acta
geologica
polonica

Vol. 40, No. 1–2 Warszawa 1990

DANUTA OLSZEWSKA

# Belemnites from the Upper Cretaceous chalk of Mielnik (eastern Poland)

ABSTRACT: In the chalk deposits exposed at Mielnik-on-Bug (eastern Poland) the assemblage of belemnites comprises four species: *Gonioteuthis* sp., *Belemnellocamax mammillatus* (NILSSON), *Belemnitella mucronata* (SCHLOTHEIM), and *Belemnella (Pachybelemnella) inflata* (ARKHANGELSKY), which assess the section to the intervals: the uppermost Lower Campanian, through the lowermost Upper Campanian, and the lowermost Maastrichtian. A stratigraphic gap associated with the hardground horizon is ascribed to the upper part of the Upper Campanian (Belemnitella langei Zone).

## INTRODUCTION

The belemnite-yielding chalk deposits exposed at Mielnik-on-Bug in eastern Poland (Text-fig. 1) were firstly reported and classified as of Senonian age by GIEDROYĆ (1886). Further recognition was presented by BIEDA (1958) who documented a Campanian and Maastrichtian age of the Mielnik chalk (*see also* POŻARYSKI 1960) with the boundary lying at the hardground level (*see* Text-fig. 2). While the subsequent studies generally confirmed a Maastrichtian age of the chalk above the hardground, the stratigraphic position of the lower part of the section was variously interpreted, with attributed stratigraphic position ranging between the Lower (GAŹDZICKA 1981, COLLINS & RADWAŃSKI 1982) or the Upper Campanian (ŁYSOGÓRSKI 1960, PERYT 1981) and the Lower Maastrichtian (BITNER & PISERA 1979).

The belemnites from the studied section have never been carefully elaborated besides the unpublished M. Sc. paper by ŁYSOGÓRSKI (1960) who recorded *Belemnitella mucronata* (SCHLOTHEIM), *B. langei* JELETZKY, and *Belemnella lanceolata* (SCHLOTHEIM). More recently Professor D. P. NAIDIN, University of Moscow, recognized also (*vide* GAŹDZICKA 1981, COLLINS & RADWAŃSKI 1982) such species as *Gonioteuthis gracilis* (STOLLEY) and *Belemnellocamax mammillatus* (NILSSON)

The belemnite guards from the Mielnik chalk are of various state of preservation. Besides the well preserved specimens most of them are

biogenically and/or mechanically corroded. Endo- and epibionthic bioerosion (*see* PUGACZEWSKA 1965, RADWAŃSKI 1972, OLSZEWSKA 1987) obliterated, in some cases, completely the original guard surfaces. The mechanical destruction is indicated by the presence of numerous transversally cracked guards.

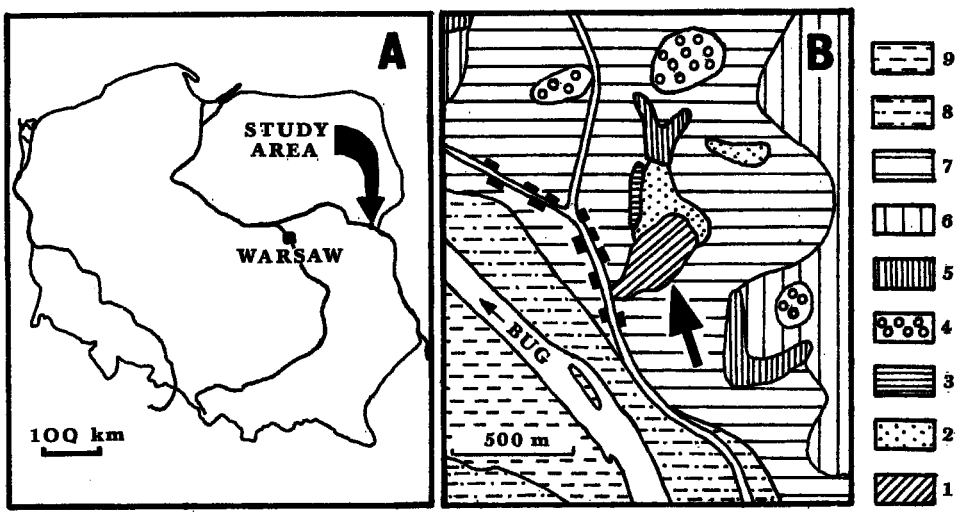



Fig. 1. Geologic setting of Mielnik-on-Bug region (*after* STAŚKIEWICZ 1971; *modified*)
**A** — Location of the study area in Poland
**B** — Geologic sketch-map of Mielnik-on-Bug region
UPPER CRETACEOUS: **1** — white chalk. TERTIARY: **2** — glauconitic-quartz sands (Oligocene), **3** — quartz sands (Miocene). PLEISTOCENE: **4** — gravels and boulders of end moraine, **5** — till, **6** — sands and boulders overlying the till, **7** — sands and boulders of fluvioglacial accumulation, **8** — sands of accumulation terrace. HOLOCENE: **9** — muds and sands of flood-plain terrace

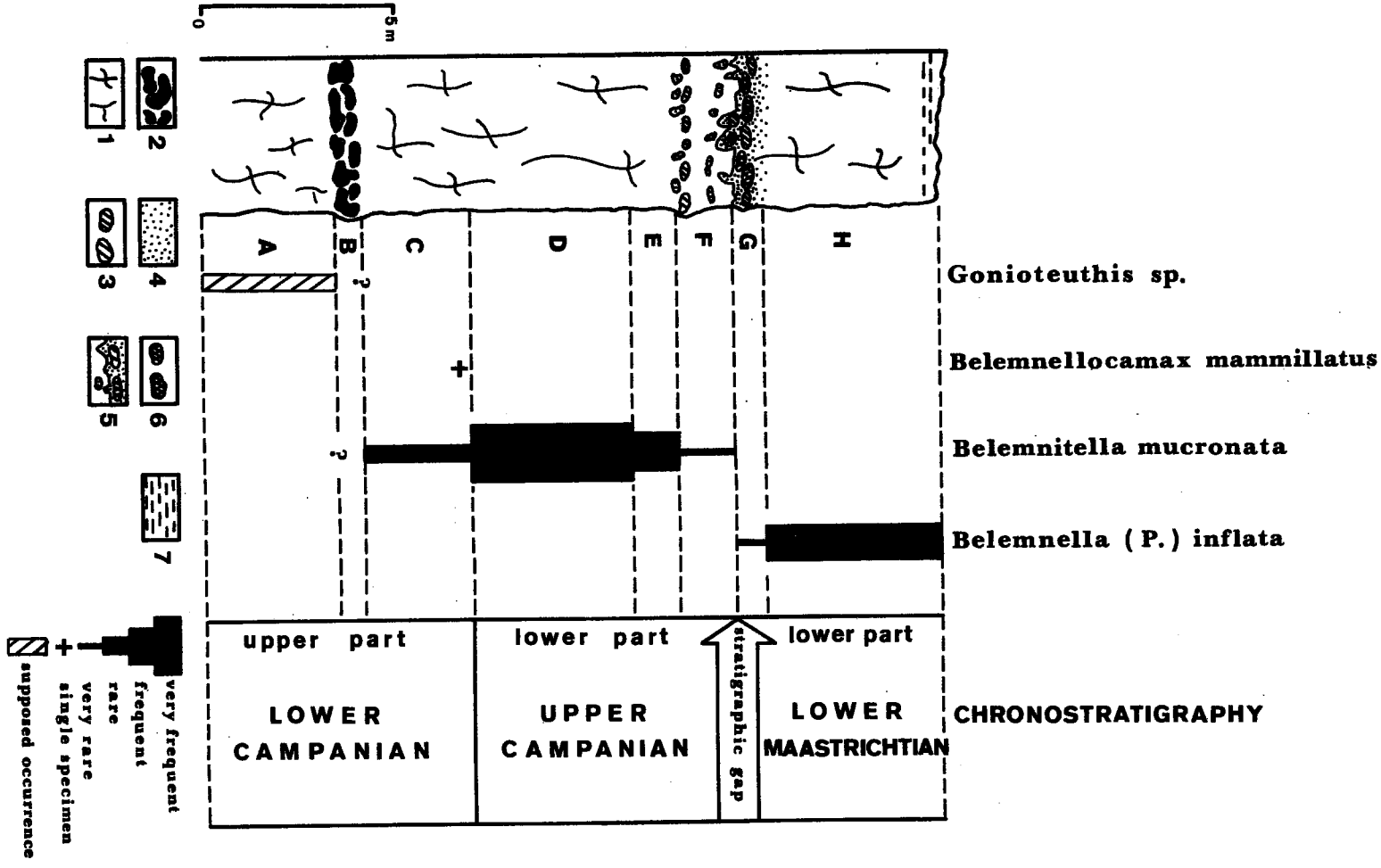
The analysis of distribution and frequency of particular belemnite taxa allowed the division of the studied section into 8 local stratigraphic units (*A* to *H*), and their detailed correlation with a standard division (Text-fig. 2).

The studied material is housed at the Geological Institute of the University of Warsaw.

---

## Fig. 2

Lithology and stratigraphy based on belemnites of white chalk exposed at Mielnik-on-Bug
**A-H** — local stratigraphic units
**1** — white chalk, **2** — flints, **3** — cemented nodules of chalk, **4** — chalk with glauconite, **5** — hardground, **6** — phosphatic pieces, **7** — marly chalk


0
5m
1
2
3
4
5
6
7
A
B
C
D
E
F
G
H
?
?
Gonioteuthis sp.
Belemnellocamax mammillatus
Belemnitella mucronata
Belemnella ( P.) inflata
upper part
lower part
lower part
stratigraphic gap
LOWER CAMPANIAN
UPPER CAMPANIAN
LOWER MAASTRICHTIAN
CHRONOSTRATIGRAPHY
very frequent
frequent
rare
very rare
single specimen
supposed occurrence

## REMARKS ON PALEOGEOGRAPHY OF LATE CRETACEOUS BELEMNITES

Within the Euro-American region in the Late Cretaceous CHRISTENSEN (1976) distinguished, with aid of the belemnite fauna, two paleobiogeographic realms: the North Temperate Realm, characterized by the family Belemnitellidae PAVLOV, and the South Temperate Realm with the dominant family Dimitobelidae WHITEHOUSE. The North Temperate Realm he divided into the North American and the North European Province. The latter stretches from Ireland in the west to the Urals in the east, being bordered to the south by the Tethyan Realm (*see* Text-fig. 3). The Campanian and Maastrichtian genera occurring in the North European Province are represented by: *Actinocamax* MILLER, *Belemnellocamax* NAIDIN, *Gonioteuthis* BAYLE, *Belemnitella* d'ORBIGNY, *Belemnella* NOWAK, and *Fusiteuthis* KONGIEL.

In the Late Coniacian, Santonian and Early Campanian in the North European Province it is possible to distinguish the Central European and the Central Russian Subprovince characterized by the presence of *Gonioteuthis* and *Belemnitella* stocks, respectively. Throughout the area of the Russian Platform these two subprovinces coincide well with the Southwestern and the Northeastern Province distinguished earlier by NAIDIN (1969b). With the end of the Early Campanian a gradual unification of belemnite fauna starts in both

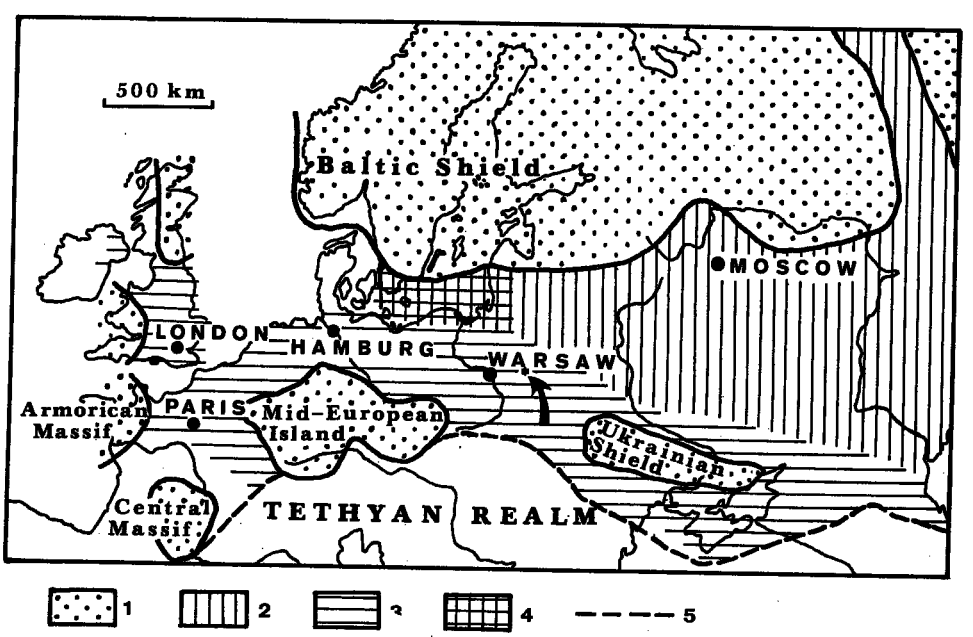



Fig. 3. Distribution of Late Cretaceous biogeographical units in Europe, based on belemnites (*after* CHRISTENSEN 1976); arrow points to Mielnik-on-Bug locality

**1** — land areas, **2** — Central Russian Subprovince, **3** — Central European Subprovince, **4** — zone of interfingering of belemnite faunas from the two subprovinces, **5** — boundary between North European Province and Tethyan Realm

subprovinces and the common occurrence of the genera *Gonioteuthis*, *Belemnellocamax* and *Belemnitella* is noted in many areas of extra-Alpine Europe (eastern part of Russian Platform, northern Germany, Scania). This is also a case at Mielnik-on-Bug where *Gonioteuthis* sp., *Belemnellocamax mammillatus* and *Belemnitella mucronata* cooccur (Text-fig. 2).

## SYSTEMATIC ACCOUNT

The studied collection of belemnites from Mielnik-on-Bug contains above 200 specimens, about 100 of which could have been subjected to biometric analysis. The majority of specimens comes from the local stratigraphic units *A*, *D*, and *H* (*see* Text-fig. 2)

The classification scheme applied here is accepted after CHRISTENSEN (1975).

### MEASUREMENT AND ABBREVIATIONS

The measured characters and abbreviations used in the text are given below (Text-fig. 4; *see also* CHRISTENSEN 1975):

**LAP** — length from apex to protoconch, in mm;
**DVDP** — dorso-ventral diameter at protoconch, in mm;
**SI** — Schatsky index, in mm;
**AA** — alveolar angle, in degrees;
**FA** — fissure angle, in degrees.

Estimates of the following statistics were calculated: N — number of specimens, X — mean value, SD — standard deviation, OR — observed range.

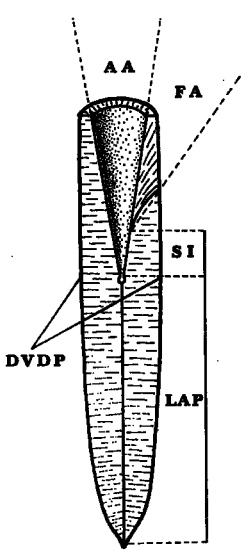



Fig. 4
Morphological elements of the split guard

## Class **Cephalopoda** CUVIER, 1794
## Subclass **Coleoidea** BATHER, 1888
## Order **Belemnitida** ZITTEL, 1895
## Suborder **Belemnopseina** JELETZKY, 1965
## Family **Belemnitellidae** PAVLOV, 1914

### Genus *Gonioteuthis* BAYLE, 1879
### *Gonioteuthis* sp.
### (Pl. 1, Figs 1—2)

MATERIAL: 21 uncomplete guards with their parts close to alveolus weathered; uncertain position in the section, probably units *A*, *B* or *C* (*see* Text-fig. 2).

DESCRIPTION: The guard is small, slender, cylindrical, rarely coniform in shape. Its maximum length is 55 mm, with average value about 40—45 mm. The respective values for width are 11 and 9 mm. The surface bears slight granulation, particularly well developed on the ventral side. Double, ventro-lateral furrows are straight. Lateral bloodvessels are sparse and poorly developed. Vascular angle is less than 30°, and in one case slightly above this value.

REMARKS: Some specimens of the genus *Gonioteuthis* from Mielnik were referred by Professor D. P. NAIDIN to as *Gonioteuthis gracilis* (STOLLEY).

STRATIGRAPHIC and GEOGRAPHIC OCCURRENCE: Within Central European Subprovince *Gonioteuthis* BAYLE is common from the Middle Coniacian up to the Lower Campanian; *G. gracilis* (STOLLEY) is an index species of the upper part of the Lower Campanian within the North European Province (CHRISTENSEN 1975, 1986).

### Genus *Belemnellocamax* NAIDIN, 1964
### *Belemnellocamax mammillatus* (NILSSON, 1827)
### (Pl. 1, Fig. 4 and Pl. 2, Figs 1—2)

1964b. *Belemnellocamax mammillatus mammillatus* (NILSSON); D. P. NAIDIN, pp. 156—161, Pl. 9, Figs 3—5.
1975. *Belemnellocamax mammillatus mammillatus* (NILSSON); W. K. CHRISTENSEN, pp. 43—46, Pl. 3, Figs 6—9; Pl. 4, Figs 1—8.
1984. *Belemnellocamax mammillatus mammillatus* (NILSSON); A. BŁASZKIEWICZ, p. 403, Pl. 175, Fig. 1.
1986. *Belemnellocamax mammillatus mammillatus* (NILSSON); W. K. CHRISTENSEN, p. 29, Pl. 2, Figs 3—5.

MATERIAL: 3 guards; one relatively well preserved, complete specimen from unit *C*; one incomplete specimen with uncertain position in the section (collection of Ass.-Professor R. MARCINOWSKI); and one specimen with broken apical part (collection of M. MACHALSKI, M. Sc.).

DESCRIPTION: The guard is massive, lanceolate in ventral and cylindrical in lateral view, markedly compressed in lateral plane at the ventral side (Pl. 2, Fig. 1d). Concentric growth layers are well visible in cross section. Double ventro-lateral furrows are poorly developed. Imprints of bloodvessels are obliterated due to weathering. The pseudoalveolus is shallow, subtriangular in cross section; with concentric growth layers well visible on its surface; ventral fissure short.

STRATIGRAPHIC and GEOGRAPHIC OCCURRENCE: The species *Belemnellocamax mammillatus* (NILSSON) is an index form of the uppermost part of the Lower Campanian, being commonly noted in Scania and in the eastern part of the Russian Platform. Single specimens were also found in northern Germany and in NE border of the Ukrainian Syneclise (*vide* NAIDIN 1964b; CHRISTENSEN 1975, 1986). The former reports from Poland concern a specimen from the Pagórki borehole (Polish Lowland); which was noted by CIEŚLIŃSKI (1960), and illustrated later by BŁASZKIEWICZ (1984), and one fragment from Mielnik determined by Professor D. P. NAIDIN (*vide* GAŹDZICKA 1981, COLLINS & RADWAŃSKI 1982).

## Genus *Belemnitella* d'ORBIGNY, 1840

Because of general problems with species discrimination of the genus from Mielnik was treated statistically and compared to the rich *Belemnitella* assemblage coming from the uppermost Campanian of the Vistula section in Central Poland, and collected by the late Professor R. KONGIEL.

The material from Mielnik comprises 72 almost complete guards from units *C, D, E,* with maximum number of specimens from unit *D* (*see* Text-fig. 2).

### Table 1

Univariate analysis of the genus *Belemnitella* from Mielnik

| Character | N | X | SD | OR |
|---|---|---|---|---|
| *LAP* | 72 | 44.8 | 6.4 | 26.5-57.5 |
| *DVDP* | 72 | 13.9 | 2.2 | 7.8-17.7 |
| *SI* | 72 | 10.9 | 1.7 | 7.8-14.8 |
| *AA* | 72 | 20.1 | 1.2 | 18-23 |
| *FA* | 72 | 16.4 | 5.8 | 10-37 |

The frequency distribution of 5 characters is shown in histograms (Text-fig. 5) which display an asymmetric distribution of particular traits. The hypothesis of their normal distribution was examined by means of Kolmogorov-Smirnov test for goodness of fit. The obtained results indicate the homogeneous sample, what suggests the whole assemblage to represent probably one species. The measured parameters of the *Belemnitella* assemblage from Mielnik are very close to those reported by CHRISTENSEN & *al.* (1975) for the belemnite assemblage of *Belemnitella mucronata mucronata* (SCHLOTHEIM) from the type locality Misburg near Hannover. The only difference concerns the slightly greater value of the Schatsky index and the slightly lower value of the fissure angle in the material from Mielnik (*see* Table 1; *compare* CHRISTENSEN & *al.* 1975; p. 41).

When treated typologically, some species of the *Belemnitella* assemblage from Mielnik could, however, be easily compared to *Belemnitella minor* JELETZKY, and one species to *B. langei* JELETZKY as distinguished by KONGIEL (1962) from the Vistula section.

In a case of *B. minor* JELETZKY, the problem of its distinction from *B. mucronata* (SCHLOTHEIM) has widely been discussed in the last decades (CHRISTENSEN & *al.* 1975; CHRISTENSEN 1986, 1988; ROBASZYNSKI & CHRISTENSEN 1989). The reservation to the independence of *B. minor* JELETZKY appeared particularly after a restudy of the holotype of JELETZKY's species by CHRISTENSEN & *al.* (1975), which showed the real values of the fissure angle to be much lower than originally cited by JELETZKY (1951) and falling well within the variability range of *B. mucronata* (SCHLOTHEIM).

According to KONGIEL (1962), in the Vistula section *B. mucronata* (SCHLOTHEIM), *B. minor* JELETZKY, and *B. langei* JELETZKY occur throughout the Upper Campanian. Because of some discrepancy between KONGIEL's (1962) data and recent view (*see e.g.* CHRISTENSEN 1975) concerning both the taxonomy and stratigraphic distribution of these species, the Author undertook a restudy of the whole *Belemnitella* assemblage from the KONGIEL's collection.

This collection, housed at the Museum of the Earth in Warsaw (Cataloque Nos: VIII Mcd), comprises 493 specimens of the genus *Belemnitella* from horizons *k-v* of POŻARYSKI (1938), corresponding to the Upper Campanian (horizons *k-t*) and the lowermost Maastrichtian (horizons

*u-v*). The number of specimens from particular horizons varies greatly, but the statistically important samples are limited to the horizons *r*, *s* and *t*, corresponding in the ammonite zonation to the Didymoceras donetzianum and the Nostoceras pozaryskii Zone, according to BŁASZKIEWICZ (1980). While a detailed elaboration of the whole collection is in progress, the statistics made on the *Belemnitella* assemblage from the horizon *t*, with relatively highest number of specimens is here presented. Moreover, a preliminary range chart of the distinguished *Belemnitella* species in the Vistula section is completed (Text-fig. 6).

The whole belemnite assemblage from the horizon *t* comes from the huge quarry at Piotrawin. The statistically treated sample contain 256 specimens, with 124 specimens preserved completely.

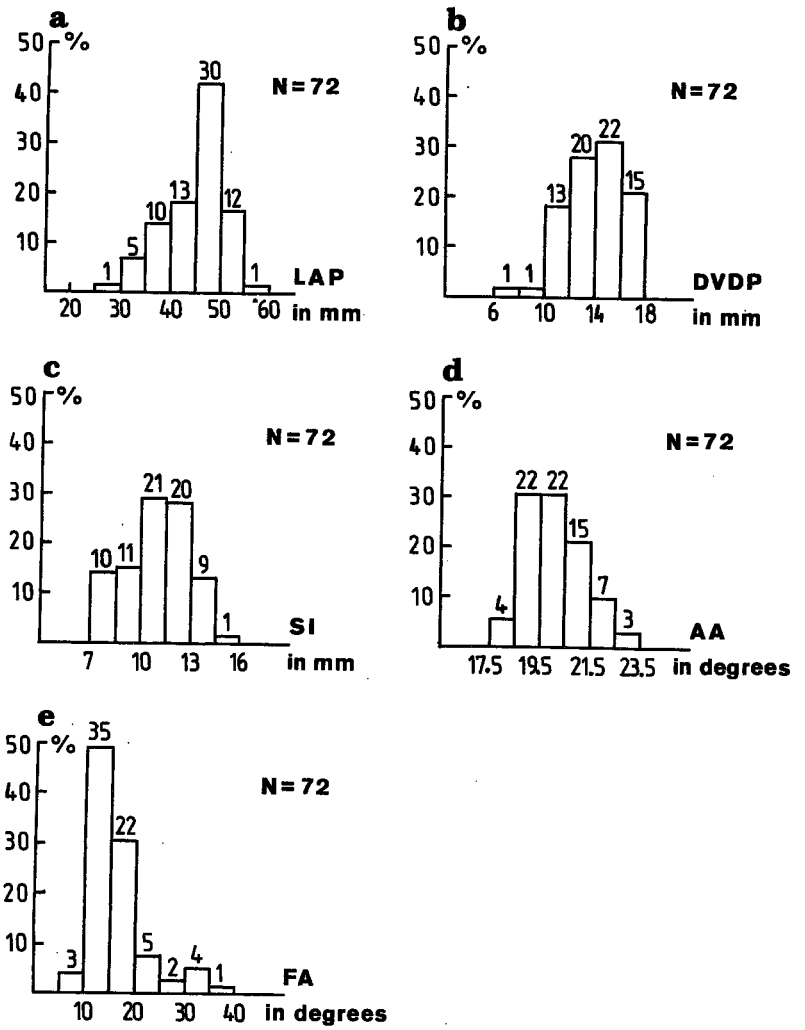



Fig. 5. Histograms of five characters of the genus *Belemnitella* from Mielnik-on-Bug
Number of specimens in every class is given above the bars
*N* — number of specimens, *LAP* — length from apex to protoconch, *DVDP* — dorso-ventral diameter at protoconch, *SI* — Schatsky index, *AA* — alveolar angle, *FA* — fissure angle

RESULTS: Frequency distribution of *LAP*, *DVDP*, *SI*, *AA*, is asymmetric (*see* Text-fig. 7*a-d*). Their examination for normality made by means of Kolmogorov-Smirnov test for goodness of fit shows a normal distribution of these characters at the 95% confidence level. The normal distribution is rejected in the case of *FA* (*see* Text-fig. 7*e*). In respect to this characteristic the whole sample may be divided into three subgroups:

**A** — the subgroup with *FA* 5—40°
**B** — the subgroup with *FA* 45—70°
**C** — the subgroup with *FA* 75—135°

which in turn were examined again by means of univariate analysis of particular characters (*see* Table 2) and their normality controlled with Kolmogorov-Smirnov test for goodness of fit.

The frequency distribution of particular characters (*see* Text-fig. 8) in subgroups *A*, *B*, and *C* examined with Kolmogorov-Smirnov test for goodness

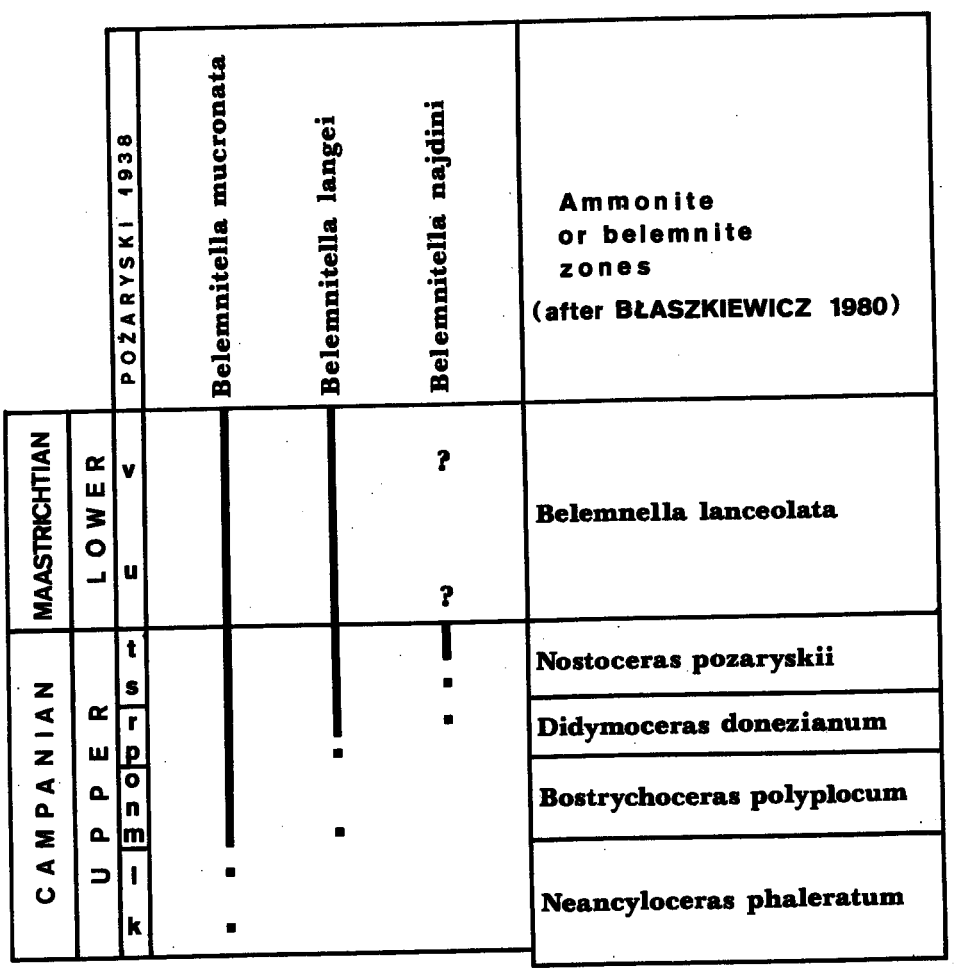



Fig. 6. Stratigraphic extent of *Belemnitella mucronata* (SCHLOTHEIM), *B. langei* JELETZKY, and *B. najdini* KONGIEL in Upper Campanian — Lower Maastrichtian section in the Middle Vistula Valley, Central Poland

of fit at the 95% confidence level shows their normal distribution, suggesting the homogeneous samples.

Table 2

A. Univariate analysis of the subgroup with *FA* 5-40°

| Character | N | X | SD | OR |
|---|---|---|---|---|
| *LAP* | 85 | 45.9 | 6.7 | 26.0-58.8 |
| *DVDP* | 159 | 11.2 | 2.0 | 5.9-16.2 |
| *SI* | 159 | 7.1 | 1.3 | 4.9-10.8 |
| *AA* | 159 | 20.3 | 0.8 | 18-23 |
| *FA* | 159 | 25.1 | 7.7 | 10-40 |

B. Univariate analysis of the subgroup with *FA* 45-70°

| Character | N | X | SD | OR |
|---|---|---|---|---|
| *LAP* | 29 | 43.3 | 6.7 | 32.7-56.7 |
| *DVDP* | 68 | 10.3 | 1.6 | 7.2-15.1 |
| *SI* | 68 | 7.0 | 1.4 | 4.1-10.9 |
| *AA* | 68 | 20.4 | 0.8 | 19-23 |
| *FA* | 68 | 56.0 | 7.1 | 46-70 |

C. Univariate analysis of the subgroup with *FA* 75-135°

| Character | N | X | SD | OR |
|---|---|---|---|---|
| *LAP* | 8 | 43.6 | 8.8 | 30.1-59.8 |
| *DVDP* | 22 | 9.5 | 1.5 | 6.9-13.5 |
| *SI* | 22 | 6.2 | 1.3 | 4.6-9.6 |
| *AA* | 22 | 20.9 | 0.8 | 20-23 |
| *FA* | 22 | 95.8 | 14.6 | 76-132 |

RESULTS: The analysis of the *Belemnitella* sample from the horizon *t* from the Vistula section, seems to indicate that the only diagnostic trait, allowing a subdivision within the *Belemnitella* assemblage, is the fissure angle (*FA*). The three distinguished subgroups, *i.e.* A — with *FA* 5—40°, B — with *FA* 45—70° and C — with *FA* 75—135° correspond to the characteristics of *Belemnitella mucronata* (SCHLOTHEIM), *B. langei* JELETZKY, and *B. najdini* KONGIEL, respectively. There is no possibility to distinguish statistically *B. minor* JELETZKY and *B. posterior* KONGIEL, which within the horizon *t* were noted by KONGIEL (1962). The Author agrees with a suggestion of ROBASZYNSKI & CHRISTENSEN (1989) that both these species most probably do not represent independent species. The species *B. minor* JELETZKY is probably synonymous with *B. mucronata* (SCHLOTHEIM), while the forms included by KONGIEL (1962) to his new species *B. posterior* KONGIEL, with respect to their fissure angle belong to *B. mucronata* (SCHLOTHEIM), *B. langei* JELETZKY or *B. najdini* KONGIEL.

## *Belemnitella mucronata* (SCHLOTHEIM, 1813)
## (Pl. 1, Fig. 3; Pl. 3, Figs 1—2; Pl. 4, Figs 1—2; Pl. 5, Fig. 1)

1912. *Belemnitella mucronata* SCHLOTHEIM; A. D. ARKHANGELSKY, p. 600, Pl. 9, Figs 3, 9, 23, 26; Pl. 10, Fig. 10.
1913. *Belemnitella mucronata* SCHLOTHEIM sp. mut. *senior*; J. NOWAK, pp. 395—398, Pl. 42, Fig. 22.
1946. *Belemnitella mucronata* SCHLOTHEIM; J. A. JELETZKY, Text-fig. 1b.
1950. *Belemnitella mucronata* SCHLOTHEIM; W. K. VASSILENKO & S. S. RAZMYSLOVA, Text-fig. 1.
1951. *Belemnitella mucronata* mut *senior* NOWAK; J. A. JELETZKY, p. 81, Pl. 1, Fig. 4; Pl. 2, Fig. 1.
1951. *Belemnitella mucronata* mut *minor* JELETZKY; J. A. JELETZKY, pp. 87—90, Pl. 1, Fig. 3.
1952. *Belemnitella mucronata* (SCHLOTHEIM); D. P. NAIDIN, pp. 82—84, Pl. 8, Figs 1—4; Pl. 19, Fig. 1; Text-figs 26—27.
1957. *Belemnitella langei* JELETZKY; T. BIRKELUND, Pl. 2, Fig. 6a-d.
1958. *Belemnitella mucronata* SCHLOTHEIM; J. J. NIKITIN, pp. 17—19, Pl. 7, Figs 1—5; Pl. 8, Figs 1, 3; Pl. 9, Figs 1—2, 4; Pl. 10, Fig. 1.
1960. *Belemnitella mucronata* (SCHLOTHEIM); K. ŁYSOGÓRSKI, pp. 33—36, Pl. 1, Fig. 2; Pl. 2, Figs 1, 3—4.

1960. *Belemnitella langei* JELETZKY; K. ŁYSOGÓRSKI; pp. 36—38, Pl. 2, Figs 2, 5—8.
1962. *Belemnitella mucronata* JELETZKY; R. KONGIEL, pp. 92—95, Pl. 17, Figs 13—15; Pl. 18, Figs 1—12.
1962. *Belemnitella minor* JELETZKY; R. KONGIEL, Pl. 14, Figs 4—12; Pl. 15, Figs 1—3, 7—12; Pl. 16, Figs 1—3.
1962. *Belemnitella posterior* KONGIEL; R. KONGIEL, Pl. 19, Figs 7—9.
1964a. *Belemnitella mucronata mucronata* ARKHANGELSKY; D. P. NAIDIN, p. 89.
1969a. *Belemnitella mucronata senior*; D. P. NAIDIN, Pl. 1, Fig. 1; Pl. 3, Figs 1,5.
1971. *Belemnitella mucronata mucronata* (SCHLOTHEIM) sensu ARKHANGELSKY; D. P. NAIDIN, Text-fig. 1, Pl. 4, Figs 1—6.
1974. *Belemnitella mucronata mucronata* (SCHLOTHEIM) sensu ARKHANGELSKY; D. P. NAIDIN, pp. 216—217, Pl. 74, Fig. 4; Pl. 76, Figs 4—5.
1975. *Belemnitella mucronata mucronata* (LINK); W. K. CHRISTENSEN, pp. 52—53, Text-fig. 22 A, B, Pl. 7, Figs 1—3; Pl. 8, Figs 1—4; Pl. 9, Figs 1—6; Pl. 10, Figs 1—2; Pl. 11, Figs 1—3.
1975. *Belemnitella minor* JELETZKY; W. K. CHRISTENSEN, Pl. 11, Figs 4—5.
1975. *Belemnitella mucronata mucronata* (SCHLOTHEIM); W. K. CHRISTENSEN & *al.*, Pl. 1, Figs 1—3; Pl. 2, Figs 1—2; Pl. 3, Figs 1—5.
1979. *Belemnitella mucronata mucronata* (SCHLOTHEIM) *sensu* ARKHANGELSKY; D. P. NAIDIN, p. 85, Pl. 1, Fig. 7; Pl. 3, Fig. 9.
1986. *Belemnitella mucronata* (SCHLOTHEIM); W. K. CHRISTENSEN, pp. 35—36, Pl. 5, Figs 3—4; Pl. 6, Figs 1—2.

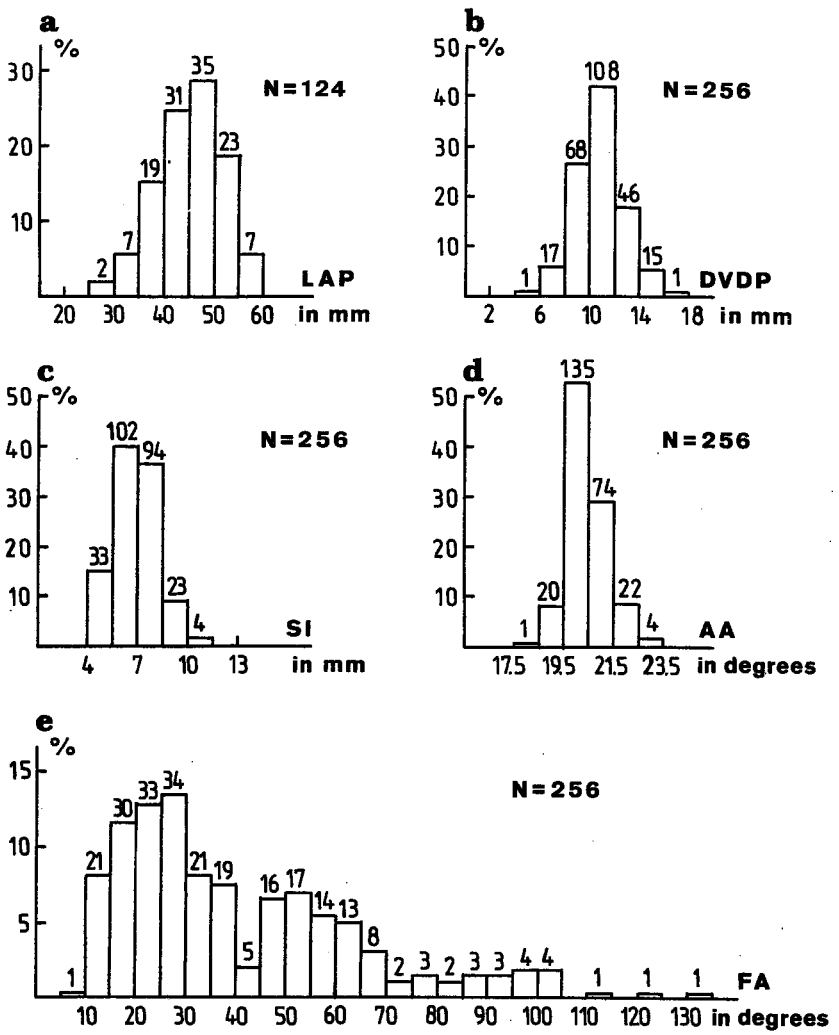



Fig. 7. Histograms of five characters of the genus *Belemnitella* from horizon *t* from Piotrawin (Middle Vistula Valley, Central Poland); explanation as in Text-fig. 5

MATERIAL: 72 almost complete guards with bottom of the ventral fissure visible; the examined specimens come from units *A?*, *B?*, *C-F* (*see* Text-fig. 2) with maximum occurrence in unit *D*.

DESCRIPTION: The guard with maximum ventral length 57.1 mm and relative width up to 17.7 mm. The shape of the guard is cylindrical, coniform (low or high), or slightly lanceolate. In side view it is cylindrical or coniform. Double ventro-lateral furrows well developed, though sometimes obliterated due to organic corrosion. Bottom of the ventral fissure is straight, rarely irregular or folded (Text-fig. 9).

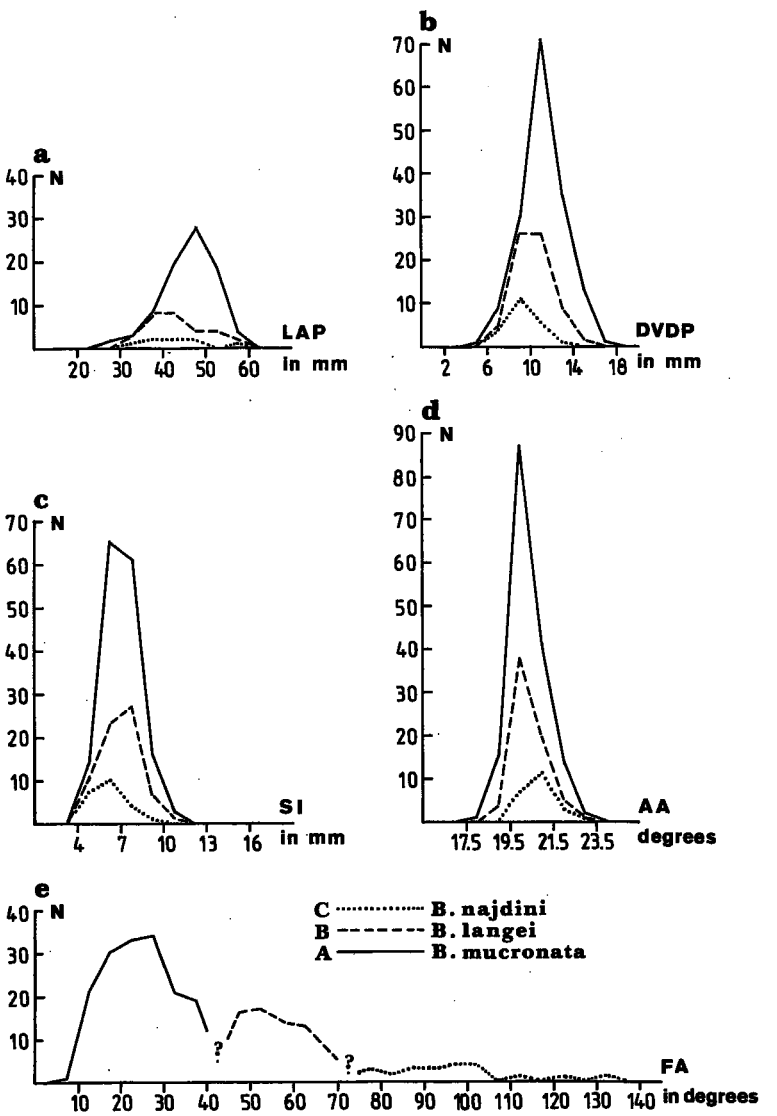



Fig. 8. Distribution of the frequency (*N*) of the five characters (*LAP, DVDP, SI, AA, FA* — *see* Text-fig. 5) within the three distinguished statistic subgroups (*A, B, C*) corresponding to: **A** — *Belemnitella mucronata* (SCHLOTHEIM), **B** — *B. langei* JELETZKY, and **C** — *B. najdini* KONGIEL; further explanation in the text

REMARKS: The assemblage of *B. mucronata* (SCHLOTHEIM) from Mielnik is very similar to the „population" of this species from Misburg (*see* CHRISTENSEN & *al.* 1975) as also from the Vistula section (horizon *t*). The differences concern only the higher values of the Schatsky index and the lower values of the fissure angle in the Mielnik material.

GEOGRAPHIC and STRATIGRAPHIC OCCURRENCE: The species *Belemnitella mucronata mucronata* (SCHLOTHEIM) is common within the North European Province, but sporadically it also occurs in the Tethyan Realm. It appears in the upper part of the Lower Campanian and ranges into the earliest Maastrichtian, being particularly frequent in the Upper Campanian (KONGIEL 1962; CHRISTENSEN 1975, 1986).

## Genus *Belemnella* NOWAK, 1913
## Subgenus *Pachybelemnella* SCHULZ, 1979

SCHULZ (1979) distinguished within the genus *Belemnella* two subgenera, *i.g.* the nominative subgenus *Belemnella,* represented by rarely occurring slender forms with high values of *LAP*, and the subgenus *Pachybelemnella* comprising massive forms with lower values of *LAP*, characteristic of the chalk facies. The sample of the genus *Belemnella* from Mielnik falls within the range of the subgenus *Pachybelemnella.*

### *Belemnella (Pachybelemnella) inflata* (ARKHANGELSKY, 1912)
### (Pl. 5, Fig. 2 and Pl. 6, Fig. 1)

1912. *Belemnitella lanceolata* SCHLOTHEIM var. *inflata*; A. D. ARKHANGELSKY, p. 609.
1960. *Belemnella lanceolata* (SCHLOTHEIM); K. ŁYSOGÓRSKI, pp. 39—41, Pl. 1, Figs 1, 3—4.
1979. *Belemnella (P.) inflata* (ARKHANGELSKY); M.-G. SCHULZ, pp. 107—110, Pl. 6, Figs 1—10.
1987. *Belemnella (P.) inflata* (ARKHANGELSKY); W. K. CHRISTENSEN, pp. 80—81, Pl. 1, Figs 1—6.

MATERIAL: 28 guards: 19 nearly complete specimens, 8 with visible bottom part of ventral fissure, 1 specimen with broken part of apex; the examined specimens come from units *G* (rare) and *H* (common).

DESCRIPTION: The guard with maximum relative length 76.5 mm and maximum relative dorso-ventral diameter 15.4 mm. Ventrally viewed it is lanceolate, in lateral view slightly lanceolate of cylindrical. In lateral plane, it is usually flattened near the ventral side. Double dorso-lateral furrows are well visible, particularly close to the apex and they are fairly undulated. Vascular imprints are well developed, crowded near the ventral fissure. The bottom of the ventral fissure, with an anterior deflection just before it, joins the walls of the alveolus; later it is straight, arched or irregular (*see* Text-fig. 10).

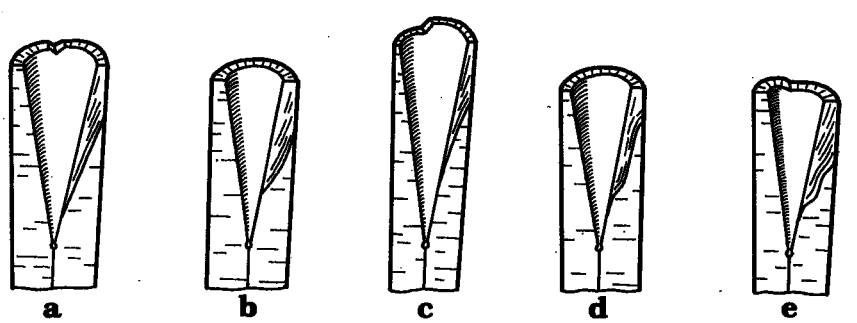



Fig. 9. Shapes of the bottom of the ventral fissure in *Belemnitella mucronata* (SCHLOTHEIM)
**a** — straight, **b** — curved in lower part, straight in upper part, **c** — straight with a terminal bend, **d** — undulating, **e** — irregular

The frequency distribution of 5 traits examined is shown in histograms (Text-fig. 11) and the normality was controlled by means of Kolmogorov-Smirnov test for goodness of fit. The obtained results indicate homogeneous sample, representing most probably one species (*see also* Table 3).

Table 3

Univariate analysis of the genus *Belemnella*

| Character | N | X | SD | OR |
|---|---|---|---|---|
| *LAP* | 27 | 65.5 | 5.0 | 53.8-76.9 |
| *DVDP* | 27 | 12.6 | 1.5 | 9.3-15.4 |
| *SI* | 28 | 1.1 | 0.8 | 0.1-3.8 |
| *AA* | 28 | 12.7 | 2.5 | 11.5-16.5 |
| *FA* | 28 | 15.9 | 6.1 | 5.5-27.0 |

REMARKS: Most of the specimens of *Belemnella (Pachybelemnella)* from Mielnik lies well (*see* Text-fig. 12) within the field of *B. (P.) inflata*. The two specimens lying close to its periphery represent probably an extreme variants of this species.

GEOGRAPHIC and STRATIGRAPHIC OCCURRENCE: The species *Belemnella (Pachybelemnella) inflata* (ARKHANGELSKY) occurs within the North European Province, being limited mainly to the chalk facies (SCHULZ 1979). It occurs in the Belemnella lanceolata Zone and B. pseudobtusa Zone of the lowermost Maastrichtian.

## BIOSTRATIGRAPHY

The presence of the genus *Gonioteuthis* in units *A, B* and *C* (in its bottom part) and the record of *Belemnellocamax mammillatus* (NILSSON) in the topmost part of unit *C* well dates the lower part of the section at Mielnik-on-Bug (units *A-C*) as the upper part of the Lower Campanian (*see* Text-fig. 2). The Upper Campanian of the succeeding units *D, E* and *F* are documented by the only belemnite species yielded in this interval, viz. *Belemnitella mucronata* (SCHLOTHEIM). The following units *G, H*, above the hardground (*see* Text-fig. 2), and characterized by a mass occurrence of *Belemnella (Pachybelemnella) inflata* (ARKHANGELSKY), may be precisely located in the lowermost Maastrichtian.

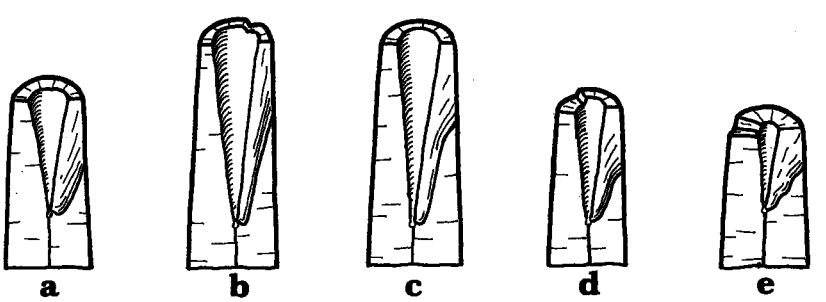



Fig. 10. Shapes of the bottom of the ventral fissure in *Belemnella (Pachybelemnella) inflata* (ARKHANGELSKY)

**a** — straight with an anterior deflection at the wall of alveolus, **b** — high, straight with an anterior deflection at the wall of the alveolus, **c** — high S-shaped, **d** — low S-shaped, **e** — irregular

With aid of belemnites, the Upper Campanian is commonly subdivided into 3 zones. From the bottom upwards it follows: Belemnitella mucronata, Belemnitella minor and Belemnitella langei Zones (*see* CHRISTENSEN 1975, 1986), corresponding to the suggested successive appearance of the index species. The number of zones is reduced however, when *Belemnitella minor* JELETZKY is included into synonymy of *Belemnitella mucronata* (SCHLOTHEIM), as it was lately suggested by ROBASZYNSKI & CHRISTENSEN 1989) and is supported by the Author, as presented above.

In the Mielnik-on-Bug section, the Upper Campanian sediments (units *D-F*) with *Belemnitella mucronata* (SCHLOTHEIM) are overlain by the chalk with *Belemnella (Pachybelemnella) inflata* (ARKHANGELSKY) of the lowermost Maastrichtian (units *G-H*). This suggests the presence of a stratigraphic gap

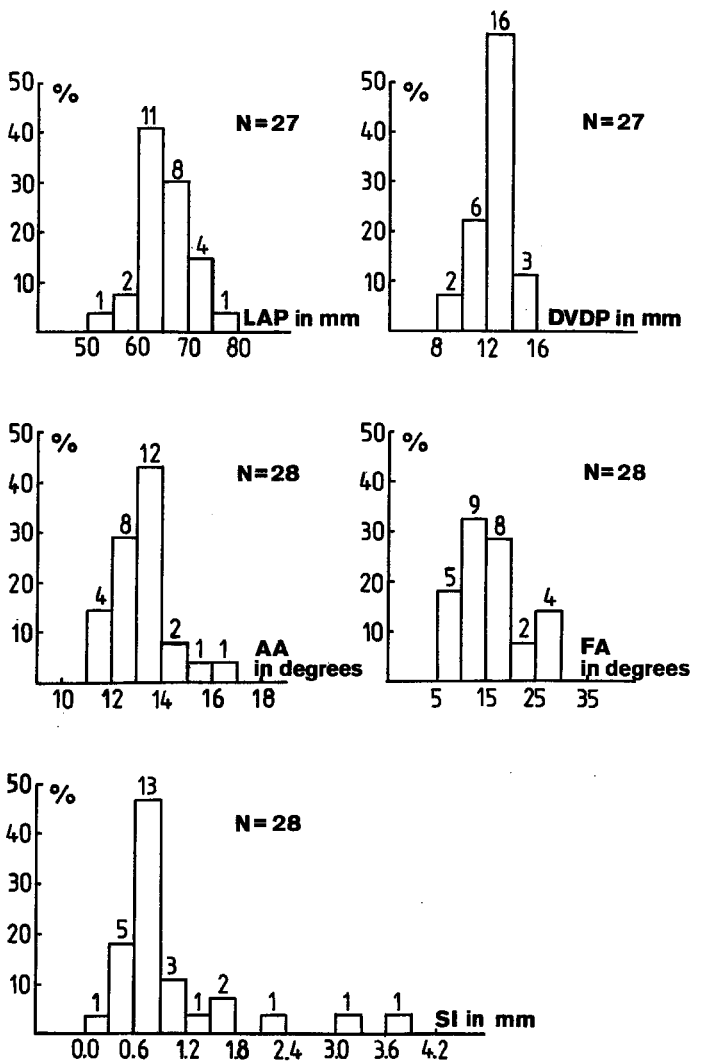



Fig. 11. Histograms of five characters of *Belemnella (Pachybelemnella) inflata* (ARKHANGELSKY); explanation as in Text-fig. 5

comprising the upper part of the upper Campanian (at least the Belemnitella langei Zone) between units *F* and *G*, associated with a hardground horizon. Consequently, the units *D-F* are thought to represent the lower part of the Upper Campanian, precisely the Belemnitella mucronata Zone.

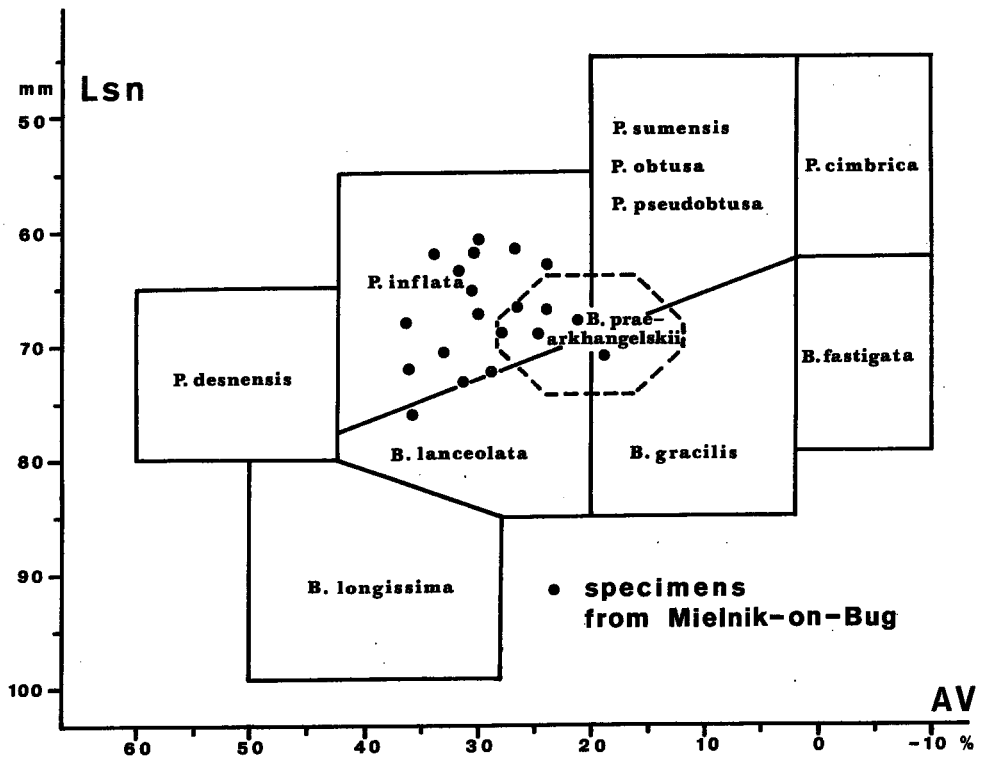



Fig. 12. Graphic key for the Lower Maastrichtian species of the subgenera *Pachybelemnella* and *Belemnella* of the genus *Belemnella* based on mean values of *Isn* and *AV* (*after* SCHULZ 1979, p. 94, Fig. 53); *Isn* — standardized length from apex to protoconch, *AV* — index which defines the shape of the guard in ventral view; black circles indicate measurements of the investigated specimens from Mielnik-on-Bug

**Acknowledgements**

The Author is greatly indepted to Professor D. P. NAIDIN (University of Moscow) and to Professor A. RADWAŃSKI (University of Warsaw) for valuable suggestions and critical comments on the manuscript; to Ass.-Professor R. MARCINOWSKI and I. WALASZCZYK, M. Sc. (both of the University of Warsaw) for scientific discussions and helpful remarks in the course of the present study; to B. WAKSMUNDZKI, M. Sc. (University of Warsaw) for drawing Text-fig. 4, 9 and 10. The photographs were taken by B. DROZD, M. Sc.

*Institute of Geology*
*of the University of Warsaw,*
*Al. Żwirki i Wigury 93,*
*02-089 Warszawa, Poland*

## REFERENCES


ARKHANGELSKY, A. D. 1912. The Upper Cretaceous deposits in the eastern part of the European Russia. *[In Russian]. Mater. Geol. Ross.*, **25**, 1—163. Petersburg.

BIEDA, E. 1958. Index foraminifers and the age of the Mielnik chalk. *Biul. Inst. Geol.*, **121** (3), 17—89. Warszawa.

BIRKELUND, T. 1957. Upper Cretaceous belemnites from Denmark. *Biol. Skr. Vid. Selsk.*, **9** (1), 1—69. København.

BITNER, M. A. & PISERA, A. 1979. Brachiopods from the Upper Cretaceous chalk of Mielnik (eastern Poland). *Acta Geol. Polon.*, **29** (1), 67—88. Warszawa.

BŁASZKIEWICZ, A. 1980. Campanian and Maastrichtian ammonites of the Middle Vistula River Valley, Poland: A stratigraphic-paleontological study. *Prace Inst. Geol.*, **42**, 1—63. Warszawa.

— 1984. Rząd Belemnitida NAEF, 1912. *In*: L. MALINOWSKA (*Ed.*), Budowa geologiczna Polski, tom 3. Atlas skamieniałości przewodnich i charakterystycznych, część 2c. Mezozoik, Kreda *[In Polish]*, pp. 398—408. Warszawa.

CHRISTENSEN, W. K. 1975. Upper Cretaceous belemnites from the Kristianstad area in Scania. *Fossils and Strata*, **7**, 1—69. Oslo.

— 1976. Palaeobiogeography of Late Cretaceous belemnites of Europe. *Paläont. Zt.*, **50** (3/4), 113—129. Stuttgart.

— 1986. Upper Cretaceous belemnites from Vomb Trough in Scania, Sweden. *Sver. Geol. Unders. Ca* **57**, 1—57. Uppsala.

— 1987. *Belemnella (Pachybelemnella) inflata* (ARKHANGELSKY) from Nagoryany, USSR. *Beitr. Paläont. Österr.*, **13**, 79—84. Wien.

— 1988. Upper Cretaceous belemnites of Europe: state of art. *In*: M. STREL & M. J. M. BLESS (*Eds*), *The Chalk District of Euregio Meuse-Rhine*, pp. 5—16.

— , ERNST, G., SCHMIDT, F., SCHULZ, M.-G. & WOOD, C. J. 1975. *Belemnitella mucronata mucronata* (SCHLOTHEIM, 1813) from the Upper Campanian: Neotype, biometry, comparision and biostratigraphy. *Geol. Jb., A* **28**, 27—57. Hannover.

CIEŚLIŃSKI, S. 1960. Biostratigraphy and extent of index forms of the Upper Cretaceous in Poland. *Kwart. Geol.*, **4** (2), 432—441. Warszawa.

COLLINS, J. S. H. & RADWAŃSKI, A. 1982. Scalpellid cirripedes from the Upper Cretaceous chalk of Mielnik (eastern Poland). *Acta Geol. Polon.*, **32** (1/2), 41—45. Warszawa.

GAŹDZICKA, E. 1981. Coccoliths and index foraminifera from the Upper Cretaceous chalk of Mielnik region, Eastern Poland. *Acta Palaeontol. Polon.*, **26** (1), 73—83. Warszawa.

GIEDROYČ, A. 1886. Recherches sur la formation géologique du terrain du gouvernement Grodno et des parties limitrophes du Royaume de Pologne et de Lithuanie. *Pam. Fizjograf.*, **6**, 3—16. Warszawa.

JELETZKY, J. A. 1946. Zur Kenntnis der Oberkretazischen Belemniten. *Geol. Fören. Stockh. Förh.*, **68** (1), 87—105. Stockholm.

— 1951. Die Stratigraphie und Belemnitenfauna des Obercampan und Maastricht Westfalens, Nordwestdeutschland und Dänemarks, sowie einige allgemeine Gliederungs-Probleme der jüngeren borealen Oberkreide Eurasien. *Beih. Geol. Jb.*, **1**, 1—142. Hannover.

KONGIEL, R. 1962. On belemnites from Maastrichtian, Campanian and Santonian sediments in the Middle Vistula Valley (Central Poland). *Prace Muz. Ziemi*, **5**, 1—148. Warszawa.

ŁYSOGÓRSKI, K. 1960. Cretaceous belemnites from the vicinity of Malbork (Pomerania), Mielnik and Kornica (Podlasie). *[In Polish]. Unpublished M. Sc. thesis;* Institute of Geology. University of Warsaw.

NAIDIN, D. P. 1952. Upper Cretaceous belemnites of western Ukraine. *[In Russian]. Mosk. Geol. Razved. Inst.*, **27**, pp. 1—170. Moskva.

— 1964a. Upper Cretaceous *Belemnitella* and *Belemnella* from the Russian Platform and some adjacent regions. *[In Russian]. Bull. Mosk. Obshch. Ispyt. Prir. Otd. Geol.*, **39** (1), 85—97. Moskva.

— 1964b. Upper Cretaceous belemnites of the Russian Platform and contiguous regions, *Actinocamax, Gonioteuthis, Belemnellocamax.* pp. 1—190. *[In Russian]. Moscow Univ. Press;* Moskva.

— 1969a. Morphology and paleobiology of the Upper Cretaceous belemnites, pp. 1—303. *[In Russian]. Moscow Univ. Press;* Moskva.

— 1969b. Biostratigraphie und Paläogeographie der Oberen Kreide der Russischen Tafel. *Geol. Jb.*, **87**, 157—186. Hannover.
— 1971. Some notes on the proposed neotype for *Belemnites mucronatus* LINK, 1807. Z. N. (S.) 1160. *Bull. Zool. Nomencl.*, **28**, 131—138. London.
— 1974. Subclass Endocochlia — Order Belemnitidae. *[In Russian]. In:* G. Y. KRYMOLTS (*Ed.*), *Atlas of Upper Cretaceous Fauna of Donbass*, pp. 197—240. Moskva.
— 1979. Belemnites. *[In Russian]. In:* G. N. PAPULOV & D. P. NAIDIN (*Eds*), The Santonian-Campanian boundary in the East-European Platform. *Acad. Sci. USSR, Urals Sci. Centre, Transact. Inst. Geol. Geochem.*, **148**, 75—86. Sverdlovsk.
NIKITIN, J. J. 1958. Upper Cretaceous belemnites of the north-eastern slope of the Dnepr-Donetz-basin. *[In Ukrainian]. Akad. Nauk Ukr. SSR, Trudy Inst. Geol. Nauk, Ser. Strat. Paleont.*, **20**, 1—92. Kiev.
NOWAK, J. 1913. Untersuchungen uber die Cephalopoden der oberen Kreide in Polen; Teil 3. *Bull. Acad. Sci. Cracovie, Sér. B.*, 335—412. Cracovie.
OLSZEWSKA, D. 1987. Facies development and sedimentation of the white chalk at Mielnik. *[In Polish]. Unpublished M. Sc. thesis;* Institute of Geology, University of Warsaw.
PERYT, D. 1981. Planktonic foraminifers and age of chalk from Mielnik (East Poland). *Bull. Pol. Acad. Sci., Sér. de la Terre*, **29** (2), 137—142. Warszawa.
POŻARYSKI, W. 1938. Senonsstratigraphie im Durchbruch der Weichsel Zwischen Rachów und Puławy in Mittelpolen. *Bull. Serv. Géol. Pologne*, **6**, 1—94. Warszawa.
— 1960. Phenomenon of hard ground in the Cretaceous section of Mielnik on the Bug river (Eastern Poland). *Kwart. Geol.*, **4** (1), 105—112. Warszawa.
PUGACZEWSKA, H. 1965. Les organismes sédentaires sur les rostres des Bélemnites du Crétacé supérieur. *Acta Palaeontol. Polon.*, **10** (1), 73—110. Warszawa.
RADWAŃSKI, A. 1972. Remarks on the nature of belemniticolid borings *Dendrina*. *Acta Geol. Polon.*, **22** (2), 257—264. Warszawa.
ROBASZYNSKI, F. & CHRISTENSEN, W. K. 1989. The Upper Campanian — Lower Maastrichtian chalks of the Mons basin, Belgium: a preliminary study of belemnites and foraminifera in the Harmignies and Ciply areas. *Geologie en Mijnobouw*, **68**, 391—408. Gravenhage.
SCHULZ, M.-G. 1979. Morphometrisch-variationsstatistische Untersuchunngen zur Phylogenie der Belemniten-Gattung *Belemnella* im Untermaastricht NW-Europas. *Geol. Jb., A* **47**, 1—157. Hannower.
STAŚKIEWICZ, E. 1971. An estimation of the extent of the chalk deposits of Mielnik, based on its geological setting. *[In Polish]. Unpublished M. Sc. thesis;* Institute of Geology, University of Warsaw.
VASSILENKO, W. K. & RAZMYSLOVA, S. S. 1950. Systematics of the belemnites. *[In Russian]. Dokl. Akad. Nauk SSSR*, **74** (3), 603—606. Moskva.

---

D. OLSZEWSKA

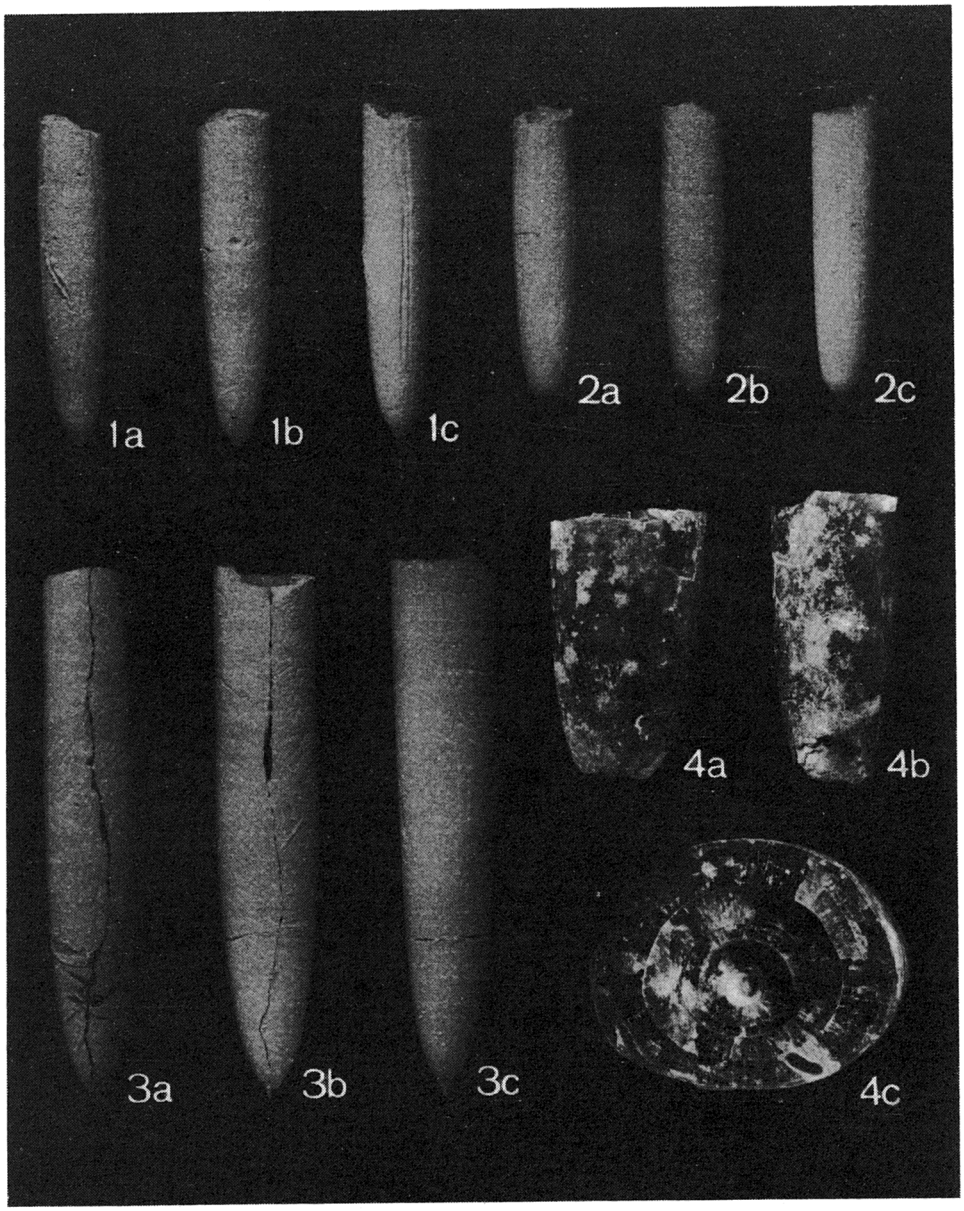
## BELEMNITY Z KREDY PISZĄCEJ MIELNIKA NAD BUGIEM

## (Streszczenie)

Belemnity z kredy piszącej Mielnika nad Bugiem (*patrz* fig. 1, 3—5, 9—12; tabele 1 i 3; oraz pl. 1—6) należą do: *Gonioteuthis* sp., *Belemnellocamax mammillatus* (NILSSON), *Belemnitella mucronata* (SCHLOTHEIM) i *Belemnella (Pachybelemnella) inflata* (ARKHANGELSKY). Wskazują one na obecność wyższej części kampanu dolnego i niższej części kampanu górnego oraz niższej części mastrychtu dolnego (*patrz* fig. 2). Luka stratygraficzna związana z poziomem twardego dna obejmuje wyższą część kampanu górnego (poziom Belemnitella langei).

W celu porównawczym przeanalizowano rodzaj *Belemnitella* z lokalnego poziomu *t* profilu środkowej Wisły, bazując na kolekcji Profesora R. KONGIELA (*patrz* fig. 6—8 oraz tabela 2). Statystyczne opracowanie pozwoliło na wyróżnienie trzech grup (*patrz* fig. 7—8) odpowiadających gatunkom *B. mucronata* (SCHLOTHEIM), *B. langei* JELETZKY i *B. najdini* KONGIEL. Okazy opisywane jako *B. minor* JELETZKY w większości przypadków należą do *B. mucronata* (SCHLOTHEIM).

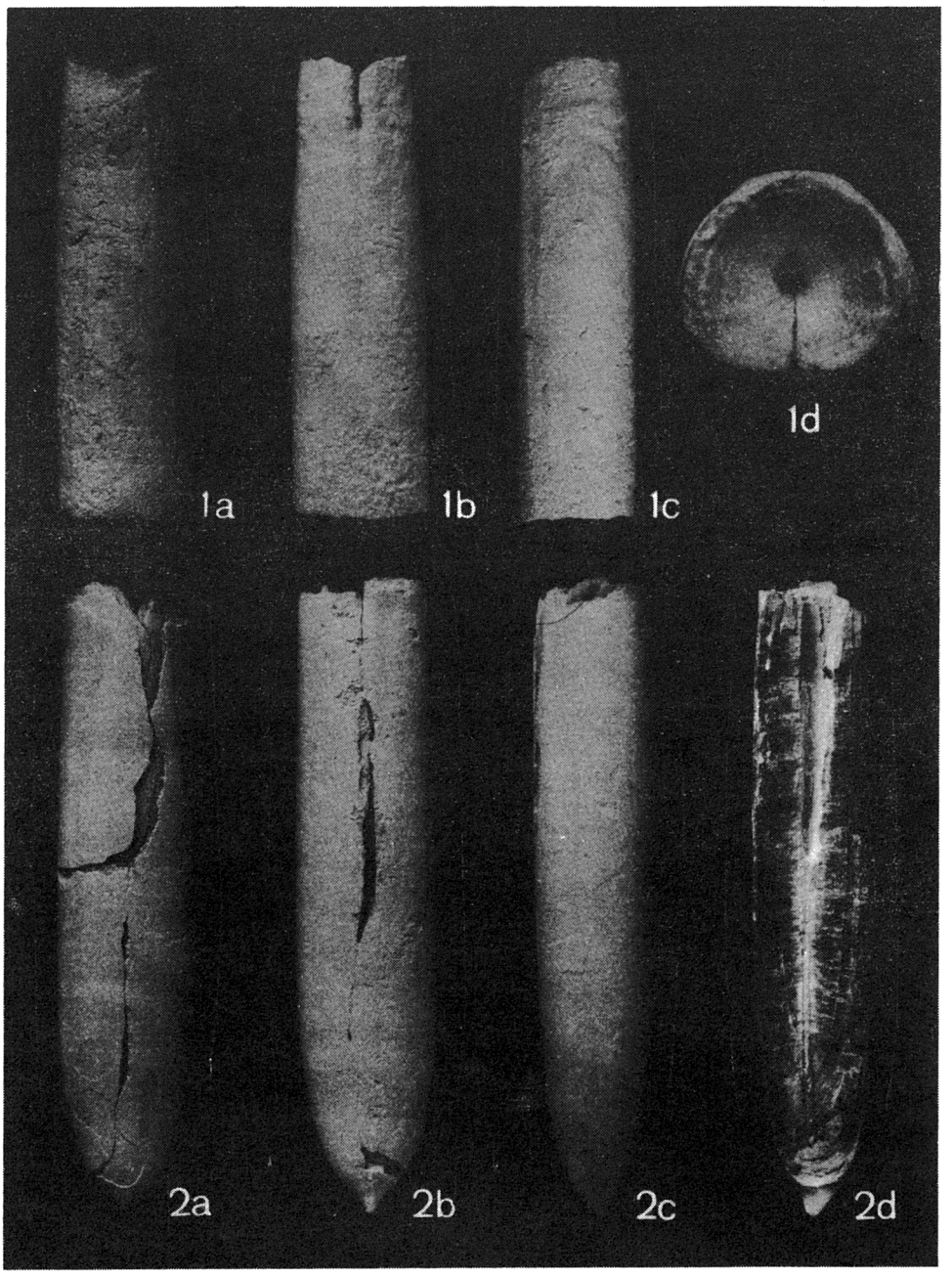
---




**1-2** — *Gonioteuthis* sp. from unit *A?* (probably upper part of Lower Campanian), senile specimens: *a* dorsal, *b* ventral, *c* lateral view; all nat. size

**3** — *Belemnitella mucronata* (SCHLOTHEIM) from unit *D* (lower part of Upper Campanian), adult specimen: *3a* dorsal, *3b* ventral, *3c* lateral view; all nat. size

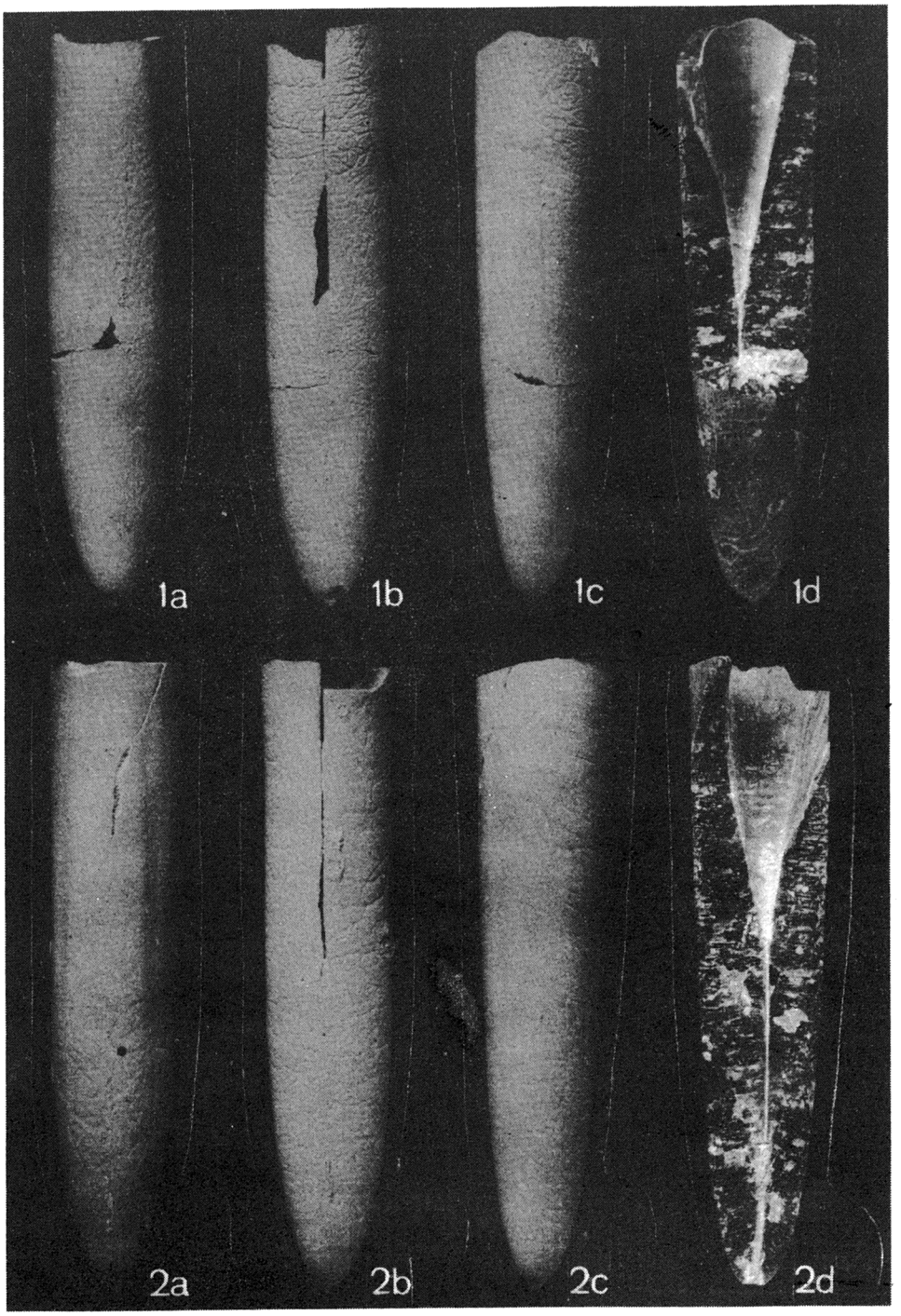
**4** — Apical part of *Belemnellocamax mammillatus* (NILSSON), senile specimen; probably upper part of Lower Campanian; *4a* dorsal, *4b* ventral view, both in nat. size; *4c* section, taken × 2



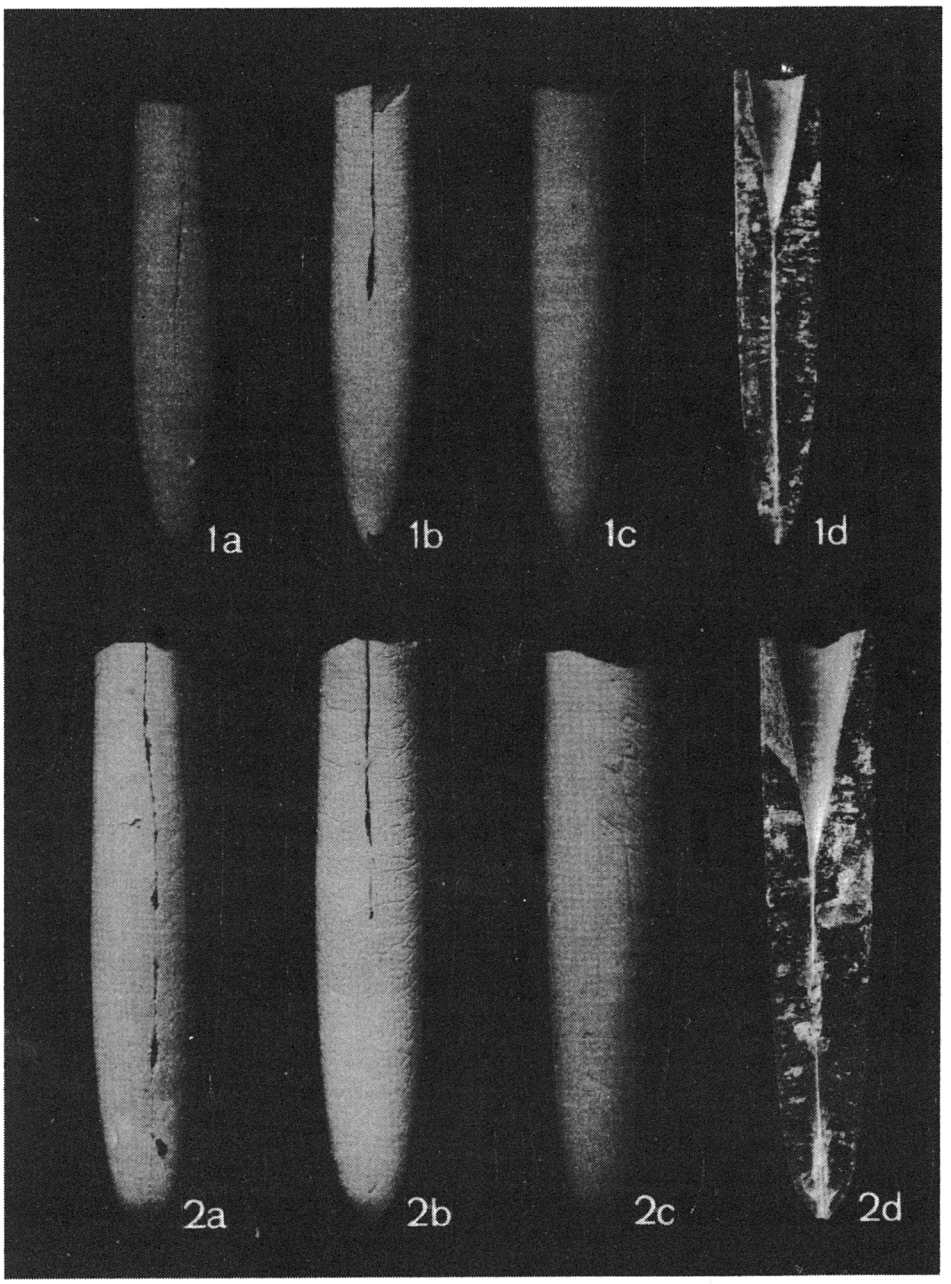

*Belemnellocamax mammillatus* (NILSSON)

**1** — Senile specimen (probably upper part of Lower Campanian): *1a* dorsal, *1b* ventral, *1c* lateral view, all nat. size; *1d* anterior view, taken ×2

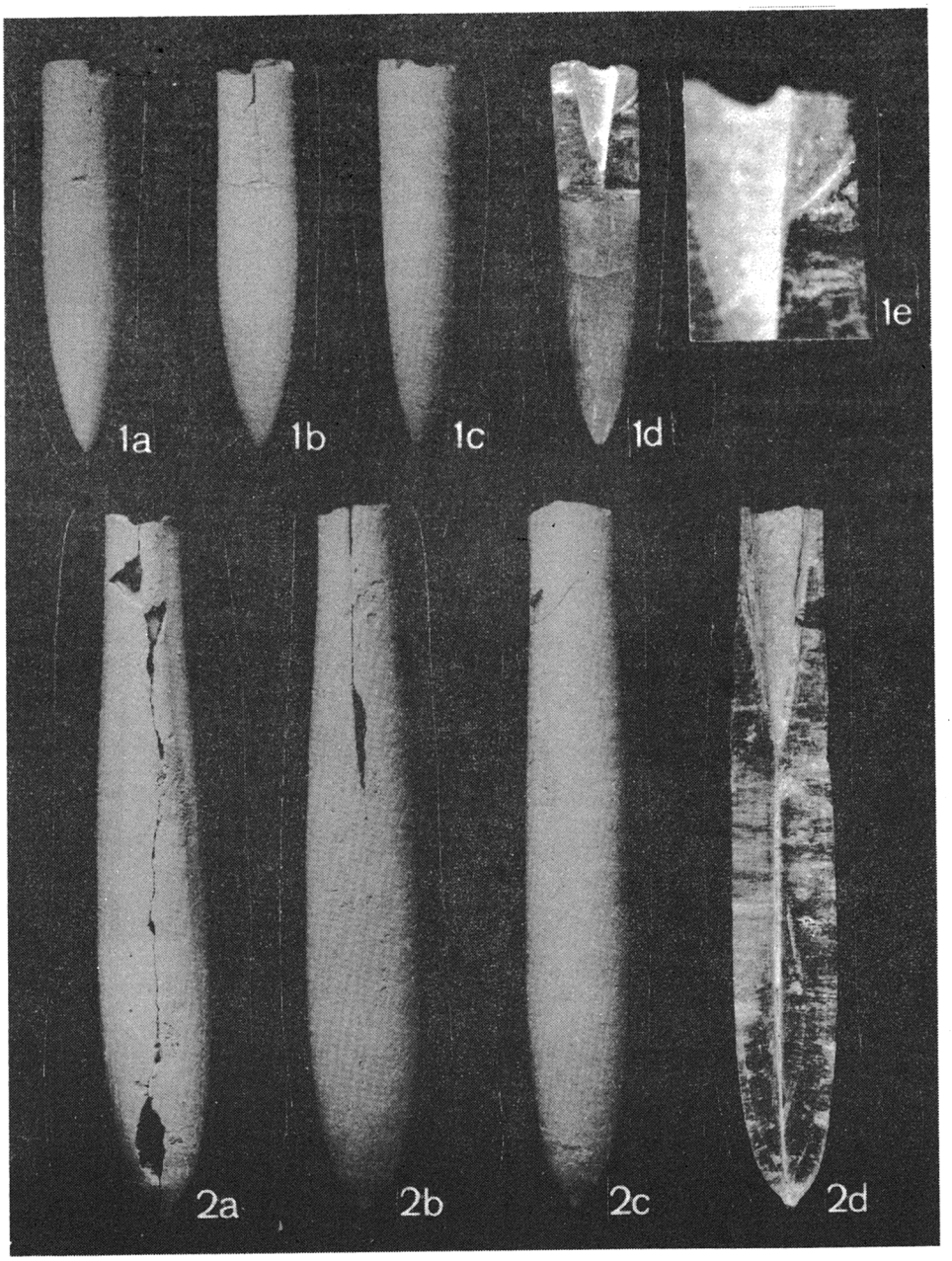
**2** — Another senile specimen from unit *C* (upper part of Lower Campanian): *2a* dorsal, *2b* ventral, *2c* lateral view, *2d* split guard; all nat. size




**1-2** — *Belemnitella mucronata* (SCHLOTHEIM) from unit *D* (lower part of Upper Campanian), both senile specimens: *a* dorsal, *b* ventral, *c* lateral view, *d* split guard showing inner characters (*compare* Text-fig. 9); all nat. size

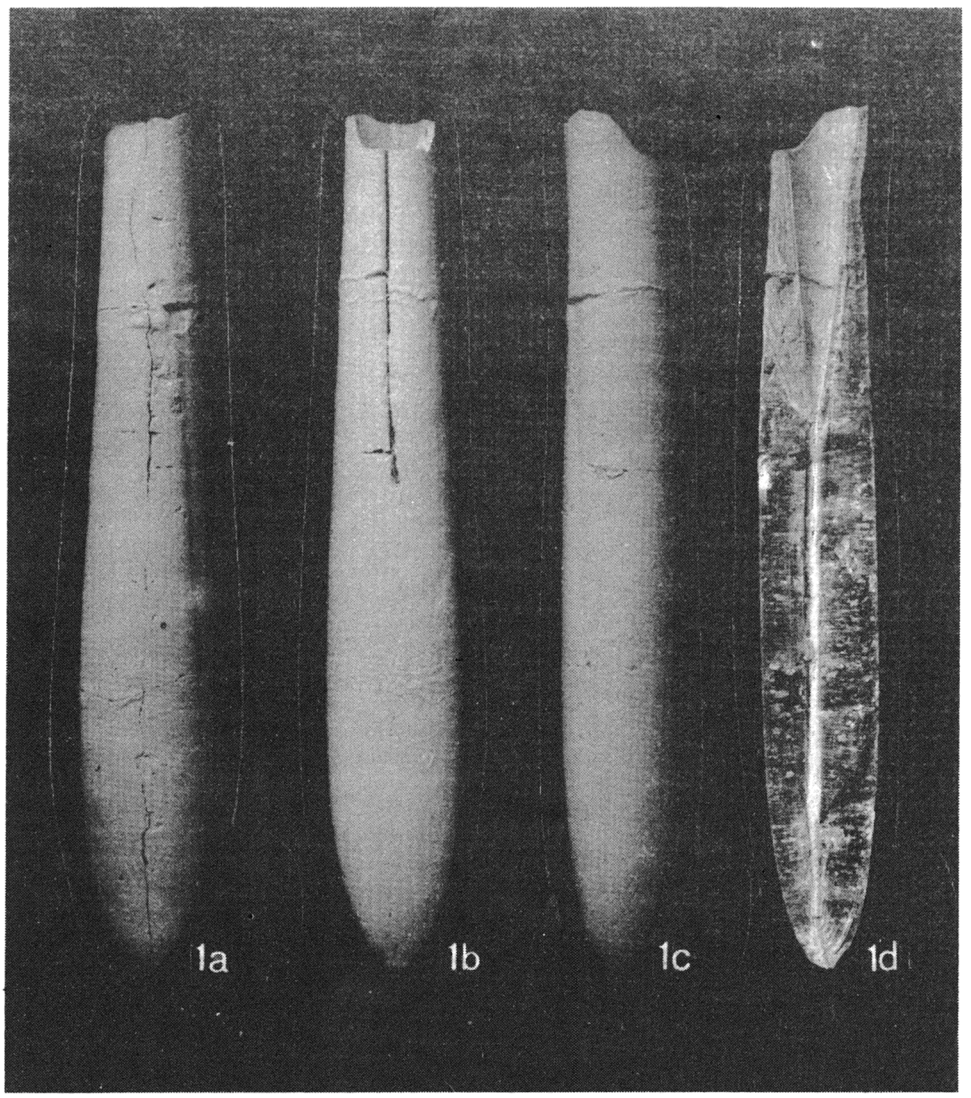



**1-2** — *Belemnitella mucronata* (SCHLOTHEIM) from unit *E* (lower part of Upper Campanian), both adult specimens: *a* dorsal, *b* ventral, *c* lateral view, *d* split guard showing inner characters (*compare* Text-fig. 9); all nat. size




**1** — *Belemnitella mucronata* (SCHLOTHEIM) from unit *E* (lower part of Upper Campanian), adult specimen: *1a* dorsal, *1b* ventral, *1c* lateral view, *1d* split guard showing inner characters, all nat. size; *1e* split anterior end showing the shape of the bottom of the ventral fissure, taken × 3

**2** — *Belemnella (Pachybelemnella) inflata* (ARKHANGELSKY) from unit *H* (lower part of Lower Maastrichtian), senile specimen: *2a* dorsal, *2b* ventral, *2c* lateral view, *2d* split guard showing inner characters (*compare* Text-fig. 10); all nat. size




**1** — *Belemnella (Pachybelemnella) inflata* (ARKHANGELSKY) from unit *H* (lower part of Lower Maastrichtian), senile specimen: *1a* dorsal, *1b* ventral, *1c* lateral view, *1d* split guard showing inner characters (*compare* Text-fig. 10); all nat. size