of Bartonian fossiliferous deposits nearby cannot be ruled out. However, to date we have found only remanié late Ypresian to early Lutetian fossils in fluvial deposits of the Palaeo-Scheldt (Schelde) in outcrop material (Zelzate, Belgium) and in currently studied boreholes alike (Moriaanshoofd, the Netherlands; see Słupik et al., 2013). The only species of *Campanile* that we have seen in Eocene deposits of western Belgium and adjacent France is *C. giganteum* (Fig. 1H), which occurs in the middle Lutetian Lede Formation. A southerly origin of the Bruine Bank *C. parisiense rarinodosum* is therefore not very likely.

The large size of the new finds of *Campanile* and the reasonably good surface preservation of the largest specimen implies that the source area was not too far removed from the Bruine Bank. The most proximate source is a band of Eocene deposits that crops out in a north-south trending belt under the sea floor of the adjacent UK sector of the North Sea (Fig. 3). Especially in the area around 2°35' E/ 52°00' N, unnamed beds of a late Lutetian to early Bartonian age crop out at or just below the sea bed (Cameron et al., 1992). According to palaeogeographic reconstructions of the southern North Sea (e.g. Gibbard, 1988), the area was drained by regional, south-north trending rivers such as the Palaeo-Medway and possibly also, at times, the larger Palaeo-Thames. Such rivers extended well into the current Dutch sector of the North Sea. The distance between the most likely source area and the Bruine Bank area is approximately eighty kilometres.

Conclusions

The presence of the late Lutetian-early Bartonian *Campanile parisiense rarinodosum* in the southern North Sea indicates biogeographic affiliation between that basin and the French Atlantic region, and hints at a lack of such a relationship between the North Sea Basin and the more proximate Paris Basin and Channel region. The Eocene species probably was derived with Quaternary rivers which eroded Eocene deposits situated just below the sea floor in the UK sector of the North Sea to the southwest, implying an episodic easterly extension of these rivers.

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