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UPPER CRETACEOUS BELEMNITES FROM DENMARK

BY

TOVE BIRKELUND

København 1957
i kommission hos Ejnar Munksgaard

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(*continued*)

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The delimitation of the Maastrichtian in recent literature is discussed. A schedule is given of the most important views.

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Introduction.

The Cretaceous belemnites of Denmark have been studied particularly by the late Mr. J. P. J. RAVN and recently by Dr. J. A. JELETZKY. However, the large amount of material which has now been collected justifies the present review of the group. The principal collection, in the Mineralogical and Geological Museum of the University of Copenhagen, has been enlarged by material collected by Professor A. ROSENKRANTZ, Dr. H. WIENBERG RASMUSSEN, Dr. J. TROELSEN, and Mr. S. FLORIS as well as by the present author. Furthermore Dr. H. ØDUM, Director of the Geological Survey of Denmark, has placed the collections of that institute at my disposal, and Mr. J. WIND has kindly placed his private collection at my disposal. I am most indepted to these persons and institutes for the kindness with which they have supported the present study.

I owe a special dept of gratitude to Professor A. ROSENKRANTZ and Dr. H. WIENBERG RASMUSSEN for their instructive and valuable advice during the study of the material.

Miss ESTHER JACOBSEN has undertaken the translation and the drawings are by Miss GUNNI JØRGENSEN. The manuscript has kindly been read by Dr. G. LARWOOD, University of Durham, King's College, and the translation of Russian literature has been undertaken by Mrs. H. PANDER. I thank them all for the great help which they have given me.

Finally I wish to express my sincere gratitude to the Carlsberg Foundation for financial support.

Morphology.

In the descriptions of the species of *Actinocamax*, *Belemnitella* and *Belemnella*, given below, the following morphological features of the guard are specially taken into consideration: the shape and the degree of elongation of the guard, the depth and shape of the pseudoalveolus or alveolus, the angle of the alveolar cavity, the length of the ventral fissure, the course of the bottom of the ventral fissure, the "Schatsky index", the ontogeny, and the surface markings.

The degree of elongation of the guard has proved to be of taxonomic value particularly as regards the distinction of some species which show close affinity in the more essential taxonomic features. In the genus *Actinocamax* the degree of elongation is expressed in terms of the relation of the maximum diameter in ventral view

to the length of the calcified part of the guard. For the genera *Belemnitella* and *Belemnella* the degree of elongation is difficult to express exactly in this way, as the actual length of specimens is not usually the total original length, because, due to their fragility, the anterior portions of the alveolar walls are often destroyed. VASILENKO & RASMYSLOVA (1950) have tried to rectify the error in measurement by reconstructing the

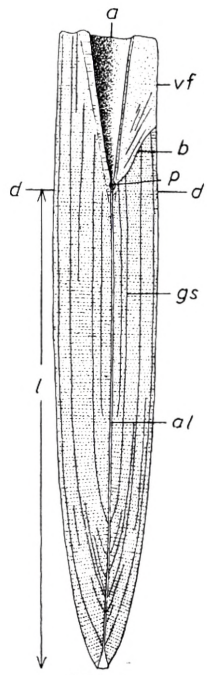


Fig. 1.

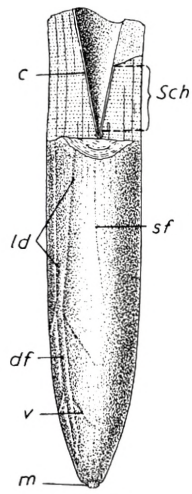


Fig. 2.

Fig. 1. *Belemnella occidentalis occidentalis* n. nom. × 1. Lower Maastrichtian. Møns Klint, Maglevandspynten. Lateral aspect, the guard is longitudinally split. a alveolus, vf ventral fissure, b bottom of the ventral fissure, p protoconch, dd dorso-ventral diameter at the protoconch, l length from the protoconch to apex, gs growthstage, al apical line.

Fig. 2. *Belemnitella langei* JELETZKY, 1948. × 1. Upper Campanian. The western part of Hvide Klint. Lateral aspect with the alveolar part split off. c conotheca, Sch "Schatsky index", sf lateral single furrow, ld dorso-lateral longitudinal depressions, df dorso-lateral double furrows, v angle between dorso-lateral double furrow and vascular impression, m mucro.

length in the same way as SWINNERTON (1936) has done for older genera of belemnites. This method is not sufficiently exact to demonstrate differences within closely related species of *Belemnitella* and *Belemnella*. In the species referred to these genera the degree of elongation is expressed, therefore, in terms of the relation of the diameter at the protoconch, measured dorso-ventrally (d), to the length from the protoconch to apex. The exact measurement of both these features in almost all specimens can be carried out independently of the destroyed anterior part.

Also the depth of the alveolus, expressed in terms of the relation of its depth to the length of the guard, is difficult to express exactly in the genera *Belemnitella* and

Belemnella because of imperfect preservation. The depth of the alveolus is expressed, therefore, in relation to the length of well preserved guards, or in relation to the estimated length of the guard, based on reconstruction.

The angle of the alveolar cavity is always measured in the dorso-ventral plane. Only in the genera *Belemnitella* and *Belemnella* does the alveolus form a regular cone the angle of which can be measured exactly.

The "Schatsky index" is the distance between the beginning of the ventral fissure on the wall of the alveolar cavity and the anterior end of the protoconch, measured in millimeters parallel to the longitudinal axis of the guard. JELETZKY (i. a. 1949 a, 1951 b) considers that the "Schatsky index" is of great taxonomic value in the genera *Belemnitella* and *Belemnella*. The taxonomic value of the "Schatsky index" in the genus *Actinocamax* is not known (JELETZKY, 1950 b). In order to show the degree of taxonomic importance of the index in this genus, this caracter is also mentioned in the description of the species of *Actinocamax*.

Ontogenetic development is of great taxonomic value (JELETZKY, i. a. 1949 a, 1951 b), and the two genera *Belemnitella* and *Belemnella* differ in their ontogeny. Great variation has been found in ontogenetic development in the species referred to the genus *Actinocamax*, suggesting that this genus may well be polyphyletic (JELETZKY, 1949 b).

Dorso-lateral longitudinal depressions, dorso-lateral double furrows, and single lateral furrows are visible on the surface of guards of *Actinocamax*, *Belemnitella* and *Belemnella* (cf. JELETZKY, 1955, pl. 56, fig. 5 b). Distinct vascular impressions commonly branch off from these furrows. In addition longitudinal striations may be present, and in some species of *Actinocamax*, granulations may be visible. The course of the posterior part of the dorso-lateral double furrows, and the size of the angle between these and the main vascular branches (*v* in text-fig. 2), may be of great taxonomic value (NOWAK, 1913; JELETZKY, i. a. 1949 a, 1951 b).

The various characters are shown in text-figs. 1–2.

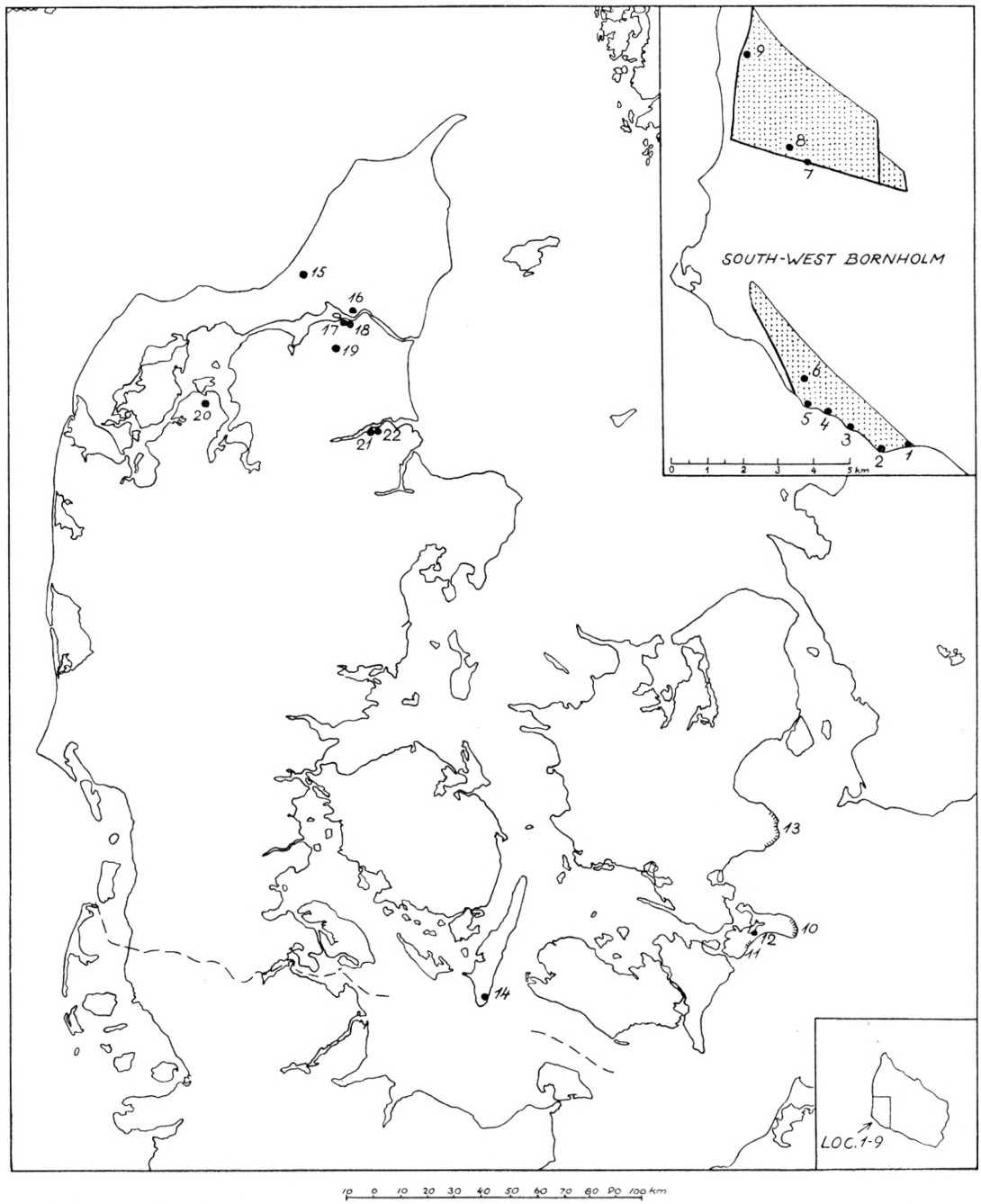


Fig. 3. Map showing the position of Upper Cretaceous localities, where belemnites have been found. In the special map showing the south-western part of Bornholm the dotted areas indicate Upper Cretaceous deposits. Loc. 1: Madsegrav; loc. 2: Arnager; loc. 3: Horsemyreodde; loc. 4: Forchhammers Klint; loc. 5: Bavnodde; loc. 6: Stampen; loc. 7: Jydegaard; loc. 8: Risenholm; loc. 9: "Glass Marl" at Mulebyaa; loc. 10: Møns Klint; loc. 11: Hvide Klint; loc. 12: Lille Bissinge; loc. 13: Stevns Klint; loc. 14: Vognsbjerg; loc. 15: Lundergaard Mose; loc. 16: Nørre Sundby; loc. 17: "Rordal", Aalborg; loc. 18: "Danmark", Aalborg; loc. 19: Nørre Flødal; loc. 20: Batum; loc. 21: "Dania"; loc. 22: "Kongsdal".

Systematic descriptions.

Genus **Actinocamax** MILLER, 1823.

Type Species *Actinocamax verus* MILLER, 1823.

Diagnosis.

Belemnites with lanceolate to subcylindrical or, in rare cases, cone-shaped guards, with dorso-lateral longitudinal depressions, dorso-lateral double furrows, and single lateral furrows; vascular impressions usually distinct, branched from these furrows; anterior part of guard incompletely calcified; anterior end of calcified part of guard forming either a cone, with the phragmocone attached to its tip, or a conical depression, with the phragmocone connected to the centre of the depression; concentric layers of the guard exposed in the wall of the cone or on the sides of the conical depression[1]; pseudoalveolus connected to the ventral surface by a ventral fissure, but due to non-calcification the ventral fissure may be absent or only the posterior part may be preserved as a flat furrow; "Schatsky index" 0 to 8 mm, but frequently less than 3 mm; degree of elongation of the early growth-stages may be relatively smaller, or greater, or the same as in the full-grown specimens.

Actinocamax primus primus ARKHANGELSKY, 1912.

Pl. 1, figs. 1a–d, 2a–d, 4.

1829 *Belemnites lanceolatus* SOWERBY, p. 208, pl. 600, figs. 8–9 (non SCHLOTHEIM, 1813).
1912 *Actinocamax primus* ARKHANGELSKY, p. 578, pl. 10, figs. 1–5.
1916 *Actinocamax plenus*, RAVN, p. 32, pl. 5, figs. 8–9 (non BLAINVILLE 1825).
1948c *Actinocamax primus*, JELETZKY, p. 340, text-fig. 1.

Synonyms. *B. lanceolatus* SOWERBY, 1829, is preoccupied by *B. lanceolatus* SCHLOTHEIM, 1813.

Diagnosis.

Actinocamax with a very elongate guard; in ventral view lanceolate, in lateral view subcylindrical to slightly lanceolate; ventral surface flattened except in the alveolar region where the guard is laterally compressed; dorsal surface flattened posteriorly; pseudoalveolus forming a low cone or slightly depressed, subtriangular or rounded trapeziform in cross-section; ventral furrow short; lateral grooves distinct; surface longitudinally striated.

Type.

JELETZKY (1948c, p. 343) has stated that the larger of two of SOWERBY's specimens is apparently a transitional form between *A. plenus* and *A. primus*. Therefore

[1] This part of the guard is called the pseudoalveolus, its shape is decided by the degree of calcification and not by the shape of the phragmocone as is the case with the genuine alveolus (cf. SAEMANN, 1861–1862; JELETZKY, 1948a).

he chose SOWERBY's smaller specimens as the type. This specimen was figured by SOWERBY, 1829, pl. 600, fig. 9. Henceforth it must be the lectotype. JELETZKY (1948c, p. 343) was in error in choosing "as type-specimen" that figured by SOWERBY, 1829, pl. 600, fig. 8.

Material.

Arnager-greensand on Bornholm: East of Arnager, 5 fragments; Madsegrav, 10 complete specimens and many fragments.

The specimens are in the collections of the Mineralogical and Geological Museum, Copenhagen.

Description.

The guard may reach a length of about 10 cm, but is seldom more than 7.5 cm long. It is very elongate; the relation between the maximum diameter of the guard, in ventral view, and its full length is frequently less than one to seven (see table 1). Young specimens are more elongate than the full-grown specimens; this is apparent from the growth-lines, pl. 1, fig. 4. In ventral aspect the guard is lanceolate, its maximum diameter being situated well behind the middle of the guard. From this point there is an even decrease in diameter anteriorly, and, in older specimens, an increasingly rapid decrease posteriorly; in young specimens the posterior decrease is slow and fairly even. In lateral aspect the guard is slightly lanceolate, or the margins are almost parallel except in the apical region. The dorsal margin may be straighter than the ventral one, the apex being slightly displaced towards the dorsal side (pl. 1, fig. 2c). The guard is ventrally flattened, except in the alveolar region where it is laterally

TABLE 1.

Specimens of *A. primus*	Entire length	Maximum diameter dorso-ventrally	Dorso-ventral diameter/ Length	Maximum diameter laterally	Lateral diameter/ Length	Diameter of the pseudoalveolus	
						dorso-ventrally	laterally
1 (pl. 1, fig. 1)	97.0	11.4	0.12	12.7	0.13	10.5	9.0
2	71.7	8.7	0.12	9.3	0.13	7.8	7.2
A. primus type	69.9	7.4	0.11	?	?	5.2	?
3 (pl. 1, fig. 2)	69.3	6.5	0.09	6.8	0.10	6.1	5.5
4	68.0	8.1	0.12	8.6	0.13	6.9	6.0
5	63.3	7.5	0.12	8.2	0.13	6.5	5.9
6	63.0	6.1	0.10	6.7	0.11	5.2	5.0
7 (pl. 1, fig. 4)	61.7	7.7	0.12	8.4	0.14	6.4	6.0
8	61.3	5.3	0.09	5.8	0.09	4.4	4.3
9	60.5	4.6	0.08	4.8	0.08	4.1	4.0
A. plenus type	79.7	?	?	14.0	0.18	9.6	9.1

All measures given in mm.

compressed, it is also slightly flattened dorsally, but only within the posterior third. The apical end is very acute in young specimens, but somewhat less acute in adult specimens. A mucro is only slightly developed or is absent.

The pseudoalveolus forms a low cone (pl. 1, fig. 1 d), or is slightly depressed (pl. 1, fig. 2 d), in both cases with a small central hole for the posterior part of the phragmocone. The cross section of the pseudoalveolus is subtriangular or rounded trapeziform with its maximum diameter in a dorso-ventral direction. Some specimens may have a ventral furrow which may continue about 15 mm behind the protoconch, but which gradually flattens out and disappears.

The dorso-lateral longitudinal depressions and double furrows are faint and only slightly diverging, the double furrows can be traced almost to the apex. The single lateral furrows are distinct, they are either parallel in the anterior part and converge towards the ventral side in the posterior part, or they converge towards the ventral side in their full extent. They often extend for one third the length of the guard, but they may be longer and sometimes can be distinguished beyond the middle of the guard.

The surface of the guard is longitudinally striated by short, fine grooves which are most pronounced ventrally and dorsally.

The dimensions of the specimens from Bornholm are shown in table 1.

Affinity with other species.

A. primus primus is very closely allied to *A. primus elongata*. The relations between these two subspecies are mentioned below on page 13. *A. primus primus* is also closely related to *A. plenus* (Blainville), 1825.

According to Arkhangelsky (1912) *A. primus* differs from *A. plenus* in being longitudinally striated, and in its rather long and distinct lateral grooves. Moreover *A. primus* is more elongate and less markedly lanceolate than *A. plenus* (Sowerby, 1829; Jeletzky, 1948c). Jeletzky (1948c) has stated that the apex is central in *A. primus*, but that it is clearly displaced towards the dorsal side of the guard in *A. plenus*. The Danish material shows, however, that the apex may also be slightly displaced towards the dorsal side in specimens of *A. primus* which in other essential characters agree with this species. But the lack of symmetry is always less marked than in *A. plenus*. Arkhangelsky (1912) also mentioned the asymmetric appearance of *A. primus*.

Jeletzky (1948c) has stated that the larger of the two specimens of Sowerby (1829, pl. 600, figs. 8–9), and possibly the specimen figured by Fritsch (1872, pl. 11, figs. 6–7) and the largest of the specimens of Arkhangelsky (1912, pl. 10, figs. 4–5), are apparently transitional forms between *A. primus* and *A. plenus*.

A complete specimen is known from Bornholm which is of a similar size and shape to the larger of the two figured by Sowerby. (Ravn (1916) also mentioned the close relation between *A. lanceolatus* Sowerby (= *A. primus*) and the specimens from Bornholm). On the surface of that specimen (pl. 1, figs. 1 a–d) only feeble longitudinal striae are visible and the lateral furrows are short and indistinct. In ventral view the

specimen is slightly asymmetric, in lateral view it is subcylindrical and symmetrical. A fragmentary specimen, similar in shape and size to the above mentioned specimen, has more marked longitudinal striae. It is apparent from table 1, that all the specimens from Bornholm, including the above-mentioned very large specimen (no. 1), show a closer affinity to the type of *A. primus*, at least in the relation between length and breadth, than to the type of *A. plenus* (BLAINVILLE, 1825–27, pl. 11, fig. 3).

It is not possible to give a full explanation of the relationship of *A. primus* to *A. plenus* without a more comprehensive collection of the latter species.

Stratigraphy.

A. primus occurs in the Middle Cenomanian (*Schloenbachia varians* zone) and in the lower part of the Upper Cenomanian (*Holaster subglobosus* zone), while *A. plenus* occurs in the Upper Cenomanian, most frequently in the upper part, and locally in the Lower Turonian (*Inoceramus labiatus* zone), (cf. JELETZKY, 1948c, p. 341).

According to RAVN (1916) the Arnager-greensand can most probably be referred to the Middle Cenomanian, the determination of the age being, among other things, based on the presence of *A. plenus* (BLAINVILLE) (= *A. primus*), *Schloenbachia varians* SOWERBY and *Schloenbachia cupei* BROGNIART. RAVN is of the opinion that other horizons, most probably younger, may also be present.

ROSENKRANTZ (1944) mentions the occurrence of *Acanthoceras* aff. *sherborni* SPATH in the Arnager-greensand immediately above the basal conglomerate. The genus is known only from the Middle and Upper Cenomanian which agrees with the age suggested by RAVN.

In addition to *A. lanceolatus* SOWERBY (= *A. primus*) a single specimen (about 8 cm long) of *A. plenus* has been recorded by STOLLEY (1930) from the Arnager-greensand. STOLLEY suggested therefore that beds of Upper Cenomanian and, particularly, transitional beds of Cenomanian-Turonian age are present. Unfortunately his specimen was not figured, nor has it been available to the present author, so that it is not possible to decide whether the specimen is really a typical *A. plenus*, or whether it is similar in form to the very large specimen figured here (pl. 1, figs. 1a–d).

Actinocamax primus elongata ARKHANGELSKY, 1912.

Pl. 1, figs. 3a–c.

1912 *Actinocamax primus* var. *elongata* ARKHANGELSKY, p. 581.
1948c *Actinocamax primus* var. *elongata*, JELETZKY, p. 340, text-fig. 2.

Diagnosis.

Actinocamax primus with a very elongate guard, in ventral view subcylindrical to slightly lanceolate, and in lateral view always subcylindrical.

Type.

The subspecies was described by ARKHANGELSKY (1912), but not figured. The specimen, figured by JELETZKY, 1948c, p. 340, text-fig. 2, is here chosen as the lectotype for this subspecies. Horizon: Cenomanian, zone of *Schloenbachia varians* SOWERBY. Locality: North-west border of the Donetz Basin (The Woroshilowgrad province; "Belaya Gora" quarry). The specimen is in the collections of the Geological Survey of Canada, Ottawa.

Material.

Arnager-greensand, Madsegrav, Bornholm, one almost complete specimen.

The specimen is in the collections of the Mineralogical and Geological Museum, Copenhagen.

Description.

The guard is very elongate. In ventral view it is subcylindrical or slightly lanceolate, the diameter thus being constant or almost constant, except in the apical region where it decreases evenly. In lateral aspect the margins of the guard are parallel except in the apical part. The apical region is very acute.

The other characters of the guard of this subspecies shows no differences from *Actinocamax primus primus*.

Affinity with other species.

A. primus elongata is very closely allied to *A. primus primus* and can only be distinguished from this species by its subcylindrical form. Transitional forms exist between the two subspecies; pl. 1, figs. 2a–d, shows a specimen of *A. primus primus* which is exceedingly close to *A. primus elongata*. Their common stratigraphical occurrence and their morphological features makes the distinction between these two subspecies doubtful.

Stratigraphy.

A. primus elongata occurs, together with *A. primus primus*, in the Middle Cenomanian and the lower part of the Upper Cenomanian.

Actinocamax lundgreni lundgreni STOLLEY, 1897.

Pl. 1, figs. 5a–d, 6.

1896 *Actinocamax mammilatus*, STOLLEY, p. 34 (non NILSSON, 1827).
1897 *Actinocamax Lundgreni* STOLLEY, p. 285, pl. 3, figs. 16–20, non 15.
1897 *Actinocamax mammilatus* mut. (ant.) *bornholmensis* STOLLEY, p. 288, pl. 4, fig. 1.
1902 *Actinocamax Lundgreni*, RAVN, p. 262.
1902 *Actinocamax bornholmensis*, RAVN, p. 262.

1912 *Actinocamax propinquus*, ARKHANGELSKY, p. 585,? pl. 10, figs. 14–15, 23–26, 34–36.
1912 *Actinocamax intermedius* ARKHANGELSKY, p. 582, pl. 9, figs. 30–31; pl. 10, figs. 6, 16–18,? 27.
1918 *Actinocamax bornholmensis*, RAVN, p. 33, pl. 2, fig. 7.
1918 *Actinocamax* sp. (cfr. *Act. strehlensis*), RAVN, p. 34, pl. 2, fig. 8.
1930 *Actinocamax Lundgreni*, STOLLEY, p. 184.
1930 *Actinocamax bornholmensis*, STOLLEY, p. 184.
1946 *Actinocamax Lundgreni*, RAVN, p. 30.

Diagnosis.

Actinocamax with a rather stout guard; in ventral aspect lanceolate, in lateral aspect commonly subcylindrical; considerably flattened dorso-ventrally; pseudo-alveolus depressed, its depth one sixth to one twentieth the entire length of the guard, subtriangular in cross section; ventral fissure up to 2 or 3 mm long; "Schatsky index" about 2 to 3.5 mm; lateral single furrows long and distinct; surface longitudinally striated; vascular impressions very faint or lacking.

Type.

The specimen, figured by STOLLEY, 1897, pl. 3, figs. 18a–c, is here chosen as the lectotype for the species. Horizon: Upper Turonian. Locality: The "Glass Marl" at Mulebyaa, Bornholm. The specimen is in the collections of the Mineralogical and Geological Museum, Copenhagen.

Material.

The "Glass Marl" at Mulebyaa, Bornholm, [including loc. 3, 5, and 8 mentioned by RAVN (1946)], 14 complete specimens and many fragments. Arnager-limestone, Arnager, Bornholm, 6 complete specimens and some fragments. Calcareous greensand at Stampe Aa, Bornholm (cf. RAVN, 1921, pp. 44–45), some fragments, which can not be referred with certainty to this species.

The specimens are in the collections of the Mineralogical and Geological Museum, Copenhagen.

Description.

The guard may be up to 6.5 cm long and is rather stout. The relation between its maximum diameter in ventral aspect and the entire length of the guard is one fifth to one seventh in adult individuals. Specimens not quite fully developed show a similar degree of elongation. It has not been possible to study the earliest growth stages. In ventral aspect the guard is lanceolate, the maximum diameter being situated behind the middle of the guard from where it decreases evenly anteriorly. The sides converge posteriorly with increasing rapidity. In lateral aspect the guard is subcylindrical to slightly lanceolate. The apex is more or less acute. The mucro is only slightly separated. Ventrally the guard is rather markedly flattened for its entire length,

and dorsally it is flattened posteriorly. Owing to weathering the guard is sometimes concentrically exfoliated round the alveolar end.

The depth of the pseudoalveolus is commonly one sixth to one tenth the entire length of the guard, in rare cases it is less depressed, and sometimes it may be only one twentieth the entire length of the guard. The cross section of the pseudoalveolus is more or less subtriangular, its diameter measured laterally is the same or less than its dorso-ventral diameter. Dorsally the edge of the pseudoalveolus may have an embayment (pl. 1, figs. 5a, d) as is seen in *Actinocamax westfalicus*. The edges of the concentric layers composing the guard, are visible in the wall of the pseudoalveolus which is otherwise smooth and without tubercles (HÖLDER, 1955: connellae) in typical specimens.

The ventral fissure is up to 3 mm long, its bottom forming a rather wide angle with the alveolar wall (values of about 50 degrees have been observed). In the three specimens in which it has been possible to measure it the "Schatsky index" is rather large (2.0, 2.4 and 3.5 mm).

The dorso-lateral longitudinal depressions and double furrows are distinctly developed. The double furrows can be traced almost as far as the apex. They show a curvature corresponding to the outline of the guard. The lateral single furrows are distinct, their length being commonly about one third the entire length of the guard and never exceeding one half the entire length of the guard. They are nearly parallel anteriorly and converge towards the ventral side posteriorly.

Distinct, longitudinal striae, consisting of short grooves, are often present on the surface of the guard. In rare cases it is possible to distinguish faint vascular impressions branching off from the posterior part of the dorso-lateral double furrows (pl. 1, fig. 5c). The angle between these and the double furrows is less than 30°. A distinct mesh of vascular impressions is never visible in typical specimens.

One young specimen differs from the typical forms in having a more depressed pseudoalveolus the wall of which is provided with a single tubercle. The depth of the pseudoalveolus is one fifth the entire length of the guard. The specimen also differs in having a faint mesh of vascular impressions on the anterior part of the ventral surface. Its ventral fissure is short, as in typical specimens. The specimen was found at Mulebyaa together with typical individuals. It may be a transitional form between *A. lundgreni* and *A. propinquus*.

Affinity with other species.

STOLLEY (1897) has established *Actinocamax lundgreni* and *A. mammilatus* mut. (ant.) *bornholmensis* on the basis of specimens collected from the "Glass Marl" of Mulebyaa and from the Arnager-limestone of the south-coast of Bornholm.

Actinocamax bornholmensis is regarded by RAVN (1902) as a full species independent of *A. mammilatus* (NILSSON), 1827, from which it is considerably different.

STOLLEY (1897) distinguished *A. bornholmensis* (from the Arnager-limestone), from *A. lundgreni* (from the "Glass-Marl"), by the absence of concentric exfoliation

TABLE 2.

	Entire length	Maximum diameter dorso-ventrally	Maximum diameter laterally	Lateral maximum diameter/ Length	Diameter of the pseudoalveolus	
					dorso-ventrally	laterally
A. sp. (cf. *strehlensis*) (RAVN, 1918, pl. 2, fig. 8)	52.0	6.9	7.3	0.14	6.4	5.9
A. lundgreni	49.5	6.8	7.4	0.15	6.4	6.1
A. lundgreni (STOLLEY, 1897, pl. 3, figs. 16a–e)	49.5	7.6	7.9	0.16	7.2	6.5

All measures given in mm.

in the anterior part of the guard, by the absence, or only faint development of a longitudinal striation on the surface, and, finally, by its deeper pseudoalveolus. The latter should thus be relatively deeper in small specimens of *A. bornholmensis* than in similar small specimens of *A. lundgreni.*

RAVN (1918) was of the opinion that *A. lundgreni* and *A. bornholmensis* are so closely allied, that they can hardly be separated, though, the cross section of the pseudoalveolus seems to be more distinctly triangular in *A. bornholmensis* than in *A. lundgreni.*

The identity of the two species was confirmed by RAVN (1946) during studies of further material; thus a faint exfoliation of the anterior part of the guard may be present in *A. bornholmensis* (RAVN, 1918, pl. 2, figs. 7 a–d), while the concentric exfoliation is not always present in *A. lundgreni.* Furthermore, the two forms exhibit the same longitudinal striation. Also the cross section of the pseudoalveolus is the same in well-preserved specimens. These observations have been confirmed by the present author. No significant or constant differences in depth of the pseudoalveolus, mentioned by STOLLEY (1897), have been found.

The young specimen figured by RAVN (1918, pl. 2, fig. 8) as *Actinocamax* sp. (cf. *A. strehlensis* FRITSCH) was referred by STOLLEY (1930) to *A. bornholmensis* (= *A. lundgreni*). According to RAVN (1918) it differs from this species by its more elongate shape. Table 2 shows the dimensions of a specimen of a similar size to *Actinocamax* sp. (cf. *A. strehlensis*), but which, in its degree of elongation, is intermediate between this specimen and a typical specimen of *A. lundgreni.* Stolley's statement is thus confirmed.

RAVN (1946, p. 32) has also mentioned as *Actinocamax* sp., together with *A.* sp. (cf. *A. strehlensis*), a specimen from Mulebyaa, the dimensions of which are in almost full agreement with *A.* sp. (cf. *A. strehlensis*), but which, contrary to this, has only a very slightly depressed pseudoalveolus. According to RAVN (1946) the specimen was collected from the Cenomanian greensand at locality 1, and thus seems to be of a different age. It appears, however, to be almost identical with a larger specimen

from the Arnager-limestone, which has a similar only slightly depressed pseudoalveolus. As only this single juvenile specimen is known from locality 1 at Mulebyaa, a specific determination cannot be made with certainty.

JELETZKY (1950b, p. 11) has mentioned the North American *A. manitobensis lawrenci* which should be closer to *A. lundgreni* than to other European species (JELETZKY, 1950, pp. 9, 20). This form is distinctly different from *A. lundgreni* and from *A. lundgreni excavata*, mentioned below, in its much greater size, its greater elongation, its more acute apical end, and in the presence of tubercles on the wall of the pseudoalveolus.

A. lundgreni is considered to be the ancestor of *A. propinquus* (JELETZKY, 1949b). The latter differs from *A. lundgreni* by its greater size, its more depressed pseudoalveolus, by its longer ventral fissure, and by its rather closely spaced vascular impressions, and by the fact that the wall of the pseudoalveolus is almost covered with tubercles.

A. lundgreni excavata from the Coniacian and Lower Santonian, described below, seems to be a transitional form between *A. lundgreni* and *A. propinquus*. With regard to the relation between *A. lundgreni lundgreni* and *A. lundgreni excavata* see page 19.

Stratigraphy.

STOLLEY (1897) has referred the "Glass Marl" at Mulebyaa to the transitional zone between the Emscherian and the *A. granulatus* zone, as he considers *A. westfalicus* to be the ancestor of *A. lundgreni*. Furthermore he is of the opinion that *Scaphites binodosus* RÖMER occurs in these deposits. The Arnager-limestone is referred to the zone of *A. granulatus* primarily because of the assumed occurrence of *Inoceramus lingua* GOLDFUSS and *Scaphites inflatus* RÖMER, and also because *A. bornholmensis* is assumed to be a transitional form between *A. lundgreni* and *A. mammilatus* (NILSSON).

RAVN (1918, 1946) referred both deposits to the Upper Turonian. The *Inoceramus* sp. from the Arnager-limestone which has previously been referred to *I. lingua* GOLDFUSS, was referred by RAVN to *I. lamarcki* PARKINSON *cuvieri* SOWERBY. At the same time he shows the presence of i. a. the Upper Turonian *Scaphites geinitzi* D'ORBIGNY, while the presence of *Scaphites inflatus* RÖMER is considered most doubtful. This determination of the age of the Arnager-limestone is probably correct for this deposit is overlain by the Lower Santonian Bavnodde-greensand. The fauna of the "Glass Marl" is very similar to that of the Arnager-limestone. *A. lundgreni* is considered identical with *A. bornholmensis*. The previously mentioned *Scaphites binodosus* RÖMER, from these deposits, was shown by RAVN to belong to the greensand at Blykobbeaa.

STOLLEY (1930) was much opposed to the results reached by RAVN, and now referred the Arnager-limestone to the Middle Emscherian, the "Glass Marl" he assumed to be older than the Bavnodde-greensand, and older possibly than the Arnager-limestone.

BROTZEN (1945, p. 34) confirmed the age determination made by RAVN.

A. lundgreni has been mentioned as occurring in deposits of Lower Senonian age. RIEDEL (1930, p. 629) has thus mentioned *A. lundgreni* and "transitional forms between *A. lundgreni* and *A. westfalicus*", occurring together with *A. westfalicus*, *A. westfalicus-granulatus*, and rare *A. granulatus*, in the Münster basin. Since *A. lundgreni* was neither described nor figured in this work, it cannot be decided whether the specimens in question agree with *A. lundgreni* from Bornholm.

JELETZKY (1948b, 1949b) mentioned *A. lundgreni*, which has a wide distribution in the Central Russian faunal province, as a zonal fossil for the Upper Coniacian (correlated by JELETZKY with the *Inoceramus undulato-plicatus* zone and here referred to the lower part of the Lower Santonian). Among the *Actinocamax* species from Russia, described by ARKHANGELSKY (1912), JELETZKY has referred the specimens of *A. intermedius*, derived from this zone, to *A. lundgreni*. Turonian specimens described under the name *A. intermedius* he referred to *A. strehlensis* (FRITSCH), 1872. In the same way, some forms from the *I. undulato-plicatus* zone, described by ARKHANGELSKY under the name *A. propinquus*, he referred to *A. lundgreni*, as is *A. plenus excavata* from Central Russia (described by SINZOW, 1915).

SINZOW's specimens were certainly collected from deposits of Upper Coniacian age (*Inoceramus involutus* zone). They differ from the typical *A. lundgreni*, from the Turonian deposits of Bornholm, i. a., in having marked vascular impressions on the surface of the guard. ARKHANGELSKY's specimens which JELETZKY referred to *A. lundgreni* were probably the forms showing affinity with SINZOW's belemnites. The specimens from the Upper Coniacian—Lower Santonian are closely related to the typical Turonian *A. lundgreni lundgreni* and are here mentioned as subspecies of *A. lundgreni* (*A. lundgreni excavata*).

Actinocamax lundgreni excavata (SINZOW), 1915.

Pl. 1, figs. 7a–d, 8.

?1896 STOLLEY, p. 31, 34.
?1897 *Actinocamax propinquus* mut. (var.) nov. STOLLEY, p. 295, pl. 3, fig. 23.
pars 1912 *Actinocamax propinquus*, ARKHANGELSKY, p. 585.
1915 *Actinocamax plenus* var. *excavata* SINZOW, pl. 8, figs. 14–18.
pars ?1949b *Actinocamax lundgreni*, JELETZKY, pp. 420–423.

Diagnosis.

A rather stout *Actinocamax lundgreni* with fairly distinct vascular impressions on the surface of the guard.

Type.

The specimen, figured by SINZOW, 1915, pl. 8, fig. 15, is here chosen as lectotype for this subspecies. Horizon: Upper Coniacian, marl containing *Inoceramus involutus*. Locality: Selo Gorenki, Simbirskoj guberni, U.S.S.R.

Material.

The greensand at Jydegaard, Bornholm (cf. GRY, 1956), 3 complete specimens and some fragments. The greensand at Stampen, Bornholm, 1 fragment, which may be referred to this subspecies.

The specimens are in the collections of the Mineralogical and Geological Museum, Copenhagen.

Description.

The length of the guard is commonly less than 7.5 cm, but it may be longer (cf. SINZOW, pl. 8, fig. 14). The guard is rather stout, the relation of the maximum diameter in ventral aspect to the entire length being one fifth to one seventh in adult specimens.

In the three specimens from Bornholm the depth of the pseudoalveolus is one sixth to one tenth the entire length of the guard.

Longitudinal striae, similar to those of *A. lundgreni lundgreni*, are visible on the surface of the guard. All the specimens show rather marked vascular impressions. The angle between the posterior part of the dorso-lateral double furrows and the main vascular branches is less than 30°.

The remaining characters of the guard of *A. lundgreni excavata* are like those of A. *lundgreni lundgreni*.

Affinity with other species.

The subspecies described here seems to be very closely related to *A. lundgreni lundgreni*. It differs from this in its fairly distinct vascular impressions and in its slightly greater size. It seems to represent a transitional form between *A. lundgreni lundgreni* and *A. propinquus*. In shape, size and structure of the pseudoalveolus it is more closely allied to the former, but in its development of vessels it is more closely comparable with the latter. Its stratigraphical occurrence also seems to agree with its suggested transitional systematic position (cf. stratigraphical section below).

The specimen figured by STOLLEY (1897, pl. 3, fig. 23) under the name *A. propinquus* mut. (var.) nov. from Stampen, Bornholm, seems to belong to the subspecies in question; STOLLEY considered this specimen to be a descendant of *A. westfalicus* and an ancestor of *A. propinquus*. JELETZKY (1949b) was of the opinion that this specimen should be referred to *A. lundgreni*, possibly as a new variety or mutation of this species. A fragment from the greensand at Stampen may also be referred to *A. lundgreni excavata*. SINZOW (1915, pl. 8, fig. 14) has figured a very large individual which shows still closer affinity with *A. propinquus* than do the other representatives of the subspecies (cf. JELETZKY, 1949b).

Stratigraphy.

A. lundgreni excavata was recorded by SINZOW (1915) from the zone of *Inoceramus involutus* (Upper Coniacian). JELETZKY (1949b) mentioned *A. lundgreni*

(? = *A. lundgreni excavata*) as an index fossil for the *I. undulato-plicatus* zone (lower part of the Lower Santonian). *A. lundgreni excavata* occurs at Jydegaard in association with *A. westfalicus* and a form closely related to *A. westfalicus* (*A.* aff. *westfalicus*). As *A. westfalicus* in Germany is not known to occur in the *I. involutus* zone and the *I. undulato-plicatus* zone but only in the following *I. cordiformis* zone (SCHMID, 1956), the greensand at Jydegaard may probably be referred to the uppermost part of the *I. undulato-plicatus* zone. The microfauna at Jydegaard suggests a Turonian-Emscherian age (BROTZEN in RAVN, 1946, p. 11).

RAVN (1921) presumed the age of the greensand at Stampen to be Senonian. This determination was based on the similarity of the facies to that of the Bavnoddegreensand. Presumably the greensand of Stampen can be referred to the same zone as that at Jydegaard, as *A. lundgreni excavata* seems also to occur in this locality.

Actinocamax propinquus propinquus MOBERG, 1885.

1885 *Actinocamax propinquus* MOBERG, p. 53, pl. 5, fig. 25.
pars 1912 *Actinocamax propinquus*, ARKHANGELSKY, p. 585.
1912 *Belemnitella mirabilis* ARKHANGELSKY, p. 615, pl. 10, figs. 28–30.
1949b *Belemnitella propinqua*, JELETZKY, p. 415, text-figs. 1–4.

Diagnosis.

Actinocamax with a rather stout guard; in ventral aspect lanceolate, in lateral aspect usually subcylindrical; often considerably flattened dorso-ventrally; pseudoalveolus subtriangular to ovate in cross section, its depth one fourth to one sixth the entire length of the guard, its wall partly covered with coarse and prominent tubercles; ventral fissure up to 2 cm long; "Schatsky index" 2.5 to 4 mm; distinct vascular impressions and longitudinal striations visible on the surface.

Type.

The individual, figured by MOBERG, 1885, pl. 5, fig. 25, is the holotype by monotypy. Horizon: Lower Santonian. Locality: Eriksdal, Sweden. The specimen is in the collections of the Museum of Natural History, Stockholm.

Material.

This subspecies is unknown in Denmark, but *A. propinquus ravni* n. subsp. does occur.

Description.

The guard may be up to 11 cm long and is usually of a stout form. The relation between the maximum diameter of the guard, in ventral view, and its full length may vary from about one fifth to one seventh. The early growth stages are comparatively

short and stout (cf. JELETZKY, 1949b, text–fig. 4). In ventral view the guard is lanceolate, in lateral view it is subcylindrical, less often it may be very slightly cone-shaped or very slightly lanceolate. The guard is flattened ventrally for its entire length, either very distinctly, or occasionally only slightly; dorsally the guard is only slightly flattened in the posterior part. The apical end is in most cases moderately acute; the mucro is only indistinctly separated from the guard.

In cross section the pseudoalveolus is slightly subtriangular to ovate, its depth is one quarter to one sixth the entire length of the guard. The walls of the pseudoalveolus are slightly convex with a covering layer of rather large, cone-shaped, irregularly distributed tubercles. These are concentrated in the posterior part where they cover the wall almost entirely, in contrast to the anterior part which is usually only irregularly covered. The uncovered parts of the wall show the edges of the concentric layers of the guard. The ventral fissure is 1 to 2 cm long; at the bottom its course is almost rectilinear or s-shaped; the angle between the bottom of the ventral fissure and the alveolar wall varies a great deal (10° to 90°); the length of the ventral fissure never exceeds that of the pseudoalveolus. The "Schatsky index" is 2.5 to 4 mm.

The dorso-lateral longitudinal depressions and double furrows are distinct and curved according to the shape of the guard. The double furrows may be traced almost to the apex. From these and from the lateral single furrows, which are also very marked, distinct vessels branch off and form a vascular system on the surface. The angle between the posterior part of the dorso-lateral double furrows and the main vascular branches is less than 30°. In addition distinct longitudinal striations consisting of quite short furrows are visible on the surface of the guard.

Affinity with other species.

See below, page 23.

Stratigraphy.

The subspecies occurs in the *I. cordiformis* zone (Lower Santonian).

Actinocamax propinquus MOBERG **ravni** n. subsp.

Pl. 2, figs. 5a–d.

?1884 *Actinocamax propinquus* MOBERG, p. 53,? pl. 6, fig. 22, non pl. 5, fig. 25.
?1897 *Belemnitella mucronata* mut. (ant.) STOLLEY, p. 296.
1921 *Actinocamax propinquus*, RAVN, p. 38, pl. 3, figs. 2a–c.
1948b *Belemnitella* ex. gr. *mirabilis*, JELETZKY, p. 594.
1949b *Belemnitella* ex. gr. *mirabilis*, JELETZKY, p. 422.
1955 *Belemnitella* ex. gr. *mirabilis*, JELETZKY, p. 481, pl. 58, figs. 5a–d.

Diagnosis.

Actinocamax propinquus with a pseudoalveolus the depth of which is one third to one quarter the entire length of the guard; tubercles on the wall of the pseudoalveolus rather small and close-set; "Schatsky index" 4 to 8 mm.

Type.

The specimen, figured by RAVN, 1921, pl. 3, figs. 2a–c, is here chosen as the holotype for this subspecies. Horizon: Lower Santonian (the zone of *Inoceramus cordiformis*). Locality: Bavnodde-greensand, west of Bavnodde, Bornholm. The specimen is in the collections of the Mineralogical and Geological Museum, Copenhagen.

Material.

Bavnodde-greensand, Bornholm: West of Bavnodde, 3 complete specimens; Bavnodde, 2 complete specimens and some fragments; Forchhammers Klint, 3 complete specimens and some fragments.

The specimens are in the collections of the Mineralogical and Geological Museum, Copenhagen.

Description.

The depth of the pseudoalveolus is one third to one quarter the entire length of the guard. The wall of the pseudoalveolus is straight or only slightly convex. The tubercles are rather small and close-set, often covering the wall entirely, although the foremost part of the wall of the pseudoalveolus may occasionally lack tubercles in some parts; within these areas the edges of the concentric layers composing the guard are visible (pl. 2, fig. 5c). In the specimen figured by JELETZKY (1955, pl. 58, fig. 5) the bottom of the ventral fissure is irregularly bent. In the Danish specimens the bottom of the ventral fissure may have a similar form or it may be almost straight or only slightly curved with the concavity forwards. The angle between the bottom of the ventral fissure and the alveolar wall is very often small (10°–15°). The "Schatsky index" is 4 to 8 mm. The vascular impressions on the surface of the guard may be very distinct and close-set (cf. RAVN, 1921, pl. 3, fig. 2b; JELETZKY, 1955, pl. 58, fig. 5b). The remaining characters of the guard of this subspecies do not differ from those of *A. propinquus propinquus*.

Affinity with other species.

See below, page 23.

Stratigraphy.

This subspecies occurs in the upper part of the *I. cordiformis* zone (Lower Santonian) and in the lower part of the Upper Santonian (JELETZKY, 1955).

Affinity between *A. propinquus* and other species, and relations between *A. propinquus propinquus* and *A. propinquus ravni*.

Actinocamax propinquus is apparently a transitional form between the genera *Actinocamax* and *Belemnitella*. An important taxonomic feature which shows the close relation of this species to the genus *Actinocamax*, is the form of the pseudoalveolus which is slightly subtriangular in cross section with a slightly convex wall on which the edges of the concentric layers of the guard are visible. Among the important taxonomic features which show the close relation to the genus *Belemnitella* can be mentioned the long ventral fissure, the distinct and close-set vascular impressions, the course of the vascular impressions, and the considerable depth of the pseudoalveolus as compared with other *Actinocamax* species. The "Schatsky index" is larger than in other species of *Actinocamax*. In the older representative, *A. propinquus propinquus*, it is of smaller size than in the genus *Belemnitella*.

The covering layer on the wall of the pseudoalveolus was mentioned by RAVN (1921), and more recently it has been studied by JELETZKY (1949b, 1955). HÖLDER (1955) used the term conellae (QUENSTEDT, 1883–85, p. 232) for the cone-shaped tubercles of which this layer is composed. A development of tubercles on the wall of the pseudoalveolus, similar to those of *A. propinquus*, may be seen in those forms of *A. mammilatus* which possess a markedly deep pseudoalveolus (MOBERG, 1885, p. 55, pl. 6, fig. 7). Similar tubercles occur in *A. granulatus* (HÖLDER, 1955, text-fig. 4), *A. quadratus* (JELETZKY, 1949b, p. 418) and *A. manitobensis lawrenci* (JELETZKY, 1950b). The tubercles must be assumed to be a homologous development in *Actinocamax* forms which possess relatively deep pseudoalveoli. In the most primitive forms of the genus *Belemnitella* (i. a. *B. praecursor* STOLLEY s. l.) faint traces of this character can still be seen, though it is most pronounced in the early ontogenetic stages (JELETZKY, 1955).

Previously *A. propinquus* was referred to *Actinocamax* (MOBERG, 1885; STOLLEY, 1897, 1930; ARKHANGELSKY, 1912; RAVN, 1921). However, all these authors have mentioned the characters which show the close relation of this species to the genus *Belemnitella*. JELETZKY (1949b) referred the species to the genus *Belemnitella*, considering the characters of that genus to be dominant, and was apparently, able to show a phylogenetic connection from *A. lundgreni*, via the species mentioned, to the species of *Belemnitella* (JELETZKY, 1948b, 1949b, 1955). The species is included here in the genus *Actinocamax* on account of the characters of the pseudoalveolus, but considering the intermediate position of the species, it must be a matter of opinion whether it is to be referred to one or the other genus.

The subspecies *A. propinquus ravni* is more closely related to the genus *Belemnitella*. It differs from *A. propinquus propinquus* especially in its deeper pseudoalveolus and its larger "Schatsky index". Also stratigraphically there is but little difference between the two subspecies.

Remarks on the nomenclature.

JELETZKY (1948b, 1949b, 1955) mentioned *A. propinquus ravni* n. subsp. under the name *Belemnitella* ex. gr. *mirabilis* ARKHANGELSKY. Since *B. mirabilis* ARKHANGELSKY is a synonym of *A. propinquus*, this name cannot be maintained. Although JELETZKY (1949b, p. 422) has pointed this out, he still used (1955) the name *B.* ex.gr. *mirabilis* for this form.

In this paper the above form is referred to *A. propinquus* as a new subspecies. JELETZKY was also of the opinion that it might be described as a mutation of *B. propinqua* (here *A. propinquus*) or as a new species.

Actinocamax verus MILLER, 1823.

Pl. 2, figs. 4a–d.

1823 *Actinocamax verus* MILLER, p. 64, pl. 9, fig. 17.
1902 *Actinocamax verus*, RAVN, p. 260.
1921 *Actinocamax verus*, RAVN, p. 37, pl. 1, figs. 13–14.

Diagnosis.

Actinocamax of small size; ventrally and laterally lanceolate; adult individuals with the maximum diameter at one third to one quarter the length of the guard in front of the apex; the alveolar end often concentrically exfoliated and thus becoming obtusely cone-shaped; guard subcircular in cross section in the middle part, ovate in the anterior part with the maximum diameter in a dorso-ventral direction; pseudoalveolus very slightly depressed or conical; ventral fissure very seldom preserved; lateral single furrows short or absent; anterior part of the surface granulated with the granulae partly merged together, forming corrugated transverse lines.

Type.

The individual figured by MILLER, 1823, pl. 9, fig. 17, is the holotype by monotypy.

Material.

Bavnodde-greensand, Bornholm: West of Bavnodde, 3 complete specimens; Bavnodde, 3 complete specimens and two fragments; Forchhammers Klint, 2 complete specimens and 5 fragments.

The specimens are in the collections of the Mineralogical and Geological Museum, Copenhagen.

Description.

The length of the guard seldom exceeds 4 cm, but may be about 5 cm. Adult specimens are markedly lanceolate both in ventral and lateral view, with the maximum

diameter at one third to one quarter the length of the guard in front of the apex. From this point the diameter decreases evenly anteriorly. Posteriorly the diameter decreases more rapidly. Younger individuals are less markedly lanceolate, with the maximum diameter at a small distance behind the middle of the guard. The alveolar end is often concentrically exfoliated, thus becoming obtusely cone-shaped. The length of the exfoliated part is up to one quarter the length of the guard. The exfoliation is symmetrical or is most marked dorsally. Projecting and radiating edges are often visible on the surface of the exfoliated part (pl. 2, figs. 4a–c). The apical end is moderately acute in adult specimens and more acute in younger individuals. The mucro, which is only slightly separated, is often weathered away leaving a round, conical depression which may stretch along the apical line to the middle part of the guard. The cross section of the guard is subcircular, except in the anterior part where it is ovate on account of a lateral flattening. This is less pronounced in younger individuals than in adult ones.

The pseudoalveolus is generally conical with, at its tip, a small hole for the posterior part of the phragmocone. In young individuals the pseudoalveolus may sometimes be slightly depressed. The cross section of the pseudoalveolus in adult specimens is ovate with the maximum diameter in a dorso-ventral direction. In young specimens the cross section may be slightly subtriangular. The ventral fissure is but seldom preserved.

The dorso-lateral longitudinal depressions rapidly converge towards the alveolar end. The dorso-lateral double furrows are visible almost as far as apex, but the lateral single furrows are usually absent or very faint.

An ornamentation of very fine granulae partly merged into corrugated transverse lines is visible on the surface of the guard (pl. 2, fig. 4d). The granulation is in most cases only visible in the anterior part, but it may cover the greater part of the surface.

Affinity with other species.

A. verus cannot be mistaken for other *Actinocamax* species from Central- and Northwest Europe on account of its small size and characteristic form. However, some specimens of *Actinocamax westfalicus* may be somewhat similar to less markedly lanceolate specimens of *A. verus*, but they can be distinguished from these by the less distinct contraction anteriorly, and by the absence of ornamentation of a similar characteristic pattern.

Arkhangelsky (1912) has described *A. laevigatus* and *A. verus fragilis* from the U.S.S.R. The former differs from *A. verus* i. a. in lacking granulations. Arkhangelsky distinguished *A. verus fragilis* from the typical *A. verus* by the greater length of the concentrically exfoliated part of its guard (one quarter to one fifth the length of the guard), the asymmetric appearance of that part, and by the presence of only few and indistinct radiating edges on the surface of that part. According to Arkhangelsky it also differs in that it lacks lateral single furrows. Najdin (1952) stated that *A. verus*

fragilis only differs from *A. verus* by the asymmetric exfoliation and the greater length of the cone. Both the typical *A. verus*, which has a rather short exfoliated part (RAVN, 1921, pl. 1, figs. 13–14), and the form described by ARKHANGELSKY are represented in the Bavnodde-greensand of Bornholm (see pl. 2, figs. 4a–d). The material shows that the asymmetric exfoliation may also be present in forms where the exfoliation is of small extent. Thus, the only character separating these two forms, is the difference in relative length of the exfoliated part. This character seems to be of little taxonomic value and the two forms are therefore mentioned here under the same name.

A. verus dnestrensis NAJDIN, 1952, from U.S.S.R. differs from *A. verus* by its depressed pseudoalveolus.

Stratigraphy.

This species occurs in the upper part of the Lower Santonian (*I. cordiformis* zone) and in the Upper Santonian.

Actinocamax westfalicus (SCHLÜTER), 1874.

Pl. 2, figs. 1a–d, 2.

1874 *Belemnites westfalicus* SCHLÜTER, p. 828, p. 850.
1876 *Actinocamax Westfalicus*, SCHLÜTER, p. 188, pl. 53, figs. 10, 12–19, non 11.
1897 *Actinocamax westfalicus*, STOLLEY, p. 276, pl. 2, figs. 1–6, pl. 3, fig. 1.
1902 *Actinocamax westfalicus*, RAVN, p. 261.
1921 *Actinocamax westfalicus*, RAVN, p. 37, pl. 1, fig. 15.

Diagnosis.

Actinocamax with a rather small guard; in ventral view slightly lanceolate, in lateral view subcylindrical to faintly lanceolate; only slightly flattened ventrally; pseudoalveolus slightly conical with a depression in the middle part or depressed in its full extent, the depth of the pseudoalveolus up to about one eighth the entire length of the guard, ovate to subtriangular in cross section, its edge often with a dorsal embayment; ventral fissure quite short; "Schatsky index" 1 to 3 mm; lateral single furrows in most cases long and distinct; surface with longitudinal striae, and usually with faint vascular impressions.

Type.

A type has never been chosen for this species. A further study of SCHLÜTER's collections is necessary before a definite choice is made.

Material.

Bavnodde-greensand, Bornholm: West of Bavnodde, 11 specimens and many fragments; Bavnodde, 34 specimens and many fragments; Forchhammers Klint, 33 specimens and many fragments (these three localities in the text mentioned as

"the Bavnodde district"); between Forchhammers Klint and Horsemyreodde, 3 typical specimens and 1 specimen referred to *A.* aff. *westfalicus*; Horsemyreodde, 3 typical specimens and 4 specimens referred to *A.* aff. *westfalicus*, and some additional fragments. Greensand at Risenholm (Blykobbeaa), 4 specimens and some fragments. Greensand at Jydegaard, 4 typical specimens and 5 specimens referred to *A.* aff. *westfalicus*, and many additional fragments. Several specimens the exact localities of which are unknown.

The specimens are in the collections of the Mineralogical and Geological Museum, Copenhagen.

Description.

The guard may reach a length of 6 cm, but in most cases it is shorter. The degree of elongation varies. The relation between the maximum diameter in ventral view and the entire length is thus one fifth to one ninth for Bornholm specimens, specimens which are not fully grown are somewhat more elongate than adult specimens. In ventral view the guard is lanceolate, or the sides are parallel except in the apical part, the maximum diameter being situated between one half and one third the entire length of the guard in front of the apex. In lateral view the guard may be slightly lanceolate, but usually the margins are parallel except in the apical part. The apical end is more or less acute; the specimens with a moderately acute apex often have a distinctly separated mucro. The guard is only slightly flattened ventrally, dorsally it is evenly rounded without flattening.

The pseudoalveolus is cone-shaped with a depression in the middle part, or it is depressed in its full extent. In the latter case the walls are slightly convex, or the anterior part forms an obtuse angle with the posterior, more abrupt end. The depth of the pseudoalveolus is up to about one eighth the entire length of the guard. In cross section the pseudoalveolus is ovate to subtriangular, often with a dorsal embayment in its edge. The ventral fissure is quite short; it may be shorter, of the same length, or slightly longer than the depth of the pseudoalveolus (pl. 2, fig. 2). The bottom of the ventral fissure may be rectilinear or anteriorly concave, forming a large angle with the alveolar wall, (often considerably more than 90°). The "Schatsky index" seems to vary from 1 to 3 mm.

The dorso-lateral longitudinal depressions and double furrows are more or less distinct. The double furrows can be traced almost to the apex; usually only faintly marked vascular impressions branch off from these furrows. Sometimes the vascular impressions cannot be distinguished. The lateral single furrows are normally distinct, their length is very varied, sometimes they may be traced just beyond the middle of the guard. The lateral single furrows converge towards the ventral side.

The longitudinal striations, which are visible on the surface of the guard, consist of fine, short grooves. In rare cases a fine granulation may be seen, even in typical specimens. The granulae are well separated or partly merged into short, somewhat corrugated transverse lines.

Affinity with other species.

Forms which are transitional between *Actinocamax granulatus* (Blainville), 1825, and *A. westfalicus* (Schlüter), 1874, have been described by Stolley (1897). They may be distinguished from the typical *A. westfalicus* by their greater size, their less markedly lanceolate shape, their deeper pseudoalveoli (approximately over one eighth the length of the guard), and usually by their surface granulations.

A. westfalicus has been recorded from the following localities (arranged in ascending stratigraphical order): Jydegaard, Horsemyreodde, the area between Horsemyreodde and Forchhammers Klint, the Bavnodde district and Risenholm (Blykobbeaa) (cf. the stratigraphical section).

In the three stratigraphically oldest localities (Jydegaard, Horsemyreodde, and the district between Horsemyreodde and Forchhammers Klint) a closely related form, *A.* aff. *westfalicus* (pl. 2, figs. 3a–d), occurs together with the typical *A. westfalicus*. In all, 10 specimens and some fragments of this related form are known. It is elongate and rather small, the guard being up to 5 cm long. In adult specimens in ventral view, the relation between the maximum diameter and the full length of the guard is one sixth to one eighth. As in the typical *A. westfalicus*, this form is usually lanceolate in ventral view and in rare cases subcylindrical. In lateral view it is subcylindrical or, less often, slightly lanceolate. The pseudoalveolus is always depressed in its full extent. The walls are slightly convex, for which reason the posterior part is more abrupt than the anterior part. No well marked angle between the posterior and anterior parts of the wall of the pseudoalveolus, often found in the typical *A. westfalicus*, has been seen in this form. The depth of the pseudoalveolus is one sixth to one eighth the entire length of the guard, and it is thus considerably more depressed than in typical specimens of *A. westfalicus*. The cross section is ovate to subtriangular. The ventral fissure is up to 3 mm long, its length never exceeding the depth of the pseudoalveolus. The bottom of the ventral fissure may be rectilinear, or anteriorly concave; it forms a large angle with the wall of the pseudoalveolus, often more than 90°. The "Schatsky index" varies from 1 to 3 mm. The dorso-lateral longitudinal depressions and double furrows, the lateral single furrows, the vascular system, and the longitudinal striations on the surface of the guard are of the same form as in the typical *A. westfalicus*. Granulations on the surface of the guard have not been seen.

A. aff. *westfalicus*, *A. westfalicus-granulatus* and *A. granulatus* have similar alveolar depths. According to Riedel (1930) the two last mentioned are respectively one seventh to one eighth and one sixth to one seventh the entire length of the guard. *A.* aff. *westfalicus* differs from these in its usually marked lanceolate form, and in the absence of granulation. It differs from *A. lundgreni lundgreni* and *A. lundgreni excavata* in its smaller size, its smaller "Schatsky index", and in its less pronounced ventral flattening.

The phylogenetic relations between this form and the typical *A. westfalicus* are uncertain. It is possible that the two forms represent a parallel evolution from a common primitive form.

At the Bavnodde-greensand localities in the Bavnodde district only typical *A. westfalicus* with slightly depressed pseudoalveoli are found. Thus the depth of the pseudoalveolus is up to one tenth the entire length of the guard, and only in a single specimen, from Forchhammers Klint, is the depth between one eighth and one ninth the entire length of the guard. Furthermore, the guards are in most cases small in size, so that most specimens are only 3.5 to 5 cm long, and only few guards reach the length of 6 cm. With a few exceptions the guards from these localities are without granulation.

Only few belemnites are known from the greensand at Risenholm (Blykobbeaa). Two of these are typical *A. westfalicus*, and two have a deeper pseudoalveolus (one seventh to one eighth the full length of the guard) and are rather large with distinct vascular systems. One of these specimens is markedly flattened ventrally. Neither of the two are granulated. It is not possible to determine these two specimens with certainty. They may represent transitional forms between *A. westfalicus* and *A. granulatus* (Grönwall, 1916). A stout, subcylindrical specimen with a distinct vascular system and a deep pseudoalveolus, from the district between Forchhammers Klint and Horsemyreodde, may possibly also be referred to this form.

Stratigraphy.

According to Schmid (1956) this species in Germany only occurs in the lower part of the Middle Santonian (corresponding to the *Inoceramus cordiformis* zone).

At Jydegaard *A. westfalicus* and the above mentioned *A.* aff. *westfalicus* both occur together with *A. lundgreni excavata* which may indicate that *A. westfalicus* and *A.* aff. *westfalicus* also occur in the uppermost part of the *I. undulato-plicatus* zone.

A. westfalicus occurs in all the Bavnodde-greensand localities. The depth of the pseudoalveolus in the specimens of *A. westfalicus* from the greensand of the Bavnodde district suggests, with reference to the occurrence of *A. propinquus ravni* in these deposits, that this area can be referred with certainty to the uppermost part of the Lower Santonian (uppermost part of the *I. cordiformis* zone). This is in agreement with the rest of the fauna (Ravn, 1921).

To judge from the dip of the beds the eastern part of the Bavnodde-greensand (at Horsemyreodde) seems to be somewhat older than the western part in the Bavnodde district (cf. Ravn, 1921). Ravn was unable to ascertain any palaeontological difference in age.

Inoceramus cordiformis Sowerby occurs in this eastern part showing that these deposits also belong to the upper part of the Lower Santonian. However, the occurrence of *A.* aff. *westfalicus* in this part of the cliff, and the total absence of this form in the Bavnodde district, suggests that older parts of the *I. cordiformis* zone are present in this area. This is confirmed by Ravn's observations on the dip of the beds.

The greensand at Risenholm, Blykobbeaa, was referred by Ravn (1946) to the Lower Santonian. No further material is available from this locality.

Undecided problems in the nomenclature of Belemnitella and Belemnella.

During this study of the Upper Cretaceous belemnites in Denmark an attempt was made to determine species correctly in accordance with the published types, but considerable confusion was found in the nomenclature used. The original intention to use the names in a revised correct sense has met with great opposition from other paleontologists who prefer a stabilizing of the nomenclature in use during recent years. A review of the nomenclatorical problems has been given by BIRKELUND & RASMUSSEN (1956).

The genus *Belemnitella* was established by D'ORBIGNY (1842) to include the species *B. mucronata*, *B. quadrata* and *B. scaniae*. Subsequently the last two have been referred to other genera, and *B. mucronata* is regarded as the type of the genus (HERRMANNSEN, 1846; NAEF, 1922).

The genus *Belemnella* was established by NOWAK (1913) as a subgenus (JELETZKY (1941) as a genus) with the type (by monotypy) *B. lanceolata* (SCHLOTHEIM), 1813.

B. mucronata was established by LINK (1807), but characterized only as a "fein gespitzte" form. It was more closely defined by SCHLOTHEIM (1813) with reference to a figure given by BREYNIUS (1732) and a figure given by FAUJAS-SAINT-FOND (1798). The latter must be removed from the species as it is identical with *Belemnitella junior* NOWAK, 1913 s. str. Thus the figure given by BREYNIUS represents the type, and it is fairly certain that this is the same as a species found at Møns Klint, Rügen, Hemmoor and other localities.

The two species *B. mucronata* and *B. lanceolata* are closely related and must be regarded as congeneric (WIND, 1955), and the generic name *Belemnella* is thus a younger subjective synonym of *Belemnitella*.

A group of species differing, i. a., in their large "Schatsky index" was regarded by NOWAK as a speciel genus, but was incorrectly referred by him, and by most later authors, to *Belemnitella*. This group has no legitimate generic name.

Having discussed the nomenclatorial problems with Dr. JELETZKY, a proposal has been submitted (by Dr. JELETZKY) to the International Commission of Zoological Nomenclature. This proposal is designed to avoid confusion resulting from a reintroduction of the generic and specific names in their proper meanings.

The International Commission on Zoological Nomenclature is asked to set aside the selection of a type specimen made by SCHLOTHEIM (1813) for the nominal species *Belemnites mucronatus* LINK, 1807, and to designate another specimen (possibly that figured by ARKHANGELSKY, 1912, pl. 9, figs. 3, 9) as the type of *Belemnites mucronatus* LINK, 1807. The specimen figured by ARKHANGELSKY is identical with, or closely related to, *B. mucronata senior* NOWAK, 1913 s. str.

A schedule is given here of revised legal names, the names used by JELETZKY

and most other recent authors, and of the names according to the proposed stabilizing of the nomenclature. This last nomenclature has been followed provisionally in the present text.

Revised legitimate names	Names used by JELETZKY (1951b)	Proposed names
No legitimate generic name.	*Belemnitella* D'ORBIGNY, 1842.	*Belemnitella* D'ORBIGNY, 1842.
— *senior senior* (NOWAK), 1913 s. str.	*Belemnitella mucronata* (SCHLOTHEIM) mut. senior NOWAK, 1913 s. str.	*Belemnitella mucronata* (LINK), 1807, sensu ARKHANGELSKY, 1912, pl. 9, figs. 3, 9.
Belemnitella D'ORBIGNY, 1842.	*Belemnella* (NOWAK, 1913, subg.) JELETZKY, 1941, genus.	*Belemnella* (NOWAK, 1913, subg.) JELETZKY, 1941, genus.
Belemnitella lanceolata (SCHLOTHEIM), 1813.	*Belemnella lanceolata* (SCHLOTHEIM, 1813) NOWAK, 1913.	*Belemnella lanceolata* (SCHLOTHEIM), 1813.
Belemnitella mucronata (SCHLOTHEIM), 1813.	*Belemnella* aff. *lanceolata* (SCHLOTHEIM) mut. *sumensis* JELETZKY, 1949.	*Belemnella occidentalis* n. nom.

Genus **Belemnitella** D'ORBIGNY, 1842 (sensu NOWAK, 1913; JELETZKY, 1941).

Type Species *Belemnitella mucronata* (LINK), 1807 sensu ARKHANGELSKY, 1912, non SCHLOTHEIM, 1813.

Diagnosis.

Belemnites with cone-shaped to lanceolate guards, the surface of which is provided with dorso-lateral longitudinal depressions and double furrows and single lateral furrows; vascular impressions branch off from all these imprints; the anterior alveolus deep (alveolar angle 19° to 26°), its wall covered by the conotheca; alveolus connected to the ventral surface by a rather long ventral fissure; distance from the protoconch of the phragmocone to the beginning of the bottom of the ventral fissure on the wall of the alveolar cavity ("Schatsky index") large (more than 4 mm); ontogenetic early growth-stages short and stout, the relation between the diameter (d) and the length from the protoconch to the apex being about the same size as or even greater than, in fully grown specimens; posterior part of the dorso-lateral double furrows rectilinear, the angle between this part and the main vascular branches being less than 30°.

Belemnitella langei JELETZKY, 1948.

Pl. 2, figs. 6a–d; pl. 3, figs. 1a–c; text-fig. 2.

?1842 *Belemnitella mucronata*, D'ORBIGNY, p. 63, pl. 7, fig. 4.
1853-57 *Belemnitella mucronata*, SHARPE, p. 6, pl. 1, figs. 2a–c.
1946 *Belemnitella mucronata* mut. *junior*, JELETZKY, p. 92, text-fig. 1c.
1948b *Belemnitella langei* JELETZKY, p. 599, text-figs. 3–4.
1949a *Belemnitella mucronata* mut. *minor* JELETZKY, p. 277.

1951b *Belemnitella mucronata* mut. *minor* JELETZKY, p. 87, pl. 1, figs. 3a–d.
1951b *Belemnitella langei*, JELETZKY, p. 93, pl. 2, figs. 3a–b, 5.
1952 *Belemnitella langei*, NAJDIN, p. 85, pl. 9, figs. 1–6; pl. 10, figs. 1–3; pl. 11, figs. 1–8; pl. 12, figs. 1–4; pl. 13, fig. 4; text-figs. 28–29.

Diagnosis.

Belemnitella with a rather stout guard, in ventral aspect slightly lanceolate, in lateral aspect cone-shaped, subcylindrical or slightly lanceolate, and only faintly flattened dorso-ventrally; depth of the alveolus about two fifths to one half the estimated length of the guard; alveolar angle 21° to 26°; ventral fissure rather long; angle between the bottom of the ventral fissure and the alveolar wall in most cases greater than 30°; "Schatsky index" 5 to 9.5 mm; vascular impressions and longitudinal striations more or less distinctly developed.

Type.

The individual figured by JELETZKY, 1948b, p. 599, figs. 3a–b, is the holotype. Horizon: The upper part of the Upper Campanian. Locality: Schetschkowy-Gory, Ssumy-district, U.S.S.R. The specimen is in Dr. JELETZKY's collections (Geological Survey of Canada, Ottawa).

Material.

The western part of Hvide Klint on Møn, 5 specimens and many fragments.

The specimens are in the collections of the Mineralogical and Geological Museum, Copenhagen.

Description.

The guard may reach a length of about 12 cm, but in most cases it is shorter. In ventral view it is slightly lanceolate, in lateral view cone-shaped, subcylindrical or slightly lanceolate. The apical end of the guard is acute, the mucro being usually only slightly separated. The ratio between the diameter (d) and the length from the protoconch to the apex seems to be one third to one fifth in most cases.

The depth of the alveolus is from two fifths to one half the estimated length of the guard. The alveolar angle varies from 21° to 26°. The bottom of the fairly long ventral fissure is evenly curved, almost rectilinear or occasionally undulating. The angle between the bottom of the ventral fissure and the alveolar wall is normally 30° to 90°, but may be greater than 90° and, in very few cases, less than 30°. The "Schatsky index" varies from 5 to 9.5 mm.

The vascular impressions on the surface of the guard may be rather distinctly developed and rather close set round the ventral fissure, but very often they are only weakly developed. A longitudinal striation of fine grooves may be visible.

Affinity with other species.

B. mucronata minor JELETZKY, 1951, is here recorded as a younger synonym for *B. langei*. JELETZKY (1951b) mentioned that the two species may be very difficult to distinguish and transitional forms commonly occur. According to JELETZKY typical specimens of *B. mucronata minor* may be distinguished from typical specimens of *B. langei* by their more marked ornamentation, their greater size, and their cone-shape in lateral view. The two species occur together in the same zone (upper part of the Upper Campanian), although, according to JELETZKY (1951b), *B. mucronata minor* may be more common in the lower part and *B. langei* in the upper part. Comparison of NAJDIN's figures of *B. langei* s. l. (NAJDIN, 1952, pl. 9, figs. 1–6; pl. 10, figs. 1–3; pl. 11, figs. 1–8; pl. 12, figs. 1–4; pl. 13, fig. 4; text-figs. 28–29) with the Danish specimens shows an even transition and the absence of correlatable variations in each of the features used for separating *B. mucronata minor* and *B. langei*. The species are also of similar stratigraphical distribution, and the present author does not distinguish between them.

B. langei differs from *B. mucronata* (LINK), 1807, sensu ARKHANGELSKY, 1912 (? = *B. mucronata senior* NOWAK, 1913 s. str.) i. a. in its smaller size, its more elongate shape, its less pronounced cone-shape in lateral view, its relatively longer ventral fissure, and in its less distinctly developed vascular impressions. *B. langei* may be very similar to *B. junior*, but can be distinguished by its less elongate and less conical form and by the fact that the ornamentation on the surface of this species is not wrinkled in appearance.

Stratigraphy.

This species occurs in the upper part of the Upper Campanian. In Denmark the species occurs in the western part of Hvide Klint.

Belemnitella junior junior (NOWAK), 1913.

Pl. 3, figs. 2a–c.

1913 *Belemnitella mucronata* mut. *junior* NOWAK, p. 398, pl. 42, fig. 18, non figs. 21, 25, 26.
1951b *Belemnitella junior*, JELETZKY, p. 99, pl. 2, figs. 2, 6, 7; pl. 3, figs. 1–2.
1952 *Belemnitella nowaki* NAJDIN, p. 90, text-fig. 30; pl. 14; pl. 15, figs. 1,3; pl. 16, figs. 2, 3; pl. 19, fig. 2; non pl. 16, fig. 1.

Diagnosis.

Belemnitella with a rather elongate guard which in ventral view is slightly lanceolate and in lateral view cone-shaped and only slightly flattened dorso-ventrally; depth of the alveolus two fifths to one half the estimated length of the guard; alveolar angle 20° to 26°; "Schatsky index" 6.5 to 8.5; closely spaced deep vascular impressions

and longitudinal striations visible on the surface; ornamentation producing a marked, wrinkled appearance on the surface, especially round the ventral fissure.

Type.

The individual figured by NOWAK, 1913, pl. 42, fig. 18, was chosen by JELETZKY (1951, p. 100) as the lectotype for this species.

Material.

Stevns Klint: North of the Kulsti Rende, 1 complete specimen and two fragments; 100 m north of Storedal, 1 badly preserved specimen which cannot be referred to this species with certainty. "Dania" at Mariager, the old chalk pit in the south wall between the two uppermost flint layers, 1 complete specimen.

Description.

The guard is long and usually rather elongate. In ventral view it is slightly lanceolate, and in lateral view slenderly cone-shaped. The walls of the guard diverge strongly at the anterior part of the alveolus. The guard is but slightly flattened ventrally. The apical end is acute to moderately obtuse, with a mucro which is long and slender in most cases and more or less distinctly separated from the guard. The ratio between the diameter (d) and the length from the protoconch to the apex varies in most cases from one quarter to one fifth in adult individuals; in rarer cases the values range from one third to one quarter.

The depth of the alveolus is two fifths to one half the actual length of the guard in well preserved specimens. The alveolar angle is 20° to 26°. The ventral fissure is rather long and the bottom of it often angular, so that the inner part forms a smaller angle with the alveolar wall than the outer part. Sometimes it is evenly curved and anteriorly convex, undulating, or, in rarer cases, it is almost rectilinear. The "Schatsky index" is 6.5 to 8.5.

The vascular impressions on the surface of the guard are strongly developed; they are deepest and most closely spaced anteriorly, ventrally and laterally. In addition there is a marked longitudinal striation consisting of longitudinal grooves the distance between which is sometimes smaller than the breadth of the furrows, though they may sometimes be more scattered. The combination of vascular impressions and longitudinal striation produces a marked, wrinkled appearance on the surface, especially round the ventral fissure.

Affinity with other species.

B. junior junior is closely allied to *B. junior nowaki* and *B. langei*. The relations of these are mentioned pages 36, 33.

Stratigraphy.

This species occurs in the lower part of the Upper Maastrichtian.

JELETZKY (1951 b) has mentioned that, in the northern part of Western Europe, this species occurs in the Upper Maastrichtian between the zone of *Belemnella lanceolata sumensis* and that of *Belemnella casimirovensis*, although, in the Maastricht area itself, it is also present in the strata containing *Belemnella lanceolata*. In Eastern Europe quite special conditions prevail as regards the stratigraphical occurrence of *Belemnitella junior*. Thus, according to NAJDIN (1952), the zone of *Belemnitella arkhangelskii* NAJDIN (= *Belemnella casimirovensis*) directly overlies that of *Belemnella lanceolata* in the Western Ukraine; *Belemnitella nowaki* NAJDIN (= *Belemnitella junior*) occurs together with *Belemnella casimirovensis* and a separate zone of *Belemnitella junior* is not represented. In the northern part of the Donetz Basin *Belemnitella junior* apparently occurs together with *Belemnella lanceolata* (JELETZKY, 1951 b). According to K. POŻARYSKA (1954) *Belemnitella mucronata* (? = *Belemnitella junior* or similar forms) occurs together with *Belemnella lanceolata* in both the Upper and the Lower Maastrichtian, and together with *Belemnella casimirovensis* in the uppermost Maastrichtian of Poland.

In the lower horizons of Stevns Klint, present in the Storedal district, a single specimen of *Belemnitella* cf. *junior* has been found. At only slightly higher horizons, north of the Kulsti Rende, *Belemnitella junior* and *Belemnella casimirovensis* are found together as in Poland. In the "Dania" chalk pits at Mariager *Belemnella casimirovensis* is the predominant species as at Stevns Klint, but the specimens have not been collected from closely determined horizons. At "Dania" a single specimen of *Belemnitella junior* has been found in the uppermost layers. Thus, in the Danish localities, there is as yet no certain indication of a single occurrence of *Belemnitella junior* below the horizon of *Belemnella casimirovensis*.

Belemnitella junior nowaki JELETZKY, 1951.

Pl. 3, figs. 3a–c.

1913 *Belemnitella mucronata* mut. *junior* NOWAK, p. 398, pl. 42, figs. 21, 25, non figs. 18, 26.
1951 b *Belemnitella junior* var. *nowaki* JELETZKY, p. 109, pl. 3, fig. 3; pl. 4, figs. 1–2.
1952 *Belemnitella nowaki* NAJDIN, p. 90, pl. 16, fig. 1; non text-fig. 30; pl. 14; pl. 15, figs. 1,3; pl. 16, figs. 2,3; pl. 19, fig. 2.

Diagnosis.

Belemnitella junior with guard distinctly lanceolate in ventral view, strongly flattened ventrally for its entire length, and dorsally flattened posteriorly.

Type.

The individual figured by NOWAK, pl. 42, fig. 21, was chosen by JELETZKY (1951 b, pl. 3) as the lectotype for this subspecies. Horizon: ?The lower part of the Upper Maastrichtian. Locality: Crzybowice in the Lwów district, U.S.S.R. The specimen is in the collections of the Geological and Paleontological Institute, Lwów.

Material.

Stevns Klint, north of the Kulsti Rende, 1 specimen.

The specimen is in the collections of the Mineralogical and Geological Museum, Copenhagen.

Description.

The guard, in ventral view, is distinctly lanceolate, and in lateral view slightly cone-shaped. It is strongly flattened ventrally for its entire length, and dorsally flattened posteriorly. The apical end is moderately obtuse or less often, as in the Danish specimen, acute. The ratio between the diameter (d) and the length from the protoconch to the apex, in the specimens figured by NOWAK (1913, pl. 42, fig. 25) and JELETZKY (1951b, pl. 4, fig. 2), is between one quarter and one fifth, and in the specimen figured here (pl. 3, fig. 3c) between one fifth and one sixth.

The course of the bottom of the ventral fissure varies. Thus, in the specimen figured by JELETZKY (1951b, pl. 4, fig. 2), it is slightly angular, as in many *B. junior junior*. The straight line drawn between the two extreme points of the bottom of the ventral fissure forms a large angle (43°) with the alveolar wall. The bottom of the ventral fissure in the Danish specimen (pl. 3, fig. 3c), however, is slightly curved, being anteriorly concave, and the straight line drawn between the two extreme points forms a small angle (17°) with the alveolar wall.

The depth of the alveolus, the size of the alveolar angle, the "Schatsky index", and the ornamentation of the surface are as in *B. junior junior*.

Affinity with other species.

This subspecies has been established on the basis of a few specimens and its range of variation is not known.

JELETZKY (1951b, p. 110) presumed that *B. junior nowaki* is shorter than the typical form due to a different ratio between the length and the breadth of the guard. JELETZKY added that this difference has not been thoroughly tested with more comprehensive material. The Danish specimen indicates also that *B. junior nowaki* may include very long and slender forms. Thus *B. junior nowaki* seems to differ from *B. junior junior* only in its pronounced ventral flattening and in its more lanceolate shape in ventral view. It occurs at the same horizon as *B. junior junior* and may represent an extreme individual variation within *B. junior*.

Stratigraphy.

B. junior nowaki occurs together with *B. junior junior* in the lower part of the Upper Maastrichtian.

Genus **Belemnella** (NOWAK, 1913 subg.) JELETZKY, 1941.

Type Species *Belemnella lanceolata* (SCHLOTHEIM), 1813.

Belemnites with slenderly cone-shaped to lanceolate guards, the surface with dorso-lateral longitudinal depressions and double furrows, and single lateral furrows from all of which vascular impressions branch off; anterior alveolus deep (the alveolar angle 12° to 21°); wall of the alveolus covered by a conotheca; alveolus connected to the ventral surface by a long ventral fissure; distance from the protoconch of the phragmocone to the beginning of the bottom of the ventral fissure on the wall of the alveolar cavity ("Schatsky index") small (0 to 4 mm); early growth-stages considerably more elongate than later growth-stages; posterior part of the dorso-lateral double furrows undulating, the angle between this part and the main vascular branches being more than 30°.

Belemnella lanceolata lanceolata (SCHLOTHEIM), 1813.

Pl. 4, figs. 1a–c, 2a–c, 3.

1732 *Breynius*, Tab. Belemnitarum, figs. 7–8.
1813 *Belemnites lanceolatus* SCHLOTHEIM, p. 111.
1912 *Belemnitella lanceolata*, ARKHANGELSKY, p. 608, pl. 9, figs. 4, 6, 10, 11, 24, 27; pl. 10, fig. 12.
1948c *Belemnella lanceolata*, JELETZKY, p. 338, pl. 20, figs. 1a, 1b.
1952 *Belemnella lanceolata*, NAJDIN, p. 101, pl. 19, fig. 3; pl. 20; pl. 21, figs. 3—6,?7, non figs. 1–2; non text-fig. 26, no. 1; text-fig. 34.

Diagnosis.

Belemnella with a very elongate guard which in ventral view is lanceolate and in lateral view lanceolate to subcylindrical; diameter of the guard (d) one fifth to one eighth the length from the protoconch to the apex; depth of the alveolus one third to two fifths the entire length of the guard; alveolar angle 12° to 16°; bottom of the ventral fissure rectilinear or forming a slight curve backwards to the alveolus; "Schatsky index" 0 to 2.5 mm; vascular impressions faint.

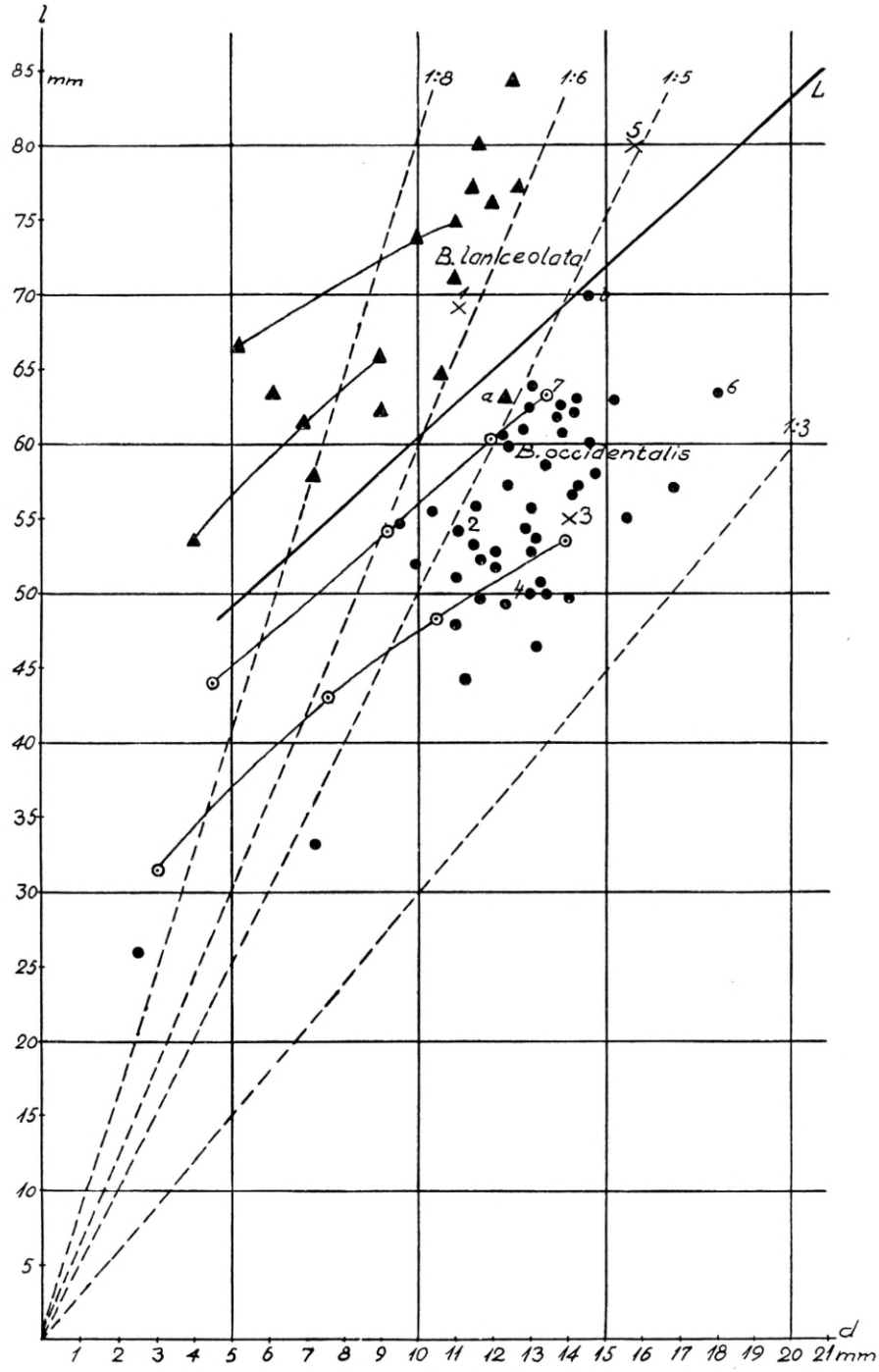
Type.

The specimen figured by BREYNIUS, 1732, Tab. Belemnitarum, figs. 7–8, is the holotype (cf. BIRKELUND & RASMUSSEN, 1956).

Material.

Møns Klint: below the indurated layer at Store Stejlebjerg, 3 complete specimens; horizon unknown, 1 complete specimen. The eastern part of Hvide Klint, 8 complete specimens.

The specimens are in the collections of the Mineralogical and Geological Museum, Copenhagen and in the collections of the Geological Survey of Denmark, Copenhagen.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1:5
1:3
L
B. lanceolata
B. occidentalis
a
b
1
2
3
4
5
6
7
d
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 mm

Fig. 4

Description.

The guard is up to about 14 cm long and very elongate. In ventral view it is usually very distinctly lanceolate, and in lateral view slightly lanceolate, or in rarer cases the margins are almost parallel in the anterior part of the guard. Ventrally the guard is flattened for its entire length, and dorsally it is flattened in the posterior part. The apical end is acute with a mucro which is usually only slightly separated. The relation between the diameter (d) and the length from the protoconch to the apex varies from one fifth to one eighth in adult specimens. It is apparent from the growth curves (text-fig. 4) that younger individuals are more elongate.

In well preserved individuals the depth of the alveolus is one third to two fifths of the actual or estimated length of the guard, but usually only a small part of the alveolus is preserved in this species. The alveolar angle varies from 12° to 16°. The bottom of the ventral fissure is rectilinear, slightly convex or concave, slightly angular or it may have a undulating course. The straight line drawn between its two extreme points forms an angle with the alveolar wall which varies from 10° to 50°. The "Schatsky index" is 0 to 2.5 mm.

The vascular impressions on the surface of the guard are, in most cases, only just visible, the angle between the posterior part of the dorso-lateral double furrows and the main vascular branches is very large, often 90°. Sometimes longitudinal striae are visible, consisting of small irregularly bent grooves.

Affinity with other species.

B. lanceolata lanceolata is closely allied to *B.* aff. *lanceolata* and *B. occidentalis*. The relations between these species are mentioned on pages 41, 45.

Stratigraphy.

This species occurs in the lower part of the Lower Maastrichtian.

It is found in the eastern part of Hvide Klint and below the indurated layer at

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Fig. 4. Diagram showing the ratio between the diameter (d) and the length (l) from the protoconch to the apex in the specimens referred to *B. lanceolata lanceolata* and *B. occidenalis occidentalis* from Balsvik (Scania, Sweden) and Møns Klint above the indurated layer. The same ratio is also indicated for the types of the two species and for some other specimens figured in the literature. The line L is drawn conform with the growth curves, indicated in the diagram, and separates the specimens referred to *B. lanceolata* (to the left) from the specimens referred to *B. occidentalis* (to the right).

▲ Balsvik.
▲—▲ Balsvik, the growth curves of these specimens are indicated.
● Møns Klint, above the indurated layer (4 figured by JELETZKY, 1951b, pl. 4, fig. 3; 6 figured in the present work, pl. 5, fig. 1).
⊙—⊙ Møns Klint, above the indurated layer, the growth curves of these specimens are indicated (7 figured in the present work, text-fig. 1).
× Other localities.
1 The type of *B. lanceolata* (figured by BREYNIUS, 1732, Tab. Belemnitarum, fig. 8). Locality unknown.
2 The type of *B. occidentalis* (figured in the present work, pl. 6, fig. 1).
3 *B. occidentalis* (figured by JELETZKY, 1951b, pl. 3, fig. 4). "Rørdal", Aalborg.
5 *B. lanceolata* (figured by JELETZKY, 1948c, pl. 20, fig. 1). Donetz, U.S.S.R.
a, b See page 46.

Møns Klint. At the former locality, the species occurs together with *B. occidentalis occidentalis* and *B.* aff. *lanceolata* and is almost as common as *B. occidentalis occidentalis*, at the latter locality, *B. occidentalis occidentalis* is the predominant species (cf. text-fig. 5). *B. lanceolata lanceolata* seems to be predominant in the lowest part of the zone containing *B. lanceolata*, while *B. occidentalis* is very rare (cf. Balsvik in Sweden, text-fig. 4). This seems to show fairly definitely that the lowest levels containing *B. lanceolata* (the lowest part of Lower Maastrichtian) are not present in the Danish localities mentioned above. The eastern part of Hvide Klint seems to be somewhat older than the chalk below the indurated layer in Møns Klint.

RAVN (in BONNESEN, BØGGILD & RAVN, 1913) has referred to *Belemnitella lanceolata* SCHLOTHEIM sp.? a belemnite fragment from the deep drilling at Grøndals Eng in Copenhagen (from the grey marl, 2648′). The fragment consists of the middle part of the guard and is impossible to determine.

Belemnella aff. **lanceolata** (SCHLOTHEIM), 1813.

Pl. 3, figs. 4a–c, 5.

1913 *Belemnitella (Belemnella) lanceolata*, NOWAK, p. 407, pl. 42, fig. 23, non fig. 20.
1946 *Belemnitella lanceolata*, JELETZKY, p. 92, fig. 1a.
non 1951b *Belemnella* n. sp. aff. *lanceolata* JELETZKY, p. 115, pl. 4, figs. 4a–c.

This form has important morphological characters in common with both *B. lanceolata lanceolata* and *B. occidentalis*. Owing to insufficient material it has not yet been possible to give a full description of this form, and for this reason no definite name has been introduced.

Material.

Lille Bissinge, 2 nearly complete specimens and many fragments. The eastern part of Hvide Klint, 2 complete specimens. Møns Klint, above the indurated layer, 4 complete specimens.

The specimens are in the collections of the Mineralogical and Geological Museum, Copenhagen.

Description.

The guard is up to 10 or 11 cm long and, in comparison with *B. lanceolata lanceolata*, is rather stout. In ventral view it is distinctly lanceolate, in lateral view less lanceolate. It is ventrally flattened for its full length, and dorsally flattened posteriorly. The apical end is acute or, less often, obtuse. The mucro is usually slightly separated from the apical end. The relation between the diameter (d) and the length

from the protoconch to the apex, varies from one third to one fifth in adult specimens; younger specimens are more elongate (cf. JELETZKY, 1946, fig. 1 a).

The depth of the alveolus, in well preserved specimens, seems to vary from one third to one half the actual or estimated length of the guard. The alveolar angle varies from 15° to 20°. The bottom of the ventral fissure is rectilinear, slightly concave, or irregularly corrugated. The angle between the alveolar wall and a straight line joining the extreme points of the bottom of the ventral fissure varies from 10° to 45°.

Vascular impressions on the surface of the guard are sometimes fairly distinct, although they may be only slightly visible. The angle between the posterior part of the dorso-lateral double furrows and the main vascular branches is very large, often as much as 90°. In some specimens a fine longitudinal striation of quite fine grooves can be seen on the surface of the guard.

Affinity with other species.

B. aff. *lanceolata* has a distinct lanceolate form similar to that of *B. lanceolata lanceolata,* but it is less elongate. Furthermore *B.* aff. *lanceolata* differs in its often larger alveolar angle. It agrees with *B. occidentalis* in its degree of elongation and in the size of its alveolar angle, but differs from *B. occidentalis* in its more pronounced contraction in the anterior part of the guard. The depth of the alveolus is so varied, in the form just described, that this character cannot be used taxonomically.

It is apparent, from the above, that *B.* aff. *lanceolata* has important taxonomic characters in common with both *B. occidentalis* and *B. lanceolata lanceolata,* and that the study of a more comprehensive collection might lead to placing the form as a subspecies of *B. occidentalis.*

The specimens figured by NOWAK (1913, pl. 42, figs. 19, 24) under the name *Belemnitella* (*Belemnella*) *lanceolata* mut. *junior,* seems to be rather closely related to this form. It differs only in its less lanceolate shape in lateral view.

Also, the specimen figured by JELETZKY (1951 b, pl. 3, figs. 5 a–c) may be closely related to *B.* aff. *lanceolata.* According to Dr. FR. SCHMID, Hannover, similar forms are common in the oldest Maastrichtian layers of the Zeltberg chalk-pit, Lüneburg. The specimen figured by JELETZKY, and the form from Zeltberg, may differ from the typical *B.* aff. *lanceolata* only in their less lanceolate form, their more obtuse apical ends and their more distinctly separated mucros. Since a few of the specimens referred to *B.* aff. *lanceolata* (pl. 3, fig. 5) have similarly obtuse apical ends and distinctly separated mucros further material may show them to be identical.

Stratigraphy.

This form occurs in the Lower Maastrichtian. At Lille Bissinge, Møn, it is the only known form. In the eastern part of Hvide Klint *B.* aff. *lanceolata* occurs together with *B. lanceolata lanceolata* and *B. occidentalis occidentalis*; it occurs together with

B. occidentalis occidentalis at Møns Klint above the indurated layer, but has not yet been found below it at which level material generally is scarce.

As *B.* aff. *lanceolata* is closely related to, or identical with, the above mentioned form from the oldest Lower Maastrichtian layers in the Zeltberg chalk-pit at Lüneburg, the chalk at Lille Bissinge is regarded here as older than other Danish Lower Maastrichtian localities. No other stratigraphically significant fossils have been found at Lille Bissinge. Further investigations are necessary before the full stratigraphical relations between *B. lanceolata* and *B.* aff. *lanceolata* can be determined.

Belemnella occidentalis occidentalis n. nom.

Pl. 5, figs. 1a–c; pl. 6, figs. 1a–c, 2; text-fig. 1.

1732 *Breynius*, Tab. Belemnitarum, figs. 1–2.
1813 *Belemnites mucronatus*, SCHLOTHEIM, p. 111.
1951b *Belemnella lanceolata* mut. *sumensis*, JELETZKY, p. 113, pl. 3, fig. 4; pl. 4, fig. 3.

Diagnosis.

Belemnella with a rather varying degree of elongation; in ventral view slightly lanceolate and in lateral aspect subcylindrical to cone-shaped; diameter of the guard (d), in full-grown individuals, one third to one sixth the length from the protoconch to the apex; alveolus deep (two fifths to one half the estimated length of the guard); alveolar angle 14° to 20°; bottom of the ventral fissure rectilinear or forming a slight curve backwards to the alveolus; "Schatsky index" 0 to 3 mm; vascular impressions faint, and longitudinal striation faint or in most cases lacking.

Synonyms and Type.

The legitimate name of this species is *B. mucronata* LINK (sensu SCHLOTHEIM) (cf. BIRKELUND & RASMUSSEN, 1956). In order to avoid any confusion resulting from a reintroduction of this specific name in its proper meaning, a proposal has been submitted to I.C.Z.N. (see the section on nomenclature, page 30). The species has been referred by JELETZKY (1951b) to *Belemnella lanceolata sumensis* JELETZKY, 1949, but is now considered as a different form. Dr. JELETZKY has proposed the name *B. occidentalis* for this form. As also Dr. JELETZKY is publishing on *B. occidentalis*, Dr. JELETZKY and the present author have agreed that the authorship should go to the person whose paper will appear first.

The specimen figured pl. 6, figs. 1a–c, is proposed as the type for this species. Horizon: The upper part of the Lower Maastrichtian. Locality: Maglevandspynten, Møns Klint. The specimen is in the collections of the Mineralogical and Geological Museum, Copenhagen.

Material.

Møns Klint: Below the indurated layer at Hvidskud, Store Stejlebjerg, and Lille Stejlebjerg, 12 complete specimens; above the indurated layer, 46 complete specimens and numerous fragments; horizon unknown, about 50 complete specimens and numerous fragments. The eastern part of Hvide Klint, on the island of Møn, 10 complete specimens and many fragments. Vognsbjerg, on the island of Langeland, 1 specimen. Langeland, the exact locality unknown, several fragments. Localities in the northern part of Jutland: "Rørdal", Aalborg, 4 complete specimens; "Danmark", Aalborg, 1 complete specimen and fragments; Aalborg, locality unknown, 5 complete specimens; Nørre Sundby, 5 complete specimens and fragments; Lundergaard Mose, 3 complete specimens and fragments; Batum, 4 complete specimens and fragments; Nørre Flødal, 1 complete specimen.

The specimens are in the collections of the Mineralogical and Geological Museum, Copenhagen and in the collections of the Geological Survey of Denmark, Copenhagen.

Description.

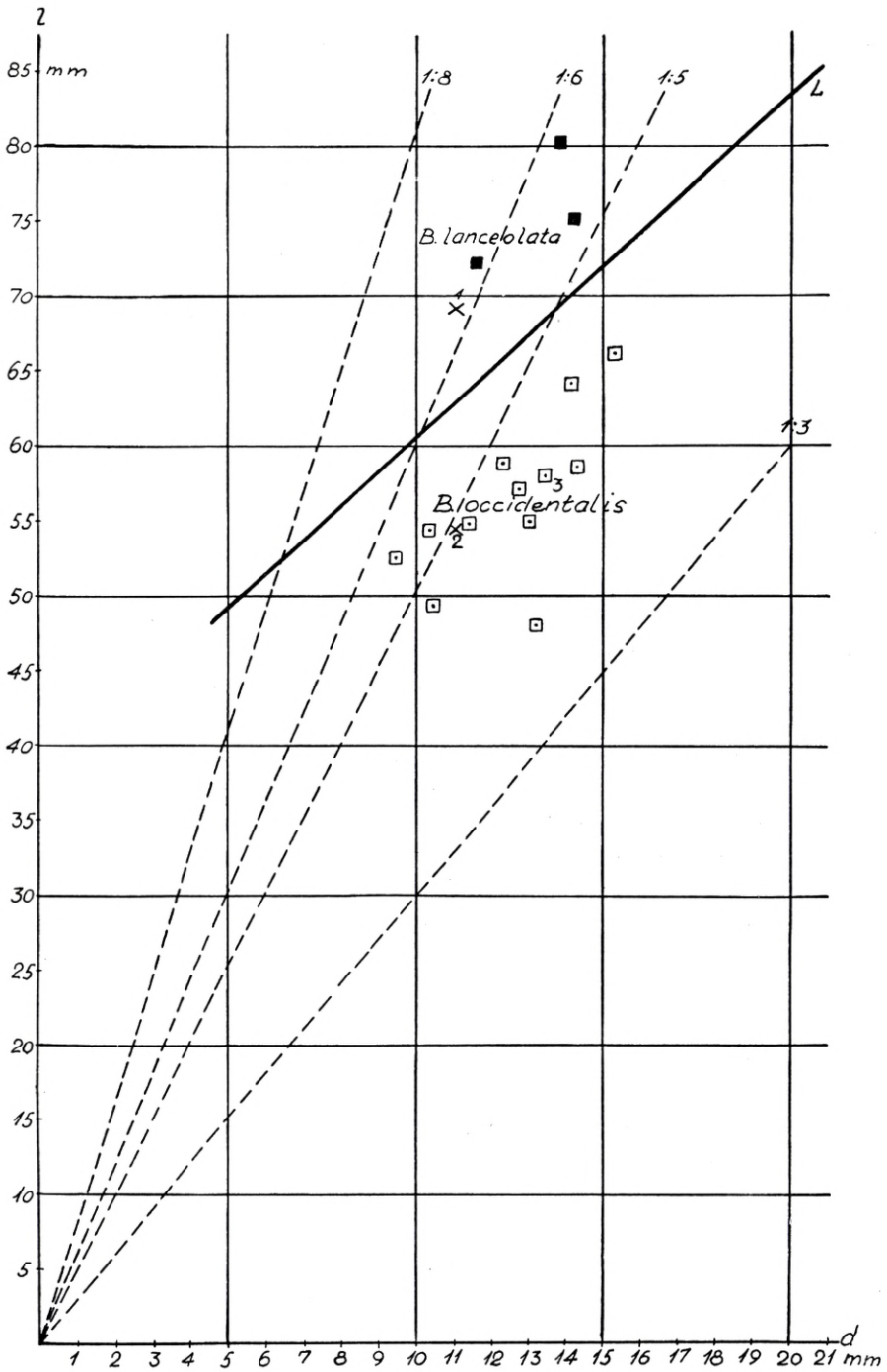
The length of the guard is up to 13 cm. In ventral aspect it is usually slightly lanceolate, or the sides are almost parallel except in the apical region. In lateral aspect it may be slightly cone-shaped, or the margins are nearly parallel except in the apical region. The guard is ventrally flattened for its entire length, dorsally it is flattened posteriorly. The apical end is acute, and the mucro is rather distinctly separated. The relation between the diameter (d) and length from the protoconch to the apex ranges from one third to one sixth in full-grown specimens; younger individuals as may be seen from the growth curves (text-fig. 4) are more elongate.

In well preserved specimens the depth of the alveolus varies from two fifths to one half the length of the guard. This is the case whether the measurement is based on the actual length or the estimated length of the guard. The alveolar angle varies from 14° to 20°. The bottom of the ventral fissure is either rectilinear, slightly convex, concave, angular or with a bend. The straight line drawn through the two extreme points of the bottom of the ventral fissure forms an angle with the alveolar wall of 10° to 40°. The "Schatsky index" is 0 to 3 mm.

The vascular impressions on the surface of the guard are usually only faintly visible. The angle between the posterior part of the dorso-lateral double furrows and the main vascular branches is very large, often 90°.

The Danish specimens of the species often show very distinct growth stages when the guard is longitudinally split and polished.

In one specimen, pl. 6, fig. 2, a silicified phragmocone has been preserved. The distance between the transverse septa of the phragmocone decreases rapidly posteriorly; 27 chambers are preserved and the siphuncle is rather narrow and is peripheral.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1:3
L
B. lanceolata
B. occidentalis
1
2
3
d
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 mm

Fig. 5.

Morphological differences in the stratigraphically youngest forms.

The localities of "Rørdal" and Nørre Sundby, according to TROELSEN's investigations of the stratigraphy of the Senonian (TROELSEN, 1937), belong to the younger strata in which *B. occidentalis* is present. These localities, and the localities at Batum, contain, in addition to the typical *B. occidentalis*, slightly different forms which have more distinct vascular impressions on the surface. These forms also have distinct, short longitudinal striae which are most pronounced ventrally and laterally. Thus they are close to *B. occidentalis cimbrica*, mentioned below, as regards ornamentation, but apart from this they do not differ from *B. occidentalis occidentalis*.

Affinity with other species.

B. occidentalis occidentalis is closely related to *B. occidentalis cimbrica*, *B.* aff. *lanceolata*, *B. lanceolata sumensis* and *B. lanceolata lanceolata*. The relations to *B. occidentalis cimbrica* and *B.* aff. *lanceolata* are mentioned on pages 49, 41.

The holotype of *B. lanceolata sumensis* JELETZKY, 1949a, text-figs. 1a–b, from the Ssumy-district, U.S.S.R., differs from *B. occidentalis* from Denmark in its more pronounced lanceolate shape in ventral view and in its less distinctly separated mucro. Also JELETZKY (1949a, p. 269) has mentioned that the depth of its alveolus is less than one third the length of the guard.

B. lanceolata lanceolata differs from *B. occidentalis* in its more elongate shape. Furthermore *B. lanceolata lanceolata* is almost always markedly lanceolate in ventral view. *B. occidentalis* is usually less lanceolate, or almost subcylindrical, in ventral view. In lateral aspect *B. lanceolata lanceolata* is lanceolate to subcylindrical, while *B. occidentalis* is subcylindrical to slightly cone-shaped. As regards the depth of the alveolus, well-preserved typical specimens of *B. occidentalis*, from Møns Klint, show that the alveolus is two fifths to one half the actual length of the guard, while the material available does not contain specimens of *B. lanceolata lanceolata* with an alveolus exceeding two fifths the estimated length of the guard. Thus the alveolus of *B. occidentalis* seems relatively deeper than that of *B. lanceolata lanceolata*.

In order to show the difference in elongation between *B. occidentalis* and *B. lanceolata lanceolata* a diagram (text-fig. 4) is given of the ratio between the distance from the protoconch to the apex and the diameter measured dorso-ventrally at the protoconch (d). This is based on specimens of *B. lanceolata lanceolata* and *B. occi-*

Fig. 5. Diagram showing the ratio between the diameter (d) and the length (l) from the protoconch to the apex in *B. lanceolata lanceolata* and *B. occidentalis occidentalis* from Møns Klint, below the indurated layer. The ratio d/l is also indicated for the types of the two species. The line L indicates the boundary between *B. lanceolata lanceolata* and *B. occidentalis occidentalis* (cf. text-fig. 4).

■ *B. lanceolata.*
□ *B. occidentalis* (3 figured in the present work, pl. 6, fig. 2).
× Other localities.
1 The type of *B. lanceolata* (figured by BREYNIUS, 1732, Tab. Belemnitarum, fig. 8). Locality unknown.
2 The type of *B. occidentalis* (figured in the present work, pl. 6, fig. 1). Møns Klint, above the indurated layer.

dentalis occidentalis from Balsvik (Scania), and from above the indurated layer at Møns Klint (cf. the stratigraphical section on page 64). In addition some specimens of *B. occidentalis* and *B. lanceolata* which have been figured in literature are also indicated in the diagram; among these are the types of the two species. The growth curves of some of the polished specimens are also indicated. It can be seen from the figure that the specimens from Balsvik, derived from the oldest deposits containing *B. lanceolata*, and the specimens from above the indurated layer at Møns Klint fall into two rather

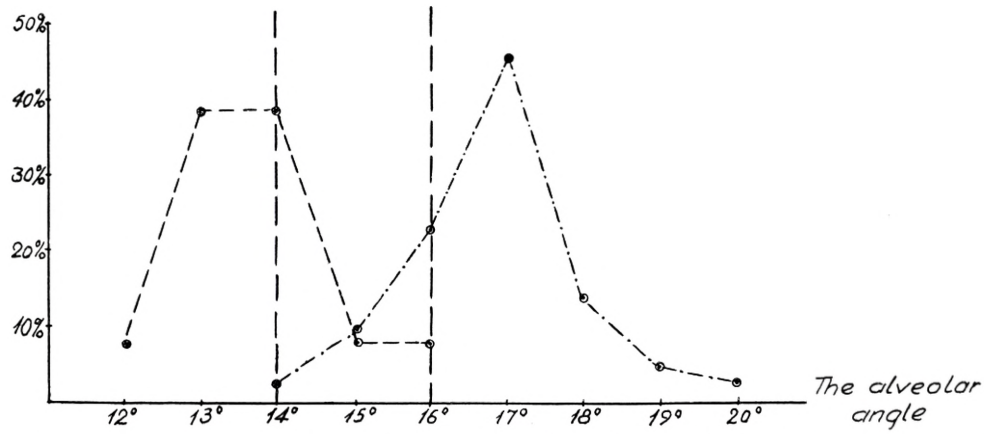


Fig. 6. Diagram showing the variation in size of the alveolar angle in *B. lanceolata lanceolata* from Balsvik (Scania) and *B. occidentalis occidentalis* from Møns Klint (above the indurated layer).

– – – – *B. lanceolata lanceolata*, Balsvik, 13 specimens.
–·–·– *B. occidentalis occidentalis*, Møns Klint, above the indurated layer, 44 specimens.

well defined groups. They can be separated at the line L which follows the course of the growth curves. The type of *B. lanceolata* lies within the variation of the guards from Balsvik, and must therefore be referred to that species, whereas the type of *B. occidentalis* lies within the variation of the guards from above the indurated layer at Møns Klint. It appears from the figure that the ratio d/l can be used taxonomically for separating these species when the absolute size of the individuals is also taken into account. A single specimen from Balsvik (marked *a* in the figure) lies within the variation of *B. occidentalis* and also agrees with *B. occidentalis* in its slightly lanceolate shape and the size of its alveolar angle. Thus this species seems to be an exceptional occurrence at this stratigraphically older locality. A specimen from Møns Klint, collected immediately above the indurated layer (marked *b* in the figure) falls on the border of variation between the two species. The specimens found below the indurated layer at Møns Klint (cf. text-fig. 5) comprise a few which correspond to the variation of *B. lanceolata*, although the bulk of the material lies within the variation of *B. occidentalis*.

The specimens of *B.* aff. *lanceolata*, mentioned on page 40, and *B. lanceolata sumensis* Jeletzky (1949a, p. 269, text-figs. 1–2) agree with *B. occidentalis* as to

the relation between the diameter (d) and the length from the protoconch to the apex. The relations between *B. occidentalis* and these two species are mentioned on pages 41, 45.

The variation in size of the alveolar angle is shown in text-fig. 6. It appears that this angle is of taxonomic value in some cases.

Stratigraphy.

This species occurs in the Lower Maastrichtian, it is of rare occurrence in the lower part, but frequent in the upper part.

In the eastern part of Hvide Klint, *B. occidentalis occidentalis* occurs together with *B. lanceolata lanceolata* and *B.* aff. *lanceolata*; in Møns Klint below the indurated layer it occurs together with *B. lanceolata lanceolata*, while above the indurated layer it occurs together with *B.* aff. *lanceolata*. Both below and above the indurated layer *B. occidentalis occidentalis* is predominant (cf. text-fig. 4). In the Aalborg district *B. occidentalis occidentalis* occurs together with *B. occidentalis cimbrica*. According to TROELSEN (1937) these deposits are younger than those in Møns Klint. JELETZKY's assumption (1951b) that *B.* n. sp. aff. *casimirovensis* (? = *B. occidentalis cimbrica*) occurs in the youngest horizons containing *B. lanceolata sumensis*, or in younger layers in the chalk-pit at Hemmoor, agrees with this interpretation.

Belemnella occidentalis cimbrica n. subsp.

Pl. 5, figs. 2a–c.

1951b *Belemnella* n. sp. aff. *casimirovensis* JELETZKY, p. 116, pl. 4, fig. 5; pl. 5, figs. 2a–b, 3; ?pl. 4, figs. 7a–b; ?pl. 5, figs. 1a–c.

Diagnosis.

Belemnella occidentalis with a rather stout guard, which in ventral view is slightly lanceolate, and in lateral view cone-shaped; diameter of the guard (d) one third to one fifth the length from the protoconch to the apex; alveolar angle 17° to 18°; "Schatsky index" 2 to 4 mm; vascular impressions fairly strong, especially round the ventral fissure; short, usually distinct, longitudinal striae present especially ventrally and laterally.

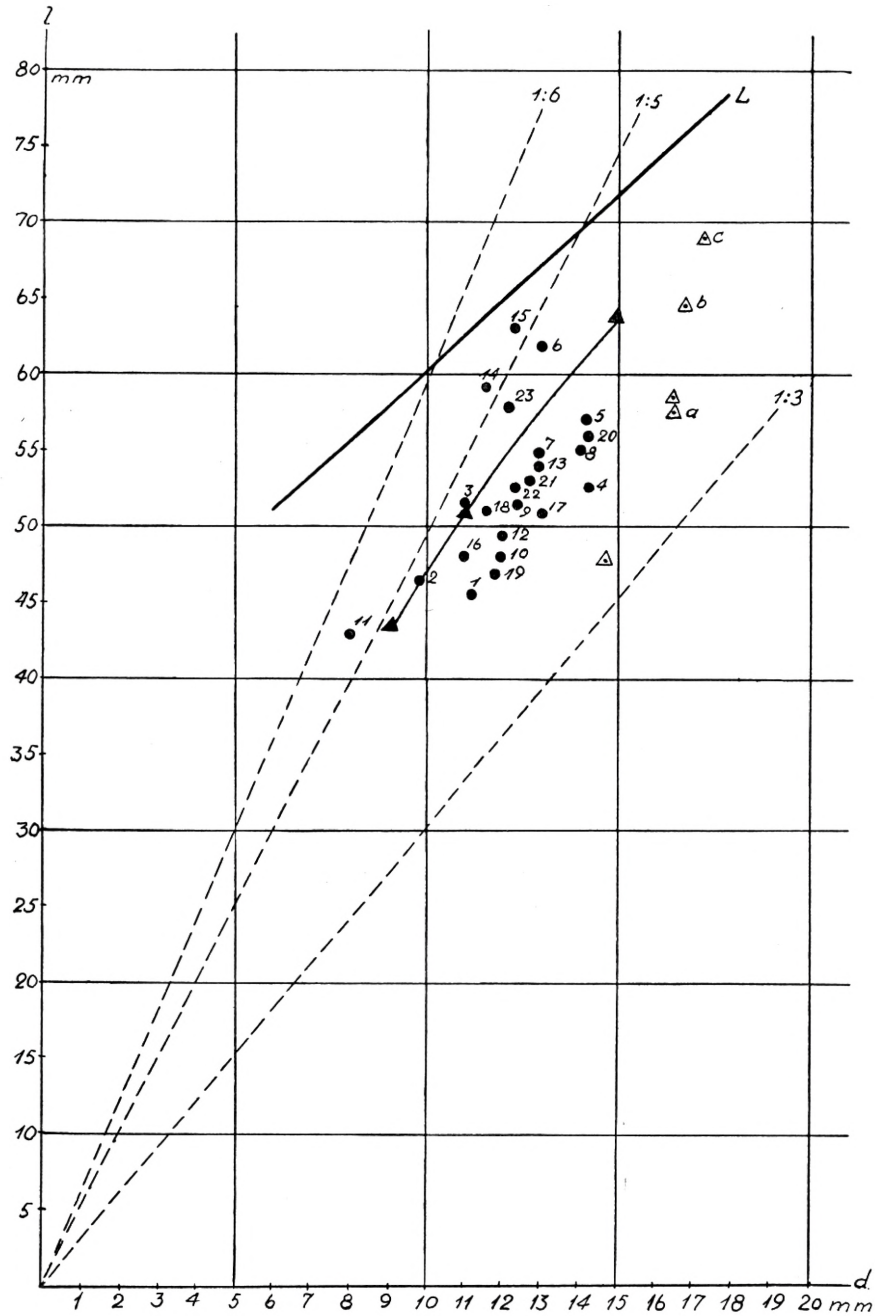
Type.

The specimen figured pl. 5, figs. 2a–c, is the holotype for this subspecies. Horizon: The uppermost part of the Lower Maastrichtian. Locality: "Rørdal" chalk-pit, Aalborg. The specimen is in the collections of the Mineralogical and Geological Museum, Copenhagen.

Material.

"Rørdal", Aalborg, 6 complete specimens and a few fragments.

The specimens are in the collections of the Mineralogical and Geological Museum, Copenhagen.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1
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d
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Fig. 7.

Description.

The guard is up to about 13 cm long. In ventral view it is very slightly lanceolate, or with almost parallel sides except in the apical region. In lateral view it is usually slightly cone-shaped. The apical end is moderately acute with a mucro, which is usually only slightly separated. The relation between the diameter (d) and the length from the protoconch to the apex varies from one third to one fifth in adult specimens (see text-fig. 7), younger individuals are more elongate.

The depth of the alveolus is from two fifths to one half the estimated length of the guard. The alveolar angle varies from 17° to 18°. The bottom of the ventral fissure is usually rectilinear posteriorly and slightly curved anteriorly; sometimes it is almost rectilinear for its entire course. The straight line between the two extreme points of the bottom of the ventral fissure forms an angle with the alveolar wall of up to 20°. The "Schatsky index" ranges from 2 to 4 mm.

Vascular impressions on the surface of the guard are generally rather distinct, but are most marked laterally where they are widely branched, and ventrally round the ventral fissure where they form a rather dense mesh. The surface of the guard is also longitudinally striated with coarse, short furrows. Sometimes these may be separated by a distance which is not greater than the breadth of the furrows, but they may be considerably more scattered. The striation is most distinct ventrally and laterally.

Affinity with other species.

B. occidentalis cimbrica is very closely allied to *B. occidentalis occidentalis*. Typical specimens can be distinguished from this species by their less contracted anterior part of the guard, their somewhat greater "Schatsky index", their usually less distinctly separated mucro, and by their characteristic surface ornamentation. Forms occur which are transitional between the two subspecies (cf. page 45).

The form regarded by JELETZKY (1951 b) as typical of *B.* n. sp. aff. *casimirovensis* is from the chalk-pit at Hemmoor (JELETZKY, 1951 b, pl. 4, figs. 7 a–b; pl. 5, figs. 1 a–c). It differs only from *B. occidentalis cimbrica* in its more conical shape and its more acute apical end. Its stratigraphical occurrence is presumed to be the same as that of *B. occidentalis cimbrica* and the two forms may perhaps be referred to the same subspecies (cf. JELETZKY, 1951 b).

Fig. 7. Diagram showing the ratio between the diameter (d) and the length (l) from the protoconch to the apex in the specimens referred to *B. occidentalis occidentalis* and *B. occidentalis cimbrica* from the localities situated in the northern part of Jutland. The line L indicates the boundary between *B. lanceolata lanceolata* and *B. occidentalis occidentalis* (cf. text-fig. 4).

● *B. occidentalis occidentalis*. Nos. 1–5: Aalborg, the exact locality unknown. Nos. 6–9: "Rørdal" (no. 8 figured by JELETZKY, 1951b, pl. 3, fig. 4). No. 10: "Danmark". Nos. 11–15: Nørre Sundby. No. 16: Nørre Flødal. Nos. 17–19: Lundergaard Mose. Nos. 20–23: Batum.

△ *B. occidentalis cimbrica* from "Rørdal" (a figured by JELETZKY, 1951 b, pl. 5, fig. 3; b figured by JELETZKY, 1951 b, pl. 5, fig. 2; c is holotype and figured in the present work, pl. 5, fig. 2).

▲–▲ *B. occidentalis cimbrica* from "Rørdal". The growth-curve of this specimen is indicated.

With regard to ornamentation and the "Schatsky index" *B. occidentalis cimbrica* resembles *B. casimirovensis*, but it can easily be distinguished from this species by the course of the bottom of the ventral fissure. Also *B. casimirovensis* is more distinctly lanceolate.

Stratigraphy.

This subspecies occurs in the uppermost part of the Lower Maastrichtian, in the younger layers containing *B. occidentalis occidentalis*.

Belemnella casimirovensis casimirovensis (SKOLOZDRÓWNA), 1932.

Pl. 6, figs. 4a–c.

1932 *Belemnitella casimirovensis* SKOLOZDRÓWNA, p. 117.
pars 1948b *Belemnitella americana*, JELETZKY, p. 587.
pars 1949a *Belemnitella? americana*, JELETZKY, p. 274.
1950 *Belemnitella kazimiroviensis*, VASILENKO & RASMYSLOVA, p. 604, fig. 1e.
1951b *Belemnella casimirovensis* var. *skolozdrównae* JELETZKY, p. 119, pl. 6, figs. 4a–d; pl. 7, figs. 1a–b, 2, 4.
1952 *Belemnitella arkhangelskii* var. *pontica*, NAJDIN, p. 97, text-fig. 32, nos. 4–6; pl. 17, figs. 2, 3; pl. 18, fig. 3 (?non ROUSSEAU, 1842); non text–fig. 32, no. 7.

Diagnosis.

Belemnella with a very elongate guard, in ventral view lanceolate, and in lateral aspect lanceolate to subcylindrical; diameter of the guard (d) about one fifth to one eighth the length from the protoconch to the apex; depth of the alveolus one third to one quarter the estimated length of the guard; alveolar angle 17° to 21°; ventral fissure very long, sometimes longer than the alveolus, the bottom s-shaped or curved with the concavity forward, its angle with the wall of the alveolar cavity greater than 50°; "Schatsky index" 2 to 4 mm; vascular impressions and the longitudinal striation strongly developed.

Type.

The specimen, figured by JELETZKY, 1951b, pl. 6, fig. 4; pl. 7, fig. 4, was chosen by JELETZKY (1951b, p. 125) as the type for this species. Horizon: The upper part of the Upper Maastrichtian. Locality: At Kaziemerz at Weichsel (Poland). The specimen is in Dr. JELETZKY's collections (Geological Survey of Canada, Ottawa).

Material.

Stevns Klint: North of the Kulsti Rende, 5 specimens; Eskesti, 3 specimens; exact locality unknown, 3 specimens and many fragments.

The specimens are in the collections of the Mineralogical and Geological Museum, Copenhagen.

Description.

The guard is up to about 12 cm long and very elongate. In ventral view it is lanceolate, in lateral view slightly lanceolate, or the margins are almost parallel except in the apical region. The guard is rather flattened ventrally for its entire length, and dorsally it is flattened posteriorly. The apical end is acute, and the mucro only slightly separated. The ratio between the diameter (d) and the length from the protoconch to the apex varies from one fifth to one eighth in full-grown individuals, younger specimens are more elongate—this is apparent from the growth curves (text-fig. 8).

In well preserved specimens the depth of the alveolus is from one quarter to one third the actual or estimated length of the guard. The alveolar angle varies from 17° to 21°. The ventral fissure is very long, sometimes descending below the alveolus. The bottom of the ventral fissure is s-shaped, or more or less distinctly curved with the concavity forwards. It always forms an angle with the alveolar wall greater than 50°, in some cases it is more than 90°. The "Schatsky index" is 2 to 4 mm.

Ventrally and laterally the vascular impressions on the surface of the guard are marked and close-set. The angle between the posterior part of the dorso-lateral double furrows and the main vascular branches is rather small, about 30°. The surface of the guard is provided with a longitudinal striation of long grooves. The combination of vascular impressions and furrows produces a marked wrinkled appearance on the surface of the guard, especially anteriorly, ventrally and laterally.

The nomenclature and synonymy.

The species *B. casimirovensis* was described by Skolozdrówna (1932) but not figured. Jeletzky (1951b) was the first to satisfactorily describe, figure, and chose a type for the species.

The subspecies is here called *B. casimirovensis casimirovensis*, as Jeletzky, who established it under the name of *Belemnella casimirovensis* var. *skolozdrównae*, explicity chose the holotype of the species as holotype for the subspecies. Jeletzky (1951b, p. 125) thus stated: "Für diese Varietät . . . . schlägt der Verf. den subspezifischen Namen *Belemnella casimirovensis* (Skolozdr. in sched.) var. *skolozdrównae* n. var. vor, wobei, um allen möglichen Unklarheiten vorzubeugen, der hiermit gewählte Holotypus der Art (Taf. 6, Fig. 4; Taf. 7, Fig. 4) gleichzeitig als Holotypus der Varietät dienen soll".

Specimens belonging to *B. casimirovensis casimirovensis*, and other subspecies of *B. casimirovensis*, Jeletzky (1948b, 1949a) has referred to *B. americana*.

Affinity with other species.

B. casimirovensis casimirovensis is closely related to *B. casimirovensis archangelskyi* and to *B. casimirovensis* n. subsp.? The relations to these are mentioned below on page 57.

Stratigraphy.

This subspecies occurs in the upper part of the Upper Maastrichtian. It is found together with *B. casimirovensis archangelskyi* and *B. casimirovensis* n. subsp.? (both subspecies described below) in Stevns Klint, north of the Kulsti Rende, and, together with *B. casimirovensis* n. subsp.? in the Eskesti district. *B. casimirovensis casimirovensis* is not known from the Mariager district where *B. casimirovensis archangelskyi* and *B. casimirovensis* n. subsp.? are found. Thus it can be seen, from the Danish specimens, that, in any case, the three subspecies of *B. casimirovensis* occur together at the same horizons. However, the very small amount of material available makes it impossible to give a full account of their stratigraphical relations. JELETZKY (1951b) has not observed any differences in their stratigraphical occurrence.

In two localities north of the Kulsti Rende *B. casimirovensis* occurs together with *Belemnitella junior*.

Belemnella casimirovensis archangelskyi JELETZKY, 1951.

Pl. 6, figs. 5a–c.

1912 *Belemnitella americana*, ARKHANGELSKY, p. 611, pl. 9, figs. 28–29 non pl. 9, figs. 7,12, 25; pl. 10, fig. 11.
pars 1948b *Belemnitella americana*, JELETZKY, p. 587.
pars 1949a *Belemnitella? americana*, JELETZKY, p. 274.
1951b *Belemnella casimirovensis* var. *archangelskyi* JELETZKY, p. 124, pl. 6, figs. 2a–d, 3a–c, ? non figs. 1a–c.
1952 *Belemnitella arkhangelskii* NAJDIN, p. 97,? text-fig. 32, no. 3; pl. 17, fig. 1.
1952 *Belemnitella arkhangelskii* var. *pensaensis* NAJDIN, p. 97, text-fig. 32, nos. 8–9; pl. 18, fig. 2.
1952 *Belemnitella arkhangelskii* var. *pontica*, NAJDIN, p. 97,? text-fig. 32, no. 7, non 4–6; non pl. 17, figs. 2,3; pl. 18, fig. 3.

Diagnosis.

Belemnella casimirovensis with a rather small and elongate guard, in ventral view lanceolate, in lateral view cone-shaped to subcylindrical; diameter (d) of adult individuals one quarter to one sixth the length from the protoconch to the apex; depth of the alveolus one third to two fifths the estimated length of the guard; ventral fissure never descending below the alveolus, bottom of the ventral fissure s-shaped, rectilinear or forwardly concave, its angle with the alveolar wall greater than 30°.

Type.

The specimen figured by ARKHANGELSKY, 1912, pl. 9, figs. 28–29, was chosen by JELETZKY (1951b, p. 124) as the holotype for this subspecies.

Material.

Stevns Klint: White Chalk below the northernmost Danian loc., 110 cm below the top of the Senonian, 1 specimen; Skeldervig, 30 cm below the top of the Senonian

in slightly indurated grey chalk, 1 specimen; 200 m north of Harvigsbraade, about 2 m below the top of the Senonian, 1 specimen; between Eskesti and Mandehoved, 1 specimen. "Dania" at Mariager, 5 specimens and some fragments (1 fragment collected above the Kjølby Gaard marl (cf. TROELSEN, 1955), horizon not indicated for the other specimens.

The specimens are in the collections of the Mineralogical and Geological Museum, Copenhagen.

Description.

The guard is up to about 10 cm long and elongate. In ventral aspect it is lanceolate, in lateral aspect slightly cone-shaped or with almost parallel margins, except in the apical region. The guard is ventrally flattened for its entire length, and dorsally flattened posteriorly. The apical end is acute, and the mucro often only slightly separated. The ratio between the diameter (d) and the length from the protoconch to the apex varies from one quarter to one sixth in adult individuals; younger specimens are more elongate (text-fig. 8).

In well preserved specimens the depth of the alveolus varies from one third to two fifths the actual or estimated length of the guard. The bottom of the long ventral fissure is s-shaped, or straight, or anteriorly concave, it forms an angle with the alveolar wall varying from 30° to 90°. In some specimens in which the angle exceeds 90° the bottom of the ventral fissure curves in such a way that the length of the ventral fissure does not exceed that of the alveolus. The "Schatsky index" is 2 to 4 mm. The vascular impressions and the ornamentation on the surface of the guard are of the same pattern as in *B. casimirovensis casimirovensis.*

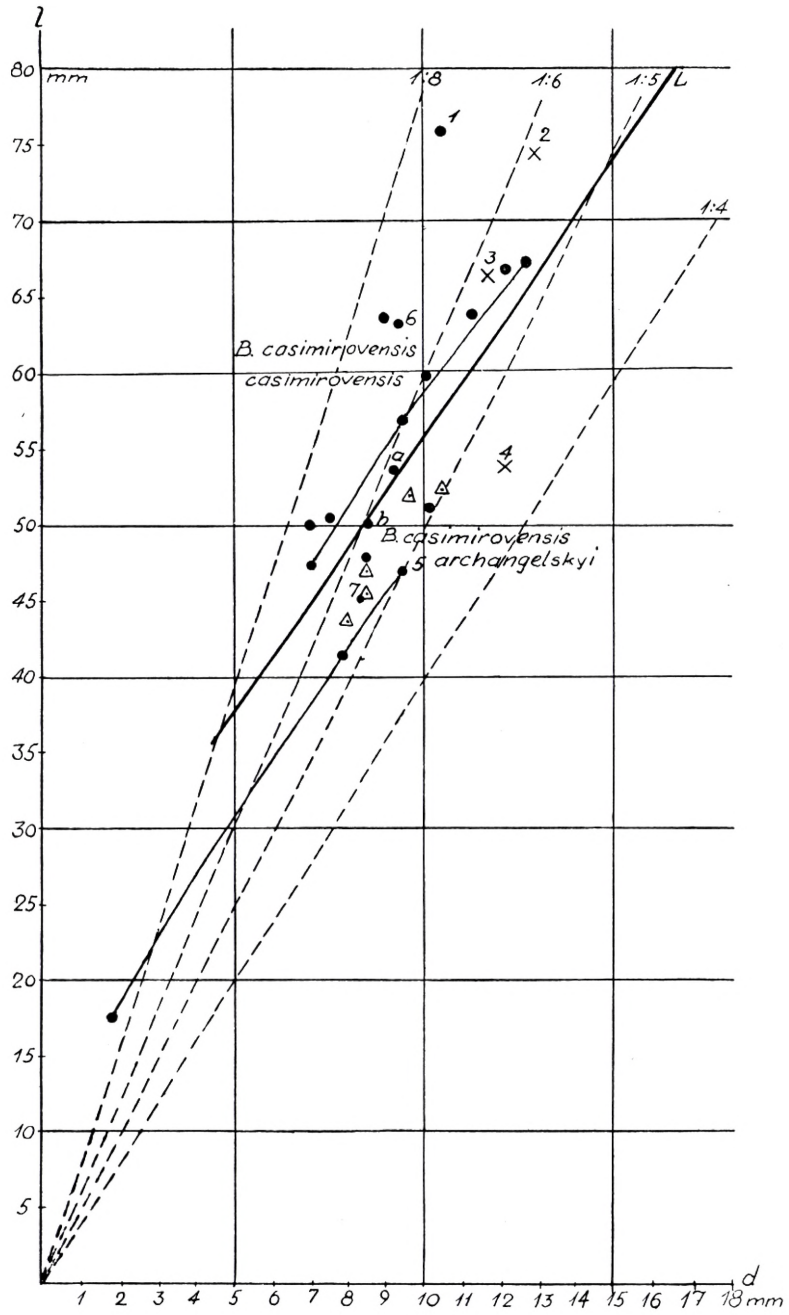
Affinity with other subspecies.

This subspecies is closely related to *B. casimirovensis casimirovensis* and to *B. casimirovensis* n. subsp.? It is possible that further investigation may show that the latter cannot be separated from *B. casimirovensis archangelskyi.*

The relations between the subspecies of *B. casimirovensis* are mentioned on page 57.

Stratigraphy.

This subspecies occurs in the upper part of the Upper Maastrichtian. The stratigraphically youngest known specimen of a belemnite from the Danish White Chalk, collected at Skeldervigen, Stevns Klint, 30 cm below the top of the Senonian, belongs to this subspecies. The subspecies occurs together with *B. casimirovensis casimirovensis* and *B. casimirovensis* n. subsp.? and, in the lower part of the zone in which it is represented, also together with *Belemnitella junior* (cf. page 35).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B. casimirovensis
casimirovensis
B. casimirovensis
archangelskyi
d
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 mm

Fig. 8.

Belemnella casimirovensis (SKOLOZDRÓWNA), 1932 n. subsp.?

Pl. 6, figs. 3a–c.

1951b *Belemnella casimirovensis* var. *archangelskyi* JELETZKY, p. 125, pl. 6, figs. 1a–c; non pl. 6, figs. 2a–d, 3a–c.

Material.

"Kongsdal" at Mariager, 2 specimens. "Dania" at Mariager, 1 specimen. Stevns Klint, north of the Kulsti Rende, 1 specimen.

The specimens are in the collections of the Mineralogical and Geological Museum, Copenhagen.

Four of the guards of *Belemnella casimirovensis* from Denmark differ so much from the others that perhaps they might be referred to a special subspecies; they agree with the specimen figured by JELETZKY (1951b, pl. 6, figs. 1a–c) which is, according to JELETZKY (1951b, p. 125), also possibly a new subspecies.

Description.

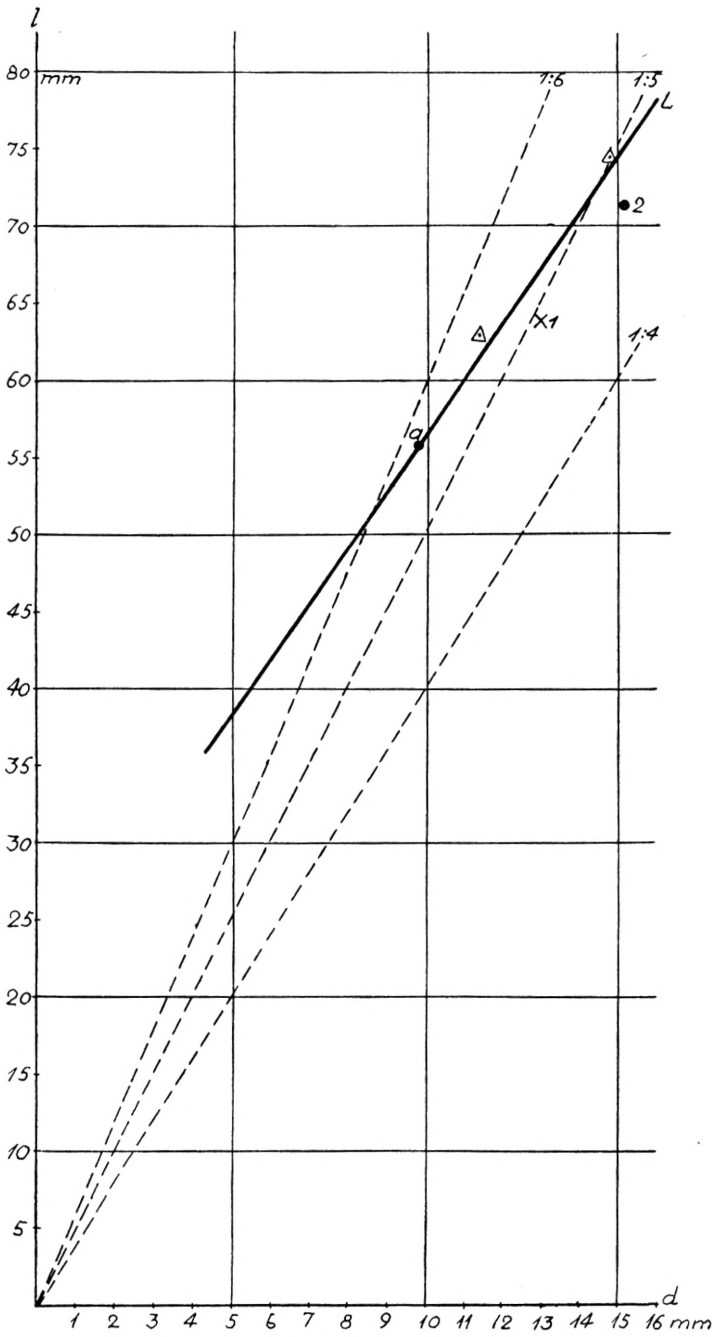
The guard is up to 11 cm long and is rather stout. In ventral view it is distinctly lanceolate, in lateral view the margins are almost parallel except in the apical region. The guard is strongly flattened ventrally for its entire length, and dorsally flattened posteriorly. The apical end is moderately acute, and the mucro more or less distinctly separated. The ratio between the diameter (d) and the length from the protoconch to the apex varies from one quarter to one sixth in adult specimens (see text-fig. 9), younger specimens are more elongate. The depth of the alveolus varies from one third to two fifths the estimated length of the guard.

The ventral fissure is s-shaped at the bottom and is long but never exceeds the length of the alveolus.

The size of the alveolar angle, the "Schatsky index", the vascular impressions, and the ornamentation of the surface are as in the other forms of *B. casimirovensis*.

Fig. 8. Diagram showing the ratio between the diameter (d) and the length (l) from the protoconch to the apex in the specimens referred to *B. casimirovensis casimirovensis* and *B. casimirovensis archangelskyi* from Danish localities. The ratio d/l is also indicated for some of the specimens figured in the literature and referred to these subspecies. The line L is drawn conform with the growth curves, indicated in the diagram, and separates the specimens referred to *B. casimirovensis casimirovensis* (to the left) from the specimens referred to *B. casimirovensis archangelskyi* (to the right).

● Stevns Klint (1 figured by JELETZKY, 1951b, pl. 7, fig. 1; 6 figured in the present work, pl. 6, fig. 4).
●—● Stevns Klint, the growth curves of these specimens are indicated (5 figured by JELETZKY, 1951b, pl. 5, fig. 4).
△ "Dania" at Mariager (7 figured in the present work, pl. 6, fig. 5).
× Other localities.
2 The type of *B. casimirovensis casimirovensis* (figured by JELETZKY, 1951b, pl. 6, fig. 4). Kaziemerz, Poland.
3 *B. casimirovensis casimirovensis* (figured by JELETZKY, 1951b, pl. 7, fig. 2). Kaziemerz, Poland.
4 *B. casimirovensis archangelskyi* (figured by JELETZKY, 1951b, pl. 6, fig. 3). Bochotniza, Poland.
a, b See page 57.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1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 mm

Fig. 9.

Affinity with other species.

The relations between *B. casimirovensis* n. subsp.? and the other subspecies of *B. casimirovensis* are mentioned below.

Stratigraphy.

This form occurs together with *B. casimirovensis casimirovensis* and *B. casimirovensis archangelskyi* in the upper part of the Upper Maastrichtian. As with the other subspecies of this species it also occurs at horizons containing *Belemnitella junior*.

Affinity of *Belemnella casimirovensis* with other species and the relations between the subspecies of *Belemnella casimirovensis*.

B. casimirovensis can easily be distinguished from other species of *Belemnella* by the characteristic course of the bottom of the ventral fissure, the "Schatsky index", and the ornamentation of the surface.

B. casimirovensis casimirovensis and *B. casimirovensis archangelskyi* are very closely related, and it may be difficult to distinguish one subspecies from the other. *B. casimirovensis casimirovensis* is subcylindrical to lanceolate in lateral view, while *B. casimirovensis archangelskyi* is subcylindrical to cone-shaped. The ventral fissure sometimes descends below the alveolus in *B. casimirovensis casimirovensis*. In *B. casimirovensis archangelskyi* the ventral fissure never seems to exceed the length of the alveolus. Finally *B. casimirovensis casimirovensis* is more elongate than *B. casimirovensis archangelskyi*. A diagram showing the ratio between the diameter (d) and the length from the protoconch to the apex is given (text-fig. 8). The diagram has been constructed according to the same principles as text-fig. 4. The line L, which follows with the growth curves, forms the boundary between *B. casimirovensis casimirovensis* and *B. casimirovensis archangelskyi*. The ratio d/l varies from one fifth to one eighth in *B. casimirovensis casimirovensis* and from one quarter to one sixth in *B. casimirovensis archangelskyi* as far as adult individuals are concerned. From the figure it is apparent that this ratio cannot always be used taxonomically unless the absolute size of the specimens is taken into account. Two specimens, labelled *a* and *b*, lie on the border between the range of variation in elongation of the two subspecies; a shows closer affinity with *B. casimirovensis casimirovensis*, *b* with *B. casimirovensis archangelskyi*.

Fig. 9. Diagram showing the ratio between the diameter (d) and the length (l) from the protoconch to the apex in the specimens referred to *B. casimirovensis* n. subsp.? from the Danish localities. The ratio d/l is also indicated for a specimen figured by JELETZKY and here referred to this subspecies. The line L indicates the boundary between *B. casimirovensis casimirovensis* and *B. casimirovensis archangelskyi* (cf. text-fig. 8).

● Stevns Klint (2 figured in the present work, pl. 6, fig. 3).
△ "Kongsdal" and "Dania" at Mariager.
× 1 *B. casimirovensis* n. subsp.? (figured by JELETZKY, 1951b, pl. 6, fig. 1). Southern Kasachstan, U.S.S.R.
a See page 58.

B. casimirovensis n. subsp.?, which occurs together with the above mentioned subspecies, may be a new subspecies characterised by its strongly lanceolate shape, its only moderately acute apical end, and its strong dorso-ventral flattening. The degree of elongation of the specimens referred to this subspecies is shown in text-fig. 9. The specimen labelled a has a doubtful taxonomic position. It is rather elongate, strongly contracted anteriorly, and distinctly flattened dorso-ventrally. It must either be a young individual of *B. casimirovensis* n. subsp.? or must be referred to *B. casimirovensis casimirovensis*.

Belemnella aff. **occidentalis** n. nom.

1951b *Belemnella* n. sp. aff. *lanceolata*, JELETZKY, p. 115, pl. 4, figs. 4a–c.

Material.

Stevns Klint: Harvigsbraade, 7 m below the top of the Senonian, 1 complete specimen, figured by JELETZKY (1951b, pl. 4, figs. 4a–c); 50 m south of the Eskesti, 30–40 m below the top of the Senonian, 1 fragment.

The specimens are in the collections of the Mineralogical and Geological Museum, Copenhagen.

The material of this form has not been enlarged since JELETZKY's investigations and reference is given to his description and figures (JELETZKY, 1951b, p. 115, pl. 4, figs. 4a–c). The form differs from *B. occidentalis*, *B. casimirovensis* and *B. lanceolata*, i. a., in its smooth surface. Furthermore it differs from *B. lanceolata* in its less degree of elongation and in its greater "Schatsky index" (3–4 mm).

Stratigraphy.

This form occurs in the Upper Maastrichtian. It seems to occur together with *Belemnella casimirovensis* in Stevns Klint; in a drilling at Brunhilde (at Hannover) it occurs together with *Belemnitella junior* (JELETZKY, 1951b; SCHMID, 1955a).

Stratigraphy.

In the present work the Upper Cretaceous series is regarded as comprising the stages Cenomanian, Turonian, Senonian, and Danian. The Senonian has been divided into the substages Coniacian, Santonian, Campanian, and Maastrichtian, a subdivision which is gaining ground at the expense of the German division of the Senonian into Emscherian, Granulatus-beds, Quadratus-beds, and Mucronata-beds (cf. SEITZ, 1952). Many diverging delimitations of stages and substages have been used in the literature. The index fossils mentioned in table 4 show the delimitation of stages and substages

as used in this publication. Especially with regard to the boundary between the Campanian and the Maastrichtian there are many diverging points of view. An illustration of some of the most important views has been given by JELETZKY (1951b), HILTERMANN (1953) and VOIGT (1956) and here in table 3.

Until recently the term "Mucronata-beds" was most frequently used, in Germany, Scandinavia, and Eastern Europe, for strata corresponding to the Upper Campanian and Maastrichtian. STOLLEY (1897) divided the "Mucronata-beds" into lower, middle and upper parts, the division being made mainly on ammonites (cf. table 3). This division was used extensively until a few years ago. STOLLEY correlated the Upper Mucronata-beds with the Maastrichtian, and the Lower and Middle Mucronata-beds with the Upper Campanian. In STOLLEY's standard section at Zeltberg (Lüneburg) the uppermost Senonian horizons are not represented. First and foremost STOLLEY used *Scaphites constrictus* as index fossil for the Upper Mucronata-beds or Maastrichtian; although from the type locality of the Maastrichtian he only included the Maastricht tuff in this substage. For the Middle Mucronata-beds STOLLEY used as index fossil, i. a., *Bostrychoceras polyplocum*.

According to W. POŻARYSKI (1938) *Bostrychoceras polyplocum* RÖMER s. l. is an artificial union of two species (*B. polyplocum* s. str. and *B. schlönbachi* KNER) which differ morphologically as well as stratigraphically. Horizons containing *B. schlönbachi* were referred by him to the Maastrichtian, and those containing *B. polyplocum* s. str. he placed in Campanian. This lower boundary for the Maastrichtian is equivalent to the lower boundary of the zone of *Scaphites constrictus* in Poland (cf. table 3). POŻARYSKI assumed that this boundary passes through STOLLEY's Middle Mucronata-beds.

Later investigations of belemnites (i. a., ARKHANGELSKY, 1912; NOWAK, 1913; VASILENKO and RASMYSLOVA, 1950; JELETZKY, 1941, 1948b, 1950a, 1951a, 1951b; NAJDIN, 1952) admit a sub-division of the Mucronata-beds (Upper Campanian and Maastrichtian). ARKHANGELSKY (1912) restricted the Mucronata-beds to the Upper Campanian, as *Belemnitella mucronata* ARKHANGELSKY non SCHLOTHEIM occurs only in these layers. Subsequently the term has been used in this meaning in most of the Russian literature and also in recent literature in Western Europe (JELETZKY, 1951b).

JELETZKY regarded the lower boundary of horizons containing *Belemnella lanceolata* as the boundary between the Campanian and the Maastrichtian. According to him this boundary is equivalent to that which separates horizons with *Bostrychoceras polyplocum* s. str. from horizons with *Bostrychoceras schlönbachi* and is also equivalent to the lower boundary of horizons containing *Scaphites constrictus*. Basing his opinion on a study of the Zeltberg profile, JELETZKY assumed, like POŻARYSKI (1938), that this boundary passes through STOLLEY's Middle Mucronata-beds (cf. table 3). However, SCHMID (1955a) has shown that the lower boundary of strata containing *Belemnella lanceolata* (= lower boundary of the Maastrichtian) agrees with STOLLEY's boundary between the Upper and Middle Mucronata-beds of that section (cf. table 3). Apart from this, SCHMID has also shown that *Bostrychoceras polyplocum*,

TABLE

STOLLEY, 1897			POŻARYSKI, 1938		MULLER & SCHENK, 1943	
Maastrichtian	Upper Mucronata-beds	*Scaphites constrictus*	Maastrichtian	*Scaphites constrictus* *Bostrychoceras schlönbachi*	Maastrichtian	*Scaphites constrictus*
Upper Campanian	Middle Mucronata-beds	*Bostrychoceras polyplocum*		*Bostrychoceras polyplocum* s. str.		*Bostrychoceras polyplocum*
	Lower Mucronata-beds	*Hoplitoplacenticeras coesfeldiense*	Upper Campanian	*Hamites phaleratus*	Upper Campanian	*Kossmaticeras theobaldianum* *Hoplitoplacenticeras coesfeldiense*

in the above-mentioned section, occurs only in the lower part of STOLLEY's Middle Mucronata-beds.

JELETZKY (1951 b) regarded the boundary used by him between the Campanian and the Maastrichtian as being in agreement with DUMONT's original definition of the Maastrichtian of the type area. JELETZKY was of the opinion that DUMONT's definition may be interpreted in such a way that not only the Maastricht tuff but also parts of older deposits should be included (JELETZKY, 1951 b, p. 15).

VAN DER HEIDE (1954) has since opposed this opinion, as, on a closer study of DUMONT's geological maps and descriptions, he concluded that the Maastrichtian only includes the Maastricht tuff (cf. table 3), a view which, i. a., agrees with CORNET & BRIART (1874) and UMBGROVE (1925–26, 1927).

When, however, the lower boundary of the Maastrichtian is drawn at the lower boundary of horizons with *Belemnella lanceolata* and *Scaphites constrictus*, this substage then comprises the horizons of its type locality, but excludes strata represented at the type locality of the Campanian (COQUAND, 1857; ABRARD, 1948, p. 279). This boundary which, as stated by SCHMID (1955 a), is equivalent to the lower boundary of STOLLEY's Upper Mucronata-beds, has been used in this paper.

MULLER and SCHENK's boundary between the Maastrichtian and the Campanian, in their Standard of the Cretaceous System (cf. table 3), cannot be applied here as

3.

	Jeletzky, 1951 b	van der Heide, 1954	Schmid, 1955 a*	
Maastrichtian	*Belemnella casimirovensis* *Belemnitella junior* *Belemnella lanceolata* mut. *sumensis* *Belemnella lanceolata*	Maastrichtian	Maastrichtian	*Scaphites constrictus* *Belemnella lanceolata*
Upper Campanian	*Belemnitella langei* *Belemnitella mucronata* mut. *minor*		Upper Campanian	*Belemnitella mucronata minor*: *Belemnitella langei*; *Bostrychoceras polyplocum*
Upper Campanian	*Belemnitella mucronata* mut. *senior*		Upper Campanian	*Belemnitella mucronata senior*

* This delimitation of the Maastrichtian has been used in the present publication.

in their paper the Maastrichtian includes horizons represented at the type locality of the Campanian.

The stratigraphical results from a study of the belemnites found on Bornholm in Denmark (cf. table 4) confirm Ravn's opinions (Ravn, 1916, 1918, 1921, 1946). Study of new collections has only made it possible to place the greensand at Jydegaard more exactly in the stratigraphical section than previously.

In older publications all the outcrops of the White Chalk usually have been referred to the upper part of the "Mucronata-beds" (with *Scaphites constrictus*) without any exact specification of the zones. Ravn (1903) and Jessen & Ødum (1923) attempted, however, to make a further division, but Troelsen (1937) was the first to make a more detailed zonal division on the basis of macro- and micro-fossils.

Troelsen divided the White Chalk into the Bostrychoceras zone?, the Lower Constrictus zone, the Middle Constrictus zone, α and β, and the Upper Constrictus zone, α, β and γ (cf. table 4).

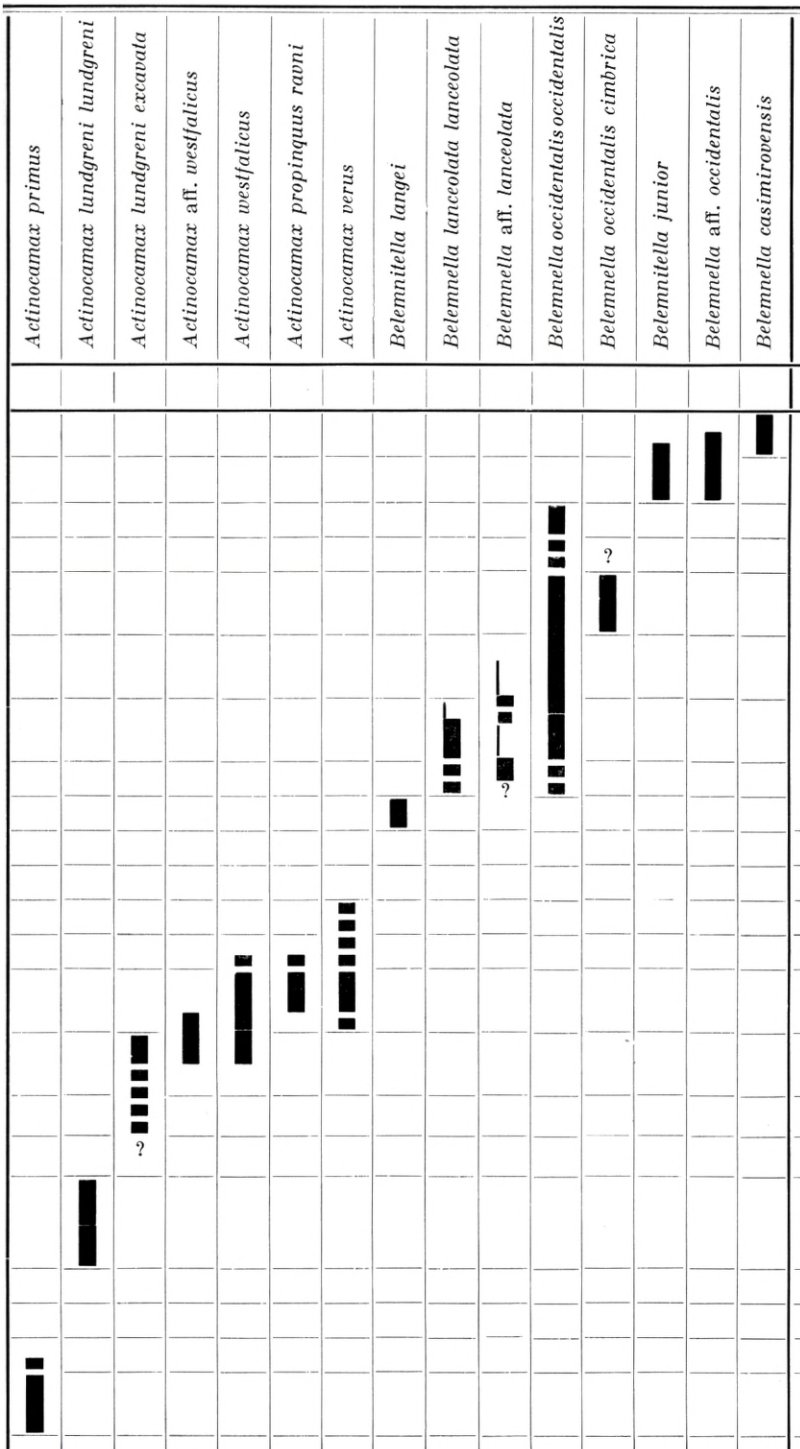
Owing to the absence of *Trigonosema pulchellum* the oldest strata in Møns Klint were presumed to belong to the Bostrychoceras zone. Later, Rosenkrantz (1940) mentioned a find of *Acanthoscaphites tridens* in these oldest strata apparently confirming this view. Subsequently it has been pointed out that this ammonite also occurs in younger deposits (Pożaryski, 1938; Ødum, 1953, Schmid, 1955 b).

TABLE

Distribution of Upper Cretaceous Belemnites in Denmark.
found in Denmark.
not found in Denmark.

Stages and substages			Troelsen, 1937	Index fossils
Danian				
Senonian	Maastrichtian	Upper Maastrichtian "Stevnsian" (Brotzen, 1945)	IV γ	*Belemnella casimirovensis*
			— ? —	
			IV β	*Belemnitella junior*
		Lower Maastrichtian "Möenian" (Brotzen, 1945)	IV α	*Belemnella lanceolata sumensis* *Belemnella occidentalis*
			III β	
			III α	*Scaphites constrictus*
			II	
			I	*Belemnella lanceolata*
	Campanian	Upper Campanian	*Bostrychoceras polyplocum*	*Belemnitella langei*
			Hoplitoplacenticeras coesfeldiense	*Belemnitella mucronata*
		Lower Campanian		*Actinocamax quadratus*
	Santonian	Upper Santonian	*Inoceramus lingua*	*Actinocamax granulatus*
			Inoceramus pinniformis	
		Lower Santonian	*Inoceramus cordiformis*	*Actinocamax westfalicus*
			Inoceramus undulato-plicatus	
	Coniacian	Upper Coniacian	*Inoceramus involutus*	
		Lower Coniacian	*Inoceramus koeneni*	
	Turonian	Upper Turonian	*Holaster planus*	
		Middle Turonian	*Terabratulina lata*	
		Lower Turonian	*Inoceramus labiatus*	
Cenomanian		Upper Cenomanian	*Acanthoceras rhotomagense*	
		Middle Cenomanian	*Schloenbachia varians*	
		Lower Cenomanian	*Mantelliceras martimpreyi*	*Neohibolites ultimus*

4.



The age of Danish Upper Cretaceous localities where belemnites have been found.

White Chalk

Batum

Stevns Klint; "Dania" at Mariager; "Kongsdal" at Mariager.

Nørre Flødal.

"Rørdal"; "Danmark"; Nørre Sundby (the Aalborg district).

Møns Klint above the indurated layer; Vognsbjerg? Lundergaard Mose?

Møns Klint below the indurated layer; the eastern part of Hvide Klint.

Lille Bissinge.

The western part of Hvide Klint.

Greensand at Risenholm; Bavnodde-greensand on the southern coast of Bornholm.

Greensand at Jydegaard; greensand at Stampen?

Arnager-limestone on the southern coast of Bornholm; the "Glass-marl" at Mulebyaa; calcareous greensand at Stampe Aa?

Arnager-greensand on the southern coast of Bornholm.

The absence of *Scaphites constrictus* in Møns Klint (RAVN, 1903; JESSEN & ØDUM, 1923; TROELSEN, 1937) may be due to a special geographical distribution of this species (JELETZKY, 1951 b).

BROTZEN (1945) made a zonal division of the Cretaceous by means of foraminifera; the whole Maastrichtian, according to BROTZEN, is characterized by *Palmula reticulata* REUSS which is supposed to have the same stratigraphical range as *Scaphites constrictus*. He divided the Maastrichtian into a lower part, characterized only by *Palmula reticulata*, a middle part containing *Pseudovalvulineria gracilis* MARSSON, and an upper part carrying *Bolivinoides petersoni* BROTZEN. The lower and middle parts together are termed the "Möenian" (after Møns Klint), while the upper part is called the "Stevnsian" (after Stevns Klint) (cf. table 4).

JELETZKY (1951 b) basing his opinions on a study of the literature and the belemnites from the Danish White Chalk, made a stratigraphical division of this unit. Only a very limited collection of belemnites from the Danish White Chalk was available to JELETZKY and, for this reason, the study of a fuller collection has, on certain points, led to a different result (cf. table 4).

The age of the chalk of the Hvide Klint has not previously been closely considered. Detailed study of this horizon was occasioned by fossils received from Mr. JØRGEN WIND, and by new collections which have been made from Hvide Klint. The western-most of the two dislocated blocks of chalk, which make up the cliff, belongs to the upper part of the Campanian with *Belemnitella langei*. This zone has not previously been known from Danish outcrops. The eastern block belongs to the Lower Maastrichtian in which both *Belemnella occidentalis occidentalis* and *Belemnella lanceolata lanceolata* occur commonly and *Belemnella* aff. *lanceolata* occurs less often.

From Lille Bissinge, only *Belemnella* aff. *lanceolata* is known. As this form seems closely related to the dominant form in the lowest Maastrichtian horizons of the Zeltberg chalk-pit, Lüneburg (cf. page 41), the chalk at Lille Bissinge may be referred to the same horizon.

All the White Chalk at Möns Klint was referred by JELETZKY to the *Belemnella lanceolata* zone (lower part of the Lower Maastrichtian). In the present work only the chalk below the indurated layer found at Store Stejlbjerg, Lille Stejlebjerg, and Hvidskud is referred to the *Belemnella lanceolata* zone, as *Belemnella lanceolata lanceolata* occurs only up to this horizon. This part belongs to the upper division of the zone, where *Belemnella occidentalis occidentalis* predominates and *Belemnella lanceolata lanceolata* is less common. The older part of the *Belemnella lanceolata* zone, in which *Belemnella lanceolata* prevails, is thus not represented at Møns Klint. The White Chalk above the indurated layer in Møns Klint is referred to the upper part of the Lower Maastrichtian (JELETZKY's *Belemnella lanceolata sumensis* zone), as *Belemnella occidentalis occidentalis* is extremely common in these horizons and, with a single exception, is the only species found.

The chalk of the Aalborg district (TROELSEN's zone III α) is, in agreement with JELETZKY, referred to the upper part of the Lower Maastrichtian.

No belemnites from TROELSEN's zones III β and IV α were available to JELETZKY, and he tentatively referred the former to the *Belemnella lanceolata sumensis* zone (Lower Maastrichtian) and the latter to the *Belemnitella junior* zone (Upper Maastrichtian). Belemnites are very rare at these levels. This is the case in the Hemmoor-profile, where, between strata with an normal content of *Belemnella occidentalis* and strata with a rather sparse occurrence of *Belemnitella junior*, there is an interval in which no belemnites are known (VOIGT, 1954; SCHMID, 1955b). A single specimen of *Belemnella occidentalis* from zone IV α (collected at Nørre Flødal) has been available to me; this specimen shows that zone III β and, at any rate, parts of zone IV α should be referred to the upper part of the Lower Maastrichtian.

Pteria danica (RAVN) has been mentioned by TROELSEN (1937) from zone IV α, β, and γ and was proposed by VOIGT (1954) as an index fossil for the Upper Maastrichtian until its possible occurrence in the Lower Maastrichtian, together with *Belemnella lanceolata sumensis*, has been proved. It has now been found that horizons containing *Pteria danica* in Jutland seem to include the top of the horizons with *Belemnella occidentalis* (= uppermost Lower Maastrichtian).

The belemnites from Batum and Lundergaard Mose have not been investigated before. It was presumed (ØDUM, 1928) that the chalk without flints at Batum could be correlated with the White Chalk without flints known from the deep boring at Grøndals Eng, in Copenhagen (BONNESEN, BØGGILD & RAVN, 1913). Here, the White Chalk without flints occurs below the White Chalk with flints and contains Scaphites constrictus. S. A. ANDERSEN (1944) assumed the chalk at Batum to be older than the *Scaphites constrictus* zone due to the occurrence of *Acanthoscaphites tridens*. *Belemnella occidentalis occidentalis* and transitional forms between this species and *Belemnella occidentalis cimbrica* are, however, represented at the Batum localities which thus belong to the upper part of the Lower Maastrichtian. At Lundergaard Mose only typical *Belemnella occidentalis* are found.

As stated by JELETZKY, TROELSEN's zones IV β and IV γ are referred to the *Belemnitella junior* and the *Belemnella casimirovensis* zones. It has not been possible to ascertain whether the lower boundary of horizons with *Pseudotextularia elegans* (index fossil for zone IV γ) and the lower boundary of layers carrying *Belemnella casimirovensis* are in agreement. In the northern part of Stevns Klint *Belemnella casimirovensis* and *Belemnitella junior* are present at the same horizon. The occurrence of these two species at the same level has not previously been found in north-west Europe, although it is known in Poland and U.S.S.R. (cf. page 35). A new find made by Mr. S. FLORIS (1954) of *Belemnella casimirovensis* in the Maastricht tuff at Geulem, Valkenburg, and subsequently stated by Dr. F. SCHMID, Hannover, and VOIGT (1956), suggests that the same horizon is represented also in this area. *Belemnella casimirovensis* has not previously been recorded from the Maastricht tuff. The fragment collected at Geulem is figured pl. 6, figs. 6a–b.

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Plates.

All figures natural size unless otherwise indicated.

PLATE 1.

Fig. 1: *Actinocamax primus primus* ARKHANGELSKY, 1912. Very large specimen. Middle Cenomanian. Arnager-greensand, Madsegrav, Bornholm. a, dorsal view; b, ventral view; c, lateral view; d, view of the anterior end.

Fig. 2: *Actinocamax primus primus* ARKHANGELSKY, 1912. Very elongate specimen, closely related to *A. primus elongata*. Middle Cenomanian. Arnager-greensand, Madsegrav, Bornholm. *a*, dorsal view; *b*, ventral view; *c*, lateral view; *d*, view of the anterior end.

Fig. 3: *Actinomax primus elongata* ARKHANGELSKY, 1912. Middle Cenomanian. Arnager-greensand, Madsegrav, Bornholm. *a*, dorsal view; *b*, ventral view; *c*, lateral view.

Fig. 4: *Actinocamax primus primus* ARKHANGELSKY, 1912. Lateral view. The specimen is split longitudinally showing the growth stages of the guard. Middle Cenomanian. Arnager-greensand, Madsegrav, Bornholm.

Fig. 5: *Actinocamax lundgreni lundgreni* STOLLEY, 1897. Upper Turonian. Arnager-limestone, Arnager, Bornholm. *a*, dorsal view; *b*, ventral view; *c*, lateral view; *d*, view of the anterior end.

Fig. 6: *Actinocamax lundgreni lundgreni* STOLLEY, 1897. Lateral view of the longitudinally split anterior part of the guard showing the pseudoalveolus and the bottom of the ventral fissure. Upper Turonian, Arnager-limestone, Arnager, Bornholm.

Fig. 7: *Actinocamax lundgreni excavata* (SINZOW), 1915. Lower part of the Lower Santonian. The greensand at Jydegaard, Bornholm. *a*, dorsal view; *b*, ventral view; *c*, lateral view; *d*, view of the anterior end.

Fig. 8: *Actinocamax lundgreni excavata* (SINZOW), 1915. Lateral view, the anterior part of the specimen is split longitudinally showing the pseudoalveolus and the bottom of the ventral fissure. Lower part of the Lower Santonian, the greensand at Jydegaard, Bornholm.

PLATE 1

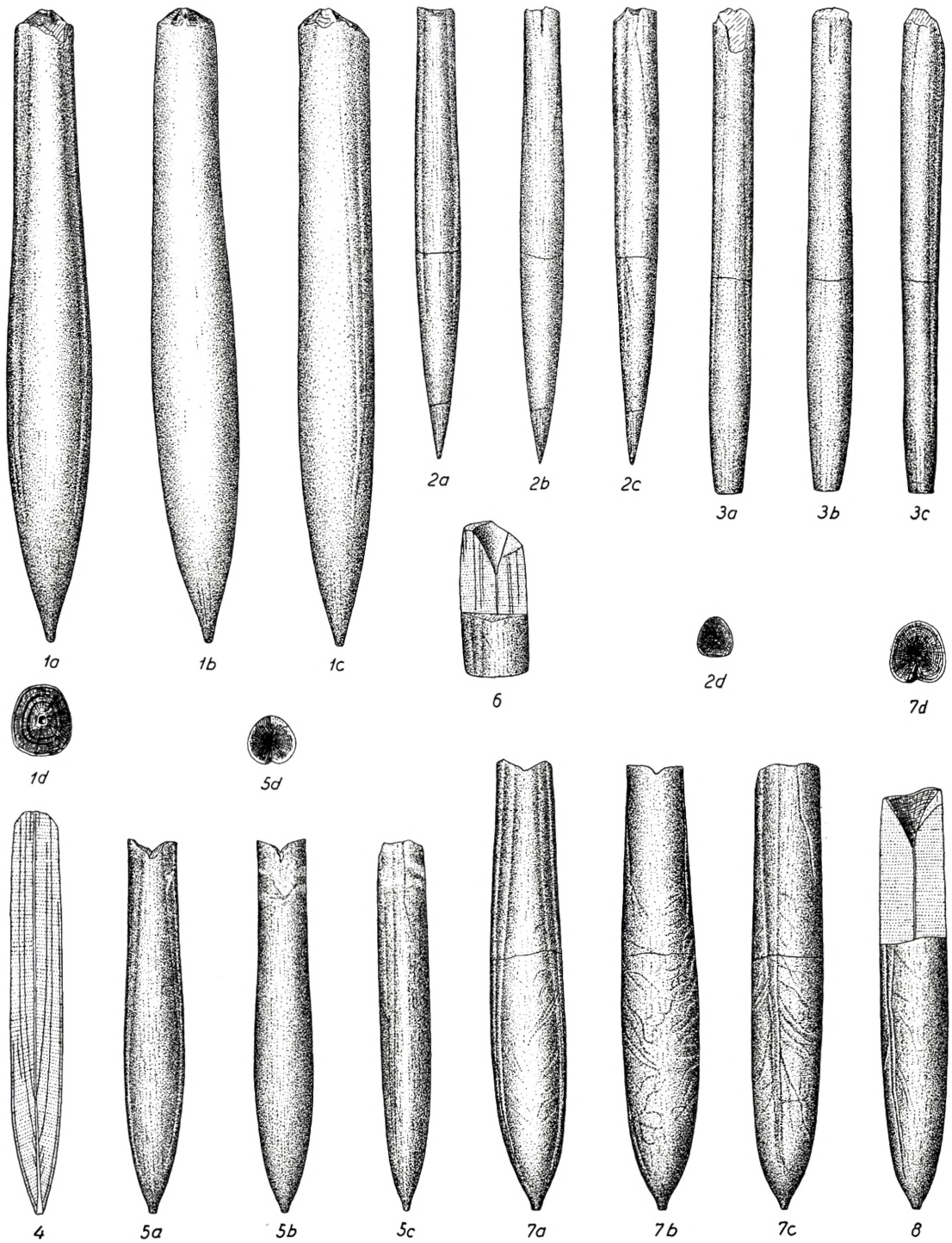

PLATE 2.

Fig. 1: *Actinocamax westfalicus* (SCHLÜTER), 1874. Upper part of the Lower Santonian. Bavnodde-greensand, Forchhammers Klint, Bornholm. *a*, dorsal view; *b*, ventral view; *c*, lateral view; *d*, view of the anterior end.

Fig. 2: *Actinocamax westfalicus* (SCHLÜTER), 1874. Lateral view, the anterior part of the specimen is split longitudinally showing the pseudoalveolus and the bottom of the ventral fissure. Upper part of the Lower Santonian. Bavnodde-greensand, Forchhammers Klint, Bornholm.

Fig. 3: *Actinocamax* aff. *westfalicus* (SCHLÜTER), 1874. Lower part of the Lower Santonian. The greensand at Jydegaard, Bornholm. *a*, dorsal view; *b*, ventral view; *c*, lateral view, the anterior part of the specimen is split longitudinally showing the rather deep pseudoalveolus and the bottom of the ventral fissure; *d*, the alveolar end.

Fig. 4: *Actinocamax verus* MILLER, 1823. Upper part of the Lower Santonian. Bavnodde-greensand, Bavnodde, Bornholm. *a*, dorsal view; *b*, ventral view; *c*, lateral view; *d*, part of the anterior ventral surface showing the ornamentation, × 15.

Fig. 5: *Actinocamax propinquus* MOBERG *ravni* n. subsp. The vascular impressions very badly preserved. Upper part of the Lower Santonian. Bavnodde-greensand, Forchhammers Klint, Bornholm. *a*, dorsal view; *b*, ventral view; *c*, lateral view, the specimen is split longitudinally showing growth stages, the pseudoalveolus with tubercles on the wall and, in the anterior part, the edges of the concentric layers of the guard and the bottom of the ventral fissure; *d*, the anterior end.

Fig. 6: *Belemnitella langei* JELETZKY, 1948. Upper part of the Upper Campanian. The western part of Hvide Klint, Møn. *a*, dorsal view; *b*, ventral view; *c*, lateral view; *d*, lateral view, the anterior part is split longitudinally showing the alveolus and the bottom of the ventral fissure.

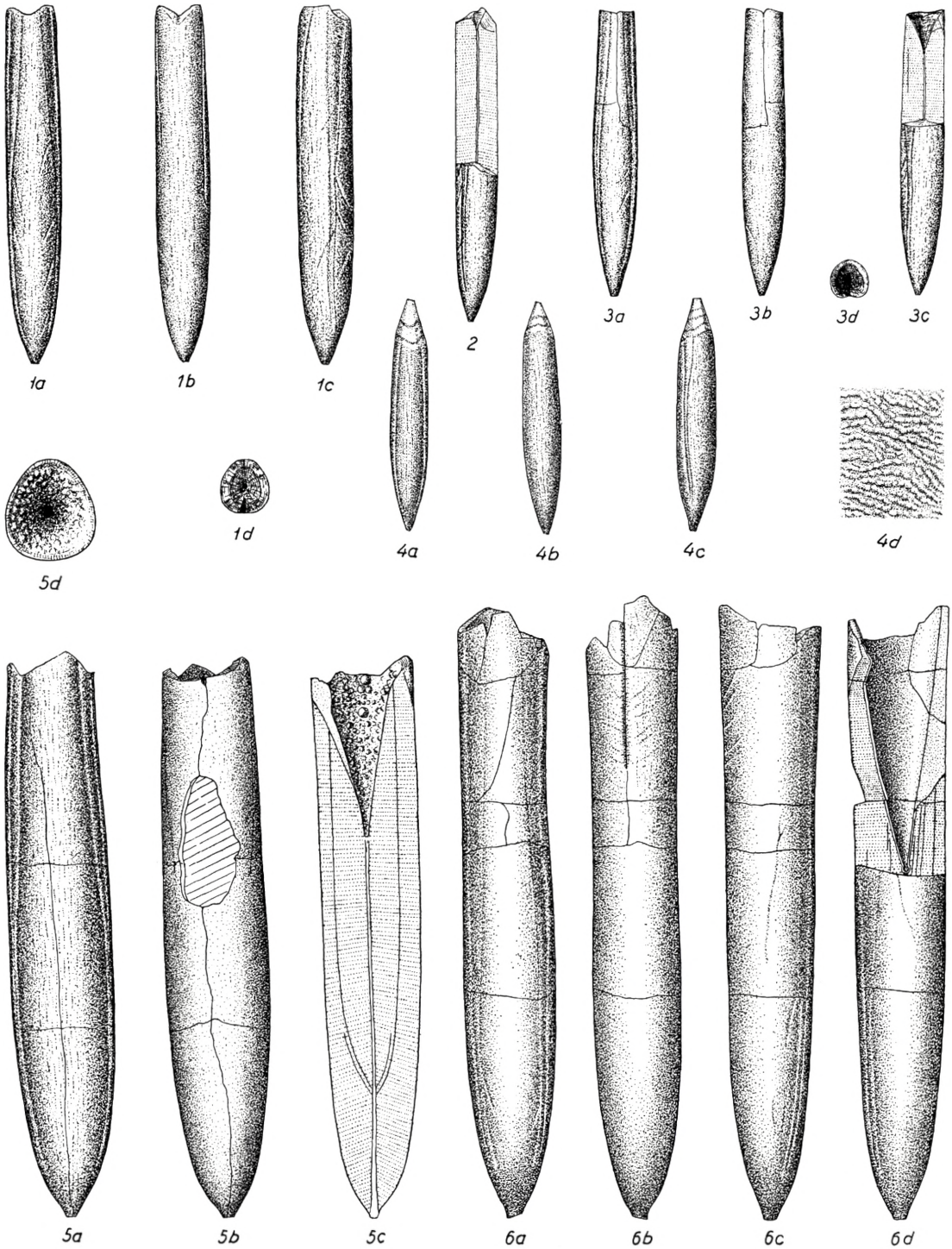
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PLATE 3.

Fig. 1: *Belemnitella langei* JELETZKY, 1948. Upper part of the Upper Campanian. The western part of Hvide Klint, Møn. *a*, dorsal view; *b*, ventral view; *c*, lateral view.

Fig. 2: *Belemnitella junior junior* (NOWAK), 1913. Upper Maastrichtian. Stevns Klint, north of the Kulsti Rende. *a*, dorsal view; *b*, ventral view; *c*, lateral view, the anterior part is split longitudinally showing the alveolus and the bottom of the ventral fissure.

Fig. 3: *Belemnitella junior nowaki* JELETZKY, 1951. Upper Maastrichtian. Stevns Klint, north of the Kulsti Rende. *a*, dorsal view; *b*, ventral view ; *c*, lateral view, the anterior part is split longitudinally showing the alveolus and the bottom of the ventral fissure.

Fig. 4: *Belemnella* aff. *lanceolata* (SCHLOTHEIM), 1813. Lower Maastrichtian. Lille Bissinge, Møn. *a*, dorsal view; *b*, ventral view; *c*, lateral view.

Fig. 5: *Belemnella* aff. *lanceolata* (SCHLOTHEIM), 1813. Lateral view, the anterior part is split longitudinally showing the alveolus and the bottom of the ventral fissure. Lower Maastrichtian, Hvidskud, Møns Klint.

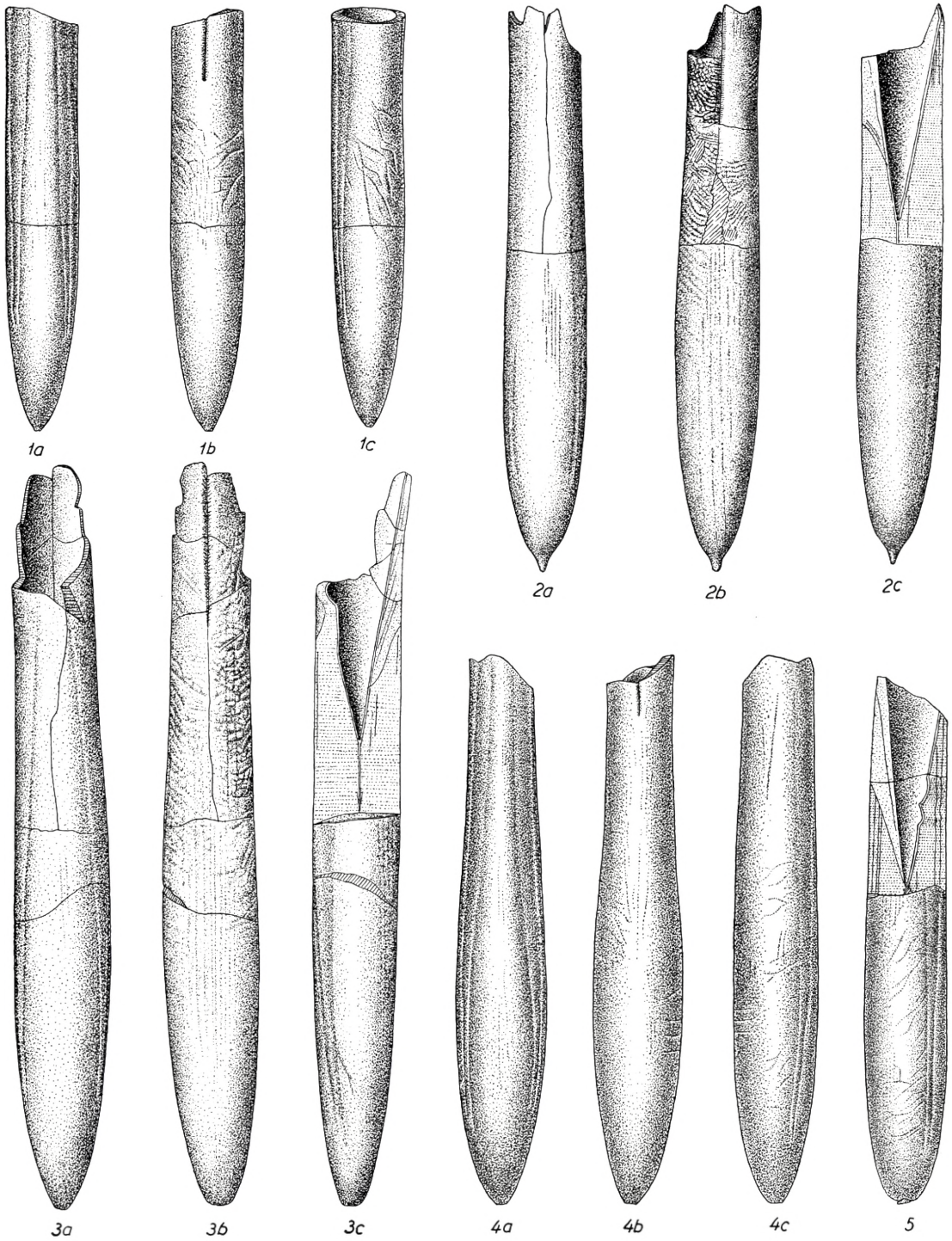
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PLATE 4.

Fig. 1: *Belemnella lanceolata lanceolata* (SCHLOTHEIM), 1813. Lower Maastrichtian. Møns Klint. *a*, dorsal view; *b*, ventral view; *c*, lateral view.

Fig. 2: *Belemnella lanceolata lanceolata* (SCHLOTHEIM), 1813. Lower Maastrichtian. The eastern part of Hvide Klint, Møn. *a*, dorsal view; *b*, ventral view; *c*, lateral view.

Fig. 3: *Belemnella lanceolata lanceolata* (SCHLOTHEIM), 1813. Lateral view, the anterior part is split longitudinally showing the alveolus and the bottom of the ventral fissure. Lower Maastrichtian. The eastern part of Hvide Klint, Møn.

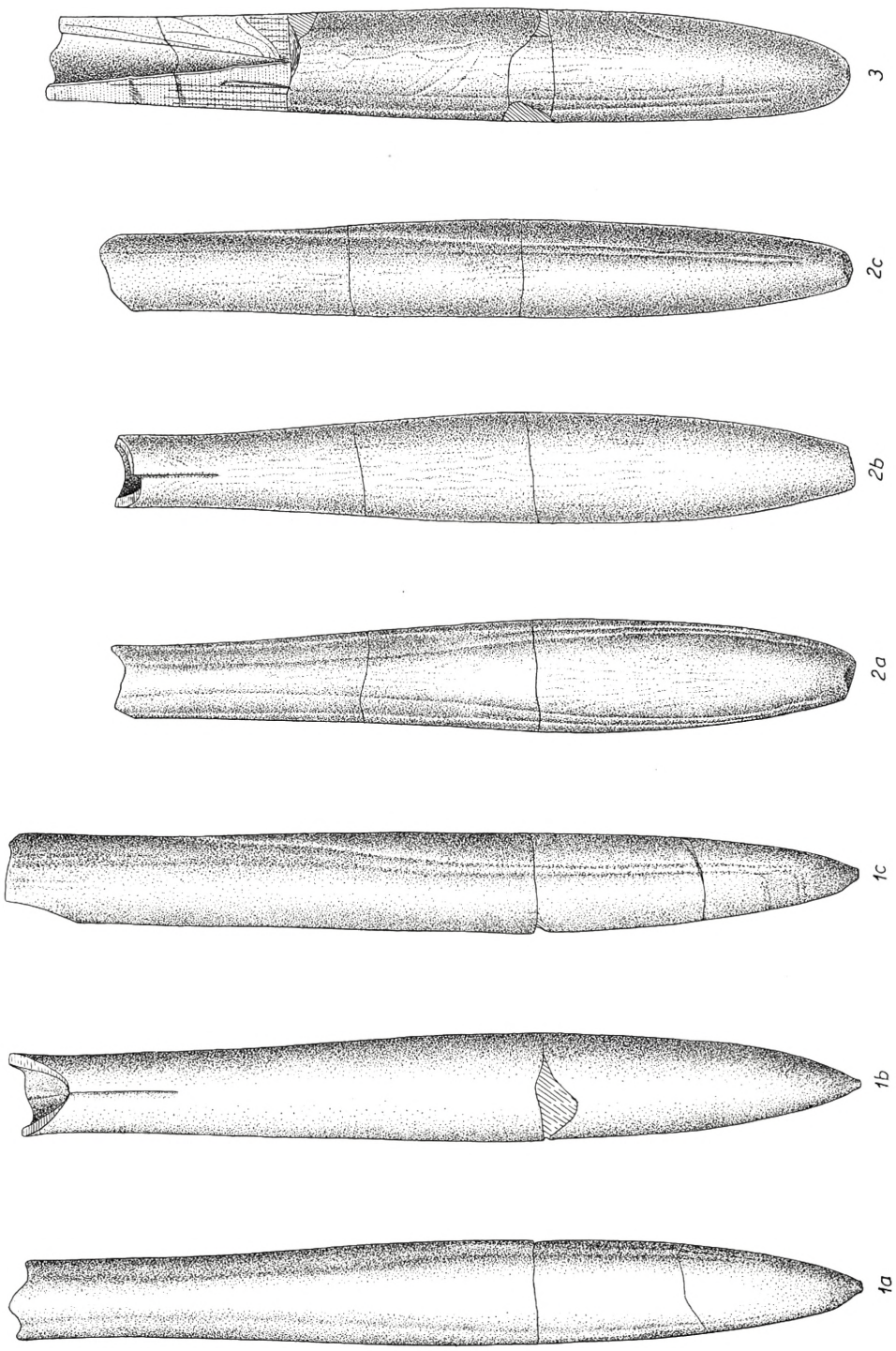
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PLATE 5.

Fig. 1: *Belemnella occidentalis occidentalis* n. nom. A very large specimen. Lower Maastrichtian. Sommerspiret, Møns Klint. *a*, dorsal view; *b*, ventral view; *c*, lateral view.

Fig. 2: *Belemnella occidentalis cimbrica* n. subsp. Holotype. The upper part of the Lower Maastrichtian. "Rørdal" chalk-pit, Aalborg. *a*, dorsal view; *b*, ventral view; *c*, lateral view, the anterior part is split longitudinally showing the alveolus and the bottom of the ventral fissure.

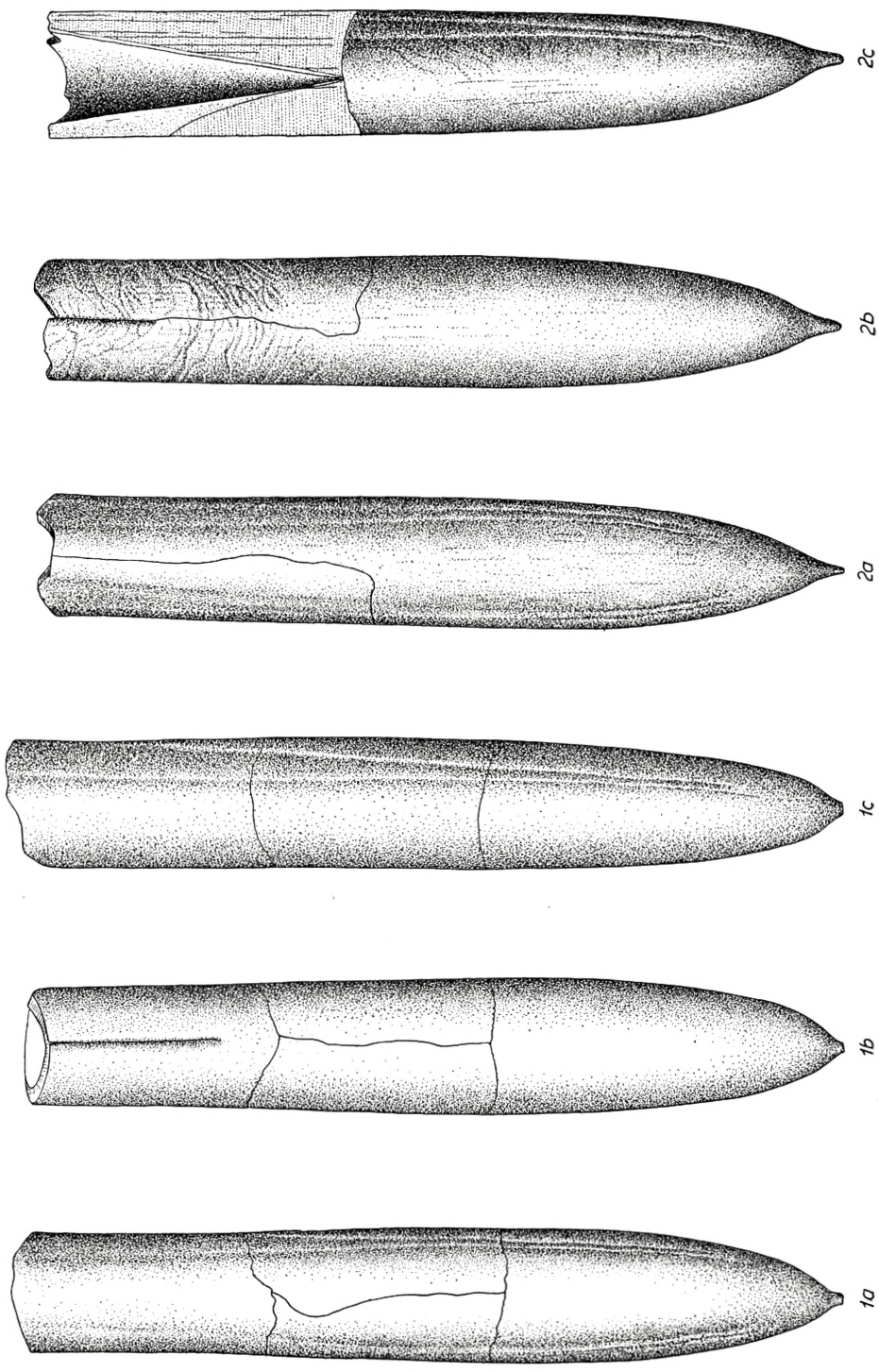
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PLATE 6.

Fig. 1: *Belemnella occidentalis occidentalis* n. nom. Type. Lower Maastrichtian. Maglevandspynten, Møns Klint. *a*, dorsal view; *b*, ventral view; *c*, lateral view, the anterior part is split longitudinally showing the alveolus and the bottom of the ventral fissure.

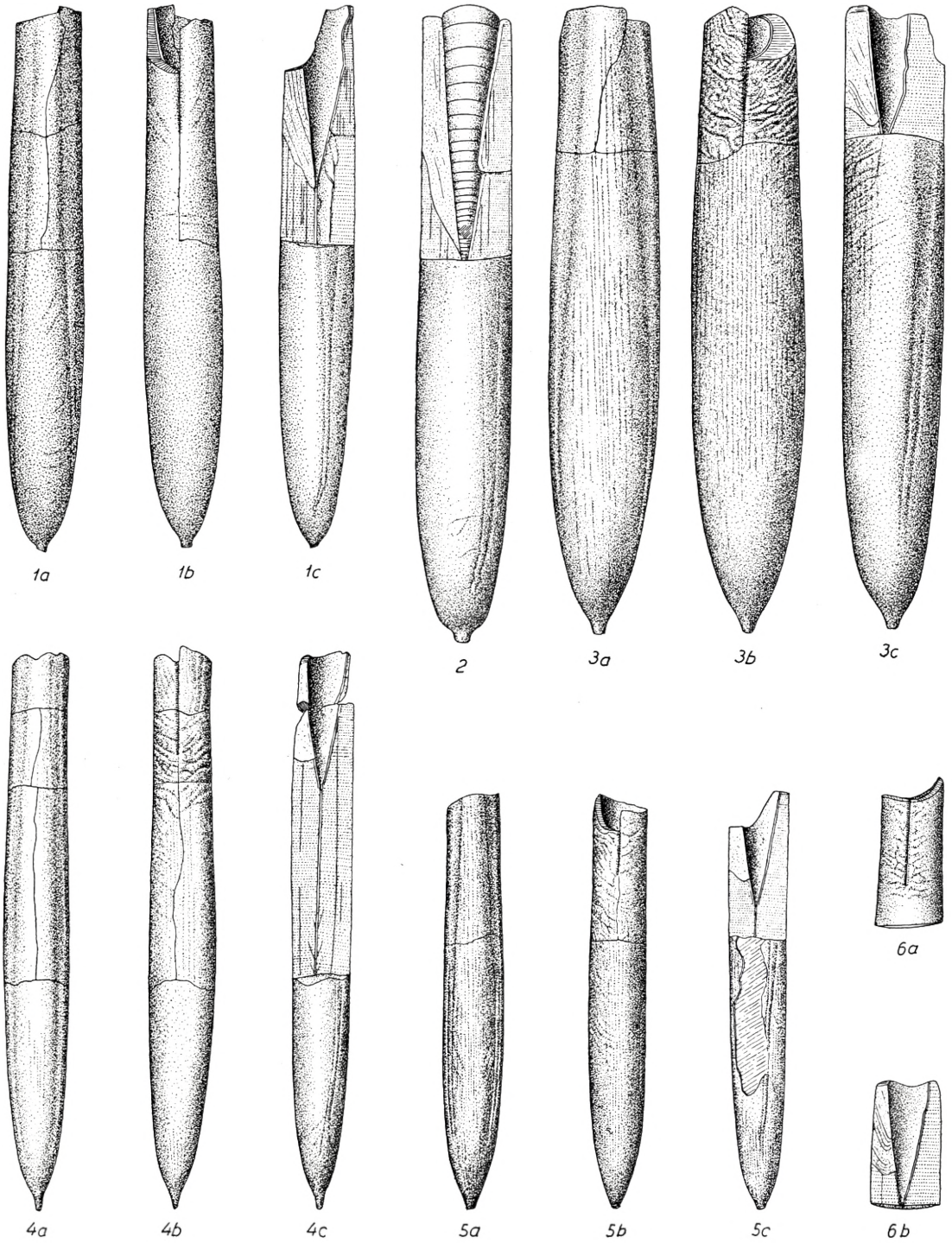
Fig. 2: *Belemnella occidentalis occidentalis* n. nom. Lateral view, the anterior part is split longitudinally showing the silicified phragmocone and the bottom of the ventral fissure. Lower Maastrichtian. Lille Stejlebjerg, 10 m below the indurated layer, Møns Klint.

Fig. 3: *Belemnella casimirovensis* (SKOLOZDRÓWNA), 1932 n. subsp.? The upper part of the Upper Maastrichtian. "Dania" chalk-pit at Mariager. *a*, dorsal view; *b*, ventral view; *c*, lateral view, the anterior part is split longitudinally showing the alveolus and the bottom of the ventral fissure.

Fig. 4: *Bellemnella casimirovensis casimirovensis* (SKOLOZDRÓWNA), 1932. The upper part of the Upper Maastrichtian. North of the Kulsti Rende, Stevns Klint. *a*, dorsal view; *b*, ventral view; *c*, lateral view, the anterior part is split longitudinally showing the alveolus and the bottom of the ventral fissure.

Fig. 5: *Belemnella casimirovensis archangelskyi* JELETZKY, 1951. The upper part of the Upper Maastrichtian. "Dania" chalk-pit at Mariager. *a*, dorsal view; *b*, ventral view; *c*, lateral view, the anterior part is split longitudinally showing the alveolus and the bottom of the ventral fissure.

Fig. 6: *Belemnella casimirovensis* (SKOLOZDRÓWNA), 1932. Upper Maastrichtian. Geulem at Valkenburg, Limburg, Nederland. *a*, the anterior part of the guard in ventral view; *b*, the anterior part of the guard in lateral view, the fragment is split longitudinally showing the bottom of the ventral fissure.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