

WALTER KEGEL CHRISTENSEN

UPPER CRETACEOUS BELEMNITES  
FROM THE VOMB TROUGH  
IN SCANIA, SWEDEN



UPPSALA 1986

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In memory of the outstanding Swedish palaeontologist and biostratigrapher Johan Christian Moberg (1854–1915) who monographed the Upper Cretaceous belemnites of Sweden a century ago in 1885. Moberg used the belemnites biostratigraphically and proposed a partly new subdivision of the Upper Cretaceous. The publication of the monograph was the culmination of Moberg's first field of activity: the Cretaceous of Sweden. Later, he mainly focussed on the Cambro-Silurian of Scania. Seen in a European context, Moberg's study was only the third monograph dealing with Upper Cretaceous belemnites, following monographs on the English belemnites by Sharpe (1853) and German belemnites by Schlüter (1876).



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## ABSTRACT

Christensen, W.K., 1986: Upper Cretaceous belemnites from the Vomb Trough in Scania, Sweden. *Sveriges geologiska undersökning. Ser. Ca, No. 57*, pp. 1-57. Pls. 1-7. Uppsala 1986. Manuscript delivered in January 1985.

Upper Cretaceous belemnites from classic outcrops and one boring in the Vomb Trough in Scania, Sweden, are described, including univariate and bivariate biometric analyses.

The Vomb Trough is a narrow, elongated, asymmetrical graben initiated in early Mesozoic times. The maximum thickness of the Upper Cretaceous strata is a little less than 800 m, and the dominant sediments are glauconitic, calcareous, clayey siltstones deposited in a fairly shallow-water marine environment. Several conglomerates with extra-basinal clasts and non-sequences occur in the Santonian and Campanian, at least close to the margin of the trough.

Thirteen belemnite taxa from the Santonian-Campanian are recognized representing the following genera: *Actinocamax* Miller, *Goniot euthis* Bayle, *Belemnello camax* Naidin, and *Belemnitella* d'Orbigny. The nominate subspecies and two other subspecies of *Actinocamax verus* are discussed; the subspecies *dnestrensis* is placed in synonymy of the nominate subspecies, and it is suggested that the subspecies *fragilis* may be a geographic subspecies. *Actinocamax* (*Paractinocamax*) is discussed and placed in synonymy of *Belemnello camax*. Two taxa of *Belemnitella*, *B. alpha* and *B. praecursor*, from the lower and middle Lower Campanian are tentatively recognized and fully discussed. Measurements of critical internal characters of the holotype of *Belemnitella praecursor* are reported. *Belemnitella*

taxa from the uppermost Lower Campanian-Lower Maastrichtian are discussed and the concept of the majority of these taxa is shown to be in a state of chaos.

The localities in the Vomb Trough are described and placed in an international stratigraphic framework on the basis of the belemnites faunas, which are compared to faunas from western Europe and the Russian Platform.

The 'Westfalicus conglomerate' at Rödmölla-Tosterup yielded *Belemnitella propinqua* and *Goniot euthis westfalica* and is from the Lower-Middle Santonian. The marl at Eriksdal is referred to the Upper Middle Santonian on the basis of *Belemnitella propinqua* and *Goniot euthis westfalicagranolata*. Lower Middle Santonian strata with *Goniot euthis westfalica* are possibly also present at Eriksdal. The outcrops at Kullemölla-Lyckås contain *Belemnitella alpha*, *Goniot euthis granolata quadrata*, *Actinocamax verus*, and *Belemnello camax ex gr. grossouvrei*, and are assigned to the basal Lower Campanian. The loose blocks at Kåseberga containing *Belemnitella ex gr. alpha/praecursor* and *Goniot euthis granolata quadrata* or *Goniot euthis quadrata* are from the Lower Campanian, possibly the basal Lower Campanian. The 'Verus conglomerate' at Rödmölla-Tosterup is sandwiched between beds from the basal Santonian and the uppermost Lower Campanian, and may therefore be of middle to late Santonian and/or early Early Campanian age. The calcareous sandstones and conglomerates (Tosterup conglomerate) at Rödmölla-Tosterup span the Lower-Upper Campanian boundary. The beds with *Belemnello camax mammillatus*, *Belemnitella mucronata*, and *Goniot euthis quad-*

*rata scaniensis?* are from the uppermost Lower Campanian, whilst the beds with *Belemnellocamax balsvikensis* are from the lower Upper Campanian. The lower part of the Köpings sandstone is referred to the uppermost Lower Campanian on the basis of *Belemnellocamax mammillatus* and *Belemnitella mucronata*, whereas the upper part is assigned to the middle Upper Campanian on the basis of *Belemnitella mucronata* and *Belemnitella* aff. *langei*. The following belemnite species from the Santonian-basal Lower Campanian are recorded from the Kullemölla boring: *Actinocamax verus*, '*Actinocamax*' *lundgreni*, *Gonioteuthis westfalica*, *Gonioteuthis* spp., *Belemnitella*

*propinqua*, and *Belemnitella* ex gr. *alpha/praecursor*. The previous biostratigraphical dating of the upper part of the boring using foraminifera is supported on belemnite evidence. Maastrichtian belemnites have not been met with, although Maastrichtian ammonites and foraminifera are known from the trough. Earlier records of stratigraphically important fossils, including ammonites and echinoderms, are reviewed.

The present belemnite study has thus demonstrated the presence of Upper Cretaceous strata from the Lower-Middle Santonian, basal Lower Campanian, uppermost Lower Campanian-lower Upper Campanian, and middle Upper Campanian.

## Introduction

Upper Cretaceous belemnites from Sweden were studied already in the first half of the 19th century by Wahlenberg (1818), Nilsson (1826, 1827), Blainville (1825–1827, 1827), and d'Orbigny (1840); these authors, however, only recorded *Belemnitella mucronata* (Schlotheim) and *Belemnellocamax mammillatus* (Nilsson).

The first detailed study on the Swedish belemnites was presented in the classical monograph on the Upper Cretaceous cephalopods of Sweden by Moberg (1885). In this work he described nine species, forms, and varieties of belemnites, which were assigned to the genera *Actinocamax* Miller and *Belemnitella* d'Orbigny. In 1894 Moberg reviewed the fauna and commented briefly upon the taxa described earlier. Swedish Upper Cretaceous belemnites have also been studied by Schlüter (1876), de Morgan (1882), Stolley (1897, 1930), Jeletzky (1949b) and, more recently, by the present author (Christensen 1970 to 1982).

Christensen (1975a) monographed the Upper Cretaceous belemnites from the Kristianstad Basin in Scania on the basis of new and old collections. In the present paper the belemnites from the Vomb Trough are monographed mainly on the basis of collections made in the last part of the 19th century and the beginning of the 20th century. The faunas are compared to and correlated with belemnite faunas from other parts of Europe, and the outcrops are placed in an international stratigraphic framework.

In the Swedish Upper Cretaceous, belemnites, above all other macrofossils, are of fundamental importance in biostratigraphy and correlation. This is also the case for the Upper Cretaceous of the Vomb Trough. The present belemnite stratigraphy is the result of progressive refinements by a series of workers, notably Schlüter (1870 to 1897), De Geer (1881 to 1889), Lundgren (1876 to 1895), Moberg (1881 to 1910), Stolley (1897 to 1932), Hennig

(1910), Lundgren (1930 to 1936), Brotzen (1936 to 1966), and Christensen (1970 to 1982). Other stratigraphically important fossil groups such as ammonites and inoceramid bivalves have been recorded from the Vomb Trough but, unfortunately, none of these groups have been revised recently. However, recent comments by various authors on ammonites and inoceramid bivalves described from the area by earlier workers are summarized here (see section on description of localities). Lastly, it should be added that a significant description of the foraminiferal fauna from Eriksdal in the Vomb Trough was presented by Brotzen (1936).

The histories of subdivision of Upper Cretaceous strata in Sweden and Germany are closely connected. The first reliable scheme was that of Schlüter (1870). Stolley (1897) subdivided the Senonian of Germany and Sweden, mainly on the basis of belemnites, into (top to bottom): *Mucronatenkreide*, *Quadratenkreide* (= *Mammillatenkreide*), *Granulatenkreide*, and *Westfalicuskreide*. This classification was used subsequently in Sweden by most authors, even as late as Bergström & Sundquist (1978), but translated into: *mucronatakrita*, *mammillatuskrita*, *granulatuskrita*, and *westfalicuskrita*. Christensen (1985) reviewed the Albian to Maastrichtian of southern Sweden and Bornholm.

During the Upper Cretaceous, two belemnite subprovinces have been recognized within the North European Province (Christensen 1975a, 1976, 1982; see Fig. 11.) The Balto-Scandian belemnite faunas can be considered as mixtures of the faunas found in the Central Russian and Central European Subprovinces, respectively. They are, therefore, very important from a stratigraphic point of view, because they provide a basis for correlation between the two subprovinces (cf. Fig. 8).

## Material

The majority of the belemnites studied were placed at my disposal from the following institutions: Geological Survey of Sweden, Uppsala (SGU); Swedish Museum of Natural History, Section of Palaeozoology, Stockholm (RM); Geological Institute, University of Lund (LM); Geological Institute, University of Stockholm (GI); and Geological Museum, University of Copenhagen (MGUH). These collections generally were made in the last part of the 19th century and the beginning of the 20th

century. The collections of J.C. Moberg and A. Lundegren constitute a substantial part of the studied material, and the belemnites figured by Moberg (1885) are also included in the study.

The outcrops in the Vomb Trough are not accessible or very badly exposed today. I have, therefore, only been able to make new belemnite collections from one locality, Rödmölla at Tosterup.

## General geologic framework

During the Mesozoic the block-faulted NW-SE trending Fennoscandian Border Zone acted as a transition zone between the stable Fennoscandian Shield and the subsiding Permo-Mesozoic Danish Subbasin, which is part of the Danish-Polish Trough. The border zone in Scania is characterized by grabens and horsts trending NW-SE and is crossed by faults with a main direction NNE-SSW, creating a mosaic of tilted blocks (Figs 1-2).

Late Lower to Upper Cretaceous deposits are found northeast of the border zone in the Kristianstad and Båstad Basins and at Särödal, further north along the Swedish west coast. Within the border zone, sediments are recorded from the Vomb Trough and the island of Bornholm. Southwest of the border zone sediments are known from the Malmö area which, from a tectonic and sedimentologic point of view, belongs to the Danish Subbasin.

The lithology and thickness of the late Lower to Upper Cretaceous strata are highly variable within the different areas. Biocalcarenes and glauconitic sandstones prevail in the basins northeast of the border zone, and the thickness of the strata is less than 200 m (Christensen 1975a). In two borings in the southern part of the Hanö Bay the thickness of the Cenomanian-Campanian is about 540 m, and sandstones and calcarenites predominate (Norling & Skoglund 1977; Norling 1981; Norling in Kumpas 1980). In the Vomb Trough the Upper Cretaceous sedimentary deposits are characterized by detrital clastic sediments such as glauconitic calcareous, clayey siltstones (Chat-

ziemmanouil 1982), and the thickness of the Upper Cretaceous was found to be about 785 m in the Köpingsberg boring (Anderegg, Norling & Skoglund 1968; Chatziemmanouil 1982). Limestones, including chalk and marly chalk, predominate in the Malmö area, and the thickness of the Upper Cretaceous is about 1640 m (Norling & Skoglund 1977). The thickness of the Upper Cretaceous stages in various areas in southern Sweden is shown in Fig. 3.

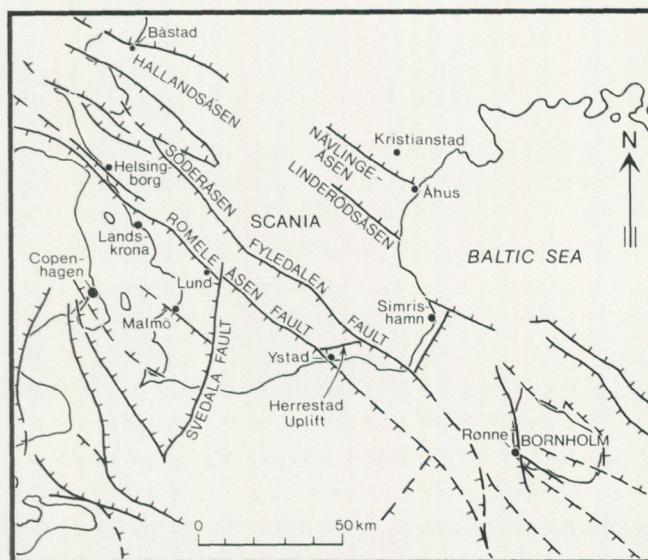


Fig. 1. Main structural trends in southern Sweden and adjacent areas. Modified from Gravesen, Rolle & Surlyk (1982).

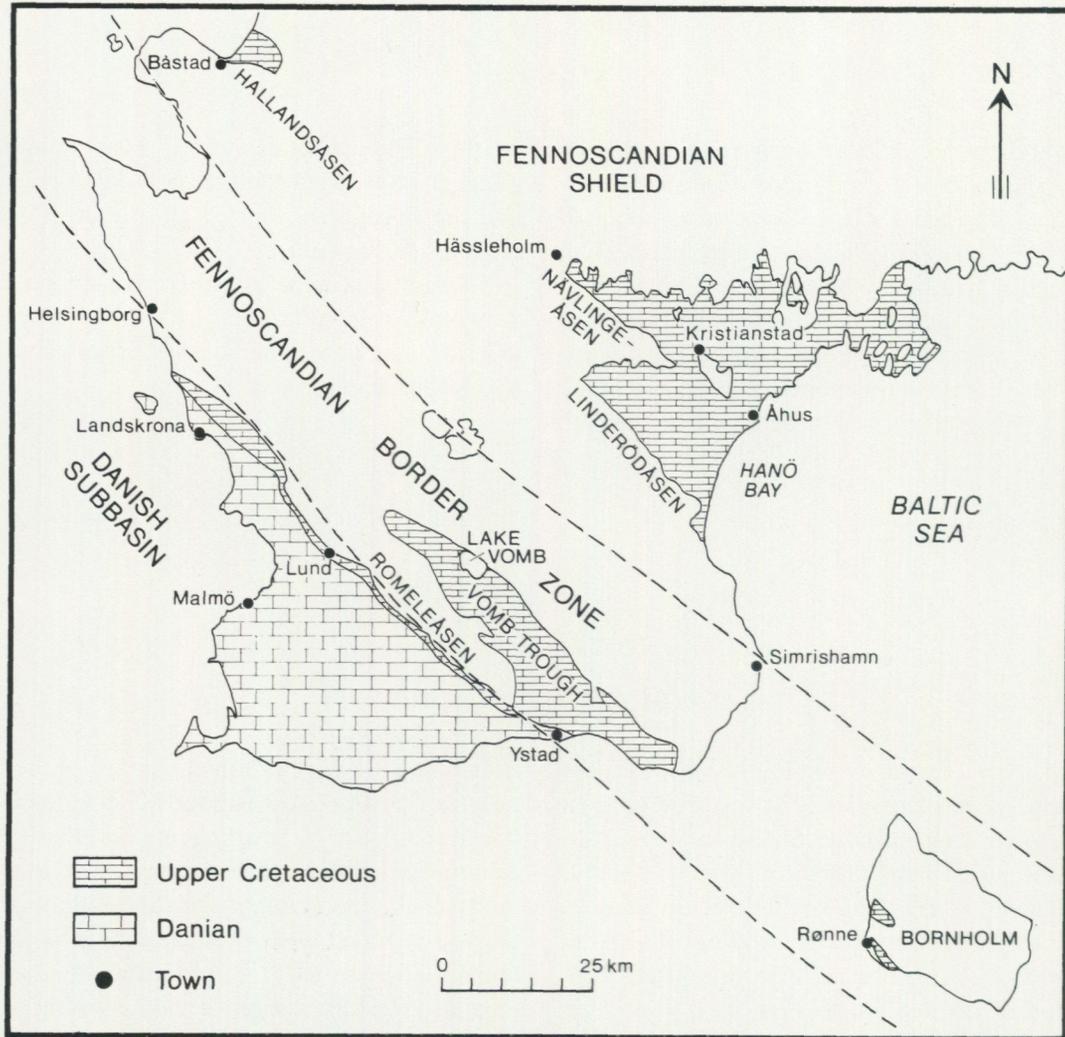


Fig. 2. Map showing the distribution of the Upper Cretaceous and Danian at the base of the Quaternary, and the approximate location of the Fennoscandian Border Zone. Modified from Gry (1960) and Bergström *et al.* (1982).

### The Vomb Trough

Norling (1982) and Chatziemmanouil (1982) described the trough as a narrow, elongated, asymmetrical graben which was initiated in the early Mesozoic (Fig. 4). The length of the trough is about 80 km; its width is about 7 km towards the northwest and 11 km towards the southeast. The trough is bounded to the northeast by the large-scale Fyledalen Fault and to the southwest by the Romeleåsen Horst, a Precambrian granitic fault block. The Herrestad Uplift, an east—west trending horst in the southern part of the trough, divides the trough into two parts. According to Chatziemmanouil (1982) the tectonic elements bordering the trough: the Romeleåsen Horst, Herrestad Uplift, and the Lower Palaeozoic Plateau northeast of the trough, were important source areas during the Upper Cretaceous. The trough was tectoni-

cally active during the Mesozoic and the thickness of the Upper Cretaceous strata varies due to differential subsidence. The greatest thickness is found in the southeastern part of the trough (Anderegg *et al.* 1968; Chatziemmanouil 1982).

Chatziemmanouil (1982) analysed the Upper Cretaceous of the trough on the basis of five borings placed along the axis of the trough. The borings were dated by means of foraminifera, and all Upper Cretaceous stages were recognized, although Lower Maastrichtian deposits were only found in the Köpingsberg borings immediately south of the Herrestad Uplift.

Several informal lithostratigraphic units, such as Eriksdal marl, Kullemölla marl, Lyckås marl, Kåseberga marl, Köpings sandstone, Valleberga sandstone, Rödmölla conglomerate, and Tosterup conglomerate, have been established for various sedimentary rocks in the trough in

| Area \ Thickness of stages in m | Albian-Cenomanian | Turonian | Coniacian | Santonian | Campanian | Maastrichtian |
|---------------------------------|-------------------|----------|-----------|-----------|-----------|---------------|
| Kristianstad Basin              | 18                | -        | -         | 55        | 105       | min. 6        |
| Hanö Bay                        | 75                | 25       | 40        | 400       | 50        | -             |
| Båstad Basin                    | 12                | -        | -         | ?         | ?         | -             |
| Vomb Trough                     | 50-60             | 90       | 85        | 390       | 160       | 50            |
| Malmö area                      | 65                | 50-75    | 75-100    | 300-350   | 350-400   | 500-700       |
| Bornholm                        | 85                | -        | 20        | 180(?)    | -         | -             |

Fig. 3. Thickness of Albian-Maastrichtian stages in various areas in southern Sweden and Bornholm, Denmark. Sources: Christensen (1975a), Norling & Skoglund (1977), Norling (1981), and Chatzimanouil (1982).

the last part of the 19th and the beginning of the 20th centuries. Some of these informal units have been used as formal lithostratigraphic units by later authors. However, these units are very badly defined or not defined at all, and they are, therefore, used informally in the present paper.

### Description of localities

Belemnites from five localities and one boring were studied (Fig. 4). All outcrops are situated in the north-eastern part of the trough close to the Fyledalen Fault. Most of the belemnite material placed at my disposal is labelled only with the name of the outcrop, and the exact horizon within the section is not indicated. This fact clearly reduces the stratigraphic potential of the material. However, most outcrops only expose some few metres of sediments, which can be referred to a specific belemnite zone. The outcrops are not accessible or are very badly exposed today, and consequently it was necessary to rely on earlier works in order to describe the localities. I have especially relied upon the studies by Lundgren (1876, 1880), Moberg (1881, 1882a, b, 1884, 1910a, b), De Morgan (1882), Hadding (1927), Hägg (1930, 1935, 1954), Lundgren (1933a, b, 1935a, b) and Brotzen (1938, 1945, 1958). Recently, the outcrops at Röd mölla-Tosterup were discussed in great detail by Gravesen (1977).

The outcrops are shown in Figs 4-6 and, where possible, their coordinates are given according to Topo-

grafiska kartan över Sverige (Topographical maps of Sweden), scale 1:50.000.

The revised stratigraphic age of the localities – in accordance with the present study – is indicated in the descriptions (see also Fig. 9). Ammonites, echinoderms, and inoceramid bivalves of stratigraphic potential were recorded and figured by earlier authors (i.a. Moberg 1885; Hägg 1930, 1935, 1954; and Lundgren 1935b). The Swedish material of these groups needs revision, but some recent published comments are included here.

The localities are listed in alphabetical order.

### Eriksdal

Moberg (1882b, 1884, 1910a) indicated two marl-pits at Eriksdal (Fig. 5), the geographical coordinates of which are:

Eriksdal A – 1D Ystad NV/2D Tomelilla SV; VB 251594  
Eriksdal B – 1D Ystad NV/2D Tomelilla SV; VB 256593

According to Moberg (1884) about 10 m of greyish-yellow sandy marl with a conglomeratic bed about 35 cm thick in the middle part of the section were exposed at Eriksdal B; the sedimentary strata dipped about 20° towards southwest. Moberg reported that fossils occurred very commonly in the sediments. Lundgren (1934, 1935a, in Brotzen 1936) mentioned that he had cleaned the section at Eriksdal B in 1931 and collected fossils bed-by-bed. Brotzen (1960: 11) claimed that the pit was filled up with Quaternary sand and gravel. This statement is, however, not correct. When I visited the outcrops in 1979, they were covered by scree and overgrown but can easily be cleaned. I succeeded in collecting some few belemnites from the topmost part of the sequence at Eriksdal B. Moberg (1884) did not comment upon Eriksdal A.

The belemnites examined in the course of the present study originate by and large from the collections made by J.C. Moberg in the last century and by A. Lundgren in 1931. The following taxa are recognized: *Goniot euthis westfalicagranulata* (Stolley), *Belemnitella propinqua propinqua* (Moberg), and *Actinocamax verus* Miller. The locality can thus be referred to the Upper Middle Santonian on belemnite evidence. It should, however, be added that in addition to *G. westfalicagranulata*, some few *westfalica*-like specimens with a relatively shallow pseudoalveolus occur at Eriksdal (see p. 26). These specimens may indicate that strata from the Lower Middle Santonian also are present at Eriksdal.

Hägg (1930:69-70) and Stolley (1930:168) recorded the crinoid *Uintacrinus* from Eriksdal and, according to both authors, this should indicate the presence of the

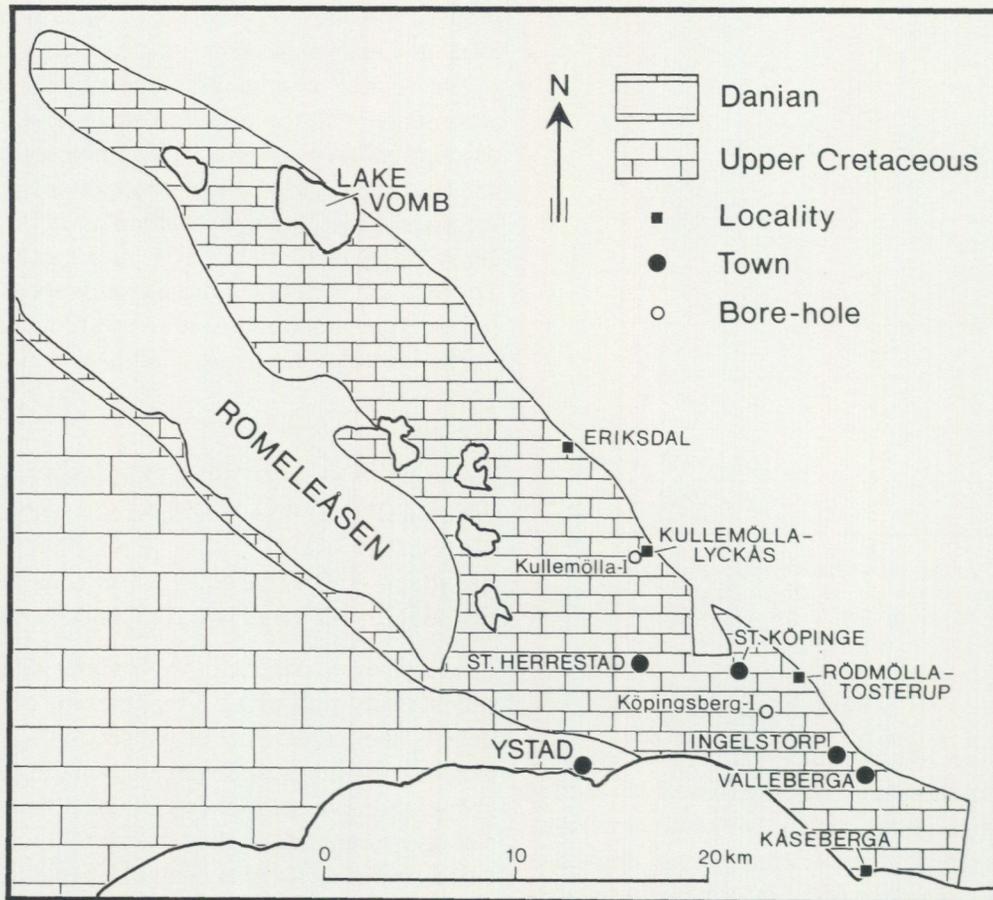


Fig. 4. Map of the Upper Cretaceous of the Vomb Trough at the base of the Quaternary showing outcrops and bore-holes. Modified from Bergström *et al.* (1982).

*Uintacrinus* Zone from the Lower Upper Santonian. It has been shown, however, by Ulbrich (1971) and Ernst & Schulz (1974) that *Uintacrinus* occurs both in the *Uintacrinus*/*G. granulata* Zone from the Lower Upper Santonian and the subjacent *G. westfalicagranulata* Zone from the Upper Middle Santonian.

According to Birkelund & Bromley (1979) one specimen of *Hauericeras cf. pseudogardeni* (Schlüter) has been found at Eriksdal; the specimen was figured as *Ammonites* n.sp.? by Moberg (1885, Pl. 2:7). *H. pseudogardeni* occurs in the Münster Basin in the so-called 'Santon 4' and 'Campan 1' of Arnold (1964), and these units were correlated by Ernst (1968, Table 1) with the *Marsupites*/*G. granulata* Zone of the Upper Upper Santonian and the *G. granulataquadrata* and *I. lingua*/*G. quadrata* Zones of the lowermost Campanian (Fig. 9). The presence of *H. cf. pseudogardeni* may thus indicate the presence of Upper Santonian rocks at Eriksdal. However, Ulbrich (1971) recorded *H. cf. pseudogardeni* from the *G. westfalicagranulata* Zone and the lower *G. granulata* Zone of the German Democratic Republic.

Therefore, it is not necessary to infer the presence of Upper Santonian rocks at Eriksdal.

Lastly, it should be mentioned that the monograph of Brotzen (1936) on the foraminiferal fauna from Eriksdal was based on material collected by A. Lundegren in 1931 from Eriksdal B.

#### Kåseberga

Loose blocks consisting of light, porous, yellow to greyish-yellow marlstones from the Upper Cretaceous are known from immediately west of the small village of Kåseberga at the sea-shore on the south coast (Lundgren 1880; Moberg 1882a; Lundegren 1935b; and Hägg 1935, 1939).

Hägg (1939) mentioned that he had collected two belemnites from a loose block, and they were referred to as *Goniot euthis quadrata* (Blainville) and *Belemnitella mucronata* (Schlotheim). I have examined the two speci-

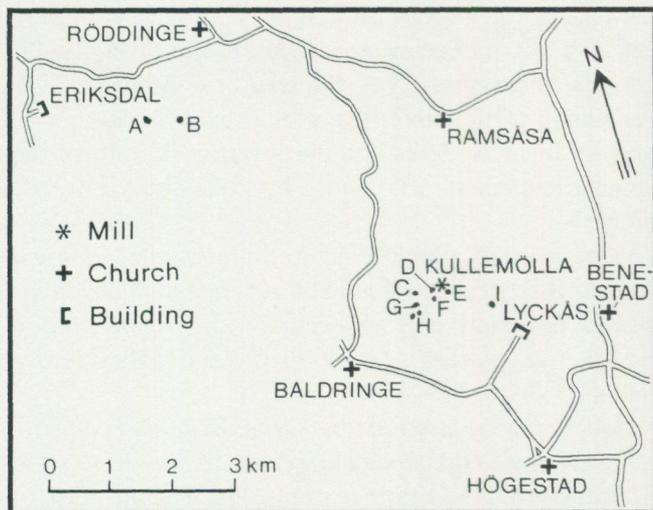


Fig. 5. Map showing outcrops at Eriksdal, Kullemölla, and Lyckås. After Moberg (1884).

mens and another specimen of *Goniot euthis* in the collection of the Geological Institute, Stockholm University. The specimen referred to as *B. mucronata* by Hägg is here assigned to *B. ex gr. alpha/praeursor* (see discussion below). A precise determination of the two specimens of *Goniot euthis* is not feasible, but they are tentatively ascribed to *G. granulataquadrata* (Stolley) or *G. quadrata* (see discussion below).

The loose blocks yielding the belemnites mentioned above are assigned to the lower part of the Lower Campanian on belemnite evidence.

Ammonites and inoceramid bivalves were recorded from the Kåseberga blocks by earlier authors, but this material needs revision.

### Köpinge

In the southeastern part of the Vomb Trough south of the Herrestad Uplift, a yellow, highly calcareous sandstone rich in glauconite, the so-called Köpinge sandstone, has been recorded from many small outcrops, the majority of which are not accessible today. The sandstone was found, notably, northeast of Ystad at Köpinge (Fig. 4). The Köpinge sandstone and its fauna were dealt with particularly by Schlüter (1870, 1876), Lundgren (1876), Moberg (1884, 1885), Stolley (1896, 1897), Grönwall (1912), Lundgren (1933a), Brotzen (1938, 1945, 1966), and Hägg (1954), who also listed the outcrops.

The Köpinge sandstone was referred to the 'Mucronatenkreide' by authors in the last part of the 19th

century and the first third of the 20th century. Stolley (1897) subdivided the 'Mucronatenkreide', mainly on the basis of ammonites, into three zones (bottom to top): a zone with *Hoplitoplacenticeras coesfeldiense*, a zone with *Bostrychoceras polyplocum*, and a zone with *Scaphites constrictus*. Hägg (1930) and Lundgren (1933a) suggested, on the basis of the ammonites recorded from the sandstone, that the sandstone apparently embraces all three zones.

Lundgren (1933a) studied the Köpinge sandstone along the Ingelstorp brook between Valleberga and Ingelstorp. Towards the east the sandstone was exposed from c. 500 m northeast of the Valleberga Church to c. 500 m northwest of the church, and Lundgren recorded *Belemnelloccamax mammillatus* from this area. He consequently referred the sandstone in this area to the *mammillatus* Zone and showed that it was older than assumed earlier. Hägg (1930:13) had collected *B. mammillatus in situ* at Valleberga Church already in 1913, but apparently he did not realise the importance of the discovery. Hägg (1954) restricted the name Köpinge sandstone to sandstone of *mucronata* Zone age as used by Stolley (1897, 1930), while similar sandstones of *mammillatus* Zone age *sensu* Stolley were referred to as Valleberga sandstone.

According to Lundgren (1933a) no outcrops were found from c. 500 m northwest of Valleberga Church to c. 600 m towards northwest. From this point and c. 1400 m towards west-southwest of Ingelstorp Church, Lundgren recorded only *Belemnitella mucronata* from the sandstone; it was therefore assigned to the *mucronata* Zone *sensu* Stolley. Lundgren mentioned that pebbles of Silurian shales were found throughout the sequence. Brotzen (1938), who visited the outcrops between Valleberga and Ingelstorp in 1937, confirmed the observations of Lundgren, and mentioned that he had seen loose blocks consisting of typical Tosterup conglomerate (see below) in this area.

The majority of the fossil material (including belemnites) kept in Swedish geological institutions is only labelled 'Köpinge', and this fact obviously reduces the stratigraphic value of the material. However, in addition to belemnites only labelled 'Köpinge', I have studied belemnites collected by A. Lundgren in 1932, F. Brotzen in 1937, and T. Birkelund and F. Brotzen in 1960 from the sandstone between Valleberga and Ingelstorp.

In the material generally labelled 'Köpinge' two taxa of *Belemnitella* are recognized: *B. aff. langei* Jeletzky and *B. mucronata* (Schlotheim). *B. aff. langei* is the dominant form and was figured as *B. mucronata* by Moberg (1885, Pl. 6:14-16, 19). The Köpinge sandstone yielding these

taxa probably belongs to the middle Upper Campanian, viz. the *B. mucronata* Zone and possibly the basal *B. 'minor'* Zone (see below).

The Köpings sandstone in the eastern part of the Valleberga-Ingelstorp area yielded *Belemnellocamax mammillatus mammillatus* (Nilsson) and *Belemnitella mucronata* (Schlotheim) and belongs to the uppermost Lower Campanian.

The Köpings sandstone in the western part of the Valleberga-Ingelstorp area yielded *B. mucronata* and *B. aff. langei*. Both taxa occur throughout the sedimentary sequence; *B. mucronata* is the dominant species in the lower part of the sequence, while *B. aff. langei* prevails in the upper part of the sequence. The Köpings sandstone in this area can thus be referred to the middle Upper Campanian.

*Belemnellocamax balsvikensis* (Brotzen), which occurs in the basal Upper Campanian, has not been recorded from the Köpings sandstone. Moreover, Maastrichtian belemnites are also unknown from the sandstone. It can thus be concluded that the Köpings sandstone on belemnite evidence can be assigned partly to the uppermost Lower Campanian and partly to the middle Upper Campanian.

Species of ammonites and echinoids of biostratigraphic value, recorded from the Köpings sandstone by earlier workers, have been the subject of published comments listed below.

*Pachydiscus stobaei* (Nilsson) was figured by Moberg (1885, Pl. 2: 1–2, 5). This species appears in Germany in the uppermost Lower Campanian *B. mucronata*/*G. quadrata gracilis* Zone, continues into the *G. vulgaris* Zone, and is used as an index fossil for the *P. stobaei*/*G. papillosa basiplana* Zone in the lower part of the Upper Campanian (Khosrovschahian 1972).

*Trachyscaphites spiniger* (Schlüter) was figured by Moberg (1885, Pl. 3:6). This species occurs in Germany in the lower part of the Upper Campanian from the *P. stobaei*/*G. papillosa basiplana* Zone to the *G. vulgaris* Zone (Schmid & Ernst 1975; Ernst, Schmid & Klischies 1979). *T. spiniger* seems to have the same vertical range as the important guide fossil *Hoplitoplacenticeras vari* (cf. Schmid & Ernst 1975).

*Bostrychoceras (Mobergoceras) junior* (Moberg) was figured by Moberg (1885, Pl. 3:14). This species occurs in Germany in the *B. mucronata*/*G. quadrata gracilis* Zone (Schmid & Ernst 1975). According to Moberg the specimen came from the *B. mucronata* Zone as used earlier. It should be stressed, however, that the Köpings sandstone was considered to belong only to the *B. mucronata* Zone in the last part of the 19th century (see above).

*Ancyloceras? elegans* Moberg was figured by Moberg (1885, Pl. 3:10). According to Blaskiewicz (1980:28–29) this specimen may be referred to *Neancyloceras phaleratum* (Griepenkerl), a species which Blaskiewicz used as an index fossil for the lowermost zone of the Upper Campanian in Poland. This zone also yielded *T. spiniger*.

Moberg (1885, Pl. 3:1) figured *Ammonites oldhami* Sharpe. This specimen should be assigned to *Pachydiscus koeneni* Grossouvre which occurs in the *N. phaleratum* and *B. polyplacum* Zones in Poland (Blaskiewicz 1980:42).

Moberg (1885) also recorded *Hoploscaphites constrictus* (Sowerby) and *Anagaudryceras cf. lueneburgense* (Schlüter) from the Köpings sandstone. The presence of these two species may indicate that part of the sandstone is from the Maastrichtian. The specimens, however, may have been collected from loose blocks in the Köpings area. In this connection it is of interest that Chatziemmanouil (1982) recorded lower Maastrichtian strata from the Köpingsberg boring, which is situated in the former area of outcrop of the Köpings sandstone.

Stokes (1975) reported *Micraster glyphus* (Schlüter) from Köpings. *M. ex gr. schroederi/glyphus* occurs in Germany from the *B. mucronata*/*G. quadrata gracilis* Zone to the *P. stobaei*/*G. papillosa basiplana* Zone (Ernst & Schulz 1980).

Stokes (1979) recorded *Diplodetus idae* (Cotteau) from Köpings and mentioned that specimens of this species were variously labelled as *Micraster coranguinum*, *M. corbovis*, *M. idae*, and *Brissopsis? cretacea*.

#### Kullemölla-Lyckås

Moberg (1882b, 1884) indicated seven outcrops at Kullemölla and one outcrop at Lyckås (Fig. 5). According to Moberg (1884) the marl pit at Lyckås (locality I) showed the same sequence as the large marl pit referred to as Kullemölla D (Stora Grafven). About 8 m of greyish-yellow sandy marl which dipped about 30° towards northwest were exposed at the latter locality. Locality Kullemölla E (Qvarnrännan) exposed a slightly deeper part of the sequence than Kullemölla D. The other pits at Kullemölla only showed sections of small thicknesses, and they were not treated in detail by Moberg. Today the outcrops are not accessible or are covered by scree and overgrown.

The outcrops at Kullemölla-Lyckås have yielded the following belemnites: *Goniot euthis granulataquadrata*, *Belemnitella alpha*, *Actinocamax verus*, and *Belemnelloccamax* ex gr. *grossouvrei*, and can thus be referred to the basal Campanian, Zone of *G. granulataquadrata*.

A. Hennig (pers. comm. in Schlüter 1897:46) reported *Marsupites* from Lyckås. This record, however, was not described in detail and has not been verified by subsequent workers. The record of *Marsupites* at Lyckås is therefore considered dubious for the time being.

### Kullemölla 1 boring

The boring was made in 1918–1919 and described by Gavelin (1919) and Lundegren (1933b, 1935b). It was commented upon later by Brotzen (1945, 1958). Recently, Chatziemmanouil (1982) reexamined the Upper Cretaceous of the boring, and four other borings in the trough, from a sedimentologic and biostratigraphic point of view. Guy-Ohlson (1982) studied the palynological content of the basal part of the boring and showed that a major unconformity is present between the Lower Jurassic and Lower Cretaceous.

The drill-hole was placed c. 850 m westsouthwest of the Kullemölla Mill rather close to the outcrops at Kullemölla mentioned above (Figs. 4–5). A little more than 600 m of Upper Cretaceous sediments, mainly consisting of glauconitic, calcareous siltstone, were found in the boring.

Lundegren (1933b, 1935b) dated the Upper Cretaceous strata on the basis of belemnites, ammonites, and inoceramid bivalves. The belemnites are revised in the present paper; the two other groups still need revision. Chatziemmanouil (1982) subdivided the Upper Cretaceous of the boring on the basis of foraminifera and, according to this author, the 28–128 m interval belongs to the Campanian, the 128–515 m interval to the Santonian, the 515–575 m interval to the Coniacian, the 575–614 m interval to the Turonian, and the 614–639 m interval to the Aptian-Cenomanian.

The following belemnites are recognized from the boring: *Actinocamax verus* Miller, 'A'. cf. *lundgreni* Stolley, *Goniot euthis westfalica* (Schlüter), *G. spp.*, *Belemnitella propinqua* (Moberg), and *B. ex gr. alpha/praecursor*.

*A. verus* was found in the 40–360 m interval, and the species is most common in the 40–190 m interval. Altogether, 42 specimens have been examined. A single specimen of 'A.' cf. *lundgreni*, earlier referred to as *G.*

*westfalica* by Lundegren (1935b), came from the 440 m level.

Representatives of the genus *Goniot euthis* were found in the 60–390 m interval. Lundegren (1935b) also reported *Goniot euthis* from the 390–440 m interval, but the belemnite specimens found in this interval are not determinable at the genus level with one exception (see above). The specimens of *Goniot euthis* are well-preserved and in some cases complete. They cannot, however, be assigned with certainty to species, because it is necessary to analyse a certain number of specimens, say at least 8–10, in order to make a reliable specific determination. Only the earliest member of the *Goniot euthis* lineage, *G. westfalica*, is easily recognizable owing to the structure of its anterior end, and several specimens of this taxon were identified from the 330–390 m interval.

A single specimen of *B. propinqua* came from the 248 m level; this specimen was referred to as *B. mucronata* by Lundegren (1935b:8). Three specimens of *B. ex gr. alpha/praecursor* came from the uppermost 20 m of the boring; these specimens also were referred to as *B. mucronata* by Lundegren (1935b:8).

The stratigraphic range of the belemnites found in the Kullemölla 1 boring are discussed in the systematic part of the paper. The biostratigraphic subdivision of the upper part of the boring by Chatziemmanouil (1982) can be supported on belemnite evidence. The uppermost part of the boring yielded *B. ex gr. alpha/praecursor* and is thus from the lower Lower Campanian, as are the sediments outcropping nearby.

### Rödmölla-Tosterup

The outcrops at Rödmölla-Tosterup (Fig. 6) were dealt with by Lundegren (1876), Moberg (1881, 1884, 1888, 1910b), de Morgan (1882), Hadding (1927), and more recently by Gravesen (1977). Gravesen reviewed in great detail literature concerning Rödmölla-Tosterup and also provided new information about some of the outcrops. The following outline relies heavily on his review.

Moberg (1910b) distinguished five outcrops at Rödmölla-Tosterup, and they were referred to as CV:1–5. Three outcrops (CV:1–3) were found in the southeastern slope of the valley of the Rödmölla brook; locality CV:4 was the large Tosterup marl pit; and locality CV:5, situated a little southwest of the marl pit, was found in the western slope of the valley. At present, CV:1 is very badly exposed; CV:2 was reexcavated by P. Gravesen

and others (see Gravesen 1977); and at CV:3 loose blocks of Tosterup conglomerate were found recently in a cultivated field (Gravesen 1977). CV:4 and CV:5 are not accessible today. The geographical coordinates are as follows:

Rödmölla CV:1 – 1D Ystad NO/2D Tomelilla SO; VB 37054805,

Rödmölla CV:2 – 1D Ystad NO/2D Tomelilla SO; VB 36954800,

Rödmölla CV:3 – 1D Ystad NO/2D Tomelilla SO; VB 36854790.

Locality CV:1 showed formerly the contact between the Lower Jurassic and the Upper Cretaceous sequence. According to Moberg (1910b) the almost vertical Upper Cretaceous sediments rested upon Lower Jurassic sandstone. The basal Cretaceous bed, the so-called 'Westfalicus conglomerate' of Hadding (1927), is a coarse-grained, greyish-yellow sandstone rich in shell fragments with numerous small dark pebbles of Lower Jurassic sedimentary rocks. Two hard beds each 50 cm thick and approximately 2 m apart were present in the lower part of the 'Westfalicus conglomerate'. Moberg (1910b) reported *Goniot euthis westfalica* and *Actinocamax verus* from this part of the sequence. I have examined specimens of *G. westfalica* labelled Tosterup 7 by J.C. Moberg in 1887. On the basis of the adherent matrix, it can be inferred with great probability that the specimens came from the 'Westfalicus conglomerate'. Moreover, I have seen one specimen of *Belemnitella propinqua* from the conglomerate. On the basis of these taxa the conglomerate can be assigned to the Lower-Middle Santonian. Moberg (1910b) mentioned that two hard beds, more or less similar to those mentioned above, were present about 50 m to the south. These beds did not yield any fossils.

The 'Westfalicus conglomerate' is succeeded upwards by loose arenaceous beds which in turn are overlain by another conglomerate, the so-called 'Verus conglomerate' of Hadding (1927) and Rödmölla conglomerate of Moberg (1910b). The 'Verus conglomerate' is rather similar to the 'Westfalicus conglomerate', only differing by containing more and larger pebbles, which consist of Lower Jurassic rocks, notably ferruginous, dark brown, fine-grained sandstones and clay iron-stones (Hadding 1927). This conglomerate yielded *A. verus* (see Moberg 1910b). The 'Verus conglomerate' and the subjacent and superjacent arenaceous beds are less inclined than the beds of the 'Westfalicus conglomerate' (cf. sketch of this part of the section by de Morgan, 1882, Fig. 8).

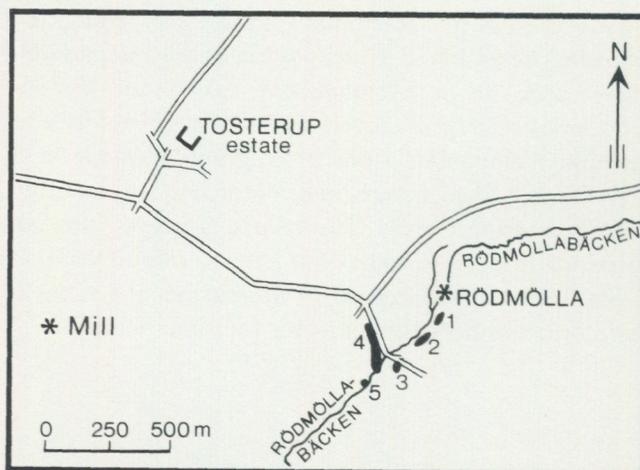


Fig. 6. Map showing outcrops at Rödmölla-Tosterup. After Moberg (1910b).

The 'Verus conglomerate' is followed upwards by calcareous sandstones in which several conglomerates or conglomeratic beds are present. These conglomerates are characterized by their content of pebbles of Silurian shales (Colonus Shale) and Lower Jurassic sandstones (Hadding 1927), and were referred to as Tosterup conglomerate by Moberg (1884, 1910b) and 'Mammillatus conglomerate' by Hadding (1927). In the former Tosterup marl pit (sketched by the Morgan 1882, Fig. 7), the calcareous sandstone was overlain by two conglomerates approximately 40 cm apart, which in turn was succeeded upwards by calcareous sandstone; the sedimentary sequence dipped about 10° towards the southeast (de Morgan 1882; Moberg 1910b). Moberg (1910b) mentioned that Upper Cretaceous strata could be followed from south of the pit to the Rödmölla brook, and conglomerates and sandstones alternated along this stretch. Moberg (1910b) recorded *Pachydiscus stobaei*, *Trachyscaphtes spiniger*, *Scaphites roemeri?*, in addition to *Belemnelloamax mammillatus* and *Belemnitella mucronata* from the calcareous sandstone underlying the conglomerates. He also mentioned that the same fossils, by and large, occurred in the conglomerates. I have studied some few specimens of *B. mammillatus* from this pit, and the sediments can therefore be referred to the uppermost Lower Campanian.

Moberg (1910b) also recorded the Tosterup conglomerate from locality CV:2, and from this outcrop he reported *B. mammillatus* and one specimen of '*Actinocamax quadratus* Blainville var.'. This specimen is most likely the same specimen as collected by J.C. Moberg in 1887 at Tosterup 5 and figured by Christensen

(1975a:20, Fig. 19). Locality CV:2 was reexcavated by P. Gravesen and others. When I visited the locality, it was about 6 m high and 8 m wide, and showed calcareous sandstone with pebbles of Silurian shales. In some horizons the pebble content was so high that the sediment could be classified as a conglomerate. This outcrop yielded the following belemnites: *B. mammillatus* (very common), *B. mucronata* (rare), and *G. quadrata scanien-sis?* Christensen (very rare). The calcareous sandstone and Tosterup conglomerate at this outcrop can thus be assigned to the uppermost Lower Campanian on belemnite evidence.

Typical Tosterup conglomerate was also found at CV:3, and here the conglomerate yielded *B. balsviken-sis*. Consequently, the conglomerate is from the basal

Upper Campanian at that locality.

#### Summarizing remarks

The oldest part of the Upper Cretaceous sequence at Röd mölla-Tosterup can be ascribed to the Lower/Middle Santonian. The so-called 'Verus conglomerate' is sandwiched between beds from the Lower/Middle Santonian and uppermost Lower Campanian, and it may therefore be referred to the upper Santonian and/or lower Lower Campanian. The alternating calcareous sandstone and conglomerates (Tosterup conglomerate) which follows upon the 'Verus conglomerate' are from the uppermost Lower Campanian and the basal Upper Campanian.

## Stratigraphy

### General outline

The Upper Cretaceous Series includes the following six stages: Cenomanian, Turonian, Coniacian, Santonian, Campanian, and Maastrichtian. All stages except the Maastrichtian have their type localities in France. The Cenomanian type locality is situated in the Paris Basin, southwest of Paris, in the environs of the Le Mans. The Turonian is based on sections in Touraine. The Coniacian, Santonian, and Campanian type localities are in the Aquitaine Basin, while the Maastrichtian type locality is the ENCI-quarry at Maastricht in southeastern Holland.

When d'Orbigny (1842) began to subdivide the Upper Cretaceous into stages, he first recognized two: the Turonian below and Senonian above. In 1847 d'Orbigny realized that the Turonian contained two different faunas and the lower part was separated as the Cenomanian. d'Orbigny (1852) discussed at length the Cenomanian and Turonian stages, and the two units were characterized by various fossil groups, such as gastropods, bivalve molluscs, foraminifera, and ammonites. The Cenomanian was referred to as the Second Zone of Rudists and the Turonian as the Third Zone of Rudists.

The Coniacian, Santonian, and Campanian stages

were introduced by Coquand (1856, 1857), who characterized them by oysters, rudists, brachiopods, echinoids, and ammonites.

The Senonian has its type locality in the Paris Basin southeast of Paris at the town of Sens. According to d'Orbigny (1842) the Senonian included all beds younger than the Turonian and older than the Danian. Maastrichtian strata are not recorded from the Paris Basin and therefore some authors have excluded the Maastrichtian from the Senonian. Hancock & Kennedy (1981) regarded the Senonian as a superstage, while Harland, Cox, Llewellyn, Pickton, Smith and Walters (1982) considered it as a subseries. Since the Senonian means different things to different authors and represent 23–24 Ma (Obradovich & Cobban 1975; van Hinte 1976; Lanphere & Jones 1978; Kennedy & Odin 1982; and Harland *et al.* 1982), it is suggested here that the Senonian should no longer be employed. The Subcommittee on Cretaceous Stratigraphy of the IUGS does not recommend the formalization of the Senonian (Birkelund, Hancock, Hart, Rawson, Remane, Robaszynski, Schmid & Surlyk 1984).

The Upper Cretaceous stages were loosely defined and the characterizing fossils were in some cases of little

biostratigraphic value. Moreover, it has later been shown that the bases of the majority of the Cretaceous stages are characterized by hiatus in the type areas (Birkelund *et al.* 1984). Consequently, many diverging points of view regarding the delimitation of the stages have been put forward in the literature. Moreover, attempted correlation of the sedimentary successions in France and Holland with successions in other areas has introduced innumerable complications. In an attempt to clarify the situation, the Subcommittee on Cretaceous Stratigraphy held a symposium on Cretaceous Stage Boundaries in Copenhagen in the autumn of 1983. At this meeting a set of stage boundary proposals and recommendations were formulated (Birkelund *et al.* 1984). Ammonites have been considered by many authors to be the most significant group in the subdivision of the Upper Cretaceous stages. As mentioned above, both d'Orbigny and Coquand used various fossils for defining the stages, and ammonites can hardly be considered more important than a number of other groups. In northern Europe, ammonites have been shown to be important for the zonation of the type Cenomanian and type Turonian and its correlatives. Nevertheless, general agreement on the Albian-Cenomanian and Cenomanian-Turonian boundaries and the subdivision of the Turonian has not been achieved (cf. Wright & Kennedy 1981; Robaszynski 1982; Alcayde 1983; Kennedy 1984; Birkelund *et al.* 1984).

The 'standard ammonite zonation' of the Coniacian-Maastrichtian was reviewed by Kennedy (1984) and, in the opinion of the present author, Kennedy clearly demonstrated that it is not workable. On the other hand, belemnites, inoceramid bivalves, and echinoids are of importance of local zonations of the Coniacian-Maastrichtian in northern Europe, and these local zonations can be correlated with little difficulties within that region, except to the type Coniacian-Campanian.

The Coniacian-Maastrichtian of northern Germany has been carefully studied during the last twenty years by a number of workers (see review by Ernst, Schmid & Klischies 1979; Schulz, Ernst, Ernst & Schmid 1984), and work is in progress on the Coniacian-Maastrichtian of Great Britain (see Bailey, Gale, Mortimore, Swiecicki & Wood 1983, 1984).

The definition of the Coniacian-Campanian stages chosen in the present paper is shown in Fig. 7, and the belemnite zonations of the Upper Cretaceous in NW-Europe, Balto-Scandian, and on the Russian Platform are shown in Fig. 8.

### The subdivision of the Upper Cretaceous of Sweden

Christensen (1975a:20-23) surveyed in great detail the zonation and correlation of the Upper Cretaceous strata of Sweden, and consequently only a review is given here. In the Upper Cretaceous of Sweden, belemnites have been shown to be of fundamental importance in biostratigraphy and correlation. The present belemnite stratigraphy is the result of progressive refinements by a series of workers, and the studies of Schlüter (1870, 1876), Moberg (1885, 1894), Stolley (1897, 1930), Jeletzky (1948, 1949b, 1951, 1958), and Christensen (1970a,b, 1971, 1973, 1975a) are particularly relevant.

The early subdivision of the Upper Cretaceous strata of Sweden and Germany is intimately connected, reflecting the activities of German paleontologists in Sweden during the last part of the 19th century. Moberg and other Swedish palaeontologists apparently also visited German localities. The first reliable subdivision of the Swedish Upper Cretaceous was made by Schlüter (1870), who distinguished (top to bottom): greensand with *Belemnitella mucronata* and biocalcarenes with *Belemnellocamax mammillatus*. Later on more belemnite zones were added by Moberg (1881, 1882a, 1885, 1894). Stolley (1897, 1930) subdivided the Senonian of Germany and Sweden into (top to bottom): *Mucronatenkreide*, *Quadratenkreide* = *Mammillatenkreide*, *Granulatenkreide*, and *Westfalicuskreide* = *Emscher*. This zonation was used subsequently in Sweden by most authors, translated into *mucronatakrita*, *mammillatuskrita*, *granulatuskrita*, and *westfalicuskrita*. Stolley (1897, 1930) correlated the Swedish strata with *Belemnellocamax mammillatus* with German strata containing *Gonioteuthis quadrata*. This correlation was not generally accepted in Sweden, and other proposals were put forward by Lundegren (1932a, 1934, 1936).

When discussing the zonation of the Swedish Upper Cretaceous it should be born in mind that up to 1930 the zonation was only concerned with the Santonian-Maastrichtian. Pre-Santonian Upper Cretaceous strata were first recorded from the Båstad Basin by Lundegren (1932b) and Stolley (1932), in the Malmö area by Brotzen (1945) and from the Kristianstad Basin by Christensen (1970a).

Christensen (1975a) discussed at length the age of the zone with *B. mammillatus* and concluded that this zone is from the uppermost Lower Campanian and is equivalent



| Belemnite zones,<br>NW Europe                        |   | Zonal belemnites,<br>Balto-Scandia            | Zonal belemnites,<br>Russian Platform   |
|--|---|---|---|
| U. Mastr.<br>U<br>L                                  | <i>B. casimirovensis</i>                    | U. Mastr.<br>L<br>L<br>U                      | U <i>B. casimirovensis</i>  |
|  | <i>B. junior</i>                            |   | L <i>B. junior</i>  |
| L. Mastrichtian<br>U<br>L<br>L<br>L<br>L<br>L        | <i>B. fastigata</i>                         | L. Mastrichtian<br>U<br>L<br>L<br>L<br>L<br>L | L. Mastrichtian<br>Belemnella<br>U <i>B. sumensis</i><br>L <i>B. lanceolata</i><br>L <i>B. licharewi</i>              |
|  | <i>B. cimbrica</i>                          |   |   |
|  | <i>B. sumensis</i>                          |   |   |
|  | <i>B. obtusa</i>                            |   |   |
|  | <i>B. pseudobtusa</i>                       |   |   |
|  | <i>B. lanceolata</i>                        |   |   |
| Upper Campanian<br>upper part<br>-----<br>lower part | <i>B. 'langei'</i>                          | Upper Campanian<br>-----<br>L                 | Upper Campanian<br>U <i>B. l. najdini</i><br>L <i>B. l. langei</i><br>L <i>B. l. minor</i>                            |
|  | <i>B. 'minor'</i>                           |   |   |
|  | <i>B. mucronata</i>                         |   |   |
| Lower Campanian<br>upper part<br>-----<br>lower part | <i>G. q. gracilis</i> / <i>B. mucronata</i> | Lower Campanian<br>-----<br>L<br>L<br>L<br>L  | Lower Campanian<br>U <i>B. mucronata</i> / <i>G. q. gracilis</i> /<br>L <i>B. mammillatus</i>                         |
|  | <i>G. q. gracilis</i>                       |   |   |
|  | <i>G. q. quadrata</i>                       |   |   |
|  | <i>G. granulataquadrata</i>                 |   |   |
| Santonian<br>U<br>-----<br>M<br>L<br>L               | <i>G. granulata</i>                         | Santonian<br>U<br>-----<br>M<br>L<br>L        | Santonian<br>U <i>B. praecursor</i> / <i>G. granulata</i><br>L <i>B. propinqua</i> /<br>L <i>A. lundgreni uilicus</i> |
|  | <i>G. westfalicagranulata</i>               |   |   |
|  | <i>G. w. westfalica</i>                     |   |   |
|  | -----                                       |   |   |
| Coniacian<br>L<br>L<br>M<br>U                        | <i>G. westfalica praewestfalica</i>         | Coniacian<br>L<br>L<br>M<br>U                 | Coniacian<br>U <i>A. lundgreni</i><br>L   |
|  | -----                                       |   |   |
| Turonian<br>L<br>L<br>M<br>U                         |   | Turonian<br>L<br>L<br>M<br>U                  | Turonian<br>L<br>L<br>M<br>U <i>A. plenus triangulus</i>  |
|  |   |   |   |
| Cenomanian<br>L<br>L<br>M<br>U                       | <i>A. plenus</i>                            | Cenomanian<br>L<br>L<br>M<br>U                | Cenomanian<br>U <i>A. plenus</i><br>L <i>A. primus</i> / <i>N. ultimus</i>  |
|  | <i>A. primus</i>                            |   |   |

UPPER CRETACEOUS BELEMNITES FROM THE VOMB TROUGH

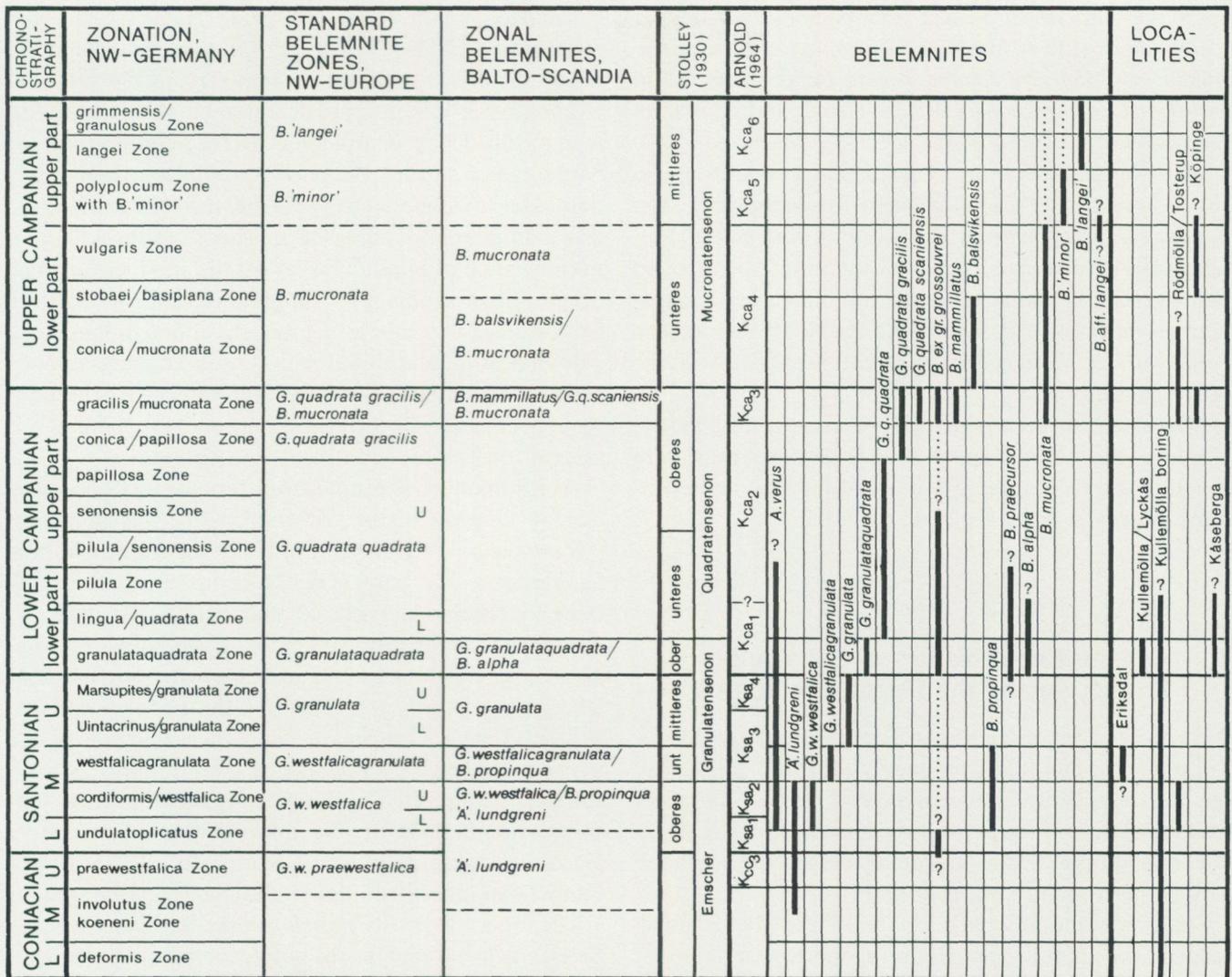


Fig. 9. Diagram showing the stratigraphic distribution of the belemnites occurring in the Vomb Trough, and the age of the localities according to the present study. In addition, the vertical distribution of belemnites used as index fossils is also shown.

falicus conglomerate') is referred to the Lower-Middle Santonian on the basis of *Gonoteuthis westfalica* and *Belemnitella propinqua*. The outcrop at Eriksdal B is assigned to the Upper Middle Santonian on the basis of *G. westfalicagranulata* and *B. propinqua*. Possibly, also Lower Middle Santonian strata were exposed at Eriksdal (see above).

Outcrops with Upper Santonian sediments are not recorded with the possible exception that the 'Verus conglomerate' at Röd mölla-Tosterup may be of that age.

The outcrops at Kullemölla-Lyckås, which yielded *Gonoteuthis granulataquadrata*, *Belemnitella alpha*, *Actinocamax verus*, and *Belemnellocomax ex gr. grossouvrei*, are ascribed to the basal Campanian, Zone of *G. granulataquadrata*. The loose blocks at Kåseberga from which *B. ex gr. alpha/praecursor* and *G. granulataquadrata* or *G. quadrata* have been collected, may also be from the basal Campanian, but it cannot be excluded that they are slightly younger.

The alternating calcareous sandstones and conglomerates (Tosterup conglomerate) at Röd mölla-Tosterup

Fig. 8. Upper Cretaceous belemnite zones in western Europe, Balto-Scandia, and the Russian Platform. Sources: Christensen (1975a), Naidin & Kopaevich (1977), Naidin (1979a, 1979b, 1981, 1983), Schulz (1978), Ernst et al. (1979), and Ernst & Schulz (1980).

span the uppermost Lower Campanian-lower Upper Campanian (the zone with *Belemnellocamax mamillatus* and *Belemnitella mucronata* and the superjacent zone with *Belemnellocamax balsvikensis* and *B. mucronata*). The oldest part of the Köpings sandstone is also from the uppermost Lower Campanian and was found in the eastern part of the Valleberga-Ingelstorp area. The Köpings sandstone from the western part of the Valleberga-Ingelstorp area and the former outcrops around Köpings can be assigned to the middle Upper Campanian on the basis of *B. mucronata* and *B. aff. langei*. The zone with *B. balsvikensis* was not recognized in the Köpings area.

Maastrichtian ammonites have been recorded from the Köpings area, and Lower Maastrichtian strata were found in the Köpingsberg boring. Maastrichtian belemnites, however, have not been recorded.

#### Depositional history of the Vomb Trough during the Upper Cretaceous

Formation of the trough was probably initiated in the Triassic since the oldest sediments recorded are of that age (Norling 1982; Chatziemmanouil 1982). The maximum thickness of strata preserved in the trough is about 1500 m and occurs close to Köpingsberg in the southern part of the trough (Norling 1982:76).

Chatziemmanouil (1982) analysed the depositional history of the Vomb Trough during the Upper Cretaceous on the basis of five borings placed along the trough axis. Three borings were situated in the northwestern part and two in the southeastern part. The maximum thickness of the Upper Cretaceous is a little less than 800 m, found in the Köpingsberg boring (Anderegg *et al.* 1968; Chatziemmanouil 1982). The analysis was based on seismic methods, sedimentologic analyses, and palaeontologic/ecologic studies of foraminifera. The dominant sediments are glauconitic, calcareous, clayey siltstones deposited in a fairly shallow-water environment. Sedimentation during the Upper Cretaceous therefore probably kept pace with subsidence. The largest rate of sedimentation was in the Coniacian and Santonian and, consequently, the major subsidence occurred in this period.

Chatziemmanouil also estimated water depths and concluded that the depth of water in the Coniacian ranged from 100–600 m at Kullemölla and 150–200 m at Köpingsberg. Water depth decreased in the early Santonian to 100–200 m in both areas. In the middle and upper Santonian a further decrease took place, and water depths were estimated to be 30–100 m at Kullemölla and less than 50 m at Köpingsberg. These sea-level fluctuations were considered to be of eustatic and local tectonic origin. Chatziemmanouil did not include information from surface outcrops in the trough, although these provide important additional data. Several conglomerates, some of which are of considerable thickness, and non-sequences occur in the Santonian and Campanian but none of these were identified in the borings.

At Rödmölla-Tosterup, Lower Jurassic rocks are overlain by Upper Cretaceous strata with a conglomerate ('Westfalicus conglomerate') from the Lower-Middle Santonian at the base. The Tosterup conglomerate is thick at Rödmölla-Tosterup and belongs to both the uppermost Lower Campanian and basal Upper Campanian. The conglomerate is also known from the Valleberga-Ingelstorp area. Parts of the upper Santonian and the Lower Campanian, with the exception of the uppermost Lower Campanian, are not present at Rödmölla-Tosterup. On the basis on information from outcrops, it can therefore be inferred that transgressive pulses took place in the early Santonian and late Lower Campanian, at least in the Rödmölla-Tosterup area.

The zone with *Belemnellocamax balsvikensis* and *Belemnitella mucronata* is not recognized in the Valleberga-Ingelstorp area, but the lack of this zone may be due to bad exposures in that area.

The youngest Cretaceous sediments are from the Maastrichtian, probably the Lower Maastrichtian. In the Köpingsberg boring the Lower Maastrichtian is terminated by a conglomerate with coal and plant remains and is overlain by Quaternary strata (Chatziemmanouil 1982). This may be attributed to erosion of still younger Cretaceous strata during the Tertiary and Quaternary Periods. A large-scale world-wide regression, however, took place towards end of the Cretaceous, and this may also explain the absence of sediments from the upper part of the Maastrichtian. In the Kristianstad Basin sediments of late Maastrichtian age are also missing (Christensen 1975a).

## Systematic part

### Morphology of the guard and terminology

The guard is usually the only part of the skeleton preserved, and external and internal characters are used for taxonomic classification. The characters are shown in Fig. 10.

The following characters generally are considered to be of taxonomic value in describing Upper Cretaceous belemnites belonging to the Belemnitellidae Pavlov: (1) size of guard, (2) shape of guard, (3) structure of the anterior end, (4) surface markings, (5) internal characters, and (6) ontogeny.

Belemnites which are completely calcified anteriorly are provided with an alveolus which houses the phragmocone. In some species, the anterior end was not completely calcified, and depending upon the degree of calcification, the anterior end may be conical with an alveolar fracture, flat with a pit in its centre, or developed as a concave pseudoalveolus.

Surface markings include dorso-lateral longitudinal depressions, dorso-lateral double furrows, lateral furrows, vascular imprints, longitudinal striation, and granulation.

The internal characters are alveolar angle, fissure angle, Schatzky distance, and the shape of the bottom of the ventral fissure. The alveolar angle is the angle of the alveolus measured in the median plane. It is measured in the anterior part of the alveolus for reasons given by Christensen (1975a). The fissure angle is the angle between the wall of the alveolus and the straight line which connects the intersection points of the bottom of the ventral fissure on the wall of the alveolus and the outer margin of the guard. The Schatzky distance is defined as the distance from the anterior part of the protoconch to the beginning of the bottom of the ventral fissure measured along the longitudinal axis of the guard (Jeletzky 1949a). These definitions were used by Birkelund (1957), Kongiel (1962) and Christensen (1975a). In this context it should be pointed out that these characters are not measured in the same way by all authors. For instance, Naidin (1952, 1959, 1974) and Schulz (1979) defined the fissure angle as the angle between the longitudinal axis of the guard and the straight line connecting the intersection points of the bottom of the ventral fissure. The difference between the two definitions is that the fissure angle in the latter case includes the half of the alveolar angle.

Moreover, the Schatzky distance is measured along the wall of the alveolus by Naidin (1952, 1959, 1974) and Ernst (1964a). I have used the original definition as proposed by Jeletzky (1949a).

The term conellae (Hölder 1955) is used descriptively for conical tubercles which may cover the wall of the alveolus or pseudoalveolus. In some species the conellae are covered by the 'white-layer' *sensu* Christensen (1975a:29).

The 'Riedel-Quotient' (Ernst 1964a) is the ratio of length of guard divided by depth of pseudoalveolus, and the 'Schlankheits-Quotient' (Ernst 1964a) is the ratio of length of guard divided by dorso-ventral diameter at the anterior end.

### Measurements and abbreviations

A list of measured characters and abbreviations is given below (cf. Fig. 10).

Total length of guard (L)  
 Length from apex to protoconch (LAP)  
 Dorso-ventral diameter at protoconch (DVDP)  
 Lateral diameter at protoconch (LDP)  
 Dorso-ventral diameter at alveolar end (DVDAE)  
 Lateral diameter at alveolar end (LDAE)  
 Maximum lateral diameter (MLD)  
 Schatzky distance (SD)  
 Alveolar angle (AA)  
 Fissure angle (FA)  
 'Riedel-Quotient' (RQ)  
 'Schlankheits-Quotient' (SQ)

Linear measurements were made with a vernier caliper to an accuracy of 0.1 mm, and angles were measured with a goniometer ocular fitted on a WILD stereomicroscope to an accuracy of 0.5°.

In earlier studies of *Belemnitella* and *Belemnella*, numerous other characters have been measured (e.g. length of reconstructed guard, depth of alveolus of reconstructed guard, etc.), but these measurements are functions of five basic measurements: LAP, DVDP, SD, FA, and AA, and are therefore of little taxonomic value, as are also the ratios obtained from these measurements.

### Biometric methods

The variability of the belemnite species and subspecies is analysed using univariate and bivariate statistical methods and is summarized by descriptive statistics, histograms, and scatter diagrams. The statistics were calculated according to standard formulae presented by Simpson, Roe & Lewontin (1960) and Sokal & Rohlf (1969). The statistical methods and tests used in the present paper were discussed at length by Christensen (1975a:31–33).

I have earlier discussed the disadvantages of using ratios in palaeontologic studies (Christensen 1973, 1974, 1975a), especially in cases where growth is allometric. In the present paper, I have only calculated ratios in those instances where the small number of available specimens presents bivariate analysis.

In the univariate analysis the estimates of the following statistics were calculated: arithmetical mean value ( $\bar{X}$ ); standard deviation (SD); and the coefficient of variation (CV). In addition, the observed range (OR) is reported, and N is the number of specimens.

The regression line is written:  $y = a + bx$ , and the original measurements were used in the calculations, because of the linear trend on ordinary graph paper and the homoscedastic variance around the regression line. The estimates of the following statistical parameters were calculated: the slope (b) and standard deviation of the slope ( $SD_b$ ); the intercept on the y-axis (a) and the standard deviation of the intercept ( $SD_a$ ); the variance ( $SD^2_{yx}$ ) and the standard deviation ( $SD_{yx}$ ) of the regression line; and the correlation coefficient (r). N is the number of specimens. The correlation coefficients were tested for significance by using Table Y in Rohlf & Sokal (1969) and t-tests on the y-intercepts were performed in order to see if the intercept differed significantly from zero. The regression lines of two samples were compared in the way described by Hald (1957:571–579).

### Classification of the Belemnitellidae

The following genera within the Belemnitellidae have received general recognition: *Actinocamax* Miller, *Goniot euthis* Bayle, *Belemnello camax* Naidin, *Belemnitella* d'Orbigny, *Belemnella* Nowak, *Belemnocamax* Crick, and *Fusiteuthis* Kongiel. The two last-mentioned genera are monotypic.

Naidin (1964b) recognized three subgenera of the genus *Actinocamax*: *A. (Actinocamax)*, *A. (Praeac-*

*tinocamax)*, and *A. (Paractinocamax)*, and two subgenera of the genus *Goniot euthis*: *G. (Goniot euthis)* and *G. (Goniocamax)*; these five subgenera were treated later as genera by Naidin & Kopaevich (1977) and Naidin (1981) among others. This classification is not followed here for reasons given by Christensen (1982). The subgenus *Paractinocamax* is further discussed below.

### The species concept in belemnites

The modern species concept in palaeontology is based on populations, rather than a few specimens (the so-called typological-morphological species concept). Species are studied by analysing the variation of homogenous populations from restricted stratigraphic intervals by means of various biometric methods. This concept has only recently been applied to Upper Cretaceous belemnites (Birkelund 1957; Kongiel 1962; Ernst 1964a, 1968; Christensen 1971, 1973, 1974, 1975a, 1975b, herein; Schulz 1979; and Jarvis 1980), and biometric studies have shown that many belemnite species and subspecies established by earlier authors are nothing but morphological variants.

Joysey (1956:84–88), Bettenstaedt (1968:356), Schulz (1979:37), and Callomon & Birkelund (1982:353) have discussed 'horizontal classification' and 'vertical classification'. It should be mentioned that Joysey used the terms chronologic for 'horizontal classification' and varietal for 'vertical classification'. 'Horizontal classification' is based upon the analysis of the variation of populations from successive horizons, and can be considered as an approximation to the biological species concept. In 'vertical classification', similar specimens from successive horizons are given the same name. 'Horizontal classification' was favoured by the authors mentioned above, and has also been used by the present author (Christensen 1971, 1973, 1975a, and herein).

Ernst (1964a, 1968) defined species of *Goniot euthis* on the basis of analysis of populations from successive horizons ('horizontal classification'). Nevertheless, the stratigraphic ranges of species of *Goniot euthis* were illustrated in diagrams using 'vertical classification'. In that way, two or three species of *Goniot euthis* occur in the same horizon. For example, *G. westfalica*, *G. westfalicagranulata*, and *G. granulata* were shown to co-occur in the upper part of the *G. westfalicagranulata* Zone (see Ernst 1966:137; Fig. 6). This line of action should be discouraged.

UPPER CRETACEOUS BELEMNITES FROM THE VOMB TROUGH

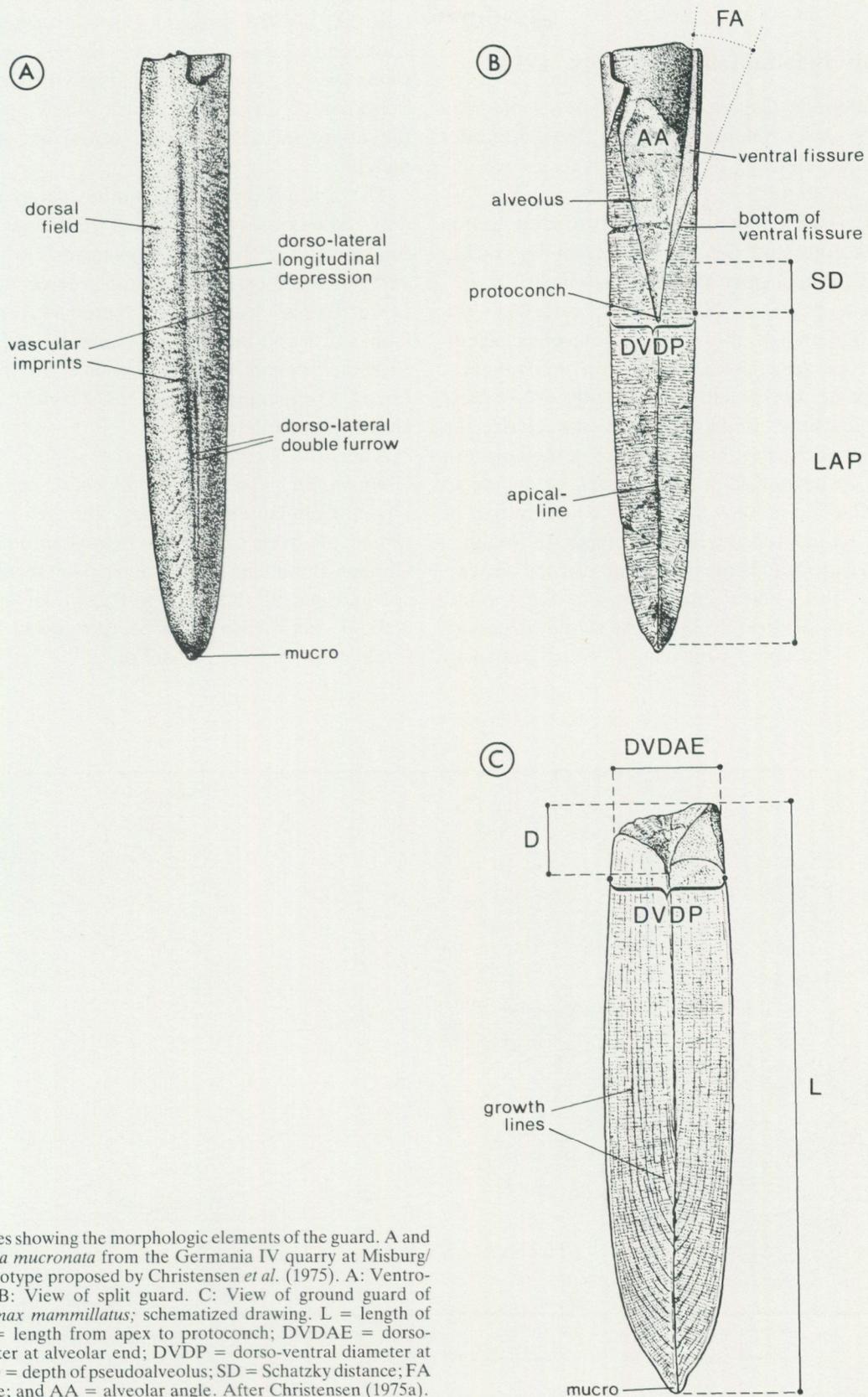


Fig. 10. Figures showing the morphologic elements of the guard. A and B: *Belemnitella mucronata* from the Germania IV quarry at Misburg/Hannover. Neotype proposed by Christensen *et al.* (1975). A: Ventrolateral view. B: View of split guard. C: View of ground guard of *Belemnellocamax mammillatus*; schematized drawing. L = length of guard; LAP = length from apex to protoconch; DVDAE = dorso-ventral diameter at alveolar end; DVDP = dorso-ventral diameter at protoconch; D = depth of pseudoalveolus; SD = Schatzky distance; FA = fissure angle; and AA = alveolar angle. After Christensen (1975a).

### Family Belemnitellidae Pavlov, 1914

Class Cephalopoda Cuvier, 1794. Subclass Coleoidea Bather, 1888. Order Belemnitida Zittel, 1895. Suborder Belemnopseina Jeletzky, 1965.

Distribution. – Belemnitellidae are restricted to the Upper Cretaceous and are reported from the Lower Cenomanian to the Upper Maastrichtian inclusive.

Christensen (1975a, 1976, 1982) reviewed the palaeobiogeography of the Upper Cretaceous belemnites of Europe (see also Combémourel, Christensen, Naidin & Spaeth 1981), and consequently only a brief outline is given here. Belemnitellidae characterize the North Temperate Realm, but occur also in the northern part of the Tethyan Realm. Belemnites belonging to Belemnitellidae are unknown from the southern part of the Tethyan Realm and the South Temperate Realm.

The North European Province was subdivided into two subprovinces: the Central European and the Central Russian Subprovinces (Fig. 11). These subprovinces are well-defined in the upper Coniacian-Lower Campanian

and characterized by independently evolving belemnite lineages; the *Goniotoothis* stock inhabited the Central European Subprovince and the *Belemnitella* stock (including '*A.* *lundgreni*') inhabited the Central Russian Subprovince. In other periods of the Upper Cretaceous the subprovinces are less distinct and may disappear completely.

The Balto-Scandian belemnite faunas can be considered as mixtures of the belemnite faunas from the two subprovinces in the upper Coniacian-Lower Campanian, and provide therefore a base for correlation. Near the Lower-Upper Campanian boundary, the belemnite faunas of Balto-Scandia are characterized by the genus *Belemnellocomax*: *B. mammillatus* in the uppermost Lower Campanian and *B. balsvikensis* in the lower Upper Campanian.

After the extinction of the genera *Actinocomax*, *Goniotoothis*, and *Belemnellocomax* near the Lower-Upper Campanian boundary, the genus *Belemnitella* spread all over the North European Province in the Upper Campanian, and has even been recorded from the northern part of the Tethyan Realm. However, no well-defined subprovinces can be recognized in the Upper Campanian and Maastrichtian.

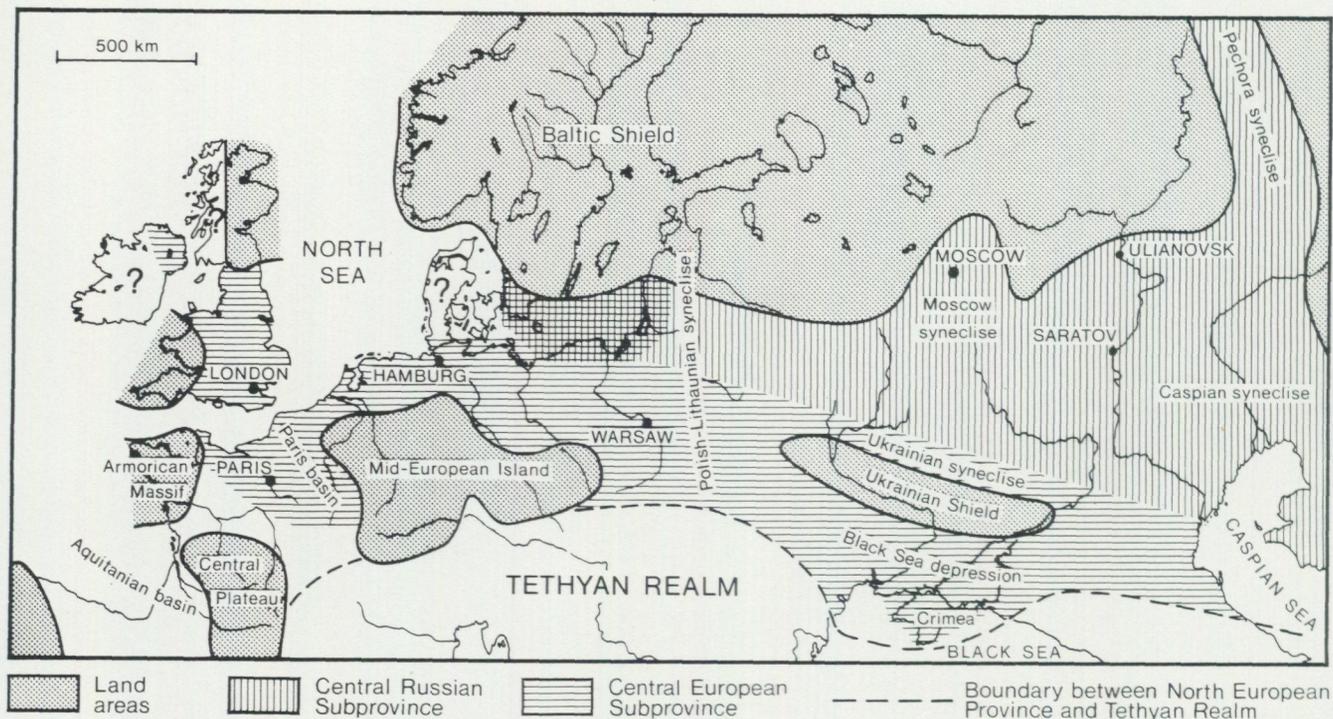


Fig. 11. Distribution of Upper Cretaceous biogeographic units in Europe based on belemnites. Upper Cretaceous land and sea areas represent maximum inundation for all stages. The boundaries of land areas are not reliable in detail and the biogeographic units are typically gradational in character. After Christensen (1976).

Genus *Actinocamax* Miller, 1823

Type species. – *Actinocamax verus* Miller, 1823

Distribution. – *Actinocamax* ranges from the Lower Cenomanian to the middle Lower Campanian inclusive. It is distributed in the North European and North American Provinces.

*Actinocamax verus* Miller, 1823

Pl. 1, fig. 1

Material. – Eriksdal: 116 complete specimens and alveolar fragments; Kullemölla: 154 complete specimens and alveolar fragments; Lyckås: 3 complete specimens. In addition, many fragments of the posterior part of the guard of a small belemnite most likely belonging to *A. verus* are present from Eriksdal and Kullemölla. Kullemölla boring: 42 specimens.

Short description. – An *Actinocamax* with a small, stout guard which is lanceolate in lateral and ventral views. The guard is flattened ventrally and the anterior end is compressed. The anterior end may have a low or high cone-shaped alveolar fracture, be flat, or have a shallow pseudoalveolus. There is a small pit in the anterior end for housing the posterior part of the phragmocone. The alveolar fracture is symmetric or asymmetric, and in the latter case the dorsal side is more incised than the ventral side. The alveolar fracture may be sharply demarcated from the surface of the guard or may continue gradually into the surface of the guard. The anterior end exhibits concentric growth layers of the guard and radiating ribs. Dorso-lateral longitudinal depressions are faintly developed, and vascular imprints are weakly developed or not present. The ventral fissure and ventral furrow are not preserved. The surface of the guard generally is covered by granules which may form corrugated transverse lines.

Affinity. – *A. verus* can be distinguished easily from other species of *Actinocamax* by its small size and stout guard. Specimens of *A. verus* having a flat anterior end or a shallow pseudoalveolus differ from juvenile specimens of *G. westfalica* in being stouter and more lanceolate in ventral view. Naidin (1964b) distinguished the following 'subspecies' of *A. verus*: *A.v. verus*, *A.v. fragilis* Arkhangelsky, 1912, and *A.v. dnestrensis* Naidin, 1952. *A.v. verus* was characterized by having a low cone-shaped alveolar fracture which generally is asymmetric and

sharply demarcated from the surface of the guard; *A.v. fragilis* was differentiated by having a high cone-shaped alveolar fracture which is up to one quarter of the entire length of the guard, and the fracture generally is asymmetric; and *A.v. dnestrensis* was distinguished by having a shallow pseudoalveolus. The variation of the structure of the anterior end is due to differential calcification.

Arkhangelsky (1912) and Naidin (1964b) considered *A.v. verus* and *A.v. fragilis* as geographic subspecies; *A.v. verus* has its main distribution in western Europe and *A.v. fragilis* on the Russian Platform. Birkelund (1957) and Christensen (1973) did not differentiate the three 'subspecies', because they occur together at outcrops in Sweden and Denmark.

Two samples of *A. verus*, from Eriksdal (upper Middle Santonian) and Kullemölla (basal Campanian), were analysed with respect to the structure of the alveolar end. With respect to the structure of the anterior end both samples showed a series of forms ranging from specimens with a high cone-shaped alveolar fracture to the specimens with a shallow pseudoalveolus with all intermediate forms. Nevertheless, the specimens of the two samples were subdivided into three groups, although it was difficult in some cases to decide to which group the specimens should be placed. Group 1 consists of specimens with a low cone-shaped alveolar fracture (*verus*-like specimens), group 2 consists of specimens with a high cone-shaped alveolar fracture (*fragilis*-like specimens), and group 3 of specimens with a shallow pseudoalveolus (*dnestrensis*-like specimens). The result is shown in Table 1, and it can be seen from this table that most specimens in the two samples belong to group 1. Some few specimens in both samples belong to groups 1 and 3. In the opinion of the author the samples exhibit a normal variation with respect to the structure of the anterior end. Similar variations are also seen in other species of *Actinocamax*, i.a. *A. plenus* (see Christensen 1974) and in *G. westfalica* (see Ernst 1964a; Christensen 1975a). It

TABLE 1. Estimates of relative abundance of three groups of *Actinocamax verus* from Eriksdal (upper Middle Santonian) and Kullemölla (basal Campanian). Group 1 contains specimens with a low cone-shaped alveolar fracture (*verus*-like specimens); group 2 includes specimens with a high cone-shaped alveolar fracture (*fragilis*-like specimens); and group 3 contains specimens with a shallow pseudoalveolus (*dnestrensis*-like specimens).

| Locality   | Group 1   | Group 2  | Group 3 | Σ   |
|------------|-----------|----------|---------|-----|
| Eriksdal   | 100 (86%) | 9 (8%)   | 7 (6%)  | 116 |
| Kullemölla | 122 (79%) | 26 (17%) | 6 (4%)  | 154 |

is therefore suggested that *A. verus dnestrensis* is placed in synonymy of *A.v. verus*. *A.v. verus* and *A.v. fragilis* may be considered as geographic subspecies if it can be demonstrated that specimens with a high cone-shaped alveolar fracture (*fragilis*-like specimens) prevail on the Russian Platform.

Remarks. – *A. verus* was recorded by Moberg (1884, 1888, 1910b) from the 'Westfalicus conglomerate' and 'Verus conglomerate' at Röd mölla-Tosterup. I have not seen *A. verus* from these conglomerate and the specimens appear to be lost.

Distribution. – *A. verus* is wide-spread in the North European Province.

*A. verus* appears in northwestern Europe in the uppermost part of the Lower Santonian *I. undulatoPLICATUS* Zone and continues into the middle Lower Campanian *O. pilula* Zone *sensu germanico* (Ernst 1963a; Christensen 1975a). In off-shore chalks *A. verus* is most common in the Upper Santonian (see Ernst & Schulz 1974; Bailey *et al.* 1983), whereas in near-shore sedimentary facies, for instance in Sweden and the Subhercynian Cretaceous, it occurs commonly also in the basal Campanian (Ulbrich 1971; Christensen herein).

According to Naidin (1864b) *A.v. fragilis* occurs on the Russian Platform from the Upper Turonian to the lower part of the Lower Campanian ('Pteria beds'), *A.v. verus* from the Coniacian to the Lower Campanian, and *A.v. dnestrensis* in the Santonian.

### Genus *Goniot euthis* Bayle, 1879

Type species. – *Belemnites quadratus* Blainville, 1827

Remarks. – The evolutionary lineage of *Goniot euthis*, in ascending order: *G. westfalica praewestfalica* Ernst & Schulz, *G.w. westfalica* (Schlüter), *G. westfalica-granulata* (Stolley), *G. granulata* (Blainville), *G. granulataquadrata* (Stolley), *G. quadrata* (Blainville), and *G. quadrata gracilis* (Stolley), has been studied especially by Stolley (1897, 1916, 1930), Ernst (1963a, 1963b, 1964a, 1964b, 1966, 1968) Ernst & Schulz (1974), Christensen (1975a, 1975b), and Jarvis (1980).

The lineage is an outstanding example of phyletic gradualism, viz. slow gradual transformation of a suite of characters within populations of *Goniot euthis* through time. The *Goniot euthis* stock existed for about 10 Ma and the general trend in evolution is the gradual calcification

of the anterior part of the guard. In *G. westfalica* the anterior end may be convexly conical, flat, or developed as a shallow pseudoalveolus, while in stratigraphically younger representatives the depth of the pseudoalveolus increases and may be up to 1/3 of the entire length of the guard. Simultaneously with the development of deeper pseudoalveolus the guard becomes increasingly stout and large, reaching a maximum in *G. quadrata*. Another characteristic feature is the gradual development of granulation. The oldest member, *G. westfalica praewestfalica*, does not possess granulation (Ernst & Schulz, 1974). The succeeding taxon, *G.w. westfalica*, shows a wide variation with respect to that character; some specimens carry scattered granules on the dorsal and/or ventral side of the guard, and sometimes the granules appear to be arranged in longitudinal rows. The same pattern is also valid for *G. westfalica-granulata*. In stratigraphically younger species, however, the granulation becomes a very prominent character. In samples of *G. westfalica* the shape of the guard is highly variable, and a great proportion of the guards are lanceolate in ventral view. In younger population the variation in the shape of the guard is smaller and guards which are lanceolate in ventral view are relatively rare. The cross-section of the anterior end is oval to pointed oval in *G. westfalica* and subrectangular to subquadrate in stratigraphically younger representatives with all intermediate stages. In the uppermost Lower Campanian, the *Goniot euthis* stock is characterized by a return of earlier features: e.g. reducing length of the guard, diminishing depth of the pseudoalveolus, and increasing slenderness of the guard.

The *Goniot euthis* lineage provides a good tool for stratigraphic purposes. It is, however, necessary to analyse homogeneous samples of a certain size in order to make a reliable specific determination, and limited material has only little stratigraphic value (Ernst 1964a; Christensen 1975a). Only the earliest member of the lineage, *G. westfalica*, is easily recognizable owing to its structure of the anterior end.

Ernst (1963a, 1963b, 1964a, 1964b, 1966, 1968) and Ernst & Schulz (1974) characterized populations of *Goniot euthis* on the basis of mean values of various ratios. Christensen (1975a) discussed the use of these ratios and suggested that the characters in question should be analysed by bivariate statistical methods. This procedure was followed by Jarvis (1980).

In studies on samples of *Goniot euthis*, the following characters are important: (1) length of guard, (2) length of guard vs. depth of pseudoalveolus, and (3) length of guard vs. dorso-ventral diameter at alveolar end.

Distribution. – *Goniot euthis* is known from the Middle Coniacian *I. involutus* Zone to the boundary between the Lower-Upper Campanian, and the extinction level of the genus has been proposed by authors as the boundary for the Lower and Upper Campanian.

The genus had its evolutionary centre in northwestern Europe and is found almost exclusively in the Central European Subprovince. A few representatives of the genus are reported from the northernmost part of the Tethyan Realm.

#### *Goniot euthis westfalica* (Schlüter, 1874)

Pl. 1, figs 2–3

Type. – The specimen figured by Schlüter (1876, Pl. 53:10) was designated as lectotype by Ernst & Schulz (1974:50).

Material. – Rödmölla-Tosterup: 10 specimens. Kulle-mölla boring, 330–390 m interval: c. 15 specimens.

Remarks. – The earliest member of the *Goniot euthis* lineage, *G. westfalica*, is closely comparable to known species of *Actinocamax*, especially with regard to structure of the anterior end, which may have a low cone-shaped alveolar fracture, be flat, or developed as a very shallow pseudoalveolus. The species is placed in the genus *Goniot euthis* on account of its undoubted relationship to later members of the lineage. The taxon can be recognized without difficulties owing to its structure of the anterior end, even if only a small number of specimens is available.

The specimens from Rödmölla-Tosterup were labelled Tosterup 7 by J.C. Moberg in 1887, but on the basis of the adherent matrix it can be inferred with great probability that they came from the 'Westfalicus conglomerate' at locality CV:1 (cf. Moberg 1910b and above).

Stratigraphy. – *G. westfalica praewestfalica* occurs in West Germany in the Middle-Upper Coniacian, and *G. w. westfalica* occurs in the upper Lower Santonian and Lower Middle Santonian (Ernst & Schulz 1974); (see Figs 8–9).

#### *Goniot euthis westfalicagranulata* (Stolley, 1897)

Pl. 2, figs 4,6

Type. – The specimen figured by Stolley (1897, Pl. 2:16; Pl. 3:6) was designated as lectotype and refigured by Christensen (1975b:128; Pl. 10:1, Fig. 2A).

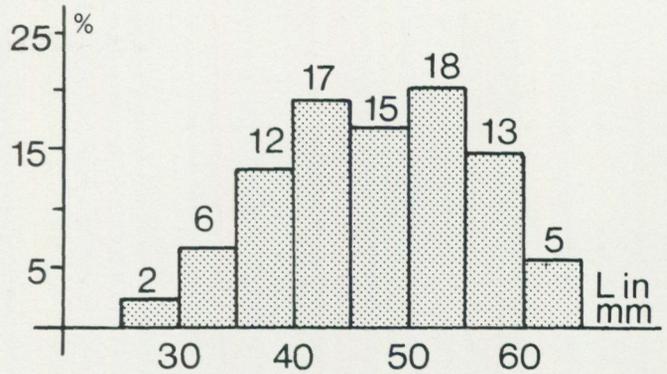


Fig. 12. Histogram of length of guard (L) of *Goniot euthis westfalicagranulata* from Eriksdal. The numbers above the bars are the actual number of specimens.

Material. – Eriksdal: 88 complete specimens and many fragments. These specimens were, by and large, collected by J.C. Moberg in the last part of the nineteenth century and by A. Lundegren in 1931 (see above). The Lundegren collection came from Eriksdal B (Lundegren 1935a:577, footnote 3), and the specimens collected by Moberg probably came from the same locality.

Biometry. – 88 complete specimens were analysed. A histogram of length of guard is shown in Fig. 12. The size-frequency distribution was tested for normality using the Kolmogorov-Smirnov test for goodness of fit. The test statistic D is 0.0420 with 88 degrees of freedom, which is not significant ( $P > 20\%$ ), implying that the distribution does not differ significantly from normality at the 5% level. The mean length of the guard is 47.4 mm and the standard deviation is 8.4 mm.

The scatter plot of length of guard vs. depth of pseudoalveolus is shown in Fig. 13, and the estimates of the statistical parameters of the regression analysis are given below.

$D = -0.0718 + 0.1081 L$ ;  $N = 88$ ;  $r = 0.6496$ ;  $SD_a = 0.6498$ ;  $SD_b = 0.0151$ ;  $SD_{yx} = 1.0573$ .

The value of the correlation coefficient is very highly significant ( $P < 0.1\%$  with 86 degrees of freedom). A t-test on the y-intercept showed that the intercept does not differ significantly from zero ( $t_a = 0.1105$  with 86 degrees of freedom;  $P > 90\%$ ) which implies an isometric relationship of the two characters.

The *Goniot euthis* sample was compared to a sample of *G. westfalicagranulata* from the quarry 'Mathilde' in northwest Germany (see Ernst 1968:278, Fig. 7). The

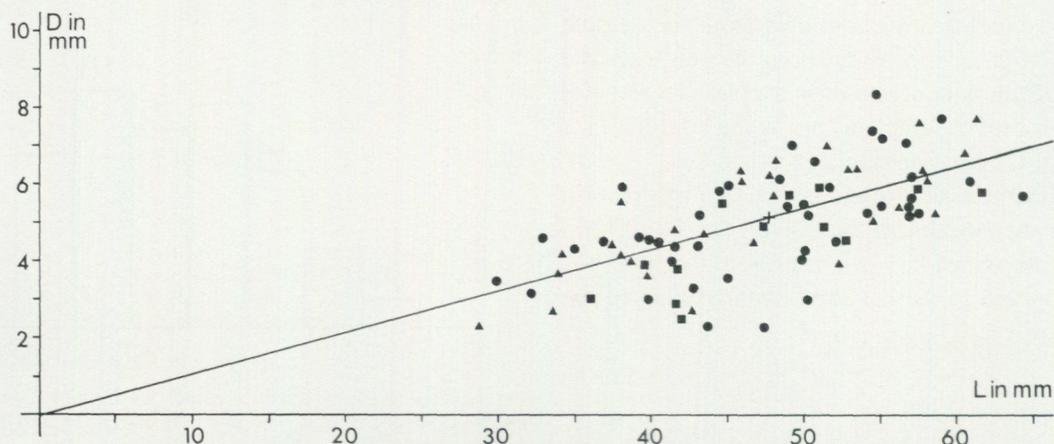


Fig. 13. Scatter diagram and regression line for *Gonioteuthis westfalicagranulata* from Eriksdal. L = length of guard; D = depth of pseudoalveolus. ● = J.C. Moberg Coll.; ■ = specimens figured by Moberg (1885); ▲ = A. Lundegren Coll.; + = mean values.

estimates of the statistical parameters of this sample are as follows:

$$D = 0.1018 + 0.1106 L; N = 51; r = 0.4809; SD_a = 1.5940; SD_b = 0.0288; SD_{yx} = 1.1775.$$

The value of the correlation coefficient is very highly significant ( $P < 0.1\%$  with 49 degrees of freedom). A *t*-test on the *y*-intercept showed that the intercept does not differ significantly from zero ( $t_a = 0.0638$  with 49 degrees of freedom;  $P > 90\%$ ), implying an isometric relationship of the two characters.

The regression lines of the two samples were compared and the test revealed that the variances, slopes and positions of the two lines do not differ at the 5% level. On the basis of the bivariate analysis the sample of *Gonioteuthis* from Eriksdal is referred to *G. westfalicagranulata*. It should be pointed out, however, that some very few specimens with a relatively shallow pseudoalveolus occur in the sample from Eriksdal. Five specimens have the following 'Riedel-Quotient': 15.6, 16.8, 16.8, 19.0, and 20.6, and they are rather *westfalica*-like. One of these specimens is figured on Pl. 1:5. In the population of *G. westfalicagranulata* from 'Mathilde', specimens with a 'Riedel-Quotient' above 15 do not occur. The presence of specimens of *Gonioteuthis* with a very shallow pseudoalveolus at Eriksdal may be explained in one or more of the following ways: (1) the sample from Eriksdal contains a larger number of specimens than the sample from 'Mathilde' and therefore shows a greater variation, (2) the sample from Eriksdal is slightly older than the sample from 'Mathilde', or (3) the sample of *G. west-*

*falicagranulata* from Eriksdal also contains some few specimens from the subjacent *G. westfalica* Zone.

Stratigraphy. – *G. westfalicagranulata* occurs in the Upper Middle Santonian (*G. westfalicagranulata* Zone).

#### *Gonioteuthis granulataquadrata* (Stolley, 1897)

Pl. 1, figs 7–8

Type. – The specimen figured by Stolley (1897, Pl. 2:23, Pl. 3:13) was designated as lectotype and refigured by Christensen (1975b:130; Pl. 10:2, Fig. 2B).

Material. – Kullemölla: 11 specimens, 6 of which are complete; Lyckås: 10 specimens, 3 of which are complete.

Remarks. – Only nine complete specimens are available from Kullemölla and Lyckås. The mean length of the guard of these specimens is 52.4 mm; the mean 'Riedel-Quotient' is 5.6; and the mean 'Schlankheits-Quotient' is 5.8. According to Ernst (1964a: 169) *G. granulataquadrata* has a mean 'Riedel-Quotient' between 5.0–6.0. The specimens were also plotted on a scatter diagram of length of guard vs. depth of pseudoalveolus for a sample of *G. granulataquadrata* from 'Weinberg' quarry (cf. Ernst 1964a:120; 1968:278; Christensen 1975a:38). The specimens from Kullemölla-Lyckås showed good agreement to the sample from 'Weinberg'. The author, therefore, does not hesitate to refer the specimens from Kullemölla-Lyckås to *G. granulataquadrata*.

Stratigraphy. – *G. granulataquadrata* occurs in the lowermost Lower Campanian (*G. granulataquadrata* Zone).

***Gonoteuthis quadrata scaniensis?* Christensen, 1975**

Pl. 1, fig. 9

Type. – The specimen figured by Christensen (1975a, Pl. 2:4) is the holotype.

Material. – Rödmölla-Tosterup, loc. 2: one alveolar fragment; Rödmölla: one complete specimen; and Tosterup 5: one alveolar fragment?

Remarks. – Synonyms were given by Christensen (1975a) who also fully described the species (including biometric analysis) on the basis of material from the Kristianstad Basin.

Two of the specimens are small and slender. The important characters of the complete specimen are as follows: length of guard is 46.5 mm, 'Riedel-Quotient' is 6.0, and 'Schlankheits-Quotient' is 5.4. It is not possible on the basis of only two specimens to refer them safely to species or subspecies. The specimen from loc. 2 was collected together with *B. mammillatus* and *B. mucronata*. In the Kristianstad Basin, *G. quadrata scaniensis* occurs together with *B. mammillatus* and *B. mucronata*, and the specimen from loc. 2 is therefore tentatively assigned to *G. quadrata scaniensis*. The complete specimen is only labelled Rödmölla and was earlier referred to as *B. mammillatus* by R. Hägg. The specimen might have come from loc. 2. The specimen labelled Tosterup 5 by J.C. Moberg in 1887 was discussed by Christensen (1975a:21).

*G. quadrata scaniensis* and *G. q. gracilis* are closely comparable. Both subspecies are small and slender but *scaniensis* differs from *gracilis* by having a more shallow pseudoalveolus.

Distribution. – *G. quadrata scaniensis* has up to now only been recorded from the uppermost Lower Campanian of Sweden.

***Gonoteuthis* spp.**

Pl. 1, figs 10–11

Remarks. – Representatives of *Gonoteuthis* occur in the 60–390 m interval of the Kullemölla boring. Some of these specimens are complete and well-preserved (Pl. 1:11). It is, however, not possible to assign them safely to species, except for *G. westfalica*, owing to the small number of specimens (see above).

Two specimens of *Gonoteuthis* from loose blocks at Kåseberga have been studied. One specimen (Pl. 1:10) has the following important characters: length of guard is

55.5 mm, 'Riedel-Quotient' is 4.7, and 'Schlankheits-Quotient' is 5.8. *Belemnitella* ex gr. *alpha/praecursor* is also known from the loose blocks, and the two specimens are therefore tentatively assigned to *G. granulataquadrata* or *G. quadrata*.

**Genus *Belemnellocamax* Naidin, 1964**

Type species. – *Belemnites mammillatus* Nilsson, 1826

Remarks. – The evolutionary lineage of *Belemnellocamax*, in ascending order, *B. ex gr. grossouvrei* (Janet), *B. mammillatus* (Nilsson), and *B. balsvikensis* (Brotzen), was studied recently by Christensen (1975a, 1976). The general trend in evolution is the gradual calcification of the anterior end of the guard, which also becomes more slender and less lanceolate in ventral view through time. Normally, the genus is not granulated, but a few granulated specimens belonging to *B. ex gr. grossouvrei* and *B. mammillatus* have been recorded (Moberg 1885; Naidin 1964b; Christensen 1982).

Naidin (1964b) referred species of the *grossouvrei* group to *A. (Paractinocamax)*, because they were claimed to have a short juvenile guard in contrast to species belonging to *Belemnellocamax*. The observation by Naidin, however, seems to be based on a single specimen of *B. grossouvrei pseudotoucasi* (Naidin 1964b:72, Fig. 15). I have studied the split guard of two specimens from Scania: (1) the holotype of *B. grossouvrei* var. *ornatus* (Moberg, 1885) from Kullemölla (basal Campanian), and (2) a specimen from Flackarp in the Kristianstad Basin (highest Lower Campanian). Both specimens have a long and elongated juvenile guard. Moreover, Dr. M.-G. Schulz, Kiel, has studied three specimens of the *grossouvrei* group from the basal Campanian of Braunschweig, and these specimens also have long and elongated juvenile guards (M.-G. Schulz, pers. comm. 1984). In addition to these observations, I have seen juvenile guards of the *grossouvrei* group from England and the Kristianstad Basin, and these guards are also very elongated. In this context it should be noted that Prof. D.P. Naidin has not seen any juvenile or adolescent specimens of the *grossouvrei* group from the Russian Platform (D.P. Naidin in litt. 1984).

On the basis of these observations, together with the fact that species of the *grossouvrei* group show strong affinity to *B. mammillatus* in several morphological characters, the *grossouvrei* group is referred to *Belemnellocamax* in the present paper.

Distribution. – *Belemnellocamax* is recorded from the Lower Santonian (possibly highest Coniacian) to the lower Upper Campanian.

*B. ex gr. grossouvrei* is widely distributed, but rare in the North European Province. *B. mammillatus* is extremely common in Scania, but rare outside that area: it has been recorded from northern Germany, Poland, and the eastern part of the Russian Platform. *B. balsvikensis* also occurs commonly in Scania, but outside this area it is unknown except for a recent find of two specimens from northern Germany (Christensen & Schulz 1976). It can thus be concluded that the area of distribution of the genus *Belemnellocamax* gradually diminished through its stratigraphic range.

***Belemnellocamax ex gr. grossouvrei* (Janet, 1891)**

Pl. 2, figs 1–2

Material. – Kullemölla: five specimens.

Remarks. – Specimens of the *B. grossouvrei* group are characterized by their large, ventrally flattened guards, which are lanceolate to strongly lanceolate in ventral view. Moreover, they have a shallow pseudoalveolus, the cross-section of which is triangular.

Specimens of the *grossouvrei* group occur rarely in western Europe and about 30 specimens are recorded from Germany, England, France, and Sweden. These specimens have been assigned to the following eight taxa: *B. grossouvrei* (Janet, 1891), *B. toucasi* (Janet, 1891), *B. alfridi* (Janet, 1891), *B. depressus* (Andreae, 1895), *B. depressus* var. *fusiformis* (Andreae, 1895), *B. mammillatus* var. *germanica* (Stolley, 1930), *B. mammillatus* var. *ornatus* (Moberg, 1885), and *B. blackmorei* (Crick, 1907).

On the Russian Platform, the *grossouvrei* group is slightly more common than in Western Europe, and about 60–70 specimens have been recorded by Russian palaeontologists (e.g. Nikitin, 1958; Naidin 1964b; Glazunova 1972). The specimens from Russia have been assigned to *B. grossouvrei pseudotoucasi* (Naidin, 1964) and *B. g. pseudoalfridi* (Naidin, 1964) by Naidin (1964b), *B. cf. toucasi* and *B. alfridi* by Glazunova (1972), and *B. toucasi* var. *seimensis* (Nikitin, 1958) by Nikitin (1958).

To sum up, eleven taxa have been established within the *grossouvrei* group on the basis of relatively little material. In the opinion of the author this group has been the subject of excessive subdivision. Hopefully, the current revision of this group on the basis of German and Swedish material by Prof. F. Schmid, Hannover, will

help solving these taxonomic problems.

According to de Grossouvre (1899:133) *B. ex gr. grossouvrei* should occur commonly in the Corbieres region of the French Pyrenees. This record, however, has not been substantiated by later authors.

Stratigraphy. – *B. ex gr. grossouvrei* is recorded in Germany from the *G. granulataquadrata* Zone of the basal Campanian and the *G. quadrata gracilis/B. mucronata* Zone of the uppermost Lower Campanian. In Sweden, the group occurs in the basal Campanian at Kullemölla (herein) and in the uppermost Lower Campanian in the Kristianstad Basin (Christensen 1975a). The group is recorded from the Upper Santonian and possibly the lowermost Campanian in France and from the Upper Santonian and Lower Campanian on the Russian Platform.

Five specimens of the *B. grossouvrei* group have been recorded from England. (1) Crick (1906) described *B. grossouvrei* from flinty chalk at Fimber, Yorkshire (Fig. 7). According to C.J. Wood (pers. comm. 1983) the specimen came from high Coniacian or basal Santonian Chalk. (2) Crick (1907) recorded *B. blackmorei* from West Harnham and according to C.J. Wood (pers. comm. 1983) it came from the top part of the *O. pilula* Zone or the base of the *G. quadrata* Zone *sensu anglico*. (3) Brighton (1930) reported *B. grossouvrei* from Ruston Parva in Yorkshire. This specimen is from the *O. pilula* Zone *sensu anglico* (C.J. Wood, pers. comm. 1983). (4) Bailey *et al.* (1983) recorded *B. grossouvrei* from Mottisfont, Brydone loc. 1067. It probably came from the *Hagenowia blackmorei* Horizon (C.J. Wood, pers. comm. 1983). (5) Crick (1907) described *Actinocamax* sp. from Fletcher & Co.'s pit at Gravesend; this specimen is of late Coniacian or early Santonian age (C.J. Wood, pers. comm. 1983). The specimen was referred to the *Mammillata* group by Jeletzky (1949a) and the *B. grossouvrei* group by Christensen (1975a). It has a rather deep pseudoalveolus, the walls of which are covered by conellae and is strongly flattened ventrally. The systematic position of the specimen is uncertain, and it may belong to the 'A.' *lundgreni* group. In addition to the specimens mentioned above I have recently found two specimens in the collections of British Museum (Natural History): An adolescent specimen from Micheldever, Hants, (C 44382) was found among a sample of specimens labelled *G. westfalica*. It is probably of basal Santonian age (C.J. Wood, pers. comm. 1983). Another specimen came from East Harnham near Salisbury (C 44331). This specimen is probably of basal *G. quadrata* Zone age *sensu anglico*.

To sum up, the *grossouvrei* group occurs from the Lower Santonian (possibly highest Coniacian) to the boundary between the Lower and Upper Campanian.

***Belemnellocamax mammillatus mammillatus* (Nilsson, 1826)**

Pl. 2, figs 3–5

Material. – Röd mölla-Tosterup, loc. 2: about 100 specimens; Köpings sandstone at Valleberga: 17 specimens.

Remarks. – Synonyms were given by Christensen (1975a), who also described the species in detail (including biometric analysis) on the basis of material from the Kristianstad Basin in Scania.

Biometry. – A sample of 25 complete specimens from Röd mölla-Tosterup, loc. 2 was analysed. The scatter plot of length of guard vs. depth of pseudoalveolus is shown in Fig. 14, and the estimates of the statistical parameters are as follows:

$$D = -1.7631 + 0.1422 L; N = 25; r = 0.7951; SD_a = 1.6565; SD_b = 0.0229; SD_{yx} = 1.3264.$$

The value of the correlation coefficient is very highly significant ( $P < 0.1\%$  with 23 degrees of freedom). A *t*-test on the *y*-intercept showed that the intercept does not differ significantly from zero ( $t_a = 1.0643$  with 23 degrees of freedom;  $30\% > P > 20\%$ ), which implies an isometric relationship of the two characters.

The sample of *B.m. mammillatus* from Röd mölla-Tosterup was compared to a sample of the same species from Ignaberga new quarry (described by Christensen

1975a:47). The estimates of the statistical parameters of the sample from Ignaberga are given below.

$$D = 0.1756 + 0.1098 L; N = 69; r = 0.6921; SD_a = 1.1031; SD_b = 0.0140; SD_{yx} = 1.4345.$$

Comparison of the regression lines of the two samples revealed that their variances, slopes, and positions do not differ significantly at the 5% level. It is therefore concluded that the sample from Röd mölla-Tosterup is of the same stratigraphic age as the sample from Ignaberga new quarry, viz. latest Early Campanian (Christensen 1975a).

Stratigraphy. – *B.m. mammillatus* occurs in the uppermost Lower Campanian in beds correlatable with the German *G. quadrata gracilis*/*B. mucronata* Zone.

***Belemnellocamax balsvikensis* (Brotzen, 1960)**

Pl. 2, figs 6–7

Material. – Röd mölla-Tosterup, loc. 3: c. 20 specimens, the majority of which are incomplete.

Remarks. – Synonyms were given by Christensen (1975a), who also fully described the species (see also Christensen & Schulz 1976). Moreover, Christensen analysed biometrically populations of the species from localities in the Kristianstad Basin and discussed the affinity of *B.m. mammillatus* and *B. balsvikensis*.

Stratigraphy. – *B. balsvikensis* occurs in the lower Upper Campanian in beds corresponding to the German *E. conica*/*B. mucronata* Zone and the lower part of the *P. stobaei*/*G. papillosa basi plana* Zone (see Christensen & Schulz 1976: Fig. 3, and Figs 8–9, herein).

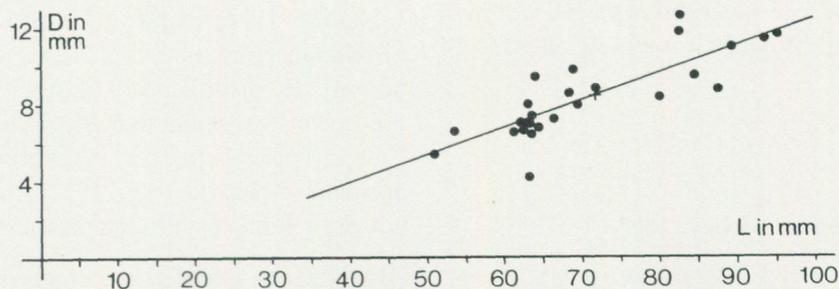


Fig. 14. Scatter diagram and regression line for *Belemnellocamax mammillatus* from Röd mölla/Tosterup, loc. 2. L = length of guard; D = depth of pseudoalveolus; + = mean values.

**Genus *Belemnitella* d'Orbigny, 1840**

Type species. – *Belemnites mucronatus* Schlotheim, 1813

Remarks. – The International Commission on Zoological Nomenclature was recently petitioned (Christensen, Ernst, Schmid, Schulz & Wood 1982) to use its plenary powers to ratify the neotype for *Belemnitella mucronata* proposed by Christensen, Ernst, Schmid, Schulz & Wood (1975) and that the name should be attributed to Schlotheim, 1813, and not to Link, 1807, its original author. This petition is still pending.

Distribution. – *Belemnitella* is known from the Lower Santonian to the uppermost Maastrichtian. The genus is widely distributed in the North European Province and has even been recorded from the northern part of the Tethyan Realm. It also occurs in the North American Province.

***Belemnitella propinqua* group**

The *B. propinqua* group includes '*Actinocamax*' *lundgreni* Stolley from the Coniacian-Middle Santonian and *B. propinqua* (Moberg) from the Lower-Middle Santonian. *B. propinqua* is generally considered to be the earliest representative of the genus. It is a well-defined species and was redescribed by Christensen (1971, 1973). It evolved from '*A.*' *lundgreni*.

'*A.*' *lundgreni* was placed in *Goniot euthis* (*Goniocamax*) by Naidin (1964b) together with several other species, including the earliest members of the *Goniot euthis* lineage. This suggestion was criticized by Ernst & Schulz (1974) and Christensen (1982). Ernst & Schulz suggested that subgenus *Goniocamax* with the type species '*A.*' *lundgreni* should be elevated to a genus or considered a subgenus of *Belemnitella*. They also suggested that only '*A.*' *lundgreni* and its ancestors should be assigned to *Goniocamax*. The suggestion by Ernst & Schulz must await further studies and is outside the scope of this paper. '*A.*' *lundgreni*, however, is placed herein in the *B. propinqua* group, because it is closely allied to *B. propinqua*.

**'*Actinocamax*' cf. *lundgreni* Stolley, 1897**

Pl. 3, fig. 1

Type. – The specimen figured by Stolley (1897, Pl. 3:18) was designated as lectotype by Birkelund (1957:14).

Material. – Kullemölla boring, 440 m level: one specimen.

Remarks. – The specimen is incomplete: the posterior part and the most anterior end of the guard are missing. The depth of the pseudoalveolus seems to have been relatively deep, and the guard is lanceolate in ventral view. Moreover, the guard has longitudinal striae and vascular markings. The specimen is therefore referred to as '*A.*' cf. *lundgreni*.

Distribution. – '*A.*' *lundgreni* occurs commonly in the Central Russian Subprovince and in Balto-Scandia. A few representatives are known from the Central European Subprovince. The species occurs in the Middle Coniacian-Middle Santonian.

***Belemnitella propinqua propinqua* (Moberg, 1885)**

Pl. 3, fig. 2

Type. – The specimen figured by Moberg (1885, Pl. 5:25) is the holotype.

Material. – Eriksdal: three specimens; Rödmölla-Tosterup, loc. 1: one specimen; and Kullemölla boring, 248 m level: one specimen.

Remarks. – Christensen (1971, 1973) described the species in detail on the basis of Swedish and Danish material, including the holotype. Christensen (1971) gave synonyms of the species and showed that the concept of *B.p. propinqua* was misinterpreted by Russian palaeontologists. The following taxa were considered to be synonyms of *B. p. propinqua*: *Actinocamax propinquus?* Moberg, 1885, *Belemnitella mucronata* mut. anterior Stolley, 1897, *B. ex gr. mirabilis* Jeletzky, 1948, *A. propinquus ravni* Birkelund, 1957, *Goniot euthis jeletzkyi* Kongiel, 1962, and *B. rylskiana* Nikitin, 1958.

Naidin (1974) employed a different concept of *B.p. propinqua* from that of Christensen (1971, 1973, and herein). He distinguished between *B.p. propinqua* from the Lower Santonian and *B.p. rylskiana* from the upper Lower-Upper Santonian, in addition to the dubious *B.p. mirabilis* Arkhangelsky, 1912 from the Santonian of northern Kazakhstan (Jeletzky 1949b).

Distribution. – *B.p. propinqua* is distributed in the Central Russian Subprovince and in Balto-Scandia. It occurs in the uppermost Lower-Middle Santonian.

*Belemnitella praecursor* group

Two taxa are tentatively placed in this group: *B. praecursor* Stolley and *B. alpha* Naidin.

*B. praecursor* was established on the basis of a single specimen from the lowermost Campanian, *G. granulata-quadrata* Zone, of the Broitzem quarry at Braunschweig (Stolley 1897; see also Ernst 1964b, 1968). It was characterized by having a smooth guard, and the internal characters were unknown, because Stolley did not split the guard. The holotype was supposed to have been misplaced or lost during the Second World War (Jeletzky, 1955), but the specimen was found in 1976 in the Geologisch-Paläontologisches Institut und Museum in Kiel (Pl. 3:4). It was subsequently split by Dr. M.-G. Schulz, Kiel, who kindly supplied the following measurements of the critical characters: length from apex to protoconch is 65.0 mm; dorso-ventral diameter at protoconch is 16.2 mm; lateral diameter at the protoconch is 16.9 mm; Schatzky distance is c. 10 mm; fissure angle is 6–7°; alveolar angle is c. 20°; and the bottom of the ventral fissure is almost straight.

Jeletzky (1955) discussed at length the evolution of Santonian and Campanian species of *Belemnitella* and the concept of *B. praecursor*. His study was based mainly on Russian material in addition to some few specimens from England and Scania. Jeletzky's concept of *B. praecursor* was broader than that of Stolley, and he also included specimens of *Belemnitella* with more or less well developed vascular markings and longitudinal striae in *B. praecursor*. According to Jeletzky, *B. praecursor* has a long, more or less slender guard, which is slightly to moderately lanceolate in ventral view and slightly to moderately conical in lateral view. The fissure angle is 5–10°, the alveolar angle averages 20–22°, the Schatzky distance is 6–10 mm, and the bottom of the ventral fissure is straight or nearly straight.

Jeletzky distinguished the following varieties of *B. praecursor*: var. *praecursor*, var. *media* Jeletzky, 1955, and var. *mucronatiformis* Jeletzky, 1955, but failed to present an appropriate biometric analysis of the varieties. *B. praecursor* var. *praecursor* was said to be characterized by having a completely smooth guard; var. *media* by having numerous, faint, longitudinal striae in addition to dorso-lateral double furrows and single lateral furrows; and var. *mucronatiformis* by having a fairly strongly sculptured guard with vascular imprints and longitudinal striae and a more or less distinct mucro. Moreover, var. *mucronatiformis* is mostly slender and somewhat lanceolate in ventral view.

*B. praecursor* var. *media* is a morphologically intermediate form between var. *praecursor* and var. *mucronatiformis*, and the varieties "... are only morphological varieties of the same specific type (parts of the same populations; ...)" (Jeletzky 1955:482). They are therefore, following §45 of the Code, to be regarded as of infrasubspecific rank. On the other hand, var. *praecursor* was only recorded from West Germany, and the earliest populations of *B. praecursor* were said to consist mainly of var. *media* and var. *praecursor*, while stratigraphically younger populations were said to be dominated by var. *mucronatiformis*. If these suggestions are shown to be correct by future studies, the varieties may be considered to be geographic or chronologic subspecies.

After Jeletzky's study of *B. praecursor*, specimens of *Belemnitella* from the uppermost Santonian and lower and middle Lower Campanian were assigned to either *B. praecursor* or *B. mucronata* by authors (e.g. see Nikitin 1958; Kongiel 1962). Ernst (1964b), however, described specimens of *Belemnitella* from the basal Campanian of the Münster Basin and showed that these specimens differed from both *B. praecursor* and *B. mucronata*. The specimens were referred to as *B. aff. mucronata senior* Nowak, *B. aff. mucronata/praecursor*, and *B. aff. senior/praecursor*.

Naidin (1964a) described and figured *B. mucronata alpha* from the lower Lower Campanian of the Russian Platform and included the English specimen, referred to as *B. ex gr. praecursor* by Jeletzky (1955, Pl. 58:1), in this subspecies.

Christensen (1975a) described *B. alpha* from Scania and discussed the relationships of *B. alpha*, *B. praecursor*, and *B. mucronata*. According to Christensen (1975a:52) *B. alpha* is closely comparable to *B. praecursor* with respect to surface markings and they both lack a well-defined mucro. Christensen also claimed that the internal characters were similar in the two species, and that the main characters separating *B. alpha* from *B. praecursor* is the stout guard. This supposed similarity is now known to be incorrect. The comparison was based on a biometric analysis of a sample of *B. alpha* from Scania and the available information of the variation of *B. praecursor*. I have recently analysed the variation of a sample of *B. praecursor* from the basal Campanian of the Hallembaye quarry in Belgium (see below), and it is apparent that the important internal characters of the two species differ. It should be stressed here that although the two species differ in several critical characters, it is not possible on the basis of only a few specimens to assign them safely to either *B. alpha* or *B. praecursor*.

***Belemnitella alpha* Naidin, 1964**

Pl. 3, fig. 5; Pl. 4, figs 1–3

- 1894 *Belemnitella mucronata* Schlotheim – Moberg, p. 77  
 1935 *Belemnitella mucronata* (Schlotheim) – Hägg, p. 65; Pl. 10:8–9  
 1955 *Belemnitella* ex gr. *B. praecursor* Stolley – Jeletzky, Pl. 58:1  
 1956 *Belemnitella mucronata alpha* Schatzky (nom. nud.) – Naidin, p. 338  
 1959 *Belemnitella mucronata alpha* Shatskij (nom. nud.) – Moskvine & Najdine, p. 505  
 1960 *Belemnitella mucronata alpha* Schatzky (nom. nud.) – Naidin, p. 51  
 1964a *Belemnitella mucronata alpha* Naidin: pp. 89–90; Pl. 1:2  
 1964b *Belemnitella* aff. *muronata senior* Nowak – Ernst, pp. 181–182; Pl. 1:2, 5  
 1974 *Belemnitella mucronata alpha* Schatzky (nom. nud.) – Naidin, p. 218, Pl. 75:3  
 1975a *Belemnitella alpha* Naidin – Christensen, pp. 51–52; Pl. 6:1–6  
 1980 *Belemnitella mucronata alpha* Schatzky (nom. nud.) – Naidin, p. 91; Pl. 10:8–9; Pl. 11:7; Textfigs 21:6, 22:3–5

History and type. – *B. mucronata alpha* was used as a manuscript name by Schatzky in 1924 (see Naidin 1964a:89, footnote 2). Naidin (1964a:89; Pl. 1:2) described and figured the taxon under discussion and hence Naidin was regarded to be the author by Christensen (1975a). A lectotype should be designated from the collection of D. P. Naidin.

Material. – Kullemölla: 14 specimens; Lyckås: 7 specimens.

Short description. – A *Belemnitella* with a large, ventrally flattened guard, which is almost cylindrical or very slightly lanceolate in ventral view, and high conical in lateral view. Commonly a mucro is only slightly delimited or not present.

The relationship of length from apex to protoconch vs. dorso-ventral diameter at protoconch is isometric (see below), and the ratio of these characters varies from about three to about four.

The shape of the bottom of the ventral fissure generally is straight or may be straight with an outward bend just below the ventral surface. The walls of the alveolus may be covered by conellae. The fissure angle is small, the Schatzky distance is large, and the alveolar angle is about 20° (see below).

The surface of the guard normally has weakly developed vascular imprints and longitudinal striae.

Biometry. – The specimens from Kullemölla and Lyckås were analysed biometrically as a single sample. Measurements of a small sample of *B. alpha* from Ringeleslätt in the Kristianstad Basin, analysed by Christensen (1975a), are also reported for comparison.

**Univariate analysis*****B. alpha* from Kullemölla-Lyckås:**

| Character | N  | $\bar{X}$ | SD   | CV   | OR        |
|-----------|----|-----------|------|------|-----------|
| LAP       | 12 | 55.1      | 10.1 | 18.3 | 41.8–68.0 |
| DVDP      | 12 | 15.8      | 3.6  | 22.8 | 11.5–20.3 |
| SD        | 7  | 11.0      | 1.3  | 11.8 | 9.6–12.6  |
| FA        | 3  | 13.3      | 0.6  | 4.4  | 13.0–14.0 |
| AA        | 11 | 20.3      | 1.1  | 5.4  | 18.5–22.0 |

***B. alpha* from Ringeleslätt (Christensen 1975a):**

| Character | N  | $\bar{X}$ | SD   | CV   | OR        |
|-----------|----|-----------|------|------|-----------|
| LAP       | 23 | 53.3      | 12.1 | 22.7 | 33.8–73.0 |
| DVDP      | 23 | 15.2      | 3.2  | 21.1 | 9.8–19.8  |
| SD        | 19 | 10.3      | 2.3  | 22.3 | 6.5–13.6  |
| FA        | 21 | 12.5      | 5.4  | 43.2 | 5.0–24.0  |
| AA        | 19 | 20.0      | 1.3  | 6.5  | 17.0–22.0 |

**Bivariate analysis**

The scatter plot of length from apex to protoconch vs. dorso-ventral diameter at protoconch of the specimens from Kullemölla-Lyckås and Ringeleslätt is shown in Fig. 15. The regression line of the Ringeleslätt sample is also shown and the estimate of the statistical parameters of this sample are given below.

***B. alpha* from Ringeleslätt (Christensen 1975a):**

DVDP = 2.2011 + 0.2441 LAP;  $SD_a = 1.2355$ ;  $SD_b = 0.0226$ ;  $SD_{yx} = 1.2828$ ;  $r = 0.9204$ ;  $N = 23$ .

The value of the correlation coefficient is very highly significant, while a t-test on the y-intercept gave a value which is not significant at the 5% level, implying an isometric relationship of the two characters (Christensen 1975a:52).

Discussion. – The mean values of length from apex to protoconch, Schatzky distance, fissure angle, and alveolar angle of the specimens from Kullemölla-Lyckås and the sample from Ringeleslätt were compared by t-tests, which showed no significant differences at the 5% level. It is obvious from Fig. 15 that the specimens from Kullemölla-Lyckås are scattered around the regression line of *B. alpha* from Ringeleslätt. The specimens from Kullemölla-Lyckås are therefore referred to *B. alpha*.

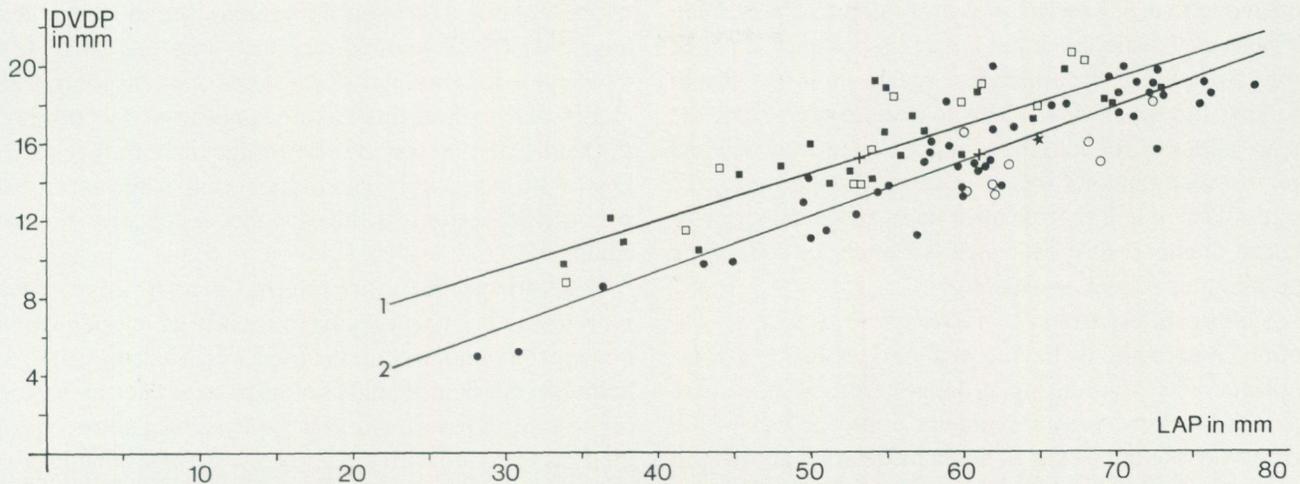


Fig. 15. Scatter diagram and regression line of *Belemnitella alpha* and *Belemnitella praecursor*. LAP = length from apex to protoconch; DVDP = dorso-ventral diameter at protoconch; + = mean values. □ = *B. alpha* from Kullemölla/Lyckås; ■ = *B. alpha* from Ringeleslätt, Kristianstad Basin; ● = *B. praecursor* from the C.P.L. quarry at Hallembaye, Belgium; ○ = *B. praecursor* from Russian Asia; \* = holotype of *B. praecursor*. Regression line marked 1 is calculated on the basis of a sample of *B. alpha* from Ringeleslätt, and regression line 2 on the basis of a sample of *B. praecursor* from Hallembaye.

Affinity. — *B. alpha* is closely comparable to *B. praecursor* and *B. mucronata*. The variation of a sample of *B. praecursor* from the basal Campanian of the C.P.L. quarry at Hallembaye in Belgium was analysed recently (Christensen & Schmid, in prep.), and the results are reported below. One specimen from Hallembaye is figured on Pl. 5:1.

#### Univariate analysis

*B. praecursor* from Hallembaye quarry:

| Character | N  | $\bar{X}$ | SD   | CV   | OR        |
|-----------|----|-----------|------|------|-----------|
| LAP       | 46 | 60.9      | 11.8 | 19.4 | 20.1–79.2 |
| DVDP      | 60 | 15.3      | 3.6  | 23.3 | 4.9–19.0  |
| SD        | 57 | 6.4       | 1.3  | 20.9 | 4.2–10.2  |
| FA        | 52 | 17.6      | 5.0  | 28.2 | 10.0–28.0 |
| AA        | 59 | 20.1      | 0.9  | 4.3  | 18.0–22.0 |

#### Bivariate analysis

The scatter plot of length from apex to protoconch vs. dorso-ventral diameter at protoconch of the sample of *B. praecursor* is shown in Fig. 15, as is the regression line. The equation on the regression line is as follows.

*B. praecursor* from Hallembaye:

$$\text{DVDP} = -2.0831 + 0.2854 \text{ LAP}; N = 46; r = 0.9208; \\ \text{SD}_a = 0.6684; \text{SD}_b = 0.0108; \text{SD}_{yx} = 0.8534.$$

The value of the correlation coefficient is very highly significant ( $P < 0.1\%$ ). A t-test on the y-intercept gave a

value of 3.1167 with 44 degrees of freedom, which is very highly significant ( $P < 0.1\%$ ), implying an allometric relationship of the two variates. This means that the ratios of length from apex to protoconch divided by dorso-ventral diameter at protoconch change during growth. Juvenile and adolescent specimens generally are slimmer than adult specimens.

The holotype of *B. praecursor* (Pl. 3:4) and some few specimens of *B. praecursor* from Russian Asia (Emba and west Kazakhstan areas) are also plotted in Fig. 15 (see also Pl. 5:2). The holotype is situated very close to the regression line of *B. praecursor* from Hallembaye. The Russian specimens are scattered around the regression line of *B. praecursor*. They are generally slimmer, however, than the Hallembaye specimens, and most of them are situated below the regression line.

The sample of *B. praecursor* from Hallembaye was compared to the sample of *B. alpha* from Ringeleslätt. The t-tests on the mean values of length from apex to protoconch, Schatzky distance, and fissure angle showed that the mean values differed significantly at the 5% level. The regression lines of the two samples were also compared. No significant differences were found in the variances and slopes of the two lines. A t-test on the position of the lines, however, gave a value of 7.634 with 65 degrees of freedom, which is very highly significant ( $P < 0.1\%$ ). This means that *B. alpha* generally is more stout than *B. praecursor*.

On the basis of the uni- and bivariate analyses it can be

concluded that *B. praecursor* is more slender, has a smaller Schatzky distance, and a larger fissure angle than *B. alpha*. Moreover, *B. praecursor* reaches a larger size of the guard than *B. alpha*. This is evident both from the mean values of the length from apex to protoconch and the observed range of this characters. Furthermore, the relationship of length from apex to protoconch vs. dorso-ventral diameter at protoconch is isometric in *B. alpha* and allometric in *B. praecursor*.

*B. alpha* differs from *B. mucronata* in lacking a well-defined mucro and by having weaker developed vascular imprints. The relationship of length from apex to protoconch vs. dorso-ventral diameter at protoconch of the two species is similar, but *B. alpha* has a larger guard than *B. mucronata*. In addition, *B. alpha* has a larger Schatzky distance and a smaller fissure angle than *B. mucronata* (see Christensen, 1975a:52).

Distribution. – *B. alpha* has its main distribution in the Central Russian Subprovince and in Balto-Scandia. It has been recorded also from northern Germany and England.

The stratigraphic range of *B. alpha* in western Europe was discussed by Christensen (1975a) who concluded that the species occurs in the lower Lower Campanian. At Kullemölla-Lyckås the taxon occurs together with *G. granulataquadrata* from the basal Campanian. In Russia, *B. alpha* occurs in the upper part of the lower Lower Campanian and the middle Lower Campanian and is used as an index fossil for the middle Lower Campanian (e.g. see Naidin & Kopaeovich 1977; Naidin 1979, 1983).

***Belemnitella ex gr. alpha* Naidin/*praecursor* Stolley**

Pl. 3, fig. 3; Pl. 4, fig. 4

Material. – Kåseberga: one specimen; Kullemölla boring, 0–20 m interval: three specimens.

Remarks. – The specimen from Kåseberga (Pl. 4:4) is relatively stout and the LAP:DVDP ratio is 3.4 (52.2:15.4). The Schatzky distance is about 10 mm. The fissure angle cannot be measured because the anterior part of the alveolus is missing. However, the fissure angle seems to have been small and the bottom of the ventral fissure seems to have been straight. The guard is slightly lanceolate in ventral view and high conical in lateral view. It has well-developed longitudinal striae. The 'white-layer' is thin and conellae cover part of the wall of the alveolus.

The material from the Kullemölla boring consists of

two alveolar and one apical fragment (see Pl. 3:3). These have weakly developed vascular imprints and well-developed longitudinal striae. The two alveolar fragments seem to have small fissure angles and the bottom of the ventral fissure seems to be straight in both specimens. One of the alveolar fragment has a thin 'white-layer' and part of the bottom of the alveolus is covered by small conellae.

The four specimens are referred to as *B. ex gr. alpha/praecursor*, because they have weakly developed vascular imprints and well-developed longitudinal striae. In addition, the fissure angle seems to be small, the bottom of the ventral fissure seems to be straight, and two specimens have conellae in the alveolus. As mentioned above it is not possible on the basis of a few specimens of *Belemnitella* to assign them safely to either *B. alpha* or *B. praecursor*.

The specimen from Kåseberga was earlier referred to *B. mucronata* by Hägg (1939), as were the specimens from the Kullemölla boring (Lundegren 1935b).

Stratigraphy. – The range of *B. alpha* is discussed above. *B. praecursor* occurs in Western Germany in the *G. granulataquadrata* Zone and the succeeding *I. lingual/G. quadrata* Zone (Ernst 1946b). A single specimen was collected from the *G. senonensis* Zone of Lägerdorf (M.-G. Schulz, pers. comm.). Jarvis (1980) recorded *B. praecursor* from the Lower Campanian phosphatic chalk of France where it occurs together with *G.q. quadrata* (Fig. 7). Fletcher & Wood (1978:93 and Fig. 17) recorded *B. praecursor* from the Boheeshane A Chalk from the Lower Campanian of Northern Ireland (Fig. 7). In Russia, *B. praecursor* appears in the Upper Santonian and continues into the lower and middle Lower Campanian (Naidin & Kopaeovich 1977; Naidin 1979, 1983).

***Belemnitella* taxa from the highest Lower Campanian-Lower Maastrichtian**

More than a score of species, subspecies, and varieties of *Belemnitella* from the highest Lower Campanian–Lower Maastrichtian have been erected, and the majority of these taxa were established by east european workers. The systematics of many of these taxa are in a state of disorder and they are poorly understood.

Some species and subspecies have received recognition in many publications after they were established (e.g. *B. 'minor'* Jeletzky and *B. 'langei'* Jeletzky). Other species names have been used recently in publications by west european authors (e.g. *B. najdini* Kongiel and *B. posterior* Kongiel; see Fletcher & Wood 1978; Schulz 1978,

1982; Schulz & Schmid 1983). Some of these taxa are discussed below and in the description of *B. mucronata* and *B. aff. langei*.

*B. 'minor'* and *B. 'langei'* are used as index fossils in the Upper Upper Campanian, but the concept of the two species was in a state of disorder until recently. Christensen *et al.* (1975) discussed the two taxa and pointed out that they can only be interpreted with respect to their holotypes, because statistically evaluated populations from the respective type localities are not available. The internal characters of the holotypes were unknown before 1975.

The holotypes have now been split and it was revealed by Christensen *et al.* (1975) that the internal characters of the holotype of *B. minor* do not fit with those given in the original diagnosis (Jeletzky 1951). Moreover, it was also shown that the holotype of *B. minor* falls within the variation of the 'type population' of *B. mucronata* proposed by Christensen *et al.* (1975).

With respect to *B. langei*, Christensen *et al.* (1975) showed that the internal characters of the holotype agree well with the original diagnosis for the species (Jeletzky 1948). They concluded that it is a well-defined species, and the main characters separating it from *B. mucronata* are the large relative length, the large fissure angle, the bottom of the ventral fissure which is complexly bent, and its lanceolate shape in ventral view.

The concept of *B. 'minor'* and *B. 'langei'* were misinterpreted by most earlier workers. According to Schulz (1978:78, 81) *B. langei sensu* Jeletzky probably only occurs in western Europe at a specific horizon at Kroonsmoor (West Germany), and all other records of *B. langei* from western Europe should probably be assigned to *B. najdini*.

***Belemnitella mucronata* (Schlotheim, 1813)**

Pl. 5, figs 3-4; Pl. 6, figs 1-2

- 1807 *Belemnites mucronatus* Link, p. 9
- 1885 *Belemnitella mucronata* (Schlotheim) – Moberg, p. 56; Pl. 6:13, non Pl. 6:14-16, 19
- 1912 *Belemnitella mucronata* (Schlotheim) – Arkhangelsky, p. 600; Pl. 9:3, 9, 23, 26; Pl. 10:10
- 1913 *Belemnitella mucronata* mut. *senior* Nowak, p. 395; Pl. 42:22
- 1915 *Belemnitella mucronata* var. *ponderosa* Sinzow, p. 147; Pl. 8:11-12
- 1951 *Belemnitella mucronata* mut. *senior* Nowak – Jeletzky, p. 81; Pl. 2:1, ? Pl. 1:4
- 1955 *Belemnitella mucronata* (Schlotheim) unnamed early variety – Jeletzky, p. 480; Pl. 57:1
- 1964 *Belemnitella mucronata* (Link) – Jeletzky, Fig. 1, Pl. 1:1-4

- 1964b *Belemnitella mucronata mucronata* (Schlotheim) – Ernst, Pl. 1:6
- 1972 *Belemnitella mucronata* (Link) *sensu lato* – Christensen, p. 322, Fig. 1
- 1974 *Belemnitella mucronata mucronata* (Schlotheim) – Naidin, p. 216; Pl. 74:4-5, Pl. 76:4-5
- 1975a *Belemnitella mucronata mucronata* (Link) – Christensen, p. 32; Pl. 7:1-3, Pl. 8:1-4, Pl. 9:1-6, Pl. 10:1-2, Pl. 11:1-3, Figs 22A-B
- 1975 *Belemnitella mucronata mucronata* (Schlotheim) – Christensen *et al.* p. 40; Pl. 1:1-3, Pl. 2:1-2, Pl. 3:1-5, Fig. 3
- 1979a *Belemnitella mucronata mucronata* (Schlotheim) – Naidin, p. 85; Pl. 1:7, Pl. 3:9
- 1980 *Belemnitella mucronata mucronata* (Schlotheim) – Naidin p. 89; Pl. 2:3, 8

History and type. – It is generally agreed that *B. mucronata* should be interpreted with reference to the specimens figured by Arkhangelsky (1912, Pl. 9:3, 9, 23, 26, Pl. 10:10). (See Birkelund & Rasmussen 1956; Birkelund 1957; Jeletzky 1964; Naidin 1971; and Christensen *et al.* 1973.) Christensen *et al.* (1975) therefore proposed a neotype for *B. mucronata* from the lower part of the Upper Campanian of the quarry GERMANIA IV at Misburg/Hannover, NW Germany. In the present paper *B. mucronata* is interpreted with respect to the proposed neotype and type-series.

Material. – Rödmölla-Tosterup, loc. 2: seven specimens; Köpinge: c. 10 specimens; and Valleberga-Ingelstorp: 21 specimens.

Description. – A *Belemnitella* with a large, ventrally flattened guard, which is almost cylindrical or slightly lanceolate in ventral view and high conical in lateral view. A mucro is well-defined.

The relationship between length from apex to protoconch and dorsoventral diameter at protoconch is isometric, and the ratio of these characters varies from about 2.5 to about 4.5, being 3.0-3.7 in most specimens.

The shape of the bottom of the ventral fissure is variable: it may be straight, straight with an outward bend just below the ventral surface, undulating, or s-shaped. It is, however, straight or straight with an outward bend in most specimens. The fissure angle varies from 5-47°, but is commonly between 15-30°. The Schatzky distance varies from 4.5-15.0 mm, and is generally between 5.5-10.0 mm with a mean value of about 8 mm. The alveolar angle varies from 18.0-24.0° with a mean value of about 20°.

Adult specimens have distinct vascular imprints, dorso-lateral double furrows and double depressions. Longitudinal striae usually are present.

Remarks. – The variation of three samples of *B. mucronata* from the highest Lower Campanian—Lower Upper Campanian of Scania and Germany was analysed by Christensen (1975a) and Christensen *et al.* (1975) who demonstrated significant differences in various characters. For example, specimens from Scania attain a larger size of the guard than the specimens from Germany. Christensen (1975a) suggested that the differences might be due to ecological conditions or that the samples were of slightly different age. Additional work on the variation of samples of *Belemnitella* of the same age from different areas and samples of *Belemnitella* collected bed-by-bed through a large, continuous section are necessary in order to solve this problem. Work is in progress on samples of *Belemnitella* collected bed-by-bed from the highest Lower Campanian—Lower Upper Campanian of Misburg/Höver near Hannover by Dr. M.-G. Schulz and the author.

Affinity. – *B. mucronata* is closely allied to *B. praecursor* and *B. alpha* (see discussion above).

Nowak (1913) distinguished *B. mucronata* mut. *senior* Nowak from the lower 'Mucronatenkreide' and *B. mucronata* mut. *junior* Nowak from the upper 'Mucronatenkreide', in addition to *Belemnella lanceolata* (Schlotheim) from the middle 'Mucronatenkreide'. According to Nowak (1913:402) mut. *senior* is most likely identical to *B. mucronata sensu* Arkhangelsky. Birkelund (1957) expressed the same point of view. Christensen *et al.* (1975) discussed the relationship of *B. mucronata* and *B. senior* and concluded that it remains questionable whether *B. senior* really is an independent species or whether it is an extreme variant of *B. mucronata*. On the basis of the descriptions and figures of the two taxa by Arkhangelsky (1912) and Nowak (1913), respectively, in addition to the statement by Nowak, *B. senior* is here considered a junior synonym of *B. mucronata*. On the other hand, large, stout, strongly vascularized specimens of *Belemnitella* do occur around the Lower—Upper Campanian boundary in various areas, e.g. England, Germany, and Sweden. These specimens earlier were referred to as *B. mucronata senior* or *B. senior* by authors. Future studies may show if these specimens should be referred to a new species or subspecies, or merely considered a morphological variant of *B. mucronata*.

*B. posterior* was established by Kongiel (1962) from the uppermost Campanian and lower Maastrichtian of Poland. According to Kongiel, *B. posterior* shows strong resemblance to *B. mucronata* in its external characters but differs from that species in its internal characters. The

fissure angle, for example, is larger (c. 40–90°) in *B. posterior* than in *B. mucronata*. Specimens of *Belemnitella* very closely comparable to *B. mucronata* from the basal Maastrichtian of Northern Ireland, Western Germany, and Belgium were tentatively assigned to *B. posterior* by Fletcher & Wood (1978), Schulz (1978) and Schulz & Schmid (1983). No evidence was presented that the internal characters of these specimens were studied. I have studied one specimen of *Belemnitella* from the basal Maastrichtian of Sweden. The fissure angle of this specimen is 15.0°, and it was therefore referred to *B. mucronata* (Christensen 1975a, Pl. 11:1).

*B. minor*, as interpreted with respect to the holotype, falls within the variation of *B. mucronata*. According to the original diagnosis by Jeletzky (1951) *B. minor* is distinguished from *B. mucronata* by its greater fissure angle (generally more than 30–40°), and the bottom of the ventral fissure which is complexly bent.

Distribution. – *B. mucronata* is wide-spread in the North European Province and is also recorded from the northern part of the Tethyan Realm.

It has its main occurrence in the highest Lower Campanian—Lower Upper Campanian and is used as a guide fossil for this part of the stratigraphic column. The taxon is also recorded from the Upper Upper Campanian and basal Maastrichtian.

#### *Belemnitella* aff. *langei* Jeletzky, 1948

Pl. 6, figs 3–4; Pl. 7, figs 1–4

1885 *Belemnitella mucronata* Schlotheim – Moberg, p. 56; Pl. 6:14–16, 19; non Pl. 6:13

Material. – Köpings sandstone at Köpings and Valleberga – Ingelstorp: c. 25 specimens.

Diagnosis. – A *Belemnitella* with a small, slender guard which is markedly lanceolate in ventral view and ventrally flattened. Vascular imprints are distinct and adult specimens are provided with a mucro. The fissure angle is small and the bottom of the ventral fissure is straight.

Description. – A *Belemnitella* with a small slender, ventrally flattened guard which is markedly lanceolate in ventral view and cylindrical or high conical in lateral view. Adult specimens are provided with a distinct mucro.

The relationship between length from apex to protoconch and dorso-ventral diameter at protoconch is isometric (see below), and the ratio of these characters varies from 3.9 to 5.8, being 4.3–5.0 in most specimens.

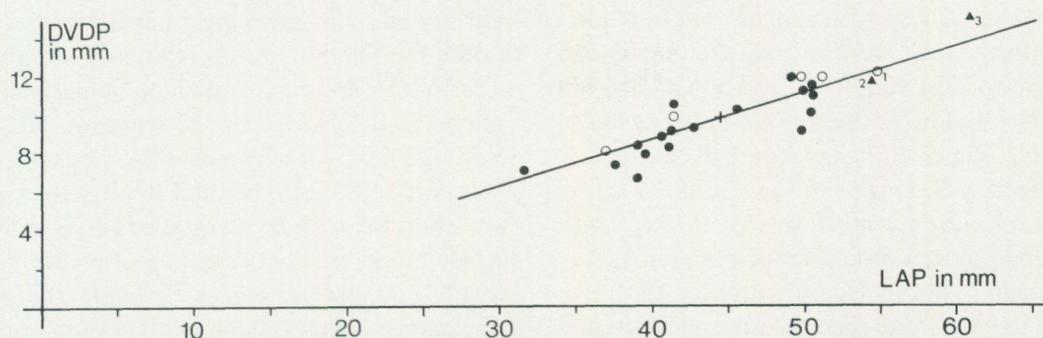


Fig. 16. Scatter diagram and regression line of *Belemnitella* aff. *langei* from the Köpinge sandstone. LAP = length from apex to protoconch; DVDP = dorso-ventral diameter at protoconch; + = mean values. ○ = specimens from 'Köpinge'; ● = specimens from Valleberga/Ingelstorp. The specimen marked 1 was figured by Moberg (1885, Pl. 6:14) as *B. mucronata*. This specimen was subsequently referred to as *B. n. sp. aff. mucronata* (= *B. pseudolanceolata* Jeletzky) by Jeletzky (1951) and Naidin (1960), *B. mucronata* var. *mobergi* by Nikitin (1958), and *B. minor* by Kongiel (1962). The specimen is refigured herein on Pl. 6:3. For comparison the holotypes of *B. langei* (▲2) and *B. minor* (▲3) are also plotted.

The ventral fissure generally is straight and the fissure angle is small (see below). The Schatzky distance varies from about 5–10 mm with a mean value of about 7 mm. The alveolar angle varies from 18–22° with a mean value of about 20°.

Adult specimens have distinct vascular imprints, dorso-lateral double furrows and dorso-lateral double depressions. Longitudinal striae usually are present.

**Biometry.** – The specimens from the Köpinge sandstone at Köpinge and Valleberga-Ingelstorp were treated as a single sample and analysed biometrically.

#### Univariate analysis

| Character | N  | $\bar{X}$ | SD  | CV   | OR        |
|-----------|----|-----------|-----|------|-----------|
| LAP       | 21 | 44.5      | 6.1 | 13.8 | 31.6–54.8 |
| DVDP      | 23 | 9.4       | 2.4 | 26.1 | 7.1–12.2  |
| SD        | 14 | 7.1       | 1.7 | 23.4 | 4.9–10.2  |
| FA        | 10 | 17.4      | 6.4 | 3.7  | 9.5–31.0  |
| AA        | 14 | 19.8      | 1.0 | 4.9  | 18.0–22.0 |

#### Bivariate analysis

The scatter diagram of length from apex to protoconch vs. dorso-ventral diameter at protoconch is shown in Fig. 16. The equation of the regression line is given below.

$$\text{DVDP} = -1.0310 + 0.2425 \text{ LAP}; N = 21; r = 0.8636; \text{SD}_a = 1.4746; \text{SD}_b = 0.0328; \text{SD}_{yx} = 0.9018.$$

The value of the correlation coefficient with 19 degrees of freedom is very highly significant ( $P < 0.1\%$ ). The t-test on the y-intercept gave a value of 0.6992 with 19 degrees of freedom, which is not significant ( $50\% > P > 40\%$ ), implying an isometric relationship of the two characters.

The holotypes of *B. langei* and *B. minor* are also plotted in Fig. 16 for comparative purpose. The holotype of *B. langei* (Pl. 7:5) is situated very close to the regression line and is within the range of *B. aff. langei*. The holotype of *B. minor* is also situated close to the regression line but falls outside the range of *B. aff. langei*.

**Remarks.** – *B. aff. langei* is closely comparable to *B. langei* with regard to overall shape and size of the guard, but differs from that species by having a smaller fissure angle, and the bottom of the ventral fissure is straight in contrast to *B. langei*. *B. aff. langei* may be considered as an ancestor of *B. langei*. The taxon is referred to as *B. aff. langei* due to the limited amount of material the stratigraphic control of which is poor.

**Affinity.** – *B. aff. langei* is distinguished from *B. mucronata* by its small slender guard which is markedly lanceolate in ventral view. With regard to surface markings and inner characters, *B. aff. langei* and *B. mucronata* are closely comparable.

*B. aff. langei* differs from the holotype of *B. langei* and specimens of *B. langei sensu* Naidin from Russia (see Pl. 7, figs 5–7) by its small fissure angle and being more flattened ventrally. Moreover, the bottom of the ventral fissure is straight and not complexly bent as in *B. langei*.

*B. aff. langei* and *B. pseudolanceolata* Jeletzky are closely comparable with respect to shape of guard, surface markings and size of fissure angle. *B. aff. langei*, however, differs from *B. pseudolanceolata* by having a smaller guard and a larger Schatzky distance.

*B. aff. langei* shows resemblance with regard to shape of guard to *B. mucronata* var. *mobergi*, *B. gorkiana*, and *B. mucrolanceolata* from the Upper Campanian of the

Ukrainian Syneclise. These taxa were erected by Nikitin (1958), but unfortunately were inadequately described and figured; they are therefore poorly understood. According to Naidin (1974) these three taxa are junior synonyms of *B. l. langei*, *B. langei minor*, *B. pseudolan- ceolata*, and possibly *B. langei najdini*.

Specimens very closely comparable to *B. aff. langei* occur in the uppermost Lower Campanian and Lower Upper Campanian in Scania (see Christensen 1975a:56; Pl. 9:3, 6; Pl. 11:2-3). These specimens were considered to be morphological variants of *B. mucronata* because they only constitute an insignificant part of the *Belemnitella* samples from these stratigraphic horizons, and they fall within the variation of *B. mucronata* in other important characters.

Distribution. — *B. aff. langei* has up to now only been recorded from the Vomb Trough in Scania. Here, it occurs in the upper part of the Köpings sandstone. At Valleberga-Ingelstorp, *B. aff. langei* and *B. mucronata* occur together; *B. mucronata* is the dominant form in the lower part of the sequence and *B. aff. langei* in the upper part. The zone with *B. mucronata* and *B. balsvikensis* is not identified in the Valleberga-Ingelstorp area (see above). It is therefore suggested that *B. aff. langei* occurs in the middle Upper Campanian, that is in beds which can be correlated with the upper part of the *B. mucronata* Zone and possibly the lower part of the *B. 'minor'* Zone (Fig. 9).

## Summary

Belemnites from five localities and one boring in the Vomb Trough have been studied. The localities, most of which lie in the periphery of the trough very close to the large-scale Fyledalen Fault, are described and placed in an international stratigraphic framework on the basis of the belemnites. The study is based mainly upon material collected in the last half of the 19th century and the first third of the 20th century. Earlier records of other stratigraphic important fossils, such as ammonites and echinoderms, are reviewed.

The belemnite faunas are correlated with belemnite faunas from western Europe and the Russian Platform, but formal belemnite zones are not established.

The depositional history of the Vomb Trough during the Upper Cretaceous is outlined. The dominant sediments are glauconitic, calcareous, clayey siltstones deposited in a fairly shallow-water environment, and the maximum thickness of the Upper Cretaceous is a little less than 800 m. Several conglomerates, some of which are of considerable thickness, and non-sequences occur in the Santonian and Campanian. The youngest sediments are from the Maastrichtian, probably the Lower Maastrichtian. The sea appears to have withdrawn from the trough in the Upper Maastrichtian, as it also did in the Kristianstad Basin farther northeast.

Thirteen belemnite taxa, representing the genera *Actinocamax* Miller, *Goniot euthis* Bayle, *Belemnello- camax* Naidin, and *Belemnitella* d'Orbigny, are described or discussed.

The nominate subspecies of *A. verus* and two other

subspecies are discussed. It is concluded that subspecies *dnestrensis* should be placed in synonymy of *A. v. verus* and that the subspecies *fragilis* is dubious. Samples of *Goniot euthis* from outcrops in the trough are compared to German samples from well-known stratigraphic levels. The subgenus *Actinocamax* (*Paractinocamax*) of Naidin is discussed and considered to be a synonym of *Belemnello- camax*. The stratigraphic range of *B. ex gr. grossouvrei* is fully discussed.

Two species of *Belemnitella* from the lower and middle Lower Campanian are tentatively recognized: *B. alpha* and *B. praecursor*. The measurements of critical characters of the holotype of *B. praecursor* are reported. The relationship of *B. alpha* and *B. praecursor* is fully discussed on the basis of the available literature, in addition to biometric analysis of samples of *B. alpha* and *B. praecursor*, respectively.

*Belemnitella* taxa from the highest Lower Campanian— Lower Maastrichtian are discussed, and the concept of many of these taxa is shown to be in a state of chaos. *B. mucronata senior* or *B. senior* is considered a synonym of *B. mucronata*. The internal characters of the holotype of *B. minor* do not fit with those given in the original diagnosis, and it falls within the variation of *B. mucronata*. *B. langei* and *B. posterior* are also discussed.

*B. aff. langei* is closely comparable to *B. langei* in its external characters, but differs from that species in its inner characters. Other species or subspecies of *Belemnitella* with guards markedly lanceolate in ventral view from the Upper Upper Campanian are also discussed.

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The International Commission on Zoological Nomenclature has designated, by use of its plenary powers, specimen number kca 5/2 in the collections of the Niedersächsisches Landesamt für Bodenforschung, Hannover, BRD, as neotype for *Belemnites mucronatus* Schlotheim, 1813 (see Opinion 1328; Bull. zool. Nomencl. 42, 222–225, September 30, 1985). The neotype was described and figured by Christensen *et al.* (1975, Pl. 1: 1).

**PLATES 1-7**

Photographed specimens were coated with ammonium chloride. Figures are of natural size except where stated.

PLATE 1

Fig. 1. *Actinocamax verus* Miller from Lyckås. Basal Campanian.

A: Dorsal view.  
B: Lateral view.  
LM LO 5724t

Figs. 2-3. *Gonoteuthis westfalica* (Schlüter) from the so-called 'Westfalicus conglomerate' at Rödmölla-Tosterup. Lower-Middle Santonian.

2A: Dorsal view.  
2B: View of the anterior end,  $\times 2$ .  
3A: Ventral view.  
3B: View of the anterior end,  $\times 2$ .  
Fig. 2 is SGU Type 5208.  
Fig. 3 is SGU Type 5209.

Fig. 4. *Gonoteuthis westfalicagranulata* (Stolley) from Erikssdal. Upper Middle Santonian.

A: Dorsal view.  
B: Lateral view.  
C: View of the anterior end,  $\times 2$ .  
RM Mo 150734.

Fig. 5. *Gonoteuthis westfalicagranulata* (Stolley) or *G. westfalica* (Schlüter) from Erikssdal.

A: Dorsal view.  
B: Lateral view.  
C: View of the anterior end,  $\times 3$ .  
The 'Riedel-Quotient' of this specimen is 16.8. The specimen was figured by Moberg (1885, Pl. 5:20) as *Actinocamax granulatus* Blainville forma *westfalica*.  
SGU Type 3902.

Fig. 6. *Gonoteuthis westfalicagranulata* (Stolley) from Erikssdal. Upper Middle Santonian.

A: Dorsal view.  
B: Lateral view.  
C: View of the anterior end,  $\times 2$ .  
RM Mo 150744.

Fig. 7-8. *Gonoteuthis granulataquadrata* (Stolley) from Lyckås. Basal Campanian.

A: Dorsal view.  
B: Lateral view.  
C: Ventral view.  
D: View of the anterior end.  
7D is  $\times 1.5$  and 8D is  $\times 2$ .

Fig. 7: The specimen is deposited in Geological Institute, Stockholm.

Fig. 8 is MGUH 16887.

Fig. 9. *Gonoteuthis quadrata scaniensis?* Christensen from Rödmölla-Tosterup. Uppermost Lower Campanian.

A: Dorsal view.  
B: Lateral view.  
C: Ventral view.  
D: View of the anterior end,  $\times 2$ .  
LM LO 5725t.

Fig. 10. *Gonoteuthis* sp. [possibly *G. granulataquadrata* (Stolley) or *G. quadrata* (Blainville)] from Kåseberga. Lower part of Lower Campanian.

A: Dorsal view.  
B: Lateral view.  
C: Ventral view.  
D: View of the anterior end,  $\times 2$ .  
The specimen is deposited in Geological Institute, Stockholm.

Fig. 11. *Gonoteuthis* sp. from the Kullemölla boring, level 200 m.

A: Dorsal view.  
B: Lateral view.  
C: Ventral view.  
D: View of the anterior end,  $\times 2$ .  
SGU Type 5210.

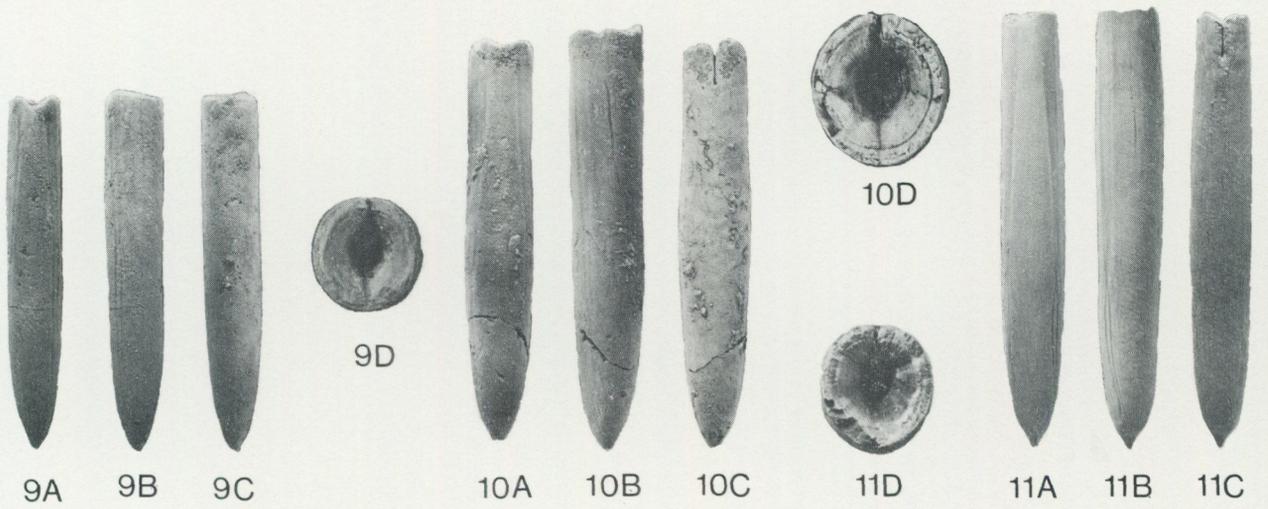
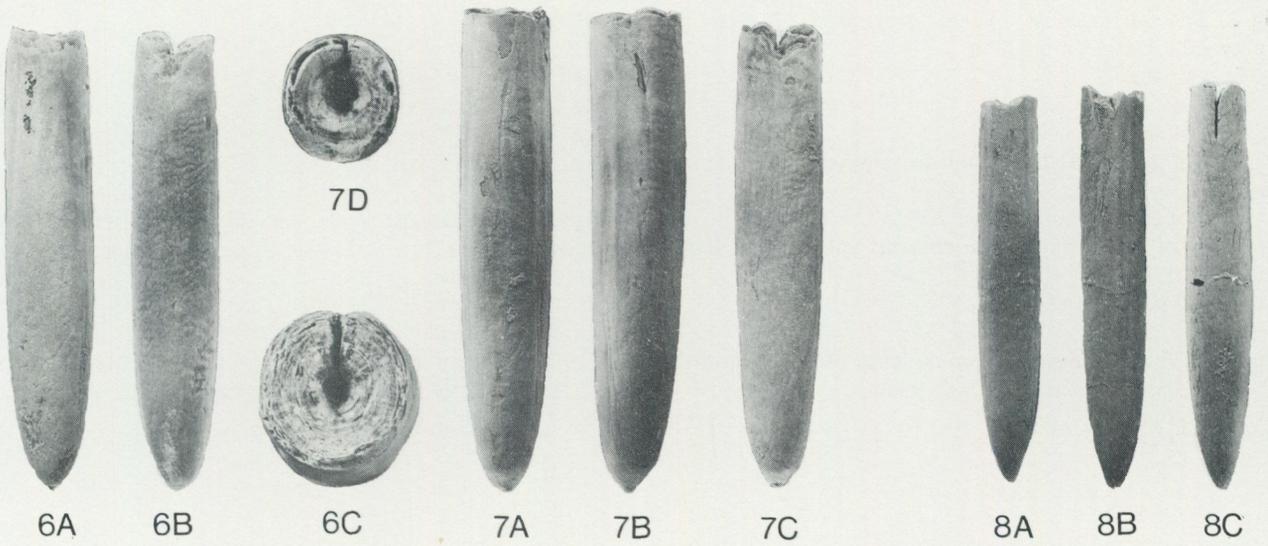
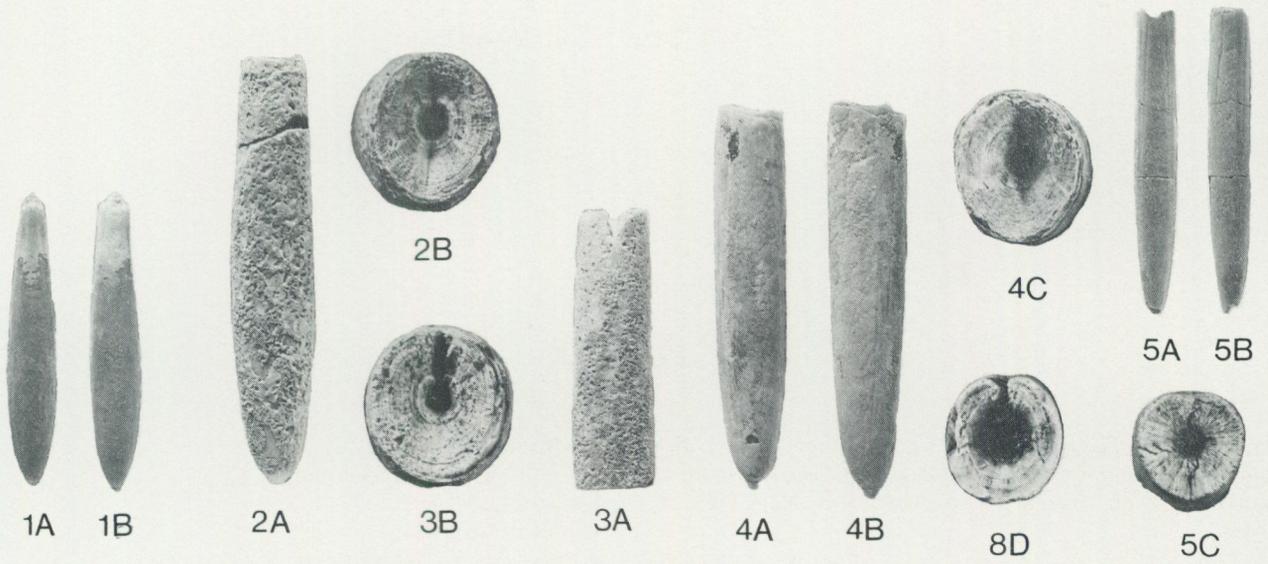


PLATE 2

Fig. 1. *Belemnellocamax* ex gr. *grossouvrei* (Janet) from Kullemölla. Basal Campanian. Dorsal view. The specimen was figured as *Actinocamax depressus* Andreae by Hägg (1935, Pl. 10:5-6).  
LM LO 3237t.

Fig. 2. *Belemnellocamax* ex gr. *grossouvrei* (Janet) from Kullemölla. Basal Campanian.

A: Dorsal view.

B: Lateral view.

C: Ventral view.

D: View of the middle part of the dorsal field showing granulation,  $\times 2$ .

E: View of the anterior end,  $\times 2$ .

Holotype of *Actinocamax mammillatus* var. *ornatus* Moberg (1885, Pl. 5:26).

LM LO 774t.

Figs. 3-5. *Belemnellocamax mammillatus* (Nilsson) from Valleberga. Uppermost Lower Campanian.

3A: Dorsal view.

3B: Lateral view.

3C: Ventral view.

3D: View of the anterior end,  $\times 3$ .

4A: Lateral view.

4B: Ventral view.

4C: View of the anterior end,  $\times 1.5$ .

5A: Dorsal view.

5B: Lateral view.

5C: Ventral view.

5D: View of the anterior end,  $\times 1.5$ .

Fig. 3 is SGU Type 5211.

Fig. 4 is SGU Type 5212.

Fig. 5 is SGU Type 5213.

Figs. 6-7. *Belemnellocamax balsvikensis* (Brotzen) from Röd-mölla-Tosterup, loc. 3. Lower Upper Campanian.

6A: Dorsal view.

6B: Lateral view.

6C: Ventral view.

Fig. 7 shows the inner characters of the pseudoalveolus,  $\times 2$ .

Fig. 6 is MGUH 16888 (ex P. Gravesen Coll.)

Fig. 7 is MGUH 16889.



1



2A



2B



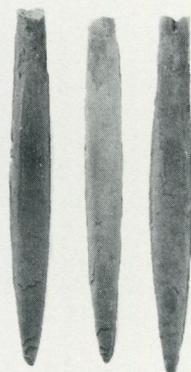
2C



2D



2E



3A 3B 3C



4C



5D



7



3D



4A



4B



5A



5B



5C



6A



6B



6C

PLATE 3

Fig. 1. '*Actinocamax*' *lundgreni* Stolley from the Kullemölla boring, level 440 m.

A: Dorsal view.

B: View of the anterior end,  $\times 3$ .

SGU Type 5214.

Fig. 2. *Belemnitella propinqua* (Moberg) from the Kullemölla boring, level 248 m. View of the split anterior end,  $\times 3$ .

SGU Type 5215.

Fig. 3. *Belemnitella* ex gr. *alpha* Naidin/*praecursor* Stolley from the Kullemölla boring, 0–20 m interval. View of the split anterior end,  $\times 3$ .

SGU Type 5216.

Fig. 4. *Belemnitella praecursor* Stolley from the Broitzem quarry at Braunschweig. *G. granulataquadrata* Zone of the basal Campanian. Cast of holotype.

A: Dorsal view.

B: Lateral view.

C: Ventral view.

D: View of the split anterior end showing inner characters.

The specimen was figured by Stolley (1897, Pl. 3:24). It is housed in the Geologisch-Paläontologisches Institut, Kiel.

Fig. 5. *Belemnitella alpha* Naidin from Kullemölla. *G. granulataquadrata* Zone of the basal Campanian.

A: Dorsal view.

B: Lateral view.

C: Ventral view, light from the left emphasizing longitudinal striae.

D: Ventral view, light from upper left corner emphasizing vascular imprints.

E: View of the split anterior end showing inner characters,  $\times 2$ .

The specimen was figured by Hägg (1935, Pl. 10:8–9) as *B. mucronata* (Schlotheim).

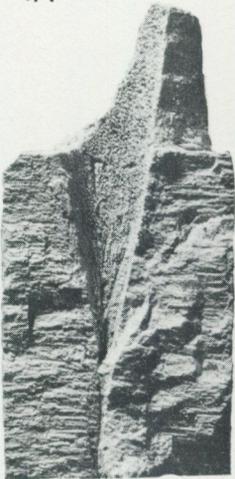
LM LO 3239t.



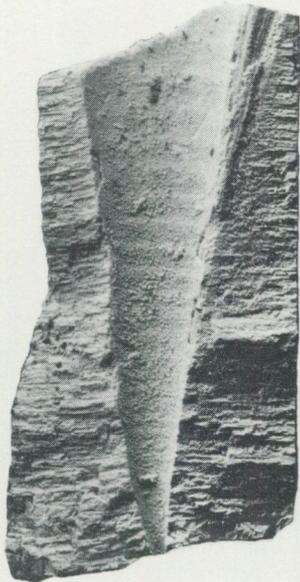
1A



1B



2



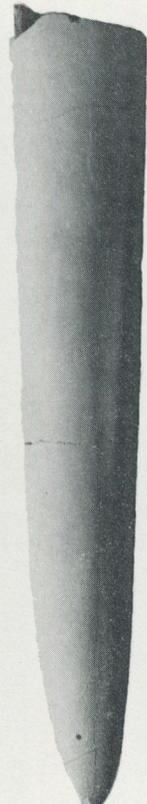
3



4D



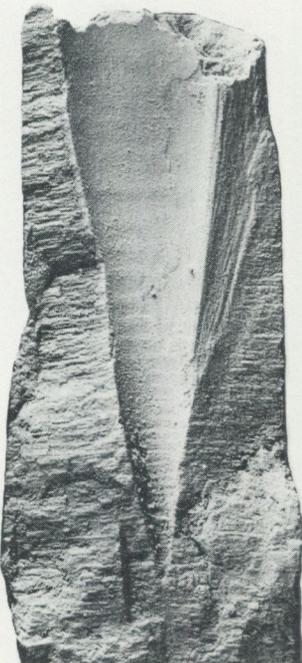
4A



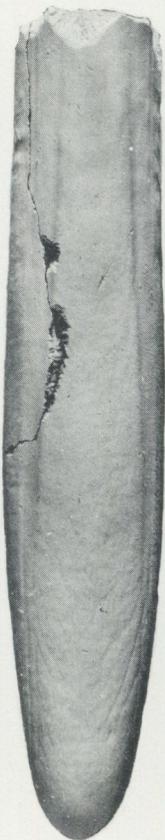
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4C



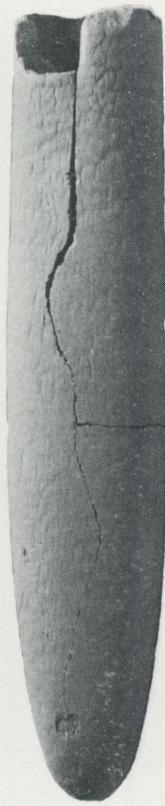
5E



5A



5B



5C



5D

PLATE 4

Figs. 1–3. *Belemnitella alpha* Naidin from the *G. granulata-quadrata* Zone of the basal Campanian.

Fig. 1. Specimen from Kullemölla.

A: Lateral view.

B: Ventral view.

SGU Type 5217.

Fig. 2. Specimen from Lyckås.

A: Dorsal view.

B: Lateral view.

C: Ventral view.

D: View of the split anterior end showing inner characters,  $\times 3$ .

MGUH 16890.

Fig. 3. Specimen from Lyckås.

A: Dorsal view.

B: Ventral view.

C: Lateral view.

D: View of the split anterior end showing inner characters,  $\times 3$ .

LM LO 5726t.

Fig. 4. *Belemnitella* ex gr. *alpha* Naidin/*praecursor* Stolley from Kåseberga. Lower part of Lower Campanian.

A: Ventral view.

B: View of the split anterior showing inner characters.

The specimen was referred to as *B. mucronata* (Schlotheim) by Hägg (1939). RM Mo 158065



1A



1B



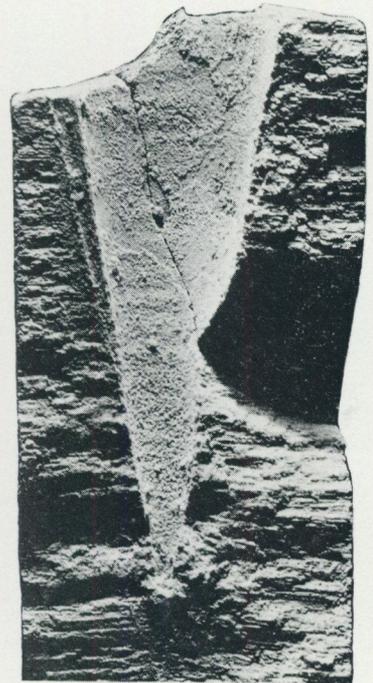
2A



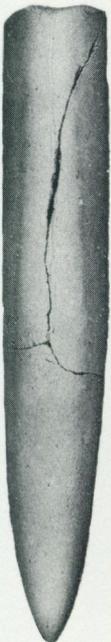
2B



2C



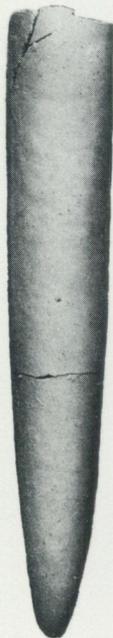
2D



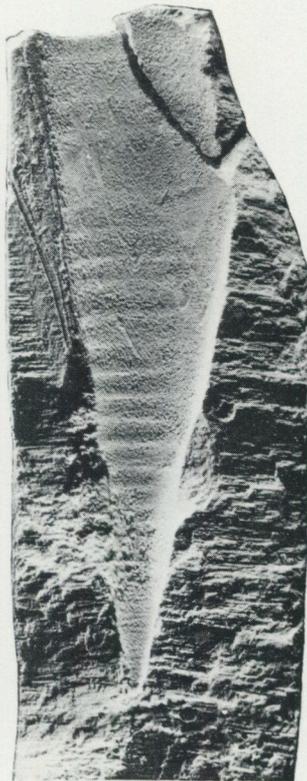
3A



3B



3C



3D



4A



4B

PLATE 5

Fig. 1. *Belemnitella praecursor* Stolley from the C.P.L. quarry at Hallembaye, Belgium. The specimen was collected from the 'Smectite' 25 cm below its upper limit. *G. quadrata* Zone of the lower Lower Campanian.

A: Dorsal view.

B: Lateral view.

C: Ventral view.

D: View of the split anterior end showing inner characters, × 1.5.

MGUH 16891.

Fig. 2. *Belemnitella praecursor* Stolley from the Aktjubinsk area, western Kazakhstan, USSR. Basal Campanian.

A: Dorsal view.

B: Lateral view.

C: Ventral view.

D: View of the split anterior end showing inner characters, × 1.5.

MGUH 16892.

Fig. 3. *Belemnitella mucronata* (Schlotheim) from the Köpings sandstone at Valleberga. Uppermost Lower Campanian.

A: Lateral view.

B: Ventral view.

SGU Type 5218.

Fig. 4. *Belemnitella mucronata* (Schlotheim) from the Köpings sandstone at Köpingsbro. The specimen presumably came from the lower part of the Upper Campanian.

A: Dorsal view.

B: Lateral view.

C: Ventral view.

D: View of the split anterior end showing inner characters, × 1.5.

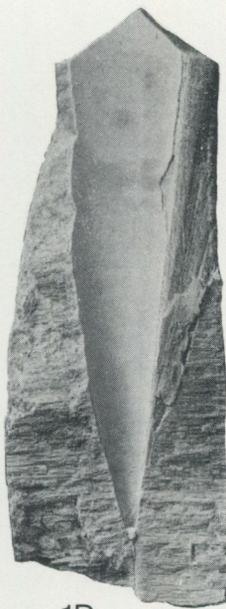
RM Mo 158066.



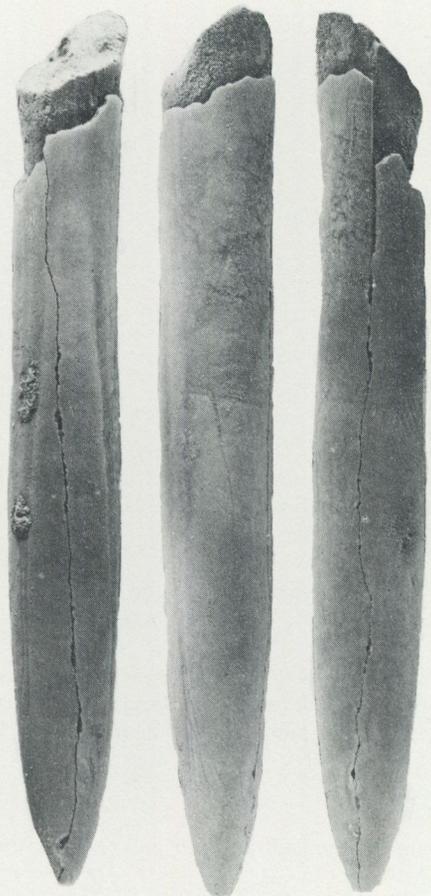
1A

1B

1C



1D



2A

2B

2C



2D



3A

3B



4D



4A

4B

4C

PLATE 6

Fig. 1. *Belemnitella mucronata* (Schlotheim) from the Köpings sandstone at Valleberga. Basal Upper Campanian.

A: Dorsal view.

B: Ventral view.

C: View of the split anterior end showing inner characters.

MGUH 16893.

Fig. 2. *Belemnitella mucronata* (Schlotheim) from the Köpings sandstone at Valleberga. The specimen probably came from the highest Lower Campanian or basal Upper Campanian.

A: Dorsal view.

B: Lateral view.

C: Ventral view.

D: View of the split anterior end showing inner characters.

RM Mo 158067.

Fig. 3. *Belemnitella* aff. *langei* Jeletzky from the Köpings sandstone at Köpings. Probably middle Upper Campanian.

A: Dorsal view.

B: Lateral view.

C: Ventral view.

D: View of the split anterior end showing inner characters.

The specimen was figured as *B. mucronata* (Schlotheim) by Moberg (1885, Pl. 6:14).

LM LO 776.

Fig. 4. *Belemnitella* aff. *langei* Jeletzky from the Köpings sandstone at Köpings. Probably middle Upper Campanian.

A: Ventral view.

B: Lateral view.

C: View of the split anterior end showing inner characters,  $\times 2$ .

SGU Type 5219.



1A



1B



2D



1C



2A



2B



2C



3A



3B



3C



3D



4C



4A



4B

PLATE 7

Figs. 1-4. *Belemnitella* aff. *langei* Jeletzky from the Köpinge sandstone at Köpinge. Probably middle Upper Campanian.

Fig. 1. A: Dorsal view.

B: Lateral view.

C: Ventral view.

D: View of the split anterior end showing inner characters,  $\times 1.5$ .

SGU Type 5220

Fig. 2. A: Dorsal view.

B: Lateral view.

C: Ventral view.

D: View of the split anterior end showing inner characters,  $\times 2$ .

SGU Type 5221.

Fig. 3. A: Dorsal view.

B: Lateral view.

SGU Type 5222.

Fig. 4. A: Dorsal view.

B: Lateral view.

C: Ventral view.

SGU Type 5223.

Fig. 5. *Belemnitella langei* Jeletzky from the quarry Schetschkowy-Gory at Seim, Ssumy Area, USSR. Cast of holotype. Uppermost Campanian, 1-2 m below the 'Lanceolatenschichten'.

A: Dorsal view.

B: Lateral view.

C: Ventral view.

Geol. Surv. Canada No. 47/96.

Figs. 6-7. *Belemnitella langei* Schatzky *sensu* Naidin from the Upper Upper Campanian. R. Don, USSR. Ex D.P. Naidin's Coll.

A: Dorsal view.

B: Lateral view.

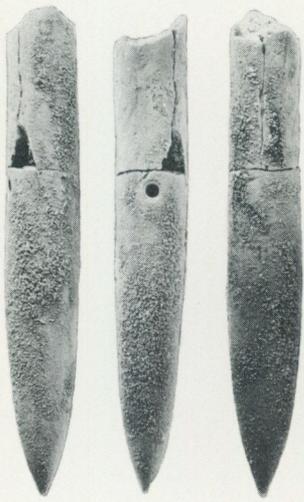
C: Ventral view.

D: View of the split anterior end showing inner characters,  $\times 2$ .

Note the large fissure angle.

Fig. 6 is MGUH 16894.

Fig. 7 is MGUH 16895.



1A 1B 1C



1D



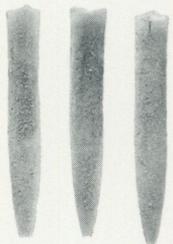
2D



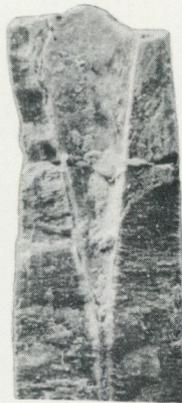
2A 2B 2C



3A 3B



4A 4B 4C



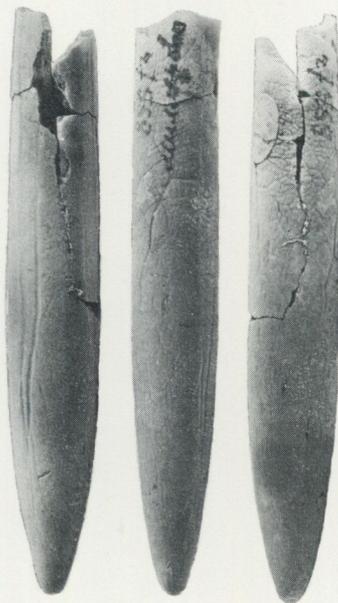
6D



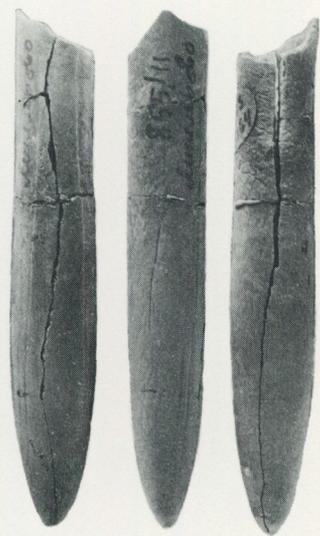
7D



5A 5B 5C



6A 6B 6C



7A 7B 7C

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