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Please note that Volume 105 of *Annals of the South African Museum* closed with Part 9 (published June 1999).

No parts were published during the year 2000.

Volume 106 is delayed and will appear within the next few months. The volume will comprise a single large part.

Volume 107 Part 1 is enclosed herewith. Please note that because of the size of this part, Volume 107 also comprises only a single part.

INSTRUCTIONS TO AUTHORS

1. MATERIAL should be original and not published elsewhere, in whole or in part.
2. LAYOUT should be as follows:
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   (b) *Abstract* of not more than 200 words, intelligible to the reader without reference to the text
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STRATIGRAPHIC AND GEOGRAPHIC DISTRIBUTION, PHYLOGENETIC TRENDS AND GENERAL COMMENTS ON THE AMMONITE FAMILY BACULITIDAE GILL, 1871 (WITH AN ANNOTATED LIST OF SPECIES REFERRED TO THE FAMILY)

By

HERBERT CHRISTIAN KLINGER
&
WILLIAM JAMES KENNEDY

The South African Museum forms part of Iziko Museums of Cape Town

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(With 197 figures)

[*MS accepted 30 January 1998*]

ABSTRACT

Systematics in the ammonite family Baculitidae, especially in the genus *Baculites*, are complicated by wide intraspecific variation and apparent strong endemism. Several aspects of the stratigraphic and geographic distribution, phylogenetic trends in ornamentation, suture lines, coiling, absolute size, dimorphism and whorl section are investigated to determine whether morphological 'spikes' can be identified to improve the biostratigraphic potential of the family. General comments on aptychi, ammonitellas, mass occurrences, muscle scars, microsculpture, predation and parasitism are provided, as well as an annotated list of species referred to the family. Some of these are figured photographically.

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INTRODUCTION

Following our description of the South African representatives of the genus *Eubaculites* Spath, 1926 (Klinger & Kennedy 1993), and the other members of the ammonite family Baculitidae Gill, 1871 (Klinger & Kennedy 1997), it became clear that the members of the family exhibit wide intraspecific variation, especially as far as ornament is concerned, and that several apparently endemic lineages are present in the most species-rich genus, *Baculites*. Coupled with the conservative shell morphology, these factors all severely limit the global biostratigraphic potential of the family—especially of the genus *Baculites*, the most common and stratigraphically longest-ranging representative of the family.

This is to be regretted, as representatives of the family are locally very common (and may even be rock-formers) and have a wide geographic distribution. The potential of the Baculitidae for biostratigraphic zonation is clearly shown in the Campanian–lowest Maastrichtian of the US Western Interior. Here, zonation is based predominantly on *Baculites* species, some of which are estimated to have had life spans of as little as 500 to 900 thousand years (Kennedy & Cobban 1976: 69). This zonation, in turn, is linked to the most precise numerical time scale known for rocks of Cretaceous age (Obradovich & Cobban 1975; Obradovich 1993).

From a consideration of the geographic and stratigraphic distribution, morphology and phylogeny of the Baculitidae, we seek to identify certain 'spikes', patterns or common trends that may be used to enhance the biostratigraphic potential of the family, especially of the genus *Baculites*.

CLASSIFICATION

Details of the systematics of the family were discussed earlier (Klinger & Kennedy 1997) (Fig. 1) and we here only list the genera referred to the family Baculitidae.

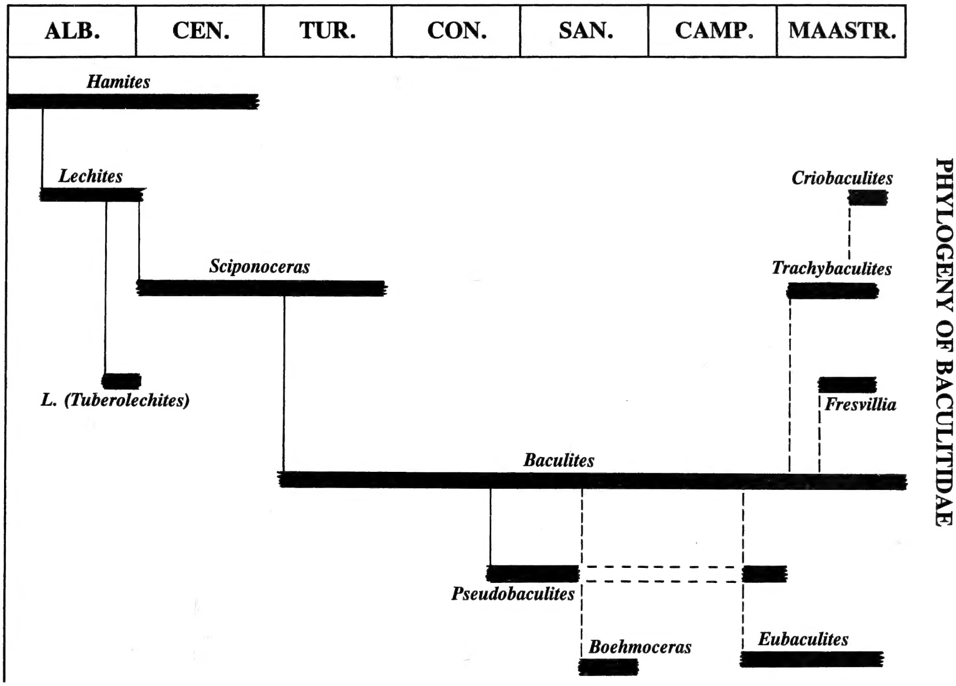


Fig. 1. Classification and phylogeny of the family Baculitidae (from Klinger & Kennedy 1997).

Genus and subgenus *Lechites* s.s. Nowak, 1908. Type species *Baculites gaudini* Pictet & Campiche, 1861.

Subgenus *Lechites (Tuberolechites)* Cooper & Kennedy, 1977. Type species *Lechites (Tuberolechites) regifex* Cooper & Kennedy, 1977.

Genus *Sciponoceras* Hyatt, 1894. Type species *Hamites baculoides* Mantell, 1822.

Genus *Baculites* Lamarck, 1799. Type species *Baculites vertebralis* Lamarck, 1799.

Genus *Pseudobaculites* Cobban, 1952. Type species *Pseudobaculites nodosus* Cobban, 1952.

Genus *Boehmoceras* Riedel, 1931. Type species *Ancyloceras krekeleri* Wegner, 1905.

Genus *Eubaculites* Spath, 1926. Type species *Baculites vagina* Forbes var. *ootacodensis* Stoliczka, 1866.

Genus *Fresvillia* Kennedy, 1986*a*. Type species *Fresvillia constricta* Kennedy, 1986*a*.

Genus *Criobaculites* Klinger & Kennedy, 1997. Type species *Hamites trabeatus* Morton, 1834.

Genus *Trachybaculites* Cobban & Kennedy, 1995. Type species *Baculites columna* Morton, 1834.

GEOGRAPHIC AND STRATIGRAPHIC DISTRIBUTION

The ammonite family Baculitidae (as a whole) has a world wide distribution, from the Arctic Circle to Antarctica, but individual genera show differing geographic distributions.

For the purpose of this discussion, we recognize the following, partly arbitrary and overlapping geographic regions where Baculitidae occur:

1. Europe—this includes both Boreal and Tethyan regions; baculites do not appear to have been affected by the Boreal/Tethyan Realm division.
2. Indo-Pacific—this is a very large area and includes the Indian Ocean areas (Zululand, Madagascar, India, Australia) and the Pacific Ocean areas (e.g. Japan, west coast of North and South America), as well as the Subantarctic Peninsula and Patagonia. The Austral and Neuquén basins of Argentina are also included in this region.
3. Gulf-Atlantic region, i.e. Gulf Coast and Atlantic Seaboard regions of North America and the Afro-American South Atlantic coastal regions (e.g. Angola, Nigeria, Cameroon and Brazil), excluding the Austral and Neuquén basins of Argentina.
4. The US Western Interior region, as defined by Cobban & Reeside (1952), including its extension into Canada and, at least in the pre-Late Campanian, into West Greenland (Birkelund 1965: 47).
5. North Africa and the Middle East.

As far as stratigraphic distribution is concerned, we must emphasize that the stage and substage boundaries of the different bio-geographic regions can only be regarded as approximate temporal equivalents. It became perfectly clear during the 1995 Symposium on Stage Boundaries in Brussels that, as yet, there is no consensus on most of the boundaries. The stratigraphic ranges of the various taxa listed and shown in the illustrations below are taken from various literature sources, and we are fully aware of the fact that the stage and substage definitions from the various regions probably do not coincide and can only be regarded as approximate.

Genus *Eubaculites*

The genus *Eubaculites* is well known, mainly as a result of recent comprehensive studies by Klinger (1976), Henderson *et al.* (1992), Kennedy & Henderson (1992), and Klinger & Kennedy (1993). It is therefore appropriate to discuss the geographic and stratigraphic distribution of the genus first, and compare the distribution of other genera with this pattern.

Eubaculites first appeared in the Upper Campanian, as *E. occidentalis* (Meek, 1862), became locally common in the Maastrichtian, and ranged into the upper Upper Maastrichtian as *E. carinatus* (Morton, 1834) in the Pétites-Pyréneés in southern France (Kennedy 1986*e*), the Biscay Region (Ward & Kennedy 1993), and the U.S. Gulf coast ((Kennedy, unpublished data). Apart from *E. occidentalis* and *E. carinatus*, four other well-defined species are referred to the genus—*E. labyrinthicus* (Morton, 1834), *E. vagina* (Forbes, 1846), *E. simplex* (Kossmat, 1895), and *E. latecarinatus* (Brunnschweiler, 1966).

Eubaculites is most common in the Gondwanan Region (Fig. 2) and, in places, is the dominant Maastrichtian heteromorph ammonite. It occurs in great numbers in Western Australia, South India, Zululand, Madagascar, southern Chile, the Neuquén Basin of Argentina, and locally in the U.S. Gulf coast region. A few specimens are also known from deposits off the southern Cape coast of South Africa (Klinger & Kennedy 1980) and from Mozambique (Crick 1924).

Some of the material described by Haas (1943) as *Baculites anceps* from Angola may be *Eubaculites* (see Klinger & Kennedy 1993: 218). If it is a *Eubaculites,* this is the only record of the genus from the west coast of Africa. Given our extensive knowledge of Nigerian Maastrichtian faunas, the absence of *Eubaculites* is conspicuous. Equally, there are, as yet, no records from Brazil, New Zealand or Antarctica. The *Baculites* cf. *vagina* recorded by Woods (1917: 36, pl. 20 (fig. 5a–d)) from Amuri Bluff, New Zealand, is too poorly preserved for positive identification (see Henderson 1970: 24–25), Marshall (1926: 155) thought that it 'almost certainly belongs to' *B. rectus*.

Occurrences in the Northern Hemisphere are scattered compared to those of the Gondwanan Region. In North America, *Eubaculites* is unknown from the US Western Interior seaway. It occurs in California and British Columbia, in the Gulf Coast Region in the Corsicana Formation of Texas, the Owl Creek Formation of Missouri and Mississippi, the Prairie Bluff Chalk of Alabama, Severn Formation of Maryland, Navesink Formation of New Jersey, and reworked into the overlying Palaeocene Hornerstown Formation.

In Europe, *Eubaculites* occurs in the Lower Maastrichtian of Austria, and the Upper Maastrichtian of south-eastern France, the Biscay Region, northern Spain (unpublished data), and a single specimen is known from Maastricht in the Netherlands. This latter occurrence is North Tethyan; the associated fauna includes rudists.

Again, the absence of *Eubaculites* from well-documented Maastrichtian deposits of northern Europe, Greenland, North Africa, the Middle East, and Central and Eastern Asia is striking. No typical Maastrichtian *Eubaculites* has as yet been recorded from Japan.

The distribution of the genus in the Maastrichtian (Fig. 2) shows that *Eubaculites* is latitudinally restricted. It is common in the southern temperate regions, rare in the northern temperate regions, and absent from the equatorial, Arctic and Antarctic regions, and from the west coast of Africa.

The geographic and stratigraphic distribution of the individual species varies.

The oldest, *E. occidentalis* occurs in the Upper Campanian–Lower Maastrichtian of California and British Columbia.

Eubaculites carinatus has the widest geographic, and longest stratigraphic distribution. It occurs in both the Lower and Upper Maastrichtian, and has been recorded from Austria, south-eastern France, the Biscay Region, the Netherlands, North America (California, Texas, Missouri, Mississippi,

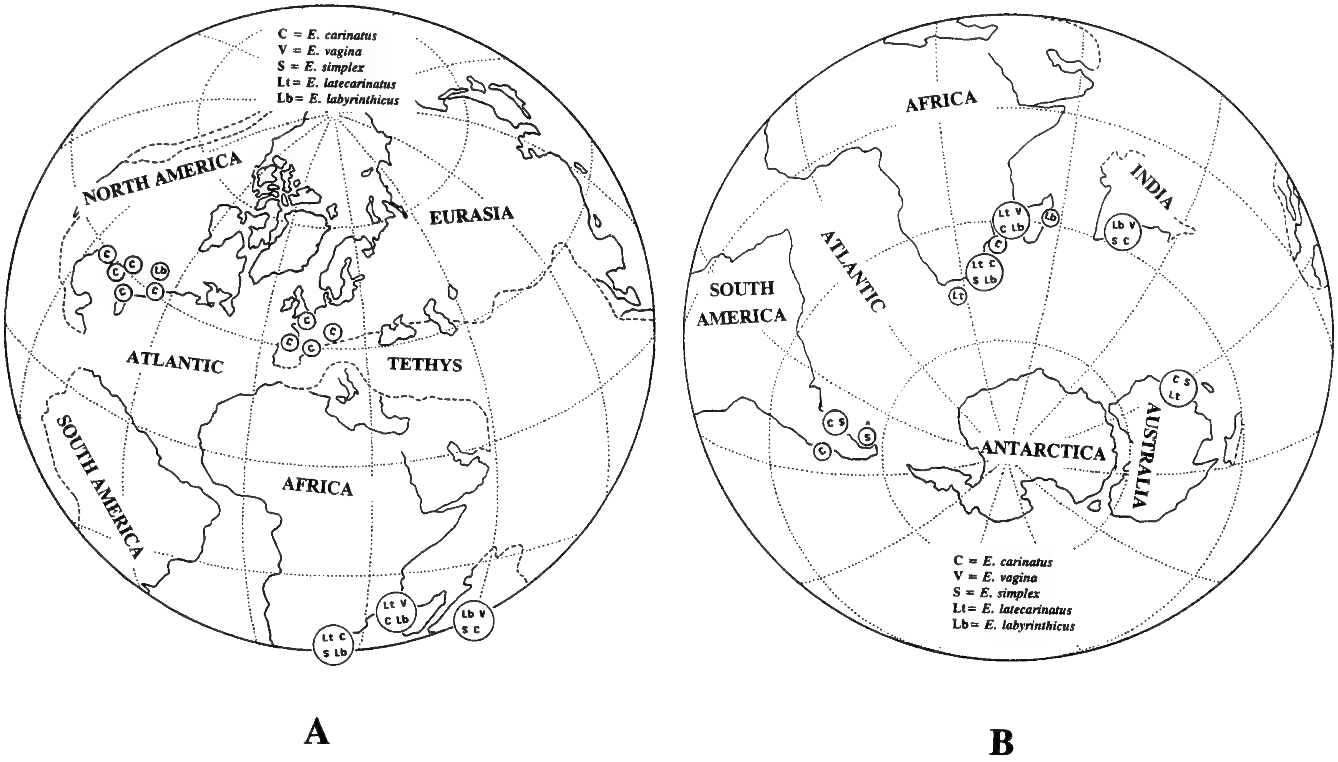


Fig. 2. Geographic distribution of the genus *Eubaculites* Spath, 1926, during the Maastrichtian.

Alabama and New Jersey), Neuquén Basin of Argentina, Quiriquina Island, Chile, Zululand, Mozambique, Madagascar, South India and Western Australia. From the available published data it appears that *E. carinatus* is common in Western Australia, Zululand, Chile, Argentina, the Owl Creek Formation of Missouri and Mississippi, uppermost Corsicana Formation (Kemp Clay) in the Brazos River section, Texas (Kennedy, unpublished data), and apparently in the Biscay Region. In contrast to the mass occurrences in Zululand and Western Australia, it is rare in Madagascar and South India.

Eubaculites labyrinthicus is only known by a few specimens from the Maastrichtian Prairie Bluff Chalk of Alabama, the Navesink Formation of New Jersey, and the St Lucia Formation of Zululand. In contrast, Collignon (1971: 15) recorded it (as *B. simplex*) as being abundant in the Lower Maastrichtian of Madagascar, where it also grows to large sizes.

Eubaculites latecarinatus first occurs in Maastrichtian a, and is very abundant in Maastrichtian I and II of the St Lucia Formation of Zululand. It is also known from offshore deposits on the Alphard Group off the southern Cape coast. Henderson *et al.* (1992) described only eleven specimens from Western Australia. It is rare in Madagascar, where apparently only two specimens are known (Klinger & Kennedy 1993, fig. 48), and none from South India or South America. Kennedy *et al.* (1997*a*: 20, figs 15a–d, k, l, 16g, h, 19) described three specimens from the Upper Maastrichtian Severn Formation of Maryland.

Eubaculites simplex is known only by the lectotype from India, a single specimen from Madagascar (as *Baculites occidentalis* in Collignon 1971: 15, pl. 645 (fig. 2390)), but it is common in Western Australia (132 specimens). In Zululand about 20 specimens are known and in Santa Cruz Province, Patagonia, five specimens (as *Baculites* sp. *in* Hünicken 1965: 64, pl. 2 (figs 3–4), pl. 3 (figs 5–6), pl. 5 (fig. 5), pl. 6 (figs 6–7), pl. 8 (figs 2–5)).

Eubaculites vagina is the dominant species of *Eubaculites* in South India, rare in Madagascar, and as yet unknown elsewhere. Fatmi & Kennedy (1999) have shown that *Baculites binodosus* Noetling, 1897, should be referred to the genus *Eubaculites*. Apart from the holotype, only six other specimens are referred to this species, all from the Upper Maastrichtian of Baluchistan, India.

To summarize, *Eubaculites* thus seems to comprise a mixture of widely distributed and endemic or geographically restricted, and long- and short-ranging species; its absence from the US Western Interior seaway and West Africa is conspicuous, as is its absence in high latitudes and equatorial regions. With these data as a basis, it is now possible to see if the other baculitid genera follow the same patterns, and, if not, where and to what extent they differ.

Genus *Lechites*

Lechites is a short-lived genus restricted to the Upper Albian. It is widely distributed in Western and Central Europe, including southern England, France, Switzerland, Austria, Hungary, Romania, Spain, Sardinia, Central Iran, North Africa, Madagascar, Zululand, South India, Hokkaido, Mexico, Texas and Antarctica. Again, the absence of the genus from West Africa and Brazil is conspicuous.

It is difficult to determine the distribution of the individual species because of lack of uniform taxonomy. *Lechites gaudini* (Pictet & Campiche, 1861) (which includes *L. communis* Spath, 1941, *L. raricostatus* Breistroffer, 1947, *L. italicus* Wiedmann & Dieni, 1968, *L. campichei* Renz, 1968, *L. vraconensis* Renz, 1968, and *L. fasciatus* Scholz, 1971, according to Cooper & Kennedy 1977: 644–645), has the widest geographic and longest stratigraphic distribution. It has been recorded from the Upper Albian of Western and Central Europe, Sardinia, North Africa, Madagascar, Zululand, South India, Hokkaido and doubtfully Mexico.

Lechites moreti Breistroffer, 1936, occurs in the Upper Albian of southern England, France, Switzerland, Spain, Sardinia, Hungary and North Africa, and possibly Texas (as *L. comanchensis* Adkins, 1920 *in* Clark 1965, pl. 3 (figs 2, 6)) (*fide* Cooper & Kennedy 1977: 652). *Lechites comanchensis* is only known from the Upper Albian of Texas. *Lechites antanimangaensis* Collignon, 1964, from the Lower Cenomanian of Madagascar, is known from the holotype only, and is based on a large body chamber fragment. It has sufficient characters in common with macroconchs of *Sciponoceras baculoides* as to suggest it to be a *Sciponoceras* (see Wright & Kennedy 1995: 314). *Lechites varicostatus* Chiriac, 1981, is only known from the Upper Albian of Romania.

Lechites thus also includes both cosmopolitan and endemic, and long- and short-lived forms, but, in contrast to *Eubaculites*, it occurs in high southern and northern latitudes. Given the extensive descriptions of Albian faunas from Angola, the absence from this region is conspicuous, as is that from Nigeria.

Genus *Sciponoceras*

Sciponoceras is widely known from the Lower Cenomanian to Upper Turonian in both hemispheres, but again is essentially absent from West Africa; a single fragment has been recorded from Angola (Cooper 1978: 70, fig. 12b–d). The specimen figured by Solger (1904: 101, figs 3–4) as *Baculites* cf. *gracilis* is of doubtful affinities (cf. Reyment 1955: 15).

Some species have wide distribution. *Sciponoceras roto* Cieśliński, 1959, which occurs in the Lower Cenomanian of southern England, France, Germany, Switzerland, Spain, Mangyschlak, Iran, Algeria, Tunisia, Tanzania, Madagascar, Zululand, and is said to range through the whole of the Cenomanian of Poland; *S. baculoides* (Mantell, 1822) is common (sometimes in flood abundance) in the lower part of the Middle Cenomanian of England and France, and ranges to the lower Upper Cenomanian; other records are from West and Central Europe, North Africa, South India, Mozambique, Zululand, Madagascar, California and Hokkaido (as a distinct subspecies perhaps), Washita Group, Texas and doubtfully Argentina (Riccardi & Aguirre Urretta 1988: C381); *S. gracile* (Shumard, 1860) is most common in the eponymous Upper Cenomanian zone of the US Western Interior (where it ranges to the top of the Cenomanian), and also occurs in California, Texas, northern Mexico, southern England, northern France, southern Germany and doubtfully Angola.

Other species are more restricted geographically: *Sciponoceras bohemicum* (Fritsch, 1872) is only known from the Turonian of England, northern France, southern Germany and Bohemia; *S. cucullatum* Collignon, 1964, from the

Lower Cenomanian of Madagascar and Lower or Middle Cenomanian of Zululand; *S. glaessneri* Wright, 1963, Middle Cenomanian of Bathhurst Island, *S. intermedium* Matsumoto & Obata, 1963, Upper Turonian of Hokkaido; *S. orientale* Matsumoto & Obata, 1963, Lower and Middle Turonian of Hokkaido, and *S. subbaculoides* (Geinitz, 1875), Cenomanian of Bohemia and Hungary; *S. kossmati* (Nowak, 1908), Turonian of India (*fide* Kennedy 1988: 108–109); *S. santacrucense* Leanza, 1970, Turonian of Patagonia, and *S. matsumotoi* Inoma, 1980, from the Cenomanian of Hokkaido.

The virtual absence of the genus from West Africa is of note, as is the near-cosmopolitan distribution of the typical US Western Interior species *S. gracile*, in contrast to the marked endemism of the later *Baculites* species of the region.

Genus *Baculites*

The geographic and stratigraphic distribution of most of the well-known, and/or adequately defined species of *Baculites*, as well as of *Eubaculites*, *Boehmoceras*, *Fresvillia*, *Criobaculites* and *Trachybaculites* is illustrated in Figures 3–19. The exact stratigraphic range of individual species is often poorly constrained, and there are problems in global correlation of stage boundaries and substages as indicated above (p. 4). Unless otherwise indicated, the stratigraphic ranges of the species in the diagrams can only be considered as approximate.

TURONIAN

Fig. 3

Only four definite *Baculites* species are known from the Turonian: *B. yokoyamai* Tokunaga & Shimizu, 1926, *B. undulatus* d'Orbigny, 1850, *B. calamus* Morrow, 1935, and *B. embaensis* Balan, 1982. Two forms in open nomenclature have been recorded from Romania (Szász 1986). Neal Larson has informed us that Dr W. A. Cobban identified a nodose baculitid from the Carlile Formation of Wyoming as cf. *B. boulei*. We suspect that *B. embaensis*, with deep constrictions may be a *Sciponoceras* and we omit this species from the diagram.

Baculites yokoyamai is best known from the US Western Interior, where it ranges throughout the stage. Summesberger (1992: 124, pl. 8 (figs 10–11)) recently recorded *B. yokoyamai* from the Middle Turonian of Austria. *Baculites calamus* is rare, and only known from the Middle Turonian *Collignoniceras woollgari* Zone of the US Western Interior, and, according to Neal Larson, based on one specimen only.

Baculites undulatus is best known from the Upper Turonian of Western Europe and Hokkaido, and was also recently recorded from Trans-Pecos Texas (Kennedy *et al.* 1989), and, according to Dr W. A. Cobban is rare in the Upper Turonian of New Mexico. It may possibly already be present in the Lower Turonian of Romania (Szász 1986: 120, pl. 1 (figs 1–2)), accompanied by a questionable baculitid with ornament very similar to that of *B. calamus*.

The first nodose baculitid (Klinger & Kennedy 1997, fig. 132) may possibly occur in the Upper Turonian of Angola and is the oldest definite record of the

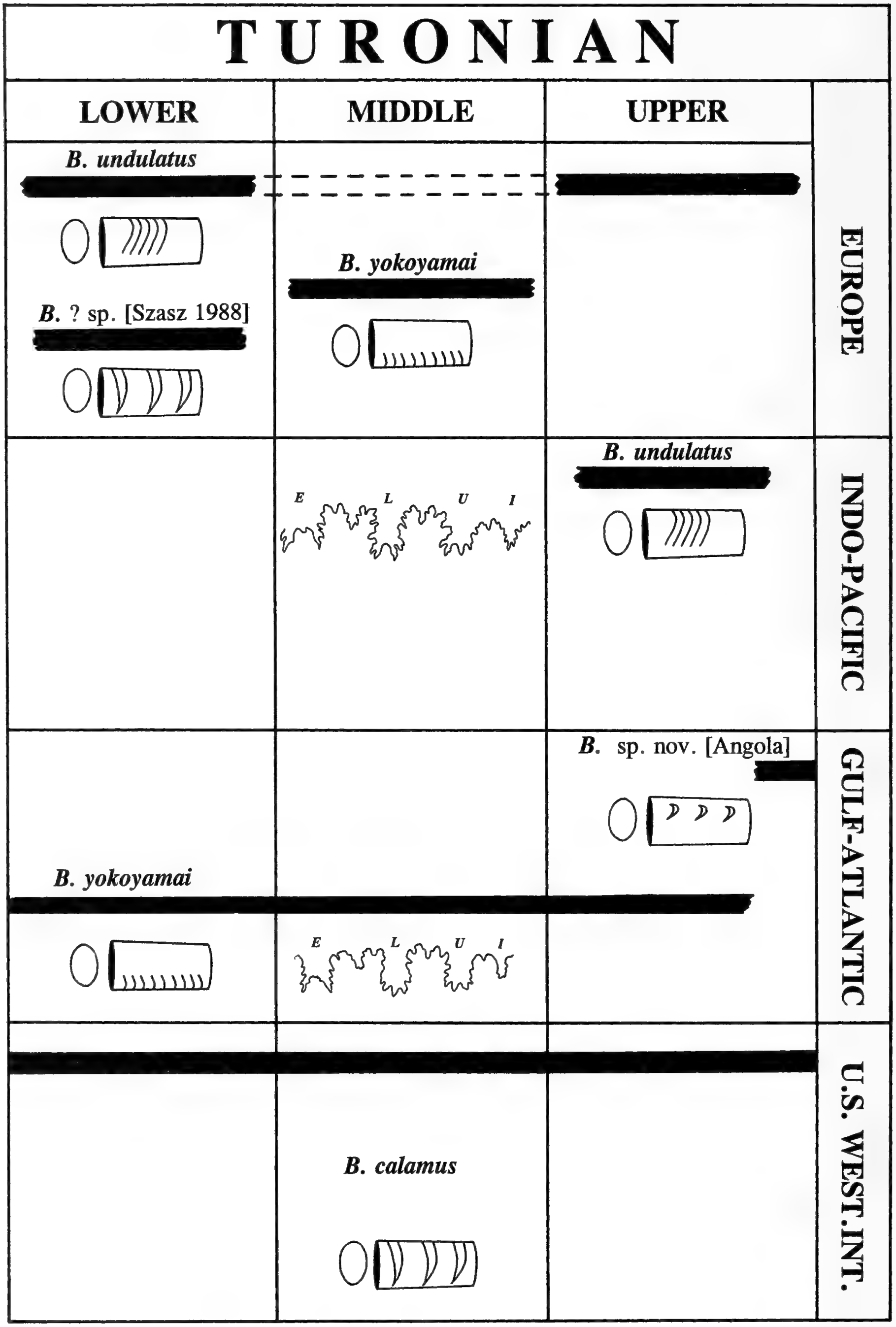


Fig. 3. Geographic and stratigraphic distribution of species of the genus *Baculites* in the Turonian.

family from Angola. Dr W. A. Cobban has informed us that nodose baculitids also occur sparingly in the Upper Turonian of the US Western Interior.

Turonian *Baculites* are a rarity and species diversity is low. Even though *B. yokoyamai* and *B. undulatus* are predominantly US Western Interior and Indo-Pacific–European species respectively, some faunal migration and mixing seems to have taken place during the Turonian.

CONIACIAN

Fig. 4

Baculites yokoyamai survives into the Lower Coniacian in the US Western Interior, the Indo-Pacific and the Gulf-Atlantic regions, but all the other species recorded from the Coniacian appear to be geographically restricted.

The baculitid faunas of the US Western Interior are predominantly endemic from the Middle Coniacian and remain so until the Maastrichtian (see Cobban 1994 for a detailed discussion). Only a few typical US Western Interior species have been recorded outside this region, and vice versa. These include: two Campanian and one Maastrichtian species recorded from Belgium by Kennedy (1993), *Baculites undatus* Stephenson, 1941, a typical Gulf Coast and Atlantic Seaboard species recorded from the Western Interior by Cobban (1973), *B. haresi*, a typical Lower Campanian Western Interior species recorded from the Atlantic Seaboard by Kennedy & Cobban (1993*e*), *B. reduncus*, another typical US Western Interior species recorded from Arkansas by Kennedy & Cobban (1993*a*), *B. crickmayi* Williams, 1930, from the Annona Chalk of Arkansas by Kennedy & Cobban (1993*a*), *Baculites* gr. of *aquilaensis* in northern Texas by Cobban & Kennedy (1992*a*), and *B. mclearni* Landes, 1940, also in Texas by Cobban & Kennedy (1993). The noded variant of *B. scotti* in Cobban (1958: 662, pl. 90 (figs 5–9)) (= *B. texanus* Kennedy & Cobban, 1999) has also been recorded from Texas, New Jersey, South Dakota and Colorado.

Pseudobaculites, with its complex suture has no equivalents outside the Western Interior in the Coniacian, and again in the Upper Campanian and Lower Maastrichtian. *Baculites mariasensis* Cobban, 1951, and *B. sweetgrassensis* Cobban, 1951, are analogues, but not equivalents of *B. yokoyamai* of the Indo-Pacific region. *Baculites codyensis* Reeside, 1927*a*, is comparable, but not identical to the tuberculate group of *B. incurvatus* Dujardin, 1837, and *B. brevicosta* Schlüter, 1876, of Europe, and *B. capensis* Woods, 1906, of the Indo-Pacific. Smooth *B. bailyi* Woods, 1906, from the Indo-Pacific has no equivalents in the Coniacian of Europe.

SANTONIAN

Figs 5–6

Nodose to ribbed forms of the Coniacian groups of *Baculites codyensis*, *B. incurvatus* and *B. capensis* persist into the Middle Santonian of the US Western Interior and Europe and Lower Campanian of the Indo-Pacific respectively. *Baculites capensis* has recently been recorded from the Gulf Coast by Kennedy & Cobban (1991*b*). Even though some individuals of these three species from these regions are morphologically inseparable, populations are

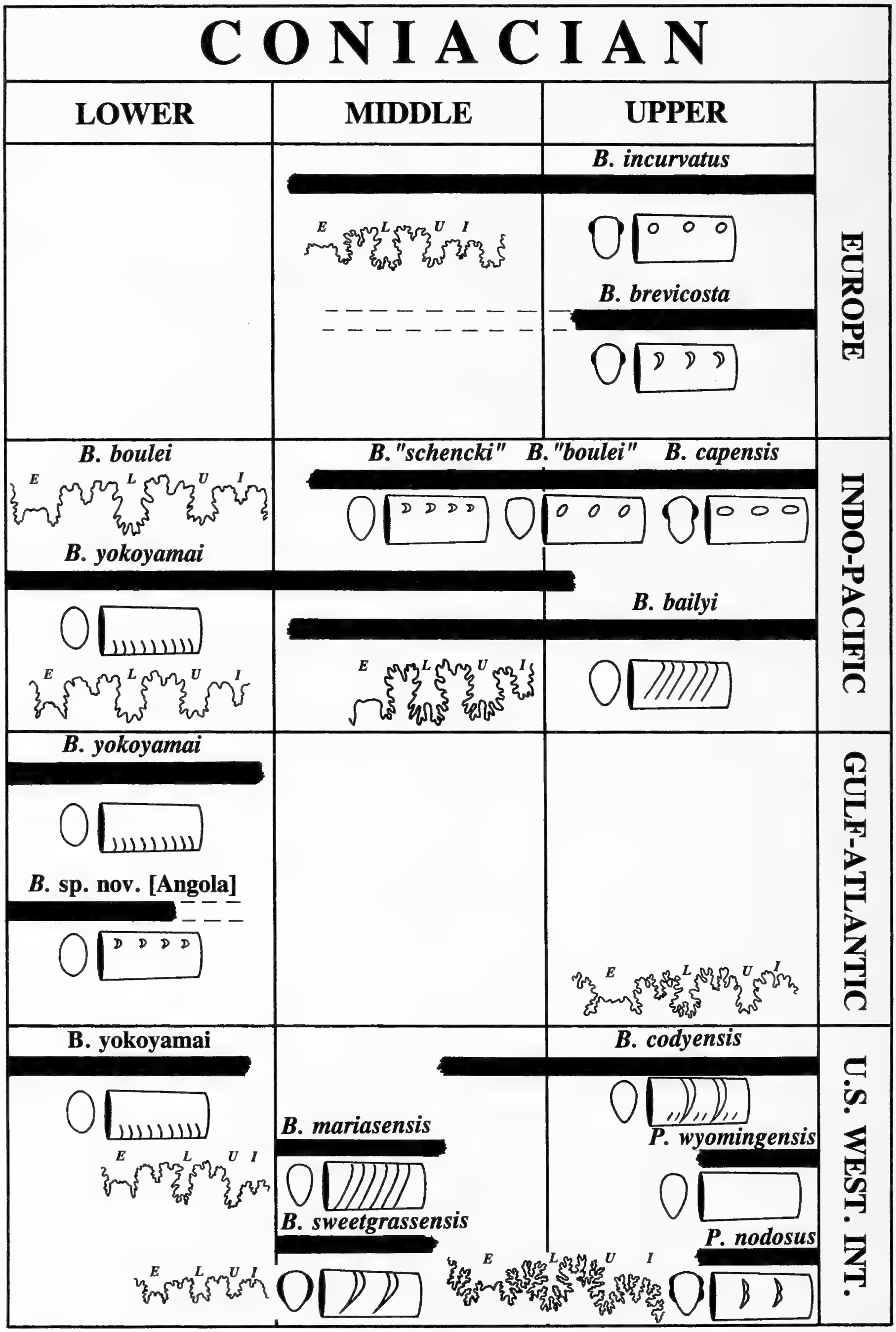


Fig. 4. Geographic and stratigraphic distribution of species of the genera *Baculites* and *Pseudobaculites* in the Coniacian.

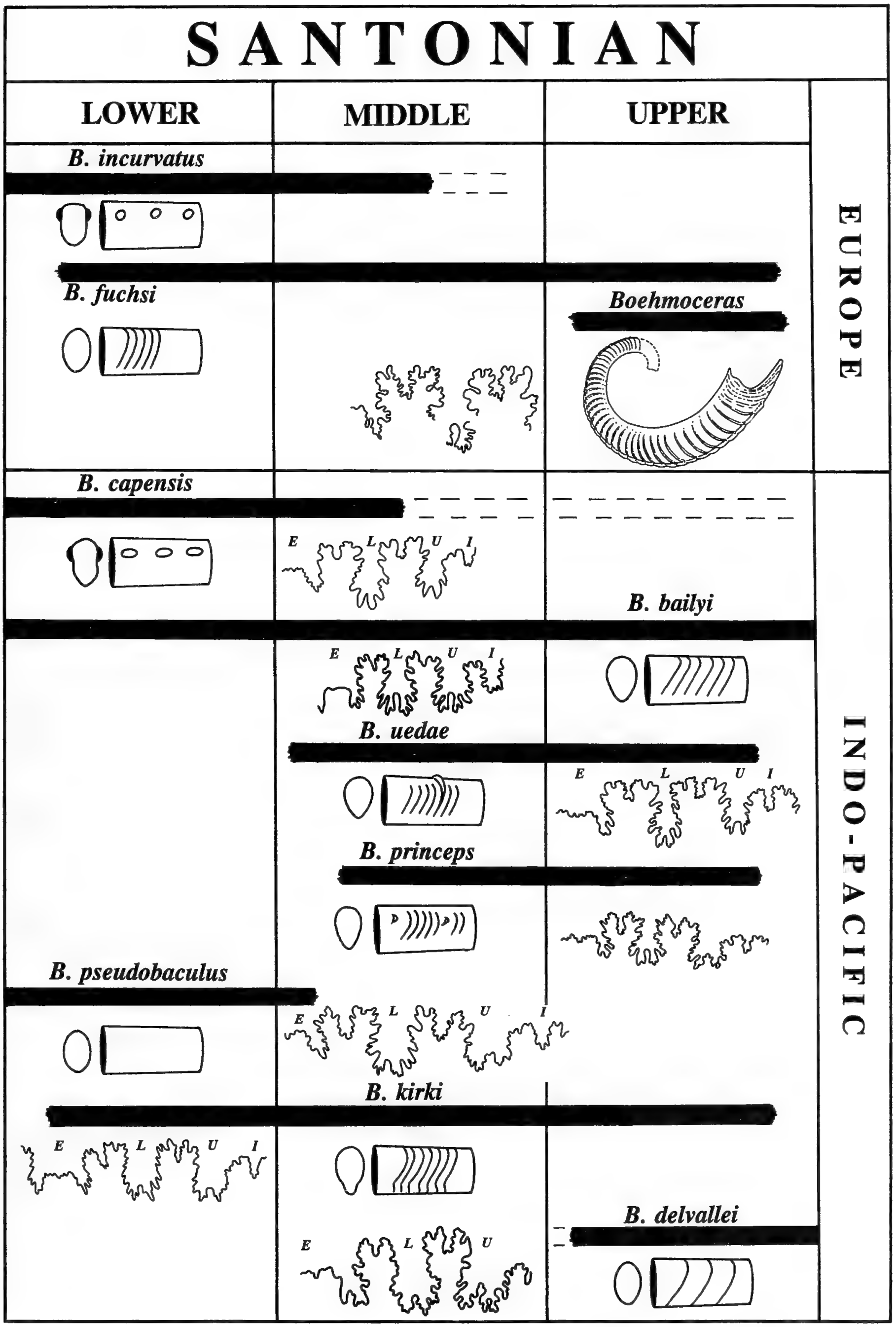


Fig. 5. Stratigraphic distribution of species of the genera *Baculites* and *Boehmoceras* in the Santonian in Europe and the Indo-Pacific.

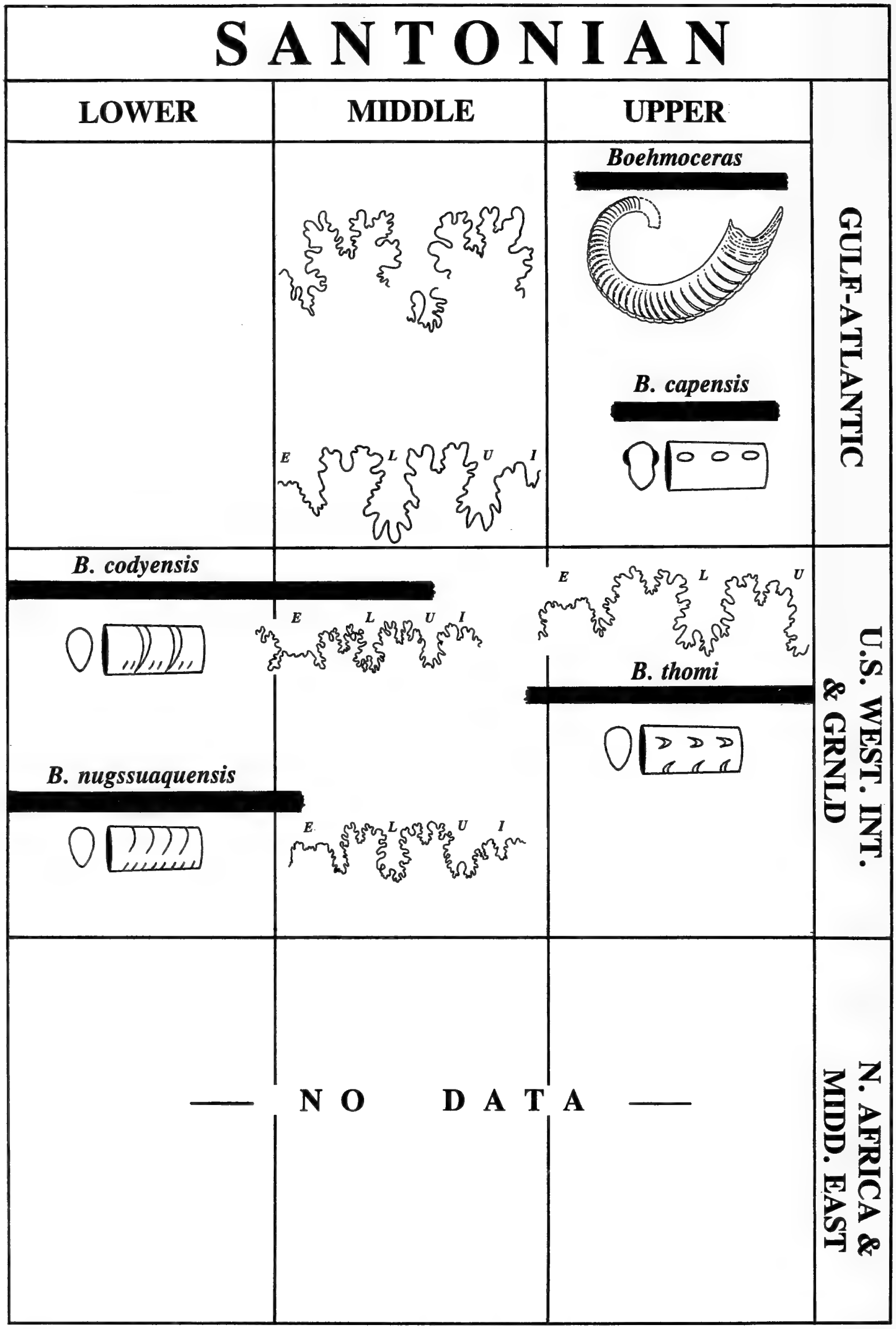


Fig. 6. Stratigraphic distribution of species of the genera *Baculites* and *Boehmoceras* in the Santonian in the Gulf-Atlantic Region, US Western Interior and Greenland, North Africa, and the Middle East.

significantly distinct. Smooth *B. bailyi* also persists up to the Lower Campanian; smooth *B. nugssuaquensis* Birkelund, 1965, from the Santonian of Greenland is an analogue. *Baculites thomi* Reeside, 1927*b*, has no equivalents outside the US Western Interior.

Several smooth forms occur in the Middle and/or Upper Santonian of the Indo-Pacific region, e.g. *B. bailyi*, *B. uedae* Matsumoto & Obata, 1963, and *B. delvallei* Riccardi, 1980. These are analogues of European *B. fuchsi* Redtenbacher, 1873. *Baculites kirki* Matsumoto, 1959, with a ventral keel, is endemic to the Santonian of California. *Boehmoceras*, as *B. arculus* (Morton 1834) (=*B. loescheri* Riedel, 1931) and *B. krekeleri* (Wegner, 1905) are rarities in the Upper Santonian of Europe, but are abundant in the US Gulf Coast as *B. arculus*.

To summarize, similarities may still be seen in some Santonian baculitids from the different regions, but most of the species appear to be endemic, especially those of the US Western Interior.

CAMPANIAN

Figs 7–14

In contrast to the Turonian to Santonian stages, radiation of *Baculites* in the Campanian appears explosive. However, if the duration of the stage is taken into account, the rate of evolution does not seem excessively accelerated.

The best documented succession is that of the US Western Interior (Figs 7–9). Lower Campanian species include *B. aquilaensis* Reeside, 1927*b*, *B. haresi* Reeside, 1927*b*, and *B. thomi*, the latter a survivor from the Santonian. The Middle and Upper Campanian succession consists of a series of ribbed and smooth species (see Scott & Cobban 1965, map I–439), many of them restricted to the Western Interior, with others also known from the Gulf Coast region. The difference between US Western Interior and Gulf Coast *Baculites* faunas (see discussion above, p. 11) may be more apparent than real. The Gulf Coast ammonite record is limited to a small number of levels only, and most of these include Western Interior taxa (Ozan, Annona, Yancy, Wolfe City Sand, *spiniger* fauna, etc.).

The succession in the Indo-Pacific is not quite as clear. Lower Campanian smooth species include *Baculites bailyi* and *B. delvallei*, both survivors from the Santonian and probably synonyms, and *B. chicoensis* Trask, 1856; nodose species include descendants of *B. capensis*, *B. tanakae* Matsumoto & Obata, 1963, *B. menabensis* Collignon, 1969, and *B. sparsinodosus* Collignon, 1969; all probably synonyms of *B. tanakae*. *Baculites sulcatus* Baily, 1855, is restricted to Pondoland and subsurface Zululand. In the Middle Campanian of Zululand and Madagascar, *B. vanhoepeni* Venzo, 1936, and *B. increscens* Collignon, 1969, are generally strongly ornamented, and homoeomorphic with the *B. obtusus*–*B. asperiformis* series of the US Western Interior. *Baculites regina* Obata & Matsumoto, 1963, from Honshu could possibly belong to this group. *Baculites nibelae* Klinger & Kennedy, 1997, succeeds this group in Zululand and equivalent forms in Madagascar and possibly the Middle East. *Baculites duharti* Hünicken, 1975, is a large, smooth baculite of the Middle to Upper Campanian of Zululand and Patagonia. *Baculites kotanii* Matsumoto *et*

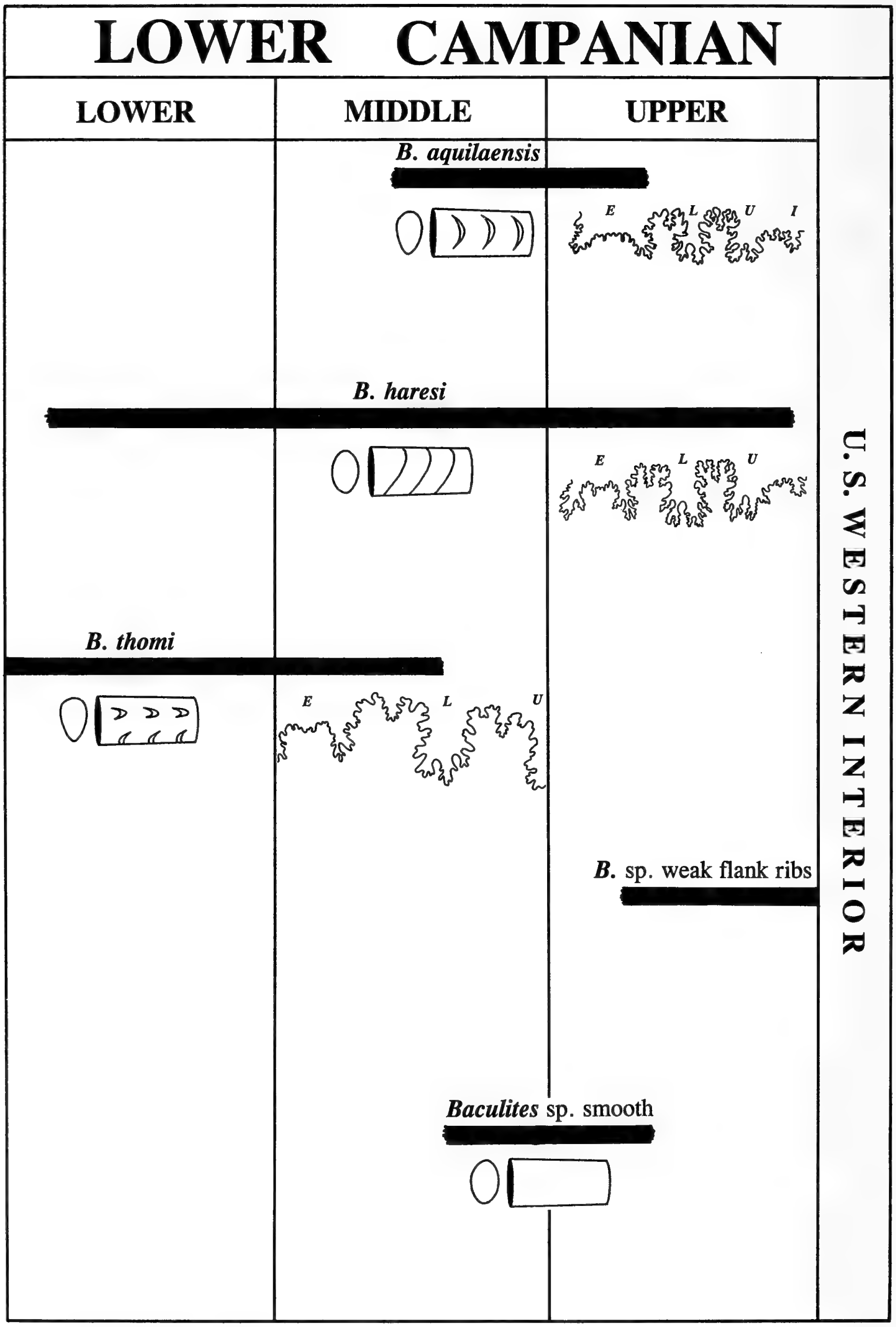


Fig. 7. Stratigraphic distribution of species of the genus *Baculites* in the Lower Campanian in the US Western Interior.

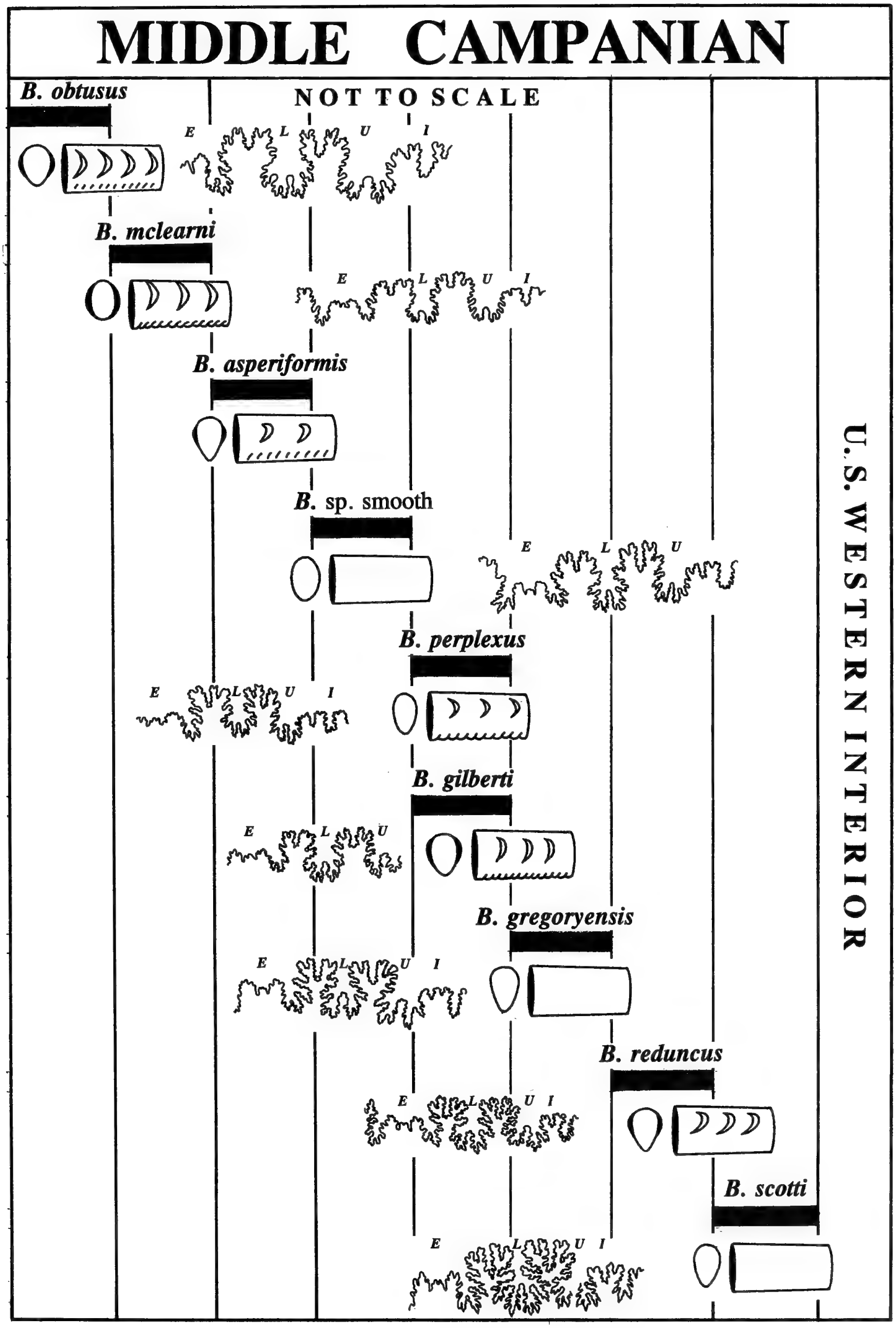


Fig. 8. Stratigraphic distribution of species of the genus *Baculites* in the Middle Campanian in the US Western Interior.

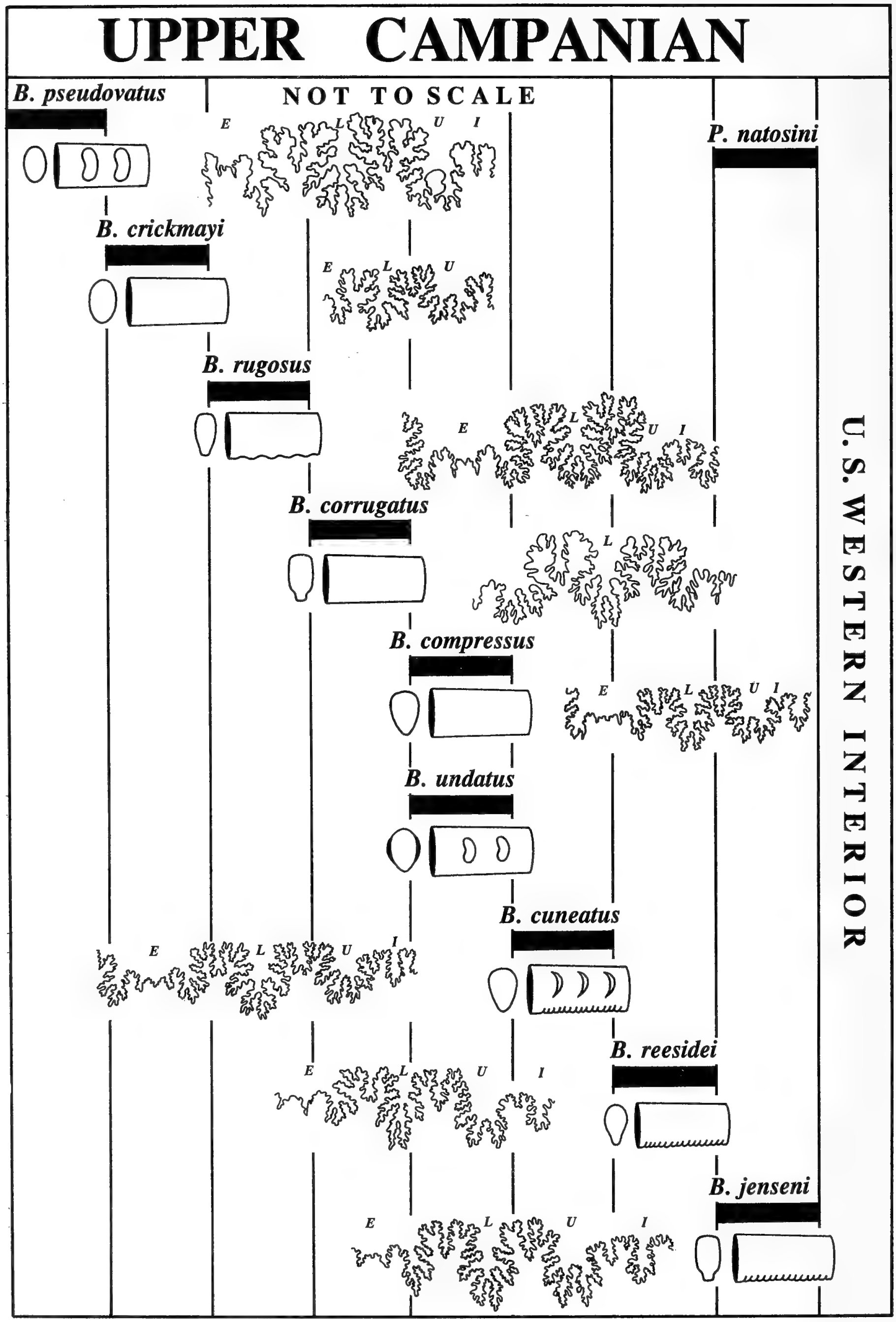


Fig. 9. Stratigraphic distribution of species of the genus *Baculites* in the Upper Campanian in the US Western Interior.

al. 1980, is a small, smooth baculite apparently endemic to Japan. *Baculites rectus* Marshall, 1926, is a smooth baculite, probably from the Upper Campanian of New Zealand, Campanian s.l. of South Africa?, and Antarctica.

Baculites subanceps Haughton, 1925, is widespread in the Upper Campanian, occurring in Angola, South Africa, California, British Columbia, Hokkaido, Antarctica, and the Middle East; smooth forms are very similar to *Eubaculites occidentalis*.

In the Gulf-Atlantic region individual species of *Baculites* are common to abundant, but diversity is low. Two fragments of *B. tanakae*? (as *B. capensis*) are recorded from the Lower Campanian of Angola by Cooper (1988), and *B. subanceps* from the Upper Campanian and/or Lower Maastrichtian. Middle Campanian *B. taylorensis* Adkins, 1929, is similar to *B. vanhoepeni* from the Middle Campanian of the Indo-Pacific region. *Baculites claviformis* Stephenson, 1941, *B. undatus* Stephenson, 1941, and *B. ovatus* Say, 1821, occur in the Upper Campanian of the Gulf Coast and Atlantic Seaboard. There are doubtful records of *B. ovatus* from the Middle East, and we have seen a single specimen from southern France. *Baculites undatus* has recently been recorded from the Western Interior (Cobban 1973; Cobban *et al.* 1992; Larson *et al.* 1997), and, with *B. texanus* is a Gulf Coast immigrant into that region during the Campanian. Lower Campanian *B. haresi*, a typical Western Interior species, was recorded from New Jersey by Kennedy & Cobban (1993*e*).

The baculites of the Middle East (Figs 192–195) are largely undescribed. North African *Baculites* cf. *ovatus* and *B. subanceps* (Luger & Gröschke 1989) probably connect with the Gulf-Atlantic and Indo-Pacific regions. *Trachybaculites? furcillatus* (Blanckenhorn, 1905) (Taubenhaus 1920) is endemic to Israel. Lefeld & Uberna (1992) mentioned *Baculites* from Libya, but the material has yet to be described.

Apart from *Baculites leopoliensis* Nowak, 1908, the European Campanian *Baculites* succession is still largely unknown, and details of the systematics still have to be worked out. The material is generally poorly preserved and lacks key morphological characters in most cases. Only *Baculites leopoliensis* Nowak, 1908, can be regarded as well-characterized. (However, see comments on the age of *B. leopoliensis* in the appendix.) The remaining species are based on a few fragments and most are best regarded as *nomina dubia* in the absence of data on intraspecific variation. Some of the baculites are very similar to *B. tanakae* and *B. vanhoepeni* of the Indo-Pacific. Kennedy & Jagt (1995) described a new species, *B. vaalsensis*, from the Lower Campanian Vaals Formation of the Aachen area (Germany, Belgium and the Netherlands); it also occurs in southern England and New Jersey (Kennedy *et al.* 1997*b*). Santamaria Zabala (1996) described two new species from northern Spain: *B. alonsoi* Santamaria Zabala (1996: 13, pl. 3 (figs 3–6)) and *B. alavensis* Santamaria Zabala (1996: 14, pl. 3 (figs 7–9)) as well as two other species in open nomenclature. *Baculites alavensis* is similar to *B. leopoliensis* and was described fully on the basis of additional material (Klinger & Küchler 1998).

The recent records of *Baculites aquilaensis* and *Baculites* 'smooth species' from Belgium by Kennedy (1993: 110, pl. 4 (figs 22–24), p. 111, pl. 5 (figs 1–12), pl. 6 (figs 5–10), text-fig. 6, respectively), typical Lower and Middle Campanian species from the US Western Interior are at first surprising,

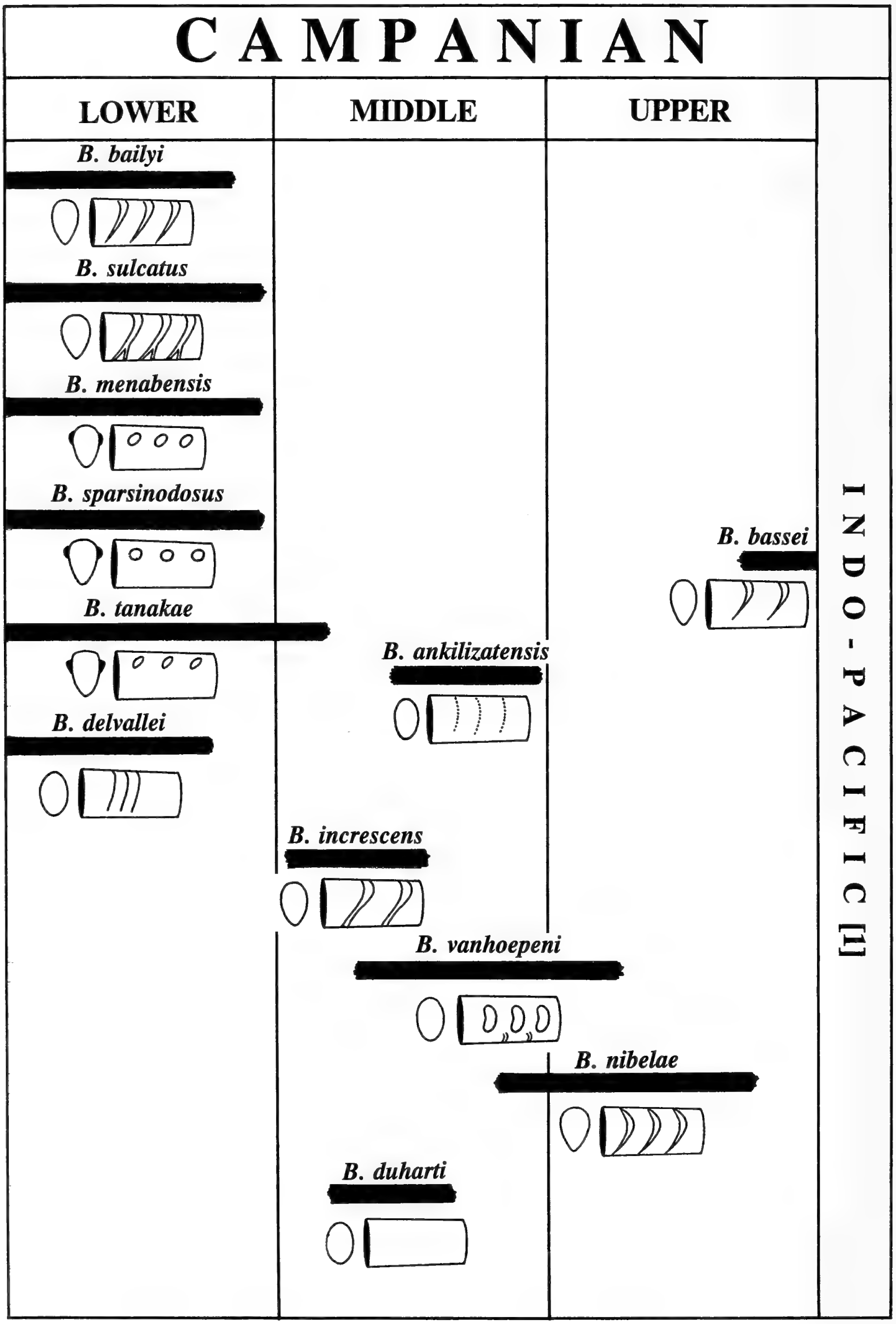


Fig. 10. Stratigraphic distribution of species of the genus *Baculites* in the Campanian in the Indo-Pacific (1).

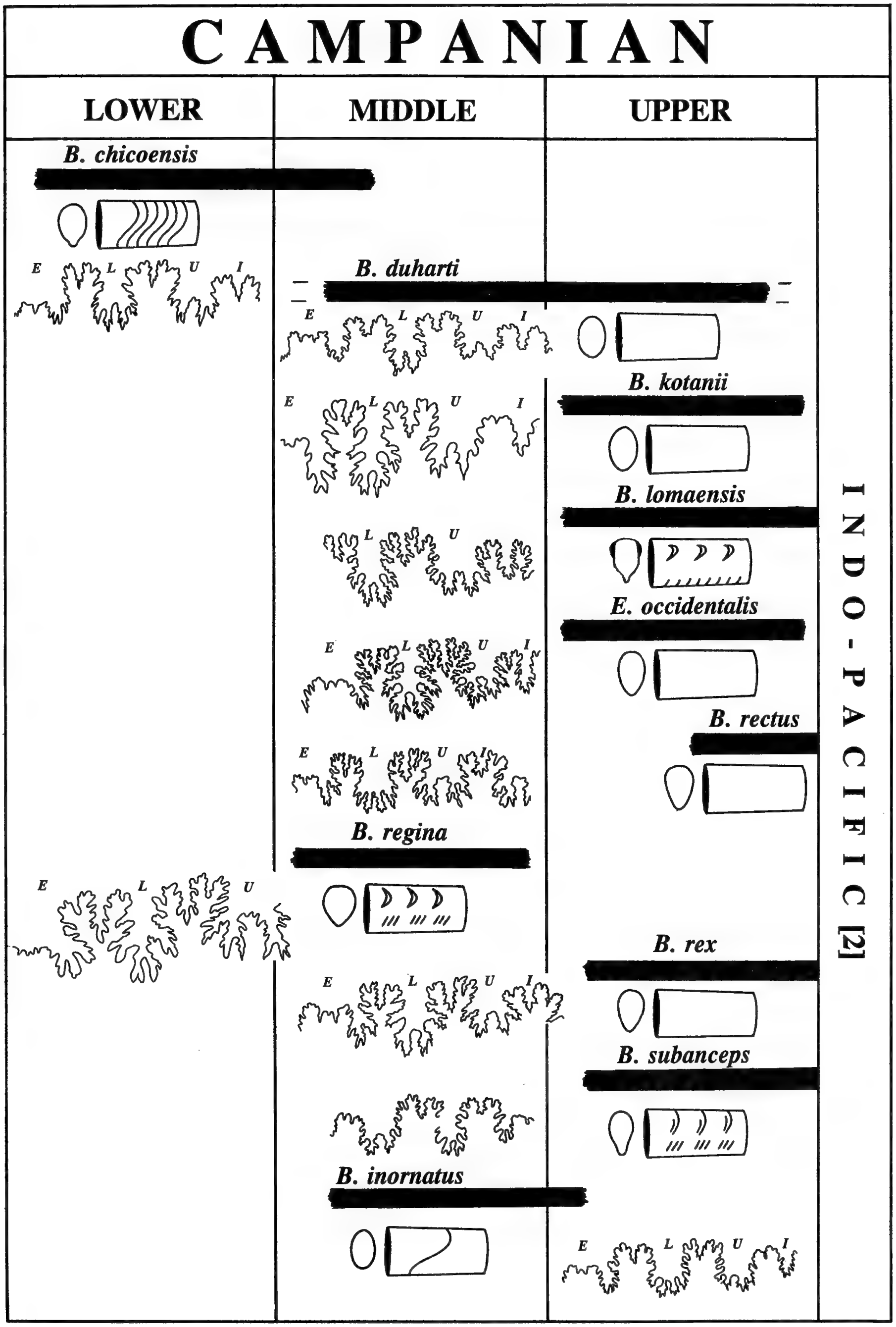


Fig. 11. Stratigraphic distribution of species of the genera *Baculites* and *Eubaculites* in the Campanian in the Indo-Pacific (2).

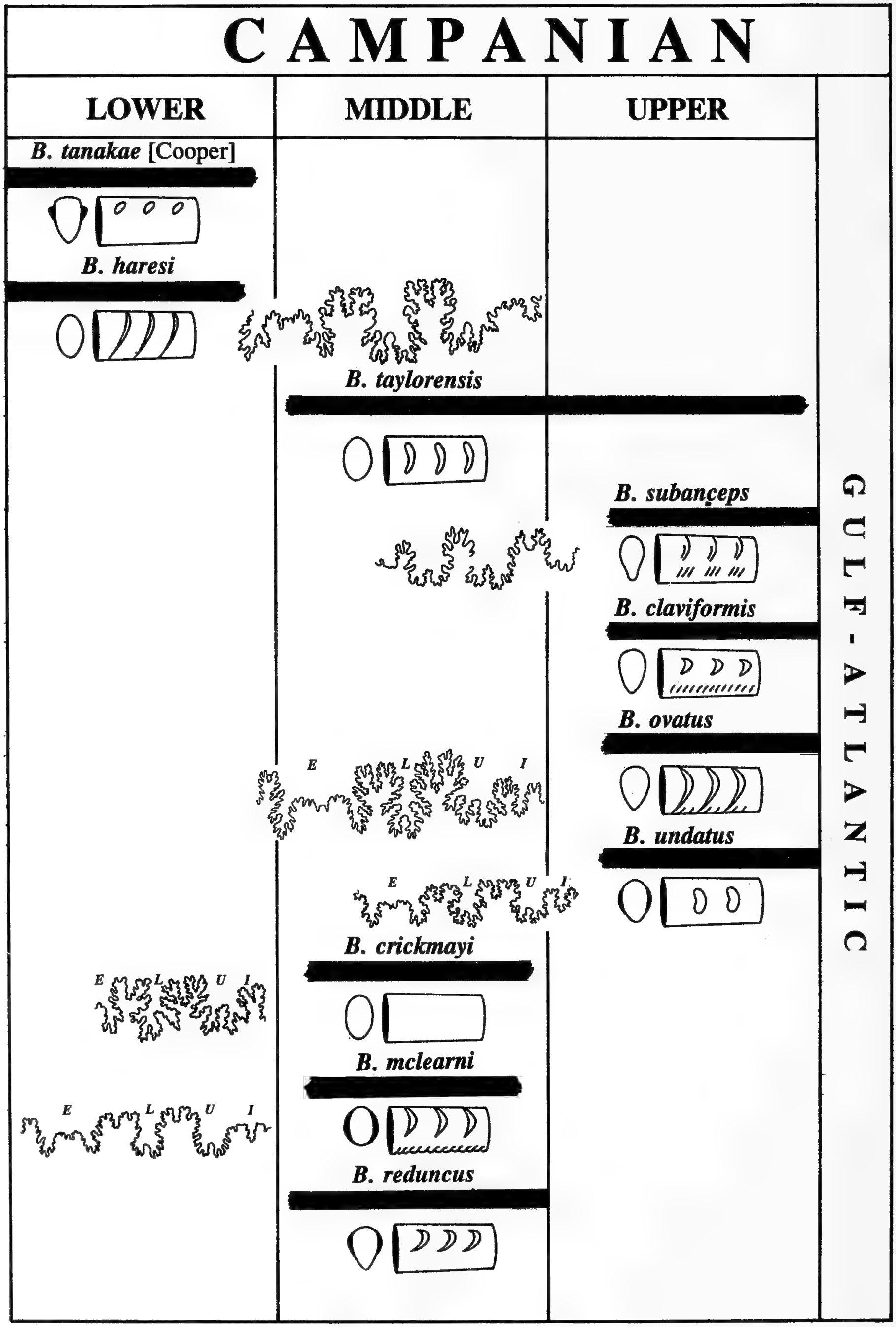


Fig. 12. Stratigraphic distribution of species of the genus *Baculites* in the Campanian in the Gulf-Atlantic Region.

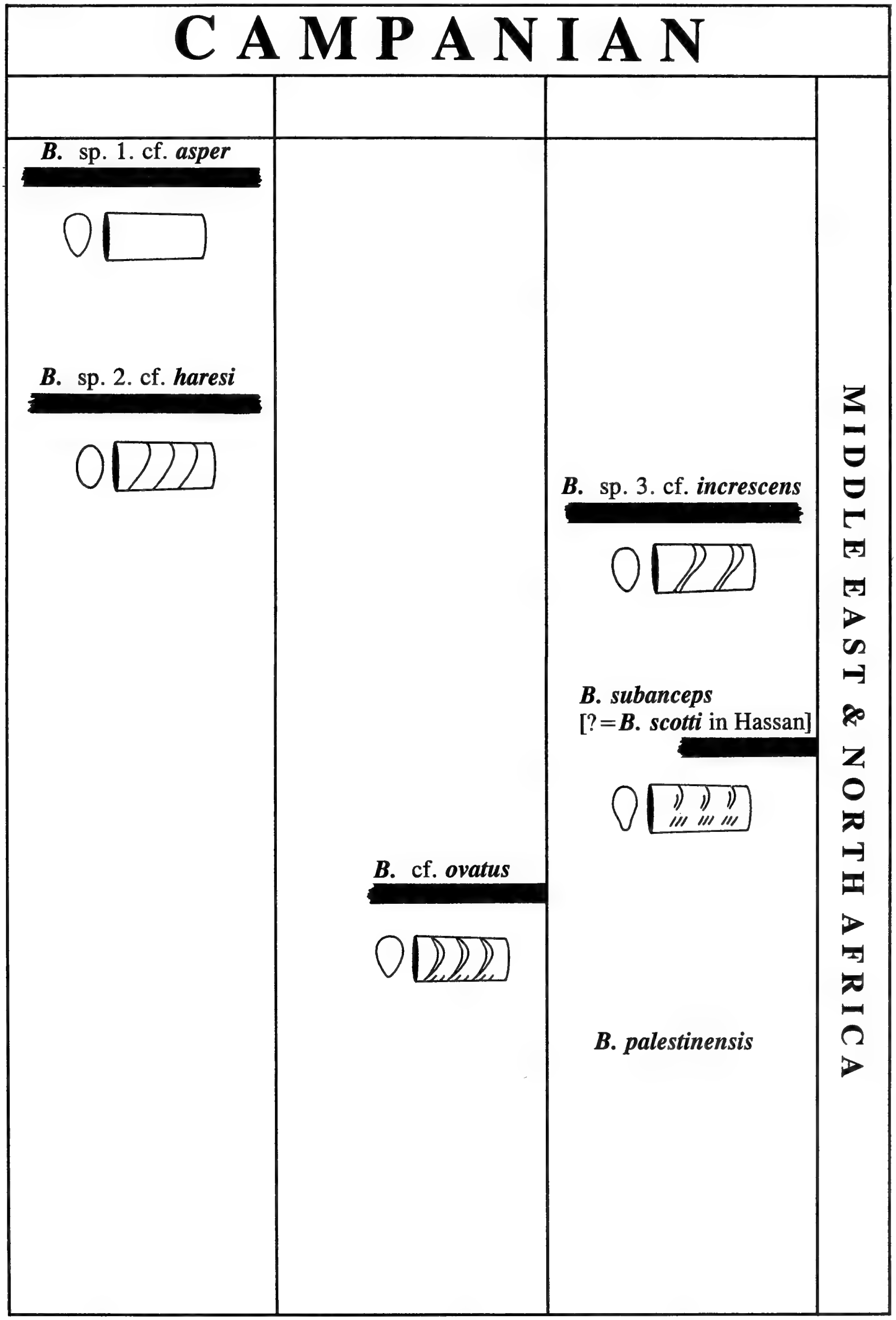


Fig. 13. Stratigraphic distribution of species of the genus *Baculites* in the Campanian in the Middle East and North Africa.

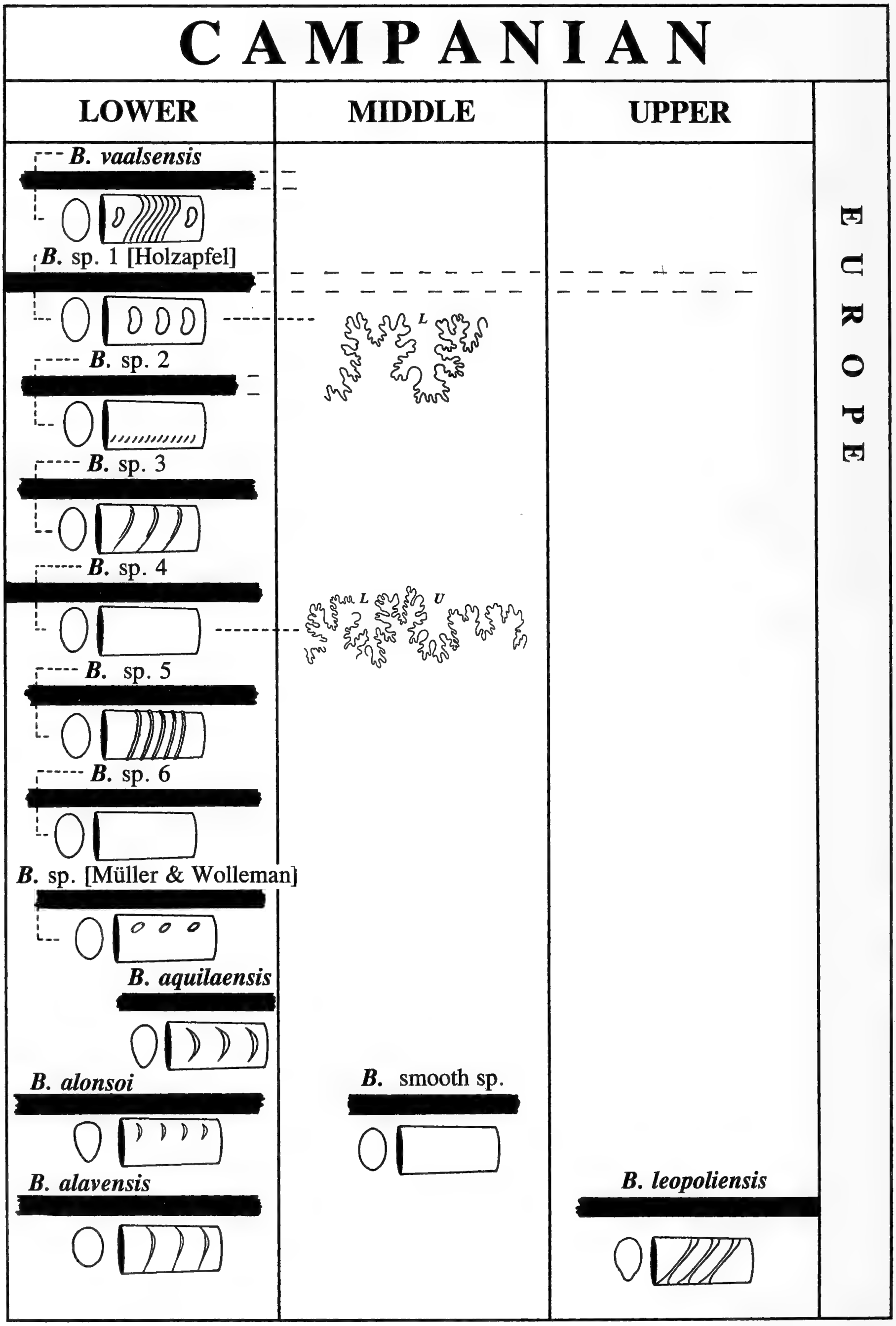


Fig. 14. Stratigraphic distribution of species of the genus *Baculites* in the Campanian in Europe.

but the poor record at other levels and localities conceal other common taxa. If these are indeed correctly identified, it certainly alters our current ideas about the currently perceived endemic character of the US Western Interior baculitid faunas.

MAASTRICHTIAN

Figs 15–19

The Maastrichtian is characterized by the dominance of *Eubaculites* in the southern Gondwanan regions, and by the presence of long-ranging *Baculites* species in Europe.

In contrast to the Campanian, the Maastrichtian baculite species of the Western Interior are few in number. The Campanian lineage of *B. compressus* Say, 1821, ended in the basal Maastrichtian with *B. eliasi* Cobban, 1958. This fauna is replaced by *B. baculus* Meek & Hayden, 1861, an immigrant from the Gulf Coast region. *Baculites baculus* gave rise to *B. grandis* Hall & Meek, 1854, and *B. clinolobatus* Elias, 1933, all large forms with broad, rib-like swellings on the flanks. The last baculitids of the Western Interior (Cobban & Kennedy 1992*c*) are all atypical. *Baculites larsoni* Cobban & Kennedy, 1992*c*, is very small, *Trachybaculites columna* (Morton, 1834) has circumperipheral ribbing and merits generic separation (Cobban & Kennedy 1995); it has recently been recorded from the Netherlands (Kennedy & Jagt 1998). *Baculites* sp. is a curved *Boehmoceras* homoeomorph, probably referable to *Criobaculites*. Fragments of a more typical large *Baculites* occur in the *Jeletzkyites nebrascensis* Zone in the Pierre Shale near Verdigre, Knox County, Nebraska (Kennedy *et al.* 1998).

European baculites are very characteristic. *Eubaculites carinatus* is a rarity, as is Upper Maastrichtian *Fresvillia*. *Baculites knorrianus* Desmarest, 1817, is a large, smooth species, typically Lower Maastrichtian but occurring in the lower Upper Maastrichtian in Denmark. *Baculites vertebralis* Lamarck, 1801, and *B. anceps* Lamarck, 1822, are best known from the Upper Maastrichtian; in Denmark they persist to the end of the stage (Birkelund 1979, 1993). Very badly preserved specimens referred to both species have been recorded from the Lower Maastrichtian of Zumaya (Ward *et al.* 1991; Ward & Kennedy 1993).

Baculites baculus, a typical Gulf Coast and US Western Interior species, has recently been recognized from Belgium (Kennedy 1993: 110, pl. 4 (figs 10, 20–21)).

As discussed above, the Indo-Pacific, especially the south Gondwanan regions, are dominated by *Eubaculites* species. Several species of *Baculites* appear to span the Campanian–Maastrichtian boundary (or are dated no more accurately than the high Campanian or low Maastrichtian). These include *B. rectus*, *B. subanceps* and *B. rex* Anderson, 1958. *Trachybaculites vicentei* (Stinnesbeck, 1986) and *B. huenickeni* Stinnesbeck, 1986, are endemic to Chile, *B. ambatryensis* is only known from Madagascar and Pakistan (Fatmi & Kennedy 1999). *Eubaculites binodosus* (Noetling, 1897) is based on the holotype and six other specimens and is only known from the Upper Maastrichtian of Baluchistan (Fatmi & Kennedy 1999).

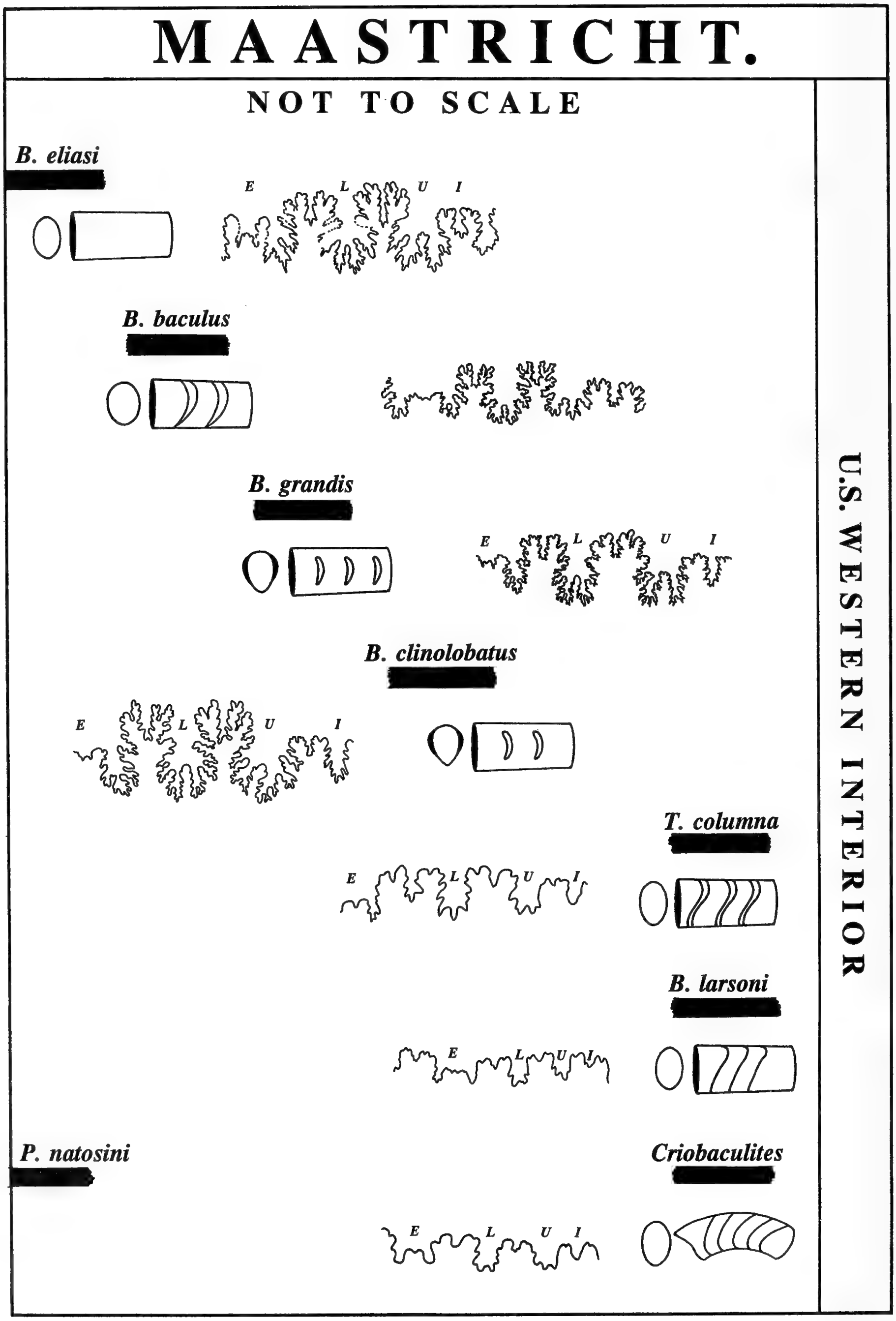


Fig. 15. Stratigraphic distribution of species of the genera *Baculites*, *Pseudobaculites* and *Criobaculites* in the Maastrichtian in the US Western Interior.

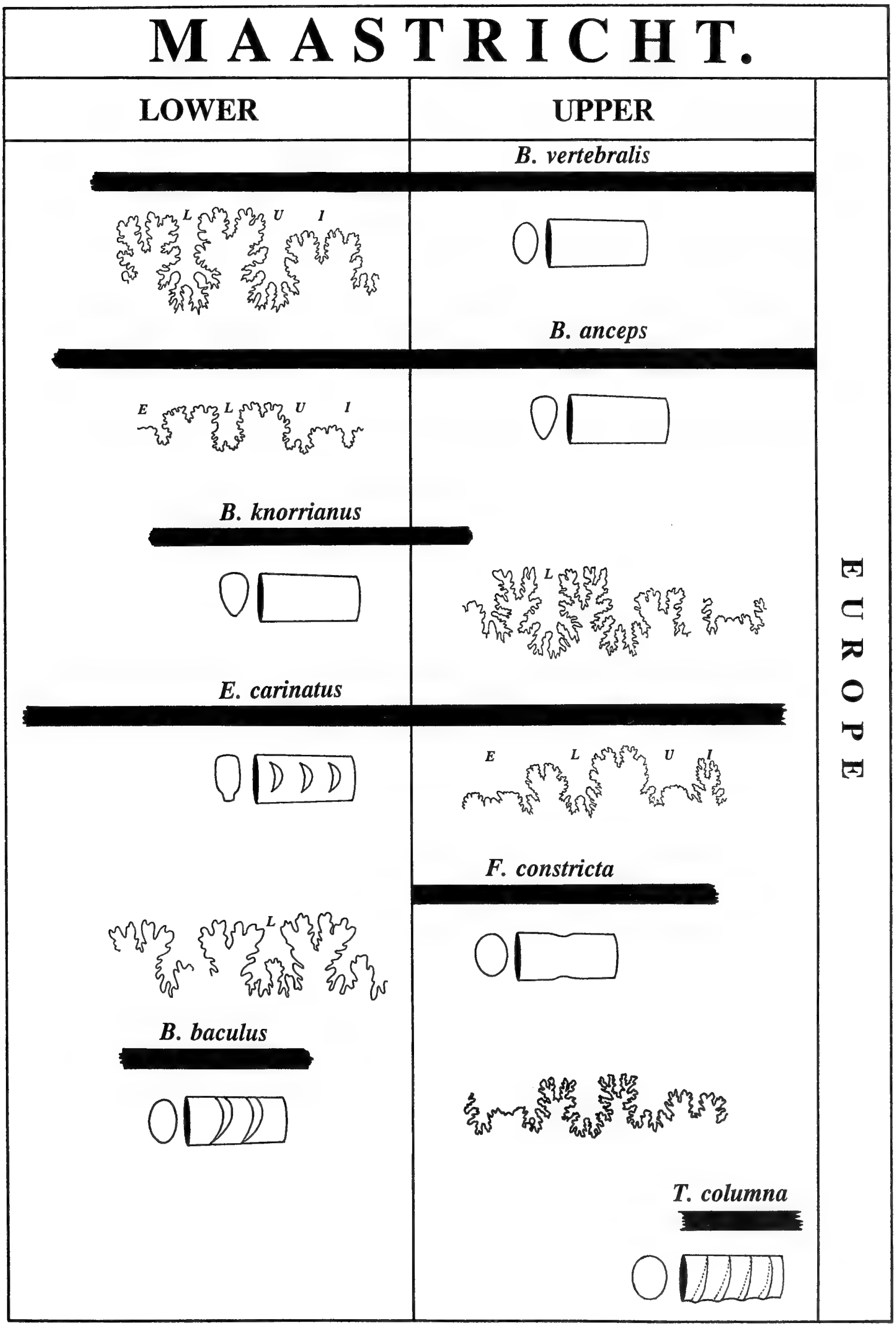


Fig. 16. Stratigraphic distribution of species of the genera *Baculites*, *Trachybaculites* *Eubaculites* and *Fresvillia* in the Maastrichtian in Europe.

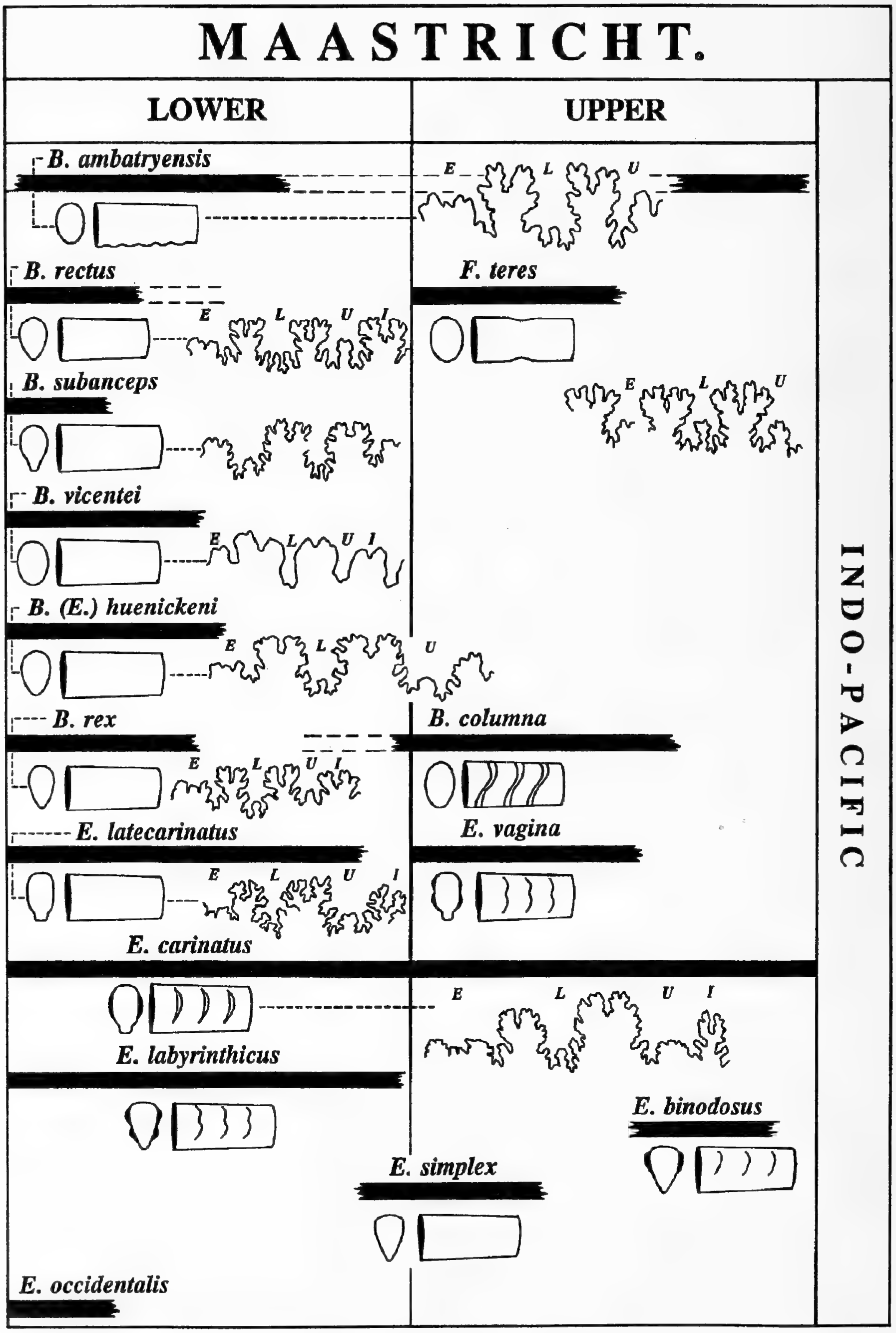


Fig. 17. Stratigraphic distribution of species of the genera *Baculites*, *Eubaculites* and *Fresvillia* in the Maastrichtian in the Indo-Pacific.

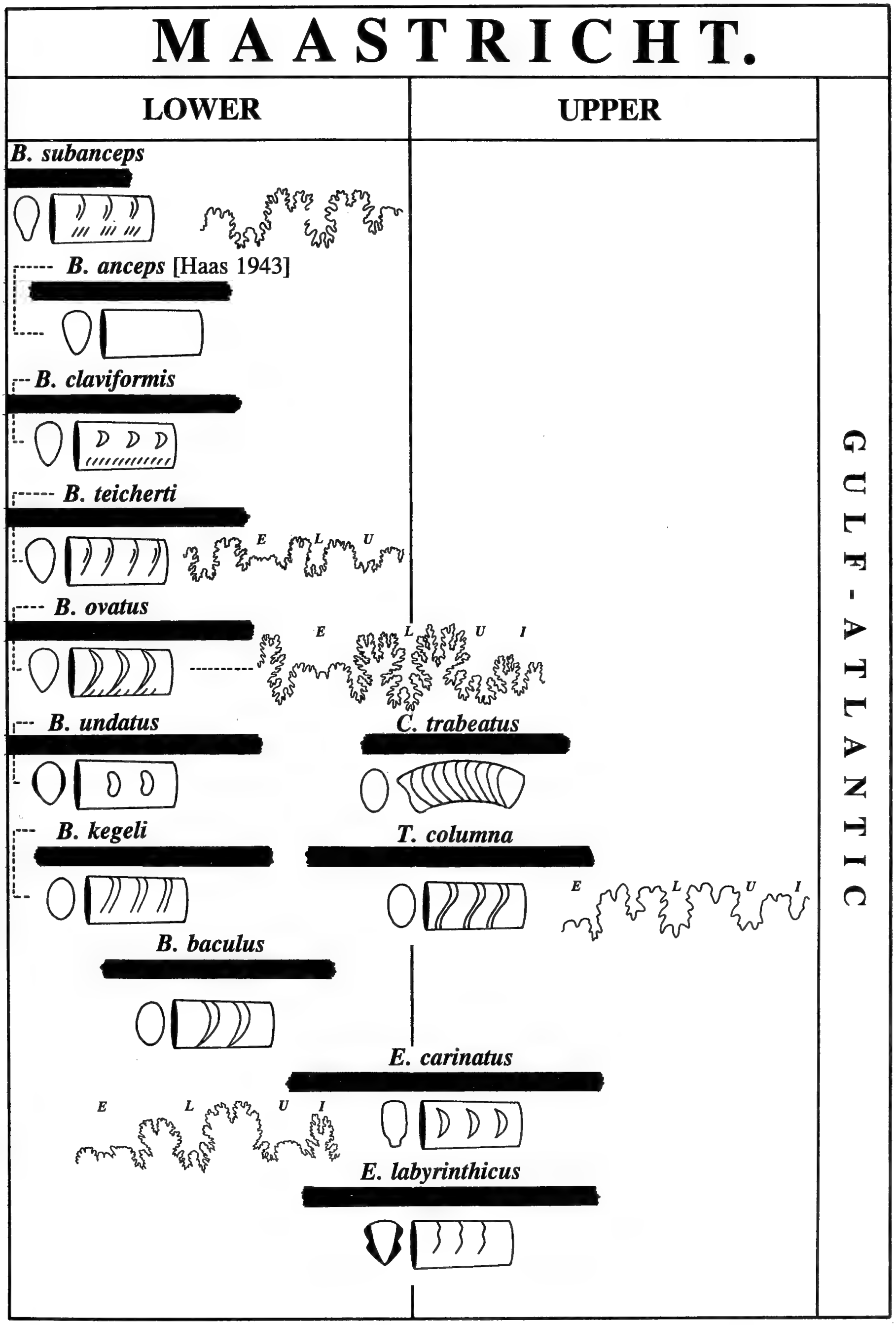


Fig. 18. Stratigraphic distribution of species of the genera *Baculites*, *Trachybaculites*, *Eubaculites*, and *Criobaculites* in the Maastrichtian in the Gulf-Atlantic Region.

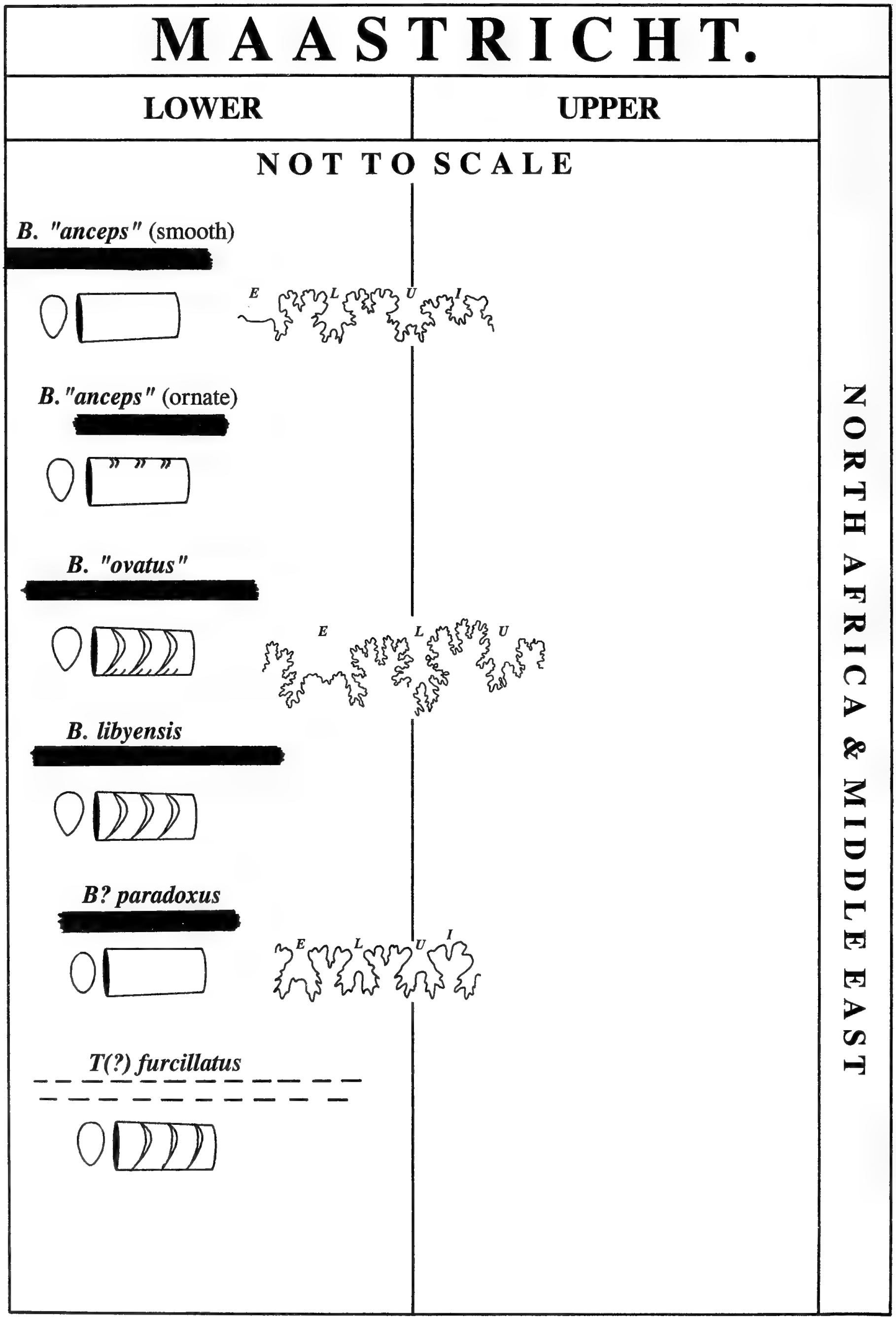


Fig. 19. Stratigraphic distribution of species of the genus *Baculites* in the Maastrichtian in North Africa and the Middle East.

In the Gulf-Atlantic Region, several species seem to span the Campanian–Maastrichtian boundary: *B. subanceps*, *B. claviformis* and *B. undatus*. *Baculites teicherti* Reyment, 1956, is endemic to Nigeria but may be a *B. subanceps*. Some doubtful specimens of *B. anceps* (SAM collections) from the Lower Maastrichtian of Angola may permit correlation with Europe and the Middle East. *Baculites baculus* and *Trachybaculites columna* permit correlation with the Western Interior. Exogastrically curved *Criobaculites trabeatus* is analogous to the Western Interior *Baculites* ?sp. of Cobban & Kennedy (1992*c*: 684, figs 1.1–1.4, 3.1).

Thus, in contrast to *Eubaculites*, *Baculites* has a wide distribution to higher northern and lower southern latitudes and across the equator; it also occurs in West Africa, albeit apparently not in very great numbers. The paucity of *Baculites* in the Southern Hemisphere in the Maastrichtian compared to the abundance of *Eubaculites* and the dominance of *Baculites* in the Northern Hemisphere are striking.

COILING

Apart from the ammonitella, the shell in the family Baculitidae is more or less straight in the majority of taxa. Criocone curvature occurs in two short-lived lineages, in the endogastric Upper Santonian *Boehmoceras* and exogastric Maastrichtian *Criobaculites* respectively.

As far as is known, the shell in *Lechites* is always straight and that of *Sciponoceras* too, except at the aperture in some (see e.g. Wright 1979: 286, or in *S. cucullatum* Collignon (1964, pl. 326 (fig. 1458)). Early (Turonian) forms of *Baculites* appear to be straight, but some of the later species may show various degrees of endogastric curvature of the body chamber. In the Coniacian and Santonian, some specimens of *B. incurvatus* and *B. capensis* have slightly curved body chambers; Meek's 1876 'group b' of *Baculites* included in Spath's (1926) genus *Euhomaloceras*, of which *B. incurvatus* is the type species. The majority of *B. capensis*, however, have straight body chambers and this feature is of no taxonomic value in these species. Kennedy & Wright (1985: 142) suggested that these curved *B. incurvatus* gave rise to crioceratitid-coiled *Boehmoceras* in the Upper Santonian; new data from the Gulf Coast (Kennedy & Cobban 1991*b*) suggest that *B. capensis* could be the ancestor. An alternate, possibly more plausible explanation is that *B. incurvatus* and *B. capensis* are synonyms as suggested earlier (Klinger & Kennedy 1997).

In later Santonian, Campanian and Maastrichtian *Baculites*, perfectly straight, as well as slightly curved species occur. A good example of a perfectly straight *Baculites* is *B. thomi* (*in* Cobban & Kennedy 1991*a*, pls 1–2). Amongst the curved species, curvature may only encompass the early whorls (e.g. in *B. cuneatus* (Cobban 1962*a*: 128), or the whole shell may be curved, more or less like a scabbard as in *B. reduncus* Cobban, 1977, or only the body chamber may be affected as in *B. claviformis* (Stephenson 1941: 404, pl. 1). Curvature of the body chamber in some of the Madagascan Campanian species of *Baculites* is as variable, as in the ancestral Coniacian–Santonian *B. capensis*, as shown by various specimens figured by Collignon (1969). Compare e.g. *B. menabensis* (Collignon 1969, pl. 518 (fig. 2036) with straight body chamber, and fig. 2037 with curved body chamber)), *B. antsirasiraensis* (Collignon, 1969, pl. 519 (fig. 2040 with straight body chamber, and fig. 2041 with curved body chamber)), *B. ventroplanus* (Collignon 1969, pl. 520 (fig. 2049 with straight body chamber and fig. 2050 with curved body chamber)). All of these are probably synonyms of *B. tanakae*. Slight curvature of the body chamber is also present in some specimens of *B. vanhoepeni* and *B. sulcatus* from the Campanian of Zululand and Pondoland, respectively. These all indicate that curvature of the body chamber in these *Baculites* is very variable and of no taxonomic significance.

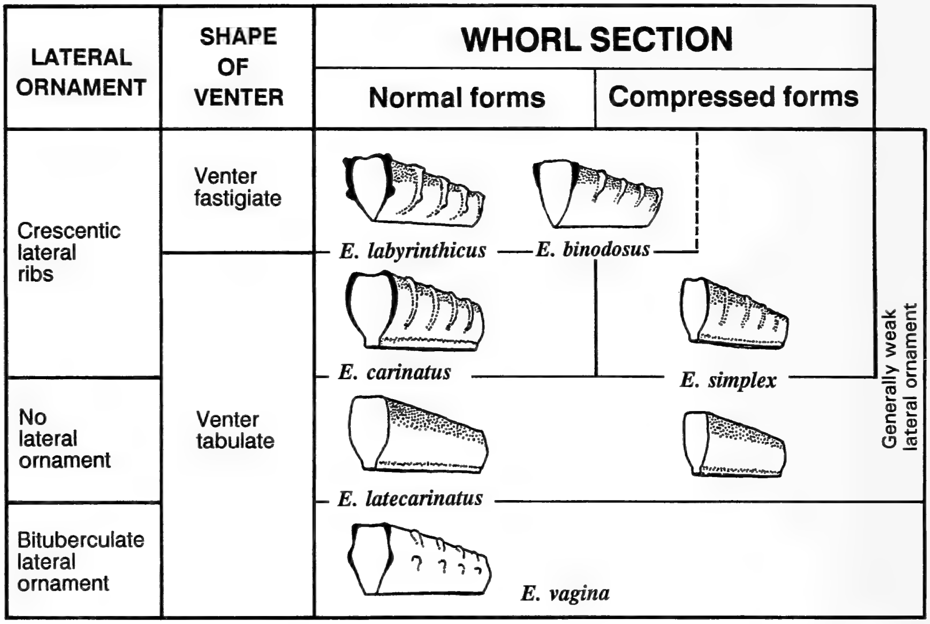


Fig. 20. Diagram to illustrate whorl sections and ornament of *Eubaculites* species in the Maastrichtian.

In the predominantly Maastrichtian genus *Eubaculites*, perfectly straight as well as curved species occur. Distinct curvature of the whole shell in a scabbard-like manner seems to be characteristic of *E. vagina* in India (see e.g. the lectotype in Klinger & Kennedy 1993, fig. 8, or fig. 13) and *E. labyrinthicus* in Madagascar (see e.g. Collignon 1971, pl. 645 (fig. 2388) (as *Baculites simplex*); Klinger & Kennedy 1993, fig. 6). In contrast, some adult specimens of *E. latecarinatus* and *E. carinatus* in Zululand reach gigantic size with whorl heights of up to 90 mm and estimated lengths of 2 metres with no sign of curvature at all.

Criobaculites trabeatus (Morton 1834: 45, pl. 15 (fig. 3)) from the Maastrichtian Prairie Bluff Chalk of Alabama is known from the holotype only, and is a body chamber fragment of a criocone exogastrically recoiled baculitid. Recently, Cobban & Kennedy (1992*c*, figs 1.1–1.4, 3.1) described another exogastrically curved heteromorph as *Baculites?* sp. from the Maastrichtian Fox

Hills Formation of South Dakota, and compared it with *Hamites trabeatus*; as mentioned above, it too is probably also a *Criobaculites*.

WHORL SECTION

Apart from obvious ontogenetic changes, the whorl section seems to be one of the few reliable features in baculitid systematics, especially in the genus *Baculites*.

The whorl section in *Lechites* and *Sciponoceras* is remarkably conservative; it is predominantly circular to elliptical.

The earliest (Turonian) baculitids, *B. yokoyamai* and *B. undulatus* retain the more or less elliptical whorl section of ancestral *Sciponoceras* (see e.g. Matsumoto & Obata 1963, text-figs 63–86). Later baculitids all have a more or less ovoid whorl section with the venter narrower than the dorsum. Some *Baculites* retain an elliptical whorl section, e.g., some Coniacian–Santonian *B. capensis*, *Baculites* smooth species of Cobban (1962*b*: 714, pl. 108 (figs 1–4)) in the Campanian, and *B. vertebralis* in the Maastrichtian, but these are few. A circular or near-circular whorl section is rare in *Baculites* s.s., but occurs in the Maastrichtian in the short-lived lineages of *Fresvillia* and *Trachybaculites*.

Some specimens of *B. capensis*, especially those from the type locality at the Mzamba Estuary, have a shallow, longitudinal depression at mid-flank. This appears to be a unique feature in *Baculites* and is probably associated with the unique lateral ornamentation of *B. capensis*.

Ventral 'keels' of variable shape (fastigiate to tabulate) and prominence are developed in several, apparently unrelated lineages of Baculitidae. The oldest *Baculites* with a distinct, siphonal keel is *B. kirki*, from the Santonian of California. According to Matsumoto (1959: 143), the keel is small and rounded, and not clearly developed on internal moulds, where the venter may be fastigiate. In the latter respect it resembles *B. tanakae* from the Campanian of Hokkaido and Madagascar.

Incipient (tabulate) keels have been recorded in *B. fuchsi* (Summesberger 1979, pl. 1 (figs 2–4)) of the Upper Santonian, in *B. bailyi* (Woods 1906: 341) from the Upper Santonian–Lower Campanian, and in *B. androtsyensis* Collignon, 1970, *B. increscens* Collignon, 1970, and *B. mamillatus* Collignon, 1970, all from the Middle Campanian of Madagascar. None of these species, however, develop sufficiently prominent keels to link them with true (ventral tabulate) keeled *Eubaculites* of the Maastrichtian.

Baculites chicoensis from the Lower Campanian has a more or less distinct ventral keel but, because of its apparent sutural complexity cannot be linked with older keeled *B. kirki* or younger, late Campanian, *E. occidentalis*. The latter is regarded by us (Klinger & Kennedy 1993) as the first true *Eubaculites* because of its distinct tabulate venter.

Two types of whorl section are present in *Eubaculites* (Fig. 20). In the first, and generally considered a diagnostic feature, seen in *E. vagina*, *E. carinatus* and *E. latecarinatus*, but not in the type species *E. labyrinthicus*, the whorl section is pyriform, with a distinct, tabulate ventral keel, separated from the convergent flanks by distinct longitudinal furrows, and a tabulate to slightly concave or convex dorsum.

In the second group of *Eubaculites*, including the type species *E. labyrinthicus*, the whorl section is distinctly trigonal to cuneate, and the venter is narrowly fastigiate, rather than broadly tabulate and the dorsum is flattened. *Eubaculites simplex* is generally more compressed than any of the other *Eubaculites* species, but the venter may be fastigiate or tabulate, even at different ends of the same specimen; the species thus links the two groups within the genus. *Eubaculites binodosus* (Noetling, 1897) also belongs to this group, and differs from *E. labyrinthicus* by having a single, dorsolateral row of tubercles.

Apart from *E. occidentalis*, there are several apparently unrelated *Baculites* species in the Upper Campanian–Lower Maastrichtian from different biogeographic regions that acquire a whorl section similar to that of *Eubaculites* as already noted by Lewy (1986: 5).

The uppermost Campanian–basal Maastrichtian baculitid assemblage from Angola described by Haughton (1925, 1926), Haas (1943) and Howarth (1965) as *B. subanceps*, *B. anceps* and *Baculites* sp. illustrate the point. *Baculites subanceps* normally has a broadly rounded venter; that of *B. anceps* is narrow, but in both populations, specimens with tabulate ventral keels occur. Seen in isolation, these could easily be referred to *Eubaculites* (see e.g. Klinger & Kennedy 1993: 218). *Eubaculites occidentalis* figured by Haggart (1991, pl. 5 (fig. 5)) is indistinguishable from Angolan *B. subanceps* in the collections of the S.A. Museum in this respect.

Baculites rioturbioensis Hünicken, 1965, from the uppermost Campanian or basal Maastrichtian of Patagonia has a distinct cuneiform whorl section as in the second group of *Eubaculites*. Again it is difficult to decide if it is a *Baculites* or a *Eubaculites*. *Baculites nibelae* and *Baculites* sp. cf. *increscens* in the Upper Campanian of Zululand and Israel respectively have a trigonal whorl section and lateral ornament very much like that of *E. labyrinthicus* described from Madagascar (e.g. Klinger & Kennedy 1993, fig. 36a–d). *Baculites bassei* Besairie, 1930, from the uppermost Campanian or basal Maastrichtian of Madagascar is another baculitid with a *Eubaculites*-like whorl section, as is *Baculites* cf. *asperoanceps* figured by Collignon (1938, pl. 6 (fig. 7)) from the Campanian–Maastrichtian of Andimaka, Madagascar. *Baculites lomaensis* Anderson, 1958, from the Lower Maastrichtian of California also has a distinct trigonal whorl section.

Baculites rugosus Cobban, 1962*a*, from the Upper Campanian of the US Western Interior is a very large species. It has a broad, corrugated, slightly tabulate venter and is superficially very similar to equally large *Eubaculites latecarinatus*. *Baculites cuneatus* Cobban, 1962*a*, from the uppermost Campanian has a cuneiform whorl section (as indicated by the name) very much like that of the second group of *Eubaculites*. *Baculites jenseni* Cobban, 1962*a*, and *B. reesidei* Elias, 1933, from the base of the Maastrichtian have incipient tabulate venters as in the first group of *Eubaculites*. All these specimens are part of the endemic Western Interior lineage, and the resemblance is mere homoeomorphy.

Baculites sp. in Stephenson (1941, pl. 76 (figs 7–8)), from the Upper Campanian of the Gulf Coast Region of the USA, has a whorl section and lateral ornament similar to that of *E. labyrinthicus* in Madagascar.

In the European region, Maastrichtian *B. anceps* typically has a tear-shaped whorl section, but also includes specimens with a fastigiate venter or incipient tabulate keels. These individuals are close to contemporary *E. carinatus*. Study of populations, however, shows them to be clearly different.

Boehmoceras krekeleri has a ventral keel, but it is rounded, and either smooth, serrated or plaited ('Zopfkiel').

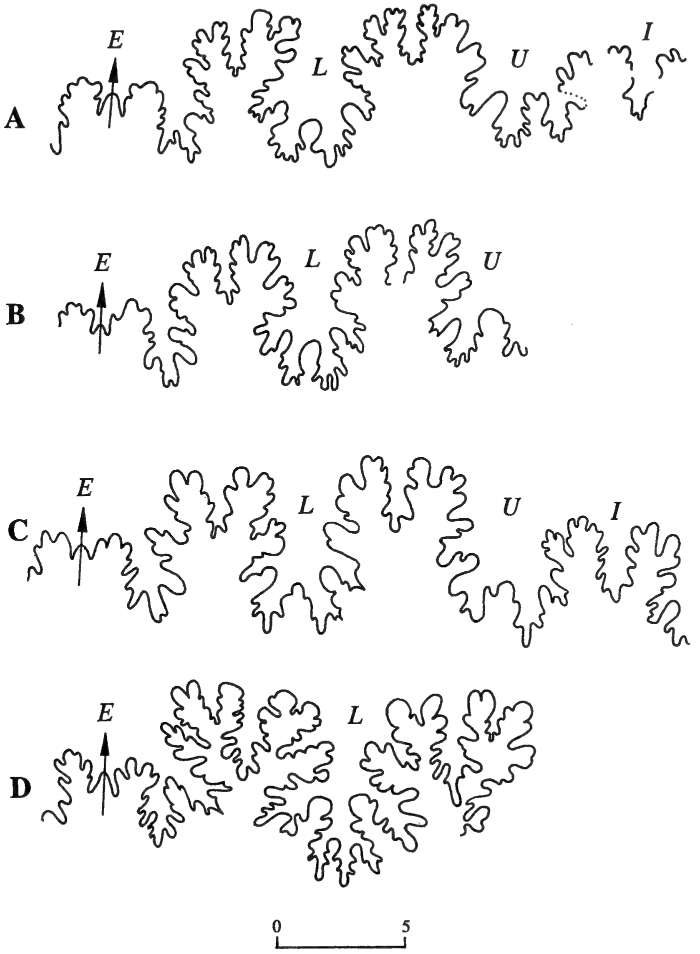


Fig. 21. Variation in details of the suture line in *Baculites vanhoepeni* Venzo, 1936. A. SAS-Z1191. B. SAM-PCZ13146. C. SAM-PCZ7706. D. SAS-Z1923.

SUTURE LINE

All baculitids have a quadrilobate adult suture. The external lobe (E), lateral (L) and umbilical (U) are large and bifid; the internal lobe (I) is smallest and trifid. References to six lobes and saddles in Baculitidae by e.g. Meek (1876:

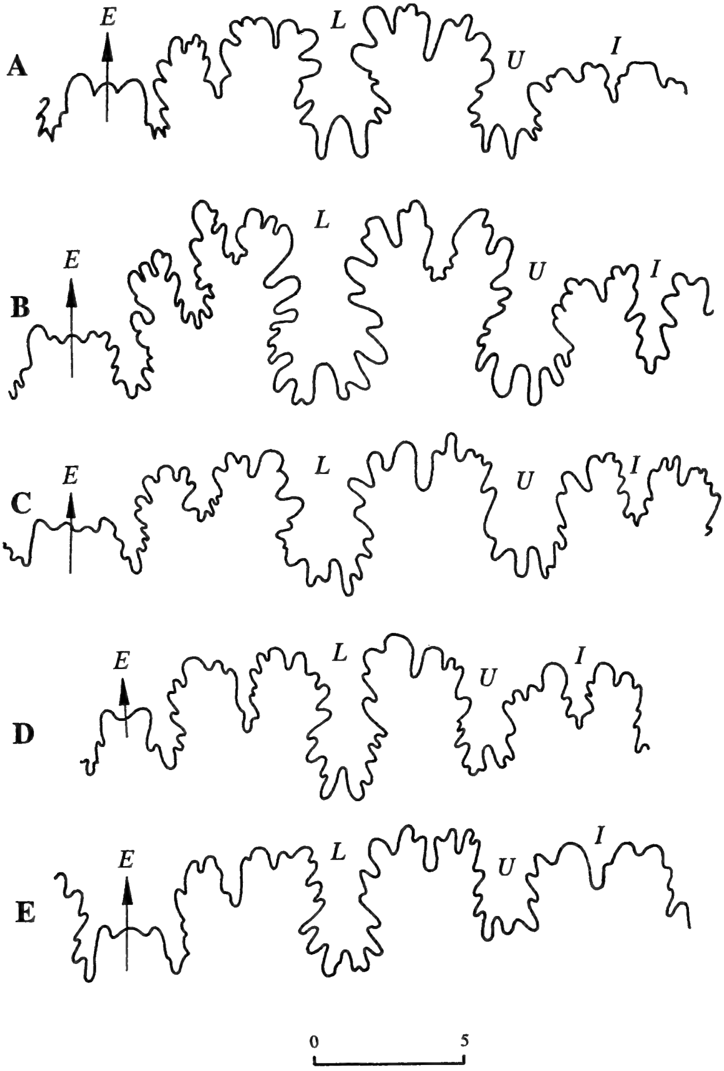


Fig. 22. Variation in details of the suture line in *Baculites capensis* Woods, 1906. A. SAS-H148/3. B. SAS-H13/6. C. SAS-H149/16. D. SAS-L12. E. NMBD1028g.

392) and Reeside (1927*a*: 3; 1927*b*: 9) include the total number of saddles and lobes around the periphery. Unfortunately, studies of the early ontogeny in *Baculites* by Brown (1892), Smith (1901), Reeside (1927*b*), Reyment (1958), Landman (1982), Bandel *et al.* (1982), and Landman & Bandel (1985) have not shown whether the early suture is truly quadrilobate or quinquelobate. Our material is not suitable to resolve this problem. The implications of quadri- versus quinquelobate early sutures in the higher systematics of heteromorph

ammonites are still controversial, see e.g. Mikhailova (1983), Doguzhaeva & Mikhailova (1982), Wiedmann *et al.* (1990) and Wright (1996).

The baculitid shell is very simple and, apart from lateral ornament (when present) and the shape of the whorl section, has very few distinguishing features. Because of this, details of the adult suture lines have received far more attention from some authors than they perhaps deserve—especially in the smooth or feebly ornamented forms of *Baculites*. Descriptions by e.g. Nowak (1908), Elias (1933) and others, illustrate the point.

Details of the adult suture that have been emphasized include:

1. Relative complexity, i.e., degree of incision of the suture. (= Index of sutural complexity 'ISC' (Ward 1980: 39)—the length of the suture line divided by the shortest distance from the umbilicus to the venter.)
2. Mode of incision and shape of the folioles, e.g. phylloid, lytoceratine, dendritic, etc.
3. Shape of the lobes and saddles, e.g. subquadrate, triangular, etc.
4. Relative length and width of the individual elements.
5. Symmetry of the saddles and lobes.

However, some words of caution are necessary before trying to recognize sutural patterns in the Baculitidae. Some are obvious, others less so. The complexity of, and degree of incision of the suture line is directly related to size, i.e. whorl diameter. Thus the suture lines of juvenile and adult specimens will be very different. Suture lines of juvenile specimens are generally not very diagnostic; they only show the quadrilobate nature of the suture. The effects of dimorphism also have to be taken into account; the suture line of a large macroconch may appear slightly more complex than that of a smaller microconch. Thus, when comparing sutures of different species, these should ideally be at similar ontogenetic stages. Simplification of the last few sutures before cessation of growth must also be taken into consideration: compare e.g. *B. knorrianus* in Kennedy & Summesberger (1987: 33, text-fig. 2). Intraspecific variation of the adult suture can be extensive: compare, for example, *B. vanhoepeni* (Fig. 21), *B. capensis* (Fig. 22), *B. ovatus* in Cobban (1974, text-fig. 4), and *E. occidentalis* in Matsumoto (1959, text-figs 64–66), etc.

Genus *Lechites*

The basic baculitid sutural pattern was already established in Albian *Lechites* (Fig. 23) with subrectangular lobes E, L and U, and small trifid I. The umbilical lobe in *Lechites* may be asymmetrically trifid, and may even be different on both sides of the same specimen, as shown by Wiedmann & Dieni (1968: 63, text-fig. 36) and Scholz (1979: 14, text-fig. 5a).

Genus *Sciponoceras*

In the Cenomanian and Turonian genus *Sciponoceras*, two basic, but largely overlapping types of suture can be distinguished (Fig. 24). In the first, the lobes and saddles are trigonal in outline, the saddles have narrow, pinched stems, and the stems of the lobes are constricted, with the dorsolateral edges of the saddles nearly touching. This type of suture is present in *S. baculoides* (see especially Matsumoto 1959, text-figs 2–3); *S. orientale* (see Matsumoto & Obata 1963, text-figs 45–49) and *Sciponoceras* sp. (Matsumoto & Obata 1963, text-fig. 4). In the other group, the saddles and lobes are subrectangular, with the stems of the saddles and lobes nearly as wide at their bases as near the apices. Examples include *S. kossmati* (?*non* Nowak *in* Matsumoto 1959, text-figs 4–6; Matsumoto & Obata 1963, text-figs 24–25), *S. gracile* (see Matsumoto 1959, text-fig. 3) and *S. intermedium* (see Matsumoto & Obata 1963, text-fig. 6).

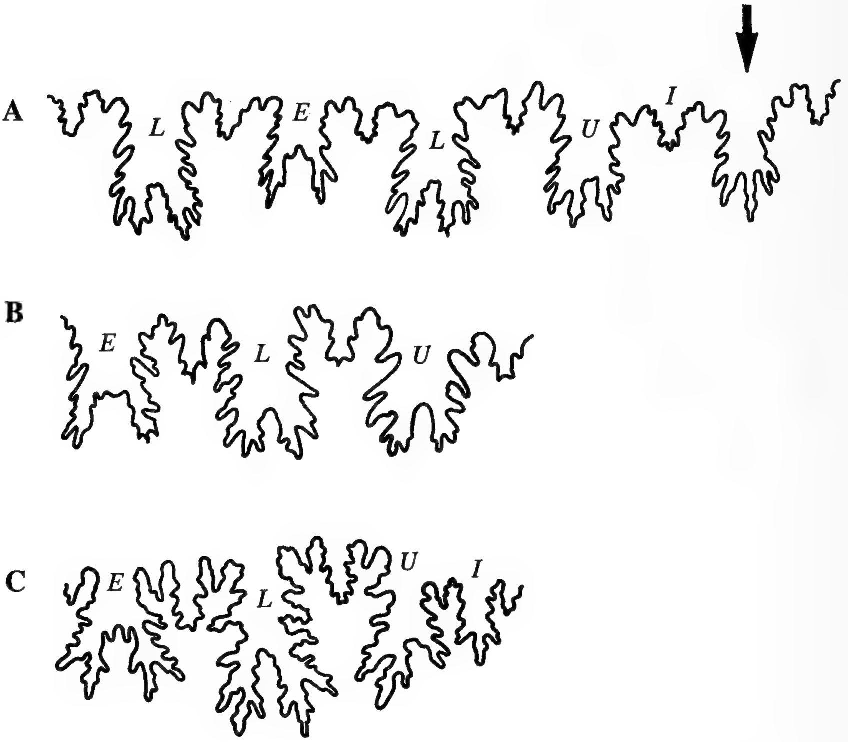


Fig. 23. Suture lines of *Lechites gaudini* (Pictet & Campiche, 1861) to show variation in symmetry of the umbilical lobe (U). A–B. After Scholz (1979, text-fig. 5A–B). C. After Wiedmann & Dieni (1968, text-fig. 36). Arrow points to subtrifid umbilical lobe (U).

Differences between the two broad types of sutures in *Sciponoceras* appear to be in part related to stratigraphic occurrence, and in part to shell shape. The first group is predominantly Cenomanian and with circular to near-circular whorl section. The second is predominantly late Cenomanian to Turonian, and associated with an elliptical whorl section. However, it should be emphasized that, given the variability of baculitid sutures, there is considerable overlap between these two types of sutures and one should be cautious in using details of the suture for specific differentiation (see also discussion by Wright & Kennedy 1981: 114).

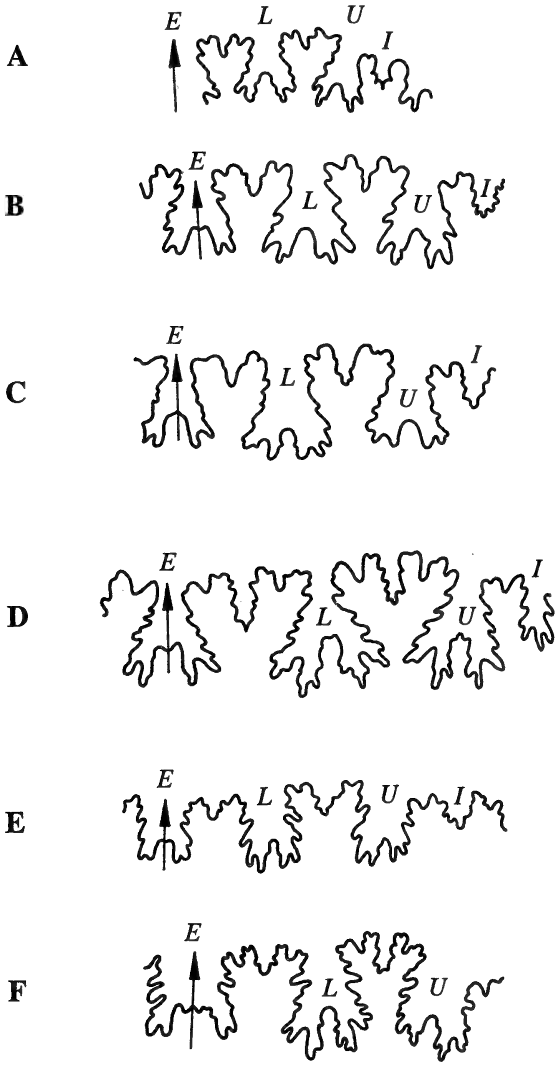


Fig. 24. Suture lines in *Sciponoceras*. A–D. *S. orientale*, with trigonal saddles and lobes. E–F. *S. kossmati*, with subrectangular elements. A–D. After Matsumoto & Obata (1963, text-figs 46–49); E–F. After Matsumoto & Obata (1963, text-figs 24–25).

Genus *Baculites*

In the oldest *Baculites*, *B. undulatus* and *B. yokoyamai*, the suture lines (Fig. 25A–C) are similar to those of the second group of *Sciponoceras*, with subrectangular, little-incised saddles and lobes (although some specimens, e.g. *B. yokoyamai in* Kennedy & Cobban 1991*a*, text-fig. 25e (herein Fig. 25C) deviate slightly from this pattern in being more complex, thus illustrating variation in the suture). On the basis of sutural similarities, it seems reasonable to derive *Baculites* from this group of *Sciponoceras*.

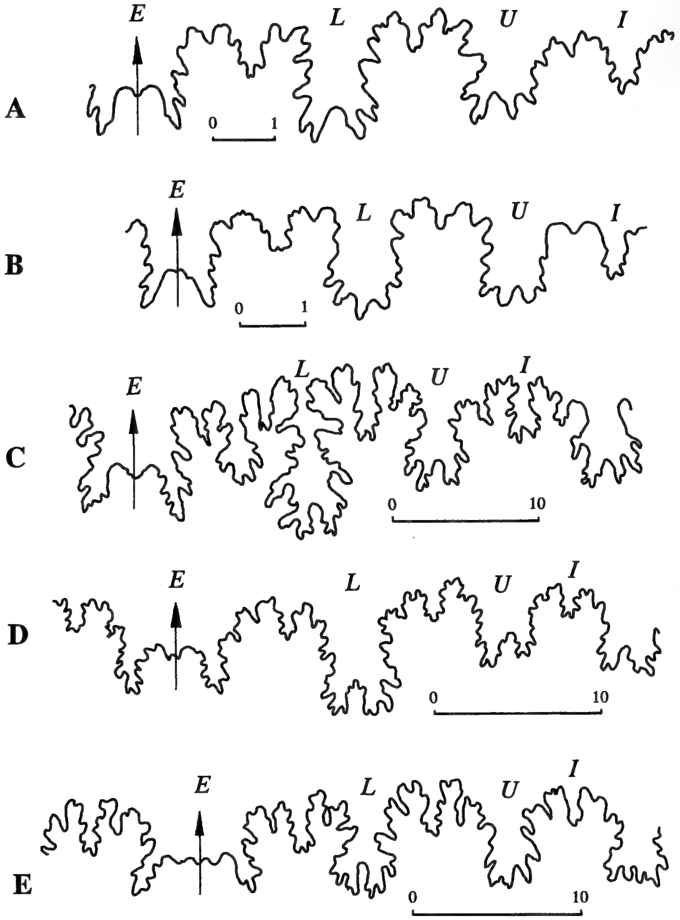


Fig. 25. Suture lines of Turonian and Coniacian *Baculites*. A. *B. undulatus* d'Orbigny, 1850. After Matsumoto & Obata (1963, text-fig. 62). B. *B. yokoyamai* Tokunaga & Shimizu, 1926. After Matsumoto & Obata (1963, text-fig. 87). C. *B. yokoyamai*. After Kennedy & Cobban (1991*a*, fig. 22A). D. *B. mariasensis* Cobban, 1951. After Kennedy & Cobban (1991*a*, fig. 25E). E. *B. codyensis* Reeside, 1927*a*. After Kennedy & Cobban (1991*a*, fig. 25F). Scale bars for size.

This simple sutural pattern is retained in the Coniacian in Europe in *B. incurvatus* (Fig. 26B–C), in the Indo-Pacific in *B. capensis* (Fig. 26D–E), *B. yokoyamai* and *B. bailyi*, and in the US Western Interior in *B. yokoyamai*, *B. mariasensis* (Fig. 25D), *B. sweetgrassensis* and *B. codyensis*. In contrast, the sutures of *Pseudobaculites*, thus far only known from three species, *P. wyomingensis* and *P. nodosus* (Fig. 26A) from the Upper Coniacian, and *P. natosini* from the Upper Campanian and Lower Maastrichtian of the US Western Interior, are extremely complex. The saddles are slender-stemmed and asymmetrically dendritic. The larger size of *Pseudobaculites* in the Coniacian

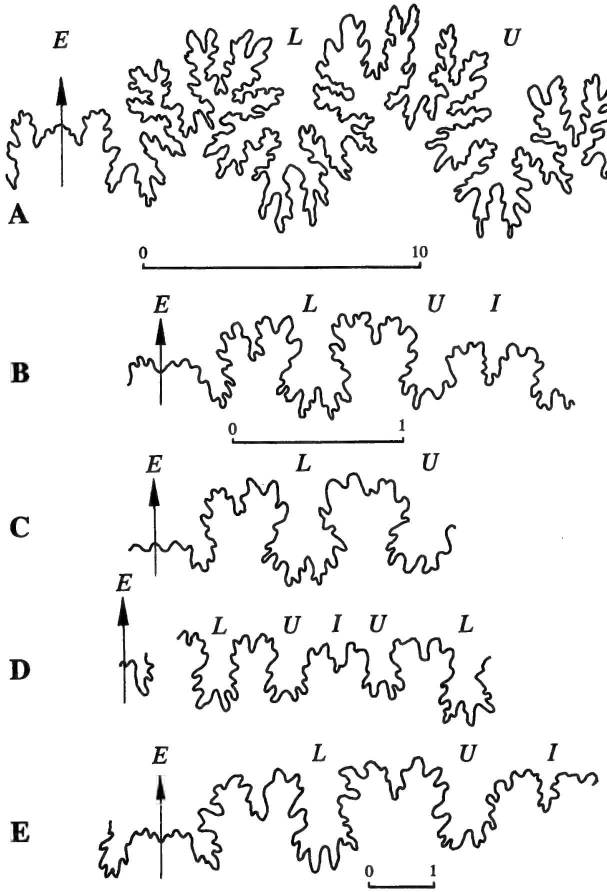


Fig. 26. Suture lines of Coniacian *Pseudobaculites* and *Baculites*. A. *Pseudobaculites nodosus* Cobban, 1952. After Kennedy & Cobban (1991*a*, text-fig. 27). B–C. *Baculites incurvatus* Dujardin, 1837. After Kennedy (1984, text-fig. 42F). D-E. *B. capensis* Woods, 1906 (= *B. boulei* Collignon, 1931). D. After Collignon, 1931, pl. 11 (fig. 14). E. After Matsumoto & Obata (1963, text-fig. 93). Scale bars for size.

alone cannot account for this phylogenetically sudden increase in sutural complexity—specimens of *B. capensis* of similar size do show a progressive increase in overall denticulation of the suture line (Fig. 22), but the elements remain more or less quadrate and unconstricted and quite simple when compared to that of *Pseudobaculites*. Sutural complexity similar to that of Coniacian *Pseudobaculites* only occurs in much younger *Baculites* and *Pseudobaculites natosini* in the Campanian and Maastrichtian.

The relatively simple *Baculites* suture is retained by the majority of baculitids in the Santonian (Fig. 28A–D), including the criocone curved genus *Boehmoceras* (Fig. 27). *Baculites pseudobaculus* (Fig. 28D), a rather poorly known species seems to have slightly asymmetrical lateral saddles, vaguely reminiscent of *Pseudobaculites*.

Reeside (1947: 2, pl. 3 (figs 1–6)) recorded three small fragments of an apparent smooth *Baculites* from questionable Santonian sediments in Haiti. The suture seems simplified, but, being small specimens, could be a juvenile feature only.

The most striking changes in the sutures of *Baculites* take place in the Campanian, especially in the Middle and Upper Campanian, and to a lesser extent in the Maastrichtian. Several broad, overlapping trends can be recognized, but their interrelationship remains obscure.

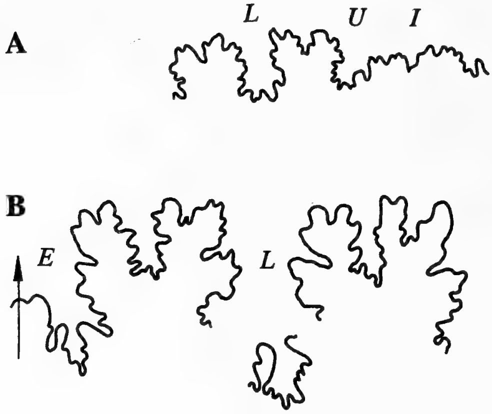


Fig. 27. Suture lines of Santonian baculitids. A. *Boehmoceras arculus* (Morton, 1834). After Kennedy & Cobban (1991*b*, fig. 12.3). B. *B. arculus*. After Kennedy (1987, text-fig. 2).

There is a general trend towards increase of the number of incisions, i.e. general lengthening of the suture line or increase in ISC. This may be partially due to the phyletic increase in size in some of the *Baculites* lineages, but it is not the only factor. The suture line of some Campanian and Maastrichtian *Baculites* is distinctly more complex than that of species of similar size of the Coniacian and Santonian.

The rate at which increase of complexity of the suture line takes place in post-Santonian *Baculites* is variable. In some lineages it is gradual, in others it is sudden. Also, the degree of complexity does not increase linearly from the beginning of the Campanian to the end of the Maastrichtian; it may peak and then simplify before the end of the Maastrichtian.

Changes in sutural complexity are best documented from the Pierre Shale in Colorado in the US Western Interior (Scott & Cobban 1965). The earliest, Middle Campanian species, *B. obtusus*, *B. mclearni* (Fig. 29A), *B. asperiformis* and *B. perplexus* (Fig. 29B) retain the simple suture of the Coniacian and Santonian *Baculites* with subrectangular saddles and lobes. Later, Middle Campanian species, e.g. *B. gregoryensis* and *B. scotti* (Fig. 29C), have a far more incised, dendritic suture in which the saddles and lobes have slender

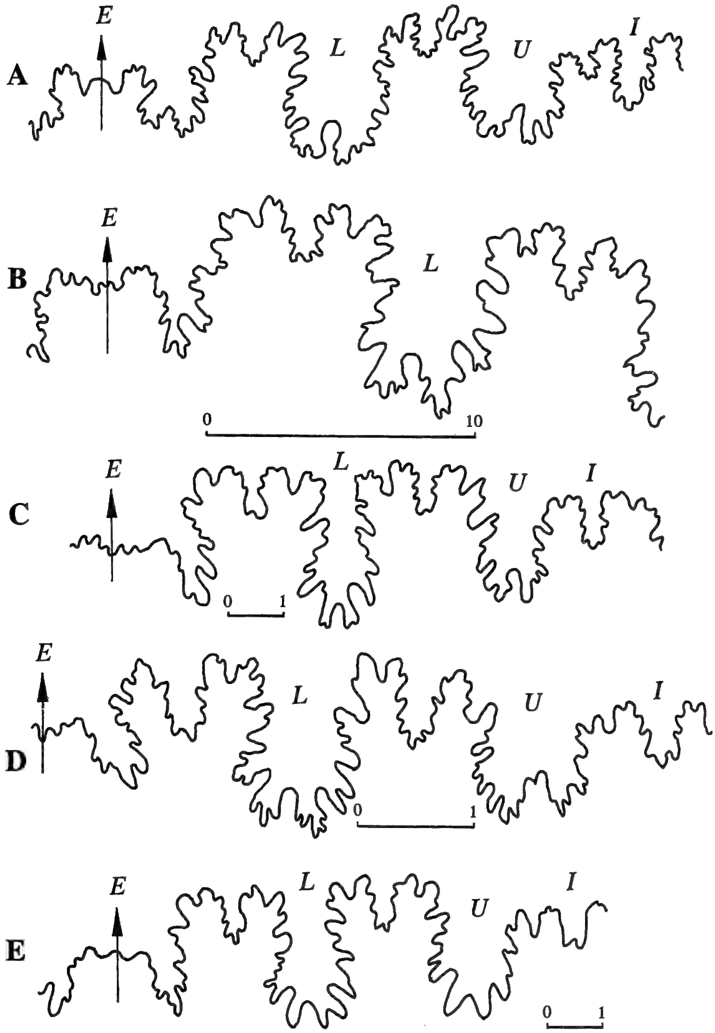


Fig. 28. Suture lines of Santonian and Campanian *Baculites*. A. *B. nugssuaqensis* Birkelund, 1965. After Birkelund (1965, text-fig. 36C). B. *B. thomi* Reeside, 1927*b*. After Cobban & Kennedy (1991*a*, fig. 2B). C. *B. uedae* Matsumoto & Obata, 1963. After Matsumoto & Obata (1963, fig. 92). D. *B. pseudobaculus* Matsumoto & Obata, 1963. After Matsumoto & Obata (1963, fig. 166). E. *B. tanakae* Matsumoto & Obata, 1963. After Matsumoto & Obata (1963, fig. 115). Scale bars for size.

bases. The baculitids of the Upper Campanian and basal Maastrichtian, e.g. *B. compressus*, *B. cuneatus*, *B. jenseni* and *B. eliasi* (Fig. 29D) have an even more incised suture line, in which, according to Scott & Cobban (1965: 2) 'the terminal branches of the lateral lobe are constricted at their base—an entirely

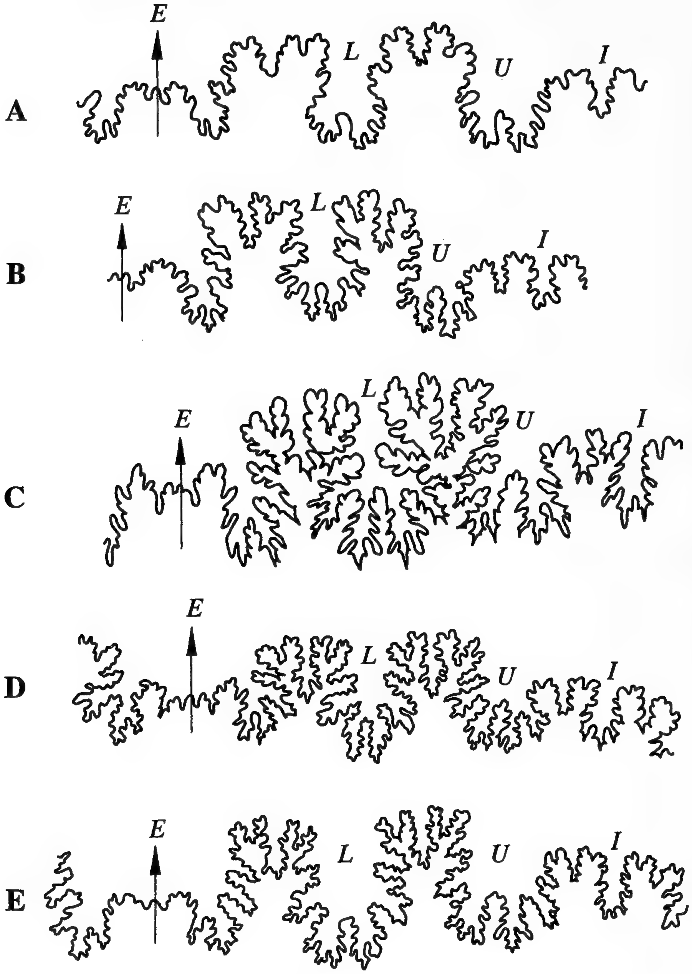


Fig. 29. Suture lines of Campanian and Maastrichtian *Baculites* of the US Western Interior. A. *B. mclearni* Landes, 1940. After Cobban (1962*b*, text-fig. 1h). B. *B. perplexus* Cobban, 1962*b*. After Cobban (1962*b*, text-fig. 1c). C. *B. scotti* Cobban, 1958. After Cobban (1958, text-fig. 1h). D. *B. compressus–eliasi* lineage. After (Scott & Cobban 1965). E. *B. baculus–clinolobatus* lineage. After Scott & Cobban (1965).

different arrangement from that of older baculites'. The remaining, later Maastrichtian species of the Western Interior, *B. baculus* (an immigrant from the Gulf Coast), and its descendants, *B. grandis* and *B. clinolobatus* have, in contrast, a simple suture (Fig. 29E), comparable to that of the *B. obtusus–B. perplexus* group.

As mentioned above, *Pseudobaculites natosini* from the Upper Campanian and Lower Maastrichtian, has a complex suture characteristic of the genus.

Details of the *Baculites* succession of the Indo-Pacific and European regions are less precisely known than those of the US Western Interior. Matsumoto

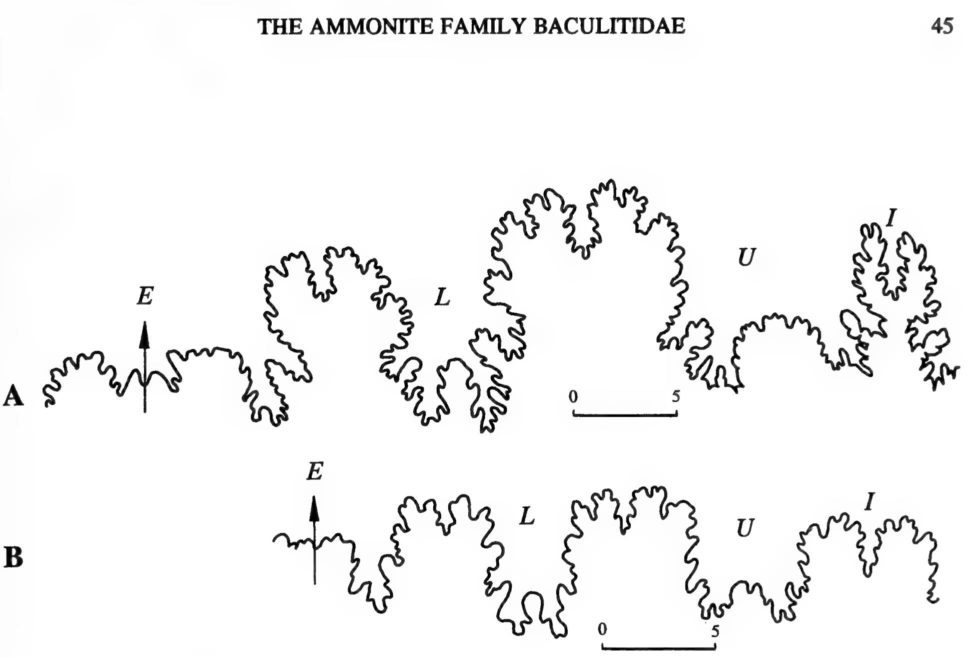


Fig. 30. Suture lines of Campanian and Maastrichtian *Baculites* and *Eubaculites*. A. *Eubaculites carinatus* (Morton, 1834). After Matsumoto (1959, text-fig. 85a). B. *B. subanceps* Haughton, 1925. SAM-6829. Scale bars for size.

In the first identifiable group, the saddles and lobes remain more or less quadrate or rectangular, and their bases unconstricted and open, as in the early, Turonian, Coniacian and Santonian *Baculites*. The width of the individual elements may vary, but their more-or-less angular outline is characteristic. In addition, some of the folioles in the lobes may become phylloid. This group typically includes *B. subanceps* (Fig. 30B), *B. inornatus* and *E. occidentalis* (Fig. 31D–E) in the Upper Campanian, and *B. anceps* (Fig. 31A), *B. palestinensis*, *B. huenickeni*, *B. teicherti* and the whole genus *Eubaculites* (Fig. 30A) in the Maastrichtian. This group corresponds more or less to Ward's (1978: 1145) 'phylloid' group. However, because of the variable development of phylloid folioles, Ward's terminology is not recommended, and we merely refer to it as group #1. The origins of this group are not fully established. Matsumoto & Obata (1963: 102, fig. 218) and Ward (1978: 1148, text-fig. 4) suggested *B. bailyi* as the ancestor.

Some of the other Campanian and Maastrichtian European baculitids, e.g. *B. leopoliensis*, *B. vertebralis* (Fig. 31B) and *B. knorrianus*, may be referable to this group, but we remain uncertain. Available suture lines of these species show a more complex pattern than in the typical representatives of this group.

A second identifiable lineage includes mainly ornate, but also smooth forms. It originated in *B. capensis*, and includes *B. sulcatus*, *B. duharti*, *B. vanhoepeni*, and ends in *B. nibelae* in Zululand (Fig. 32). All the baculitids from the Lower and Middle Campanian of Madagascar described by Collignon (1969, 1970) (see Klinger & Kennedy 1997, figs 82–89) also belong to this lineage, as does *B. tanakae* (Fig. 28E) from the Campanian of Hokkaido (which is probably the prior name for all the Lower Campanian baculites of Madagascar). In this lineage, there is a progressive increase in the degree of incision of the suture line, accompanied by a narrowing of the bases of the saddles and the lobes, resulting in a suture line comparable to that of the group of *B. gregoryensis* of the US Western Interior. According to Matsumoto & Obata (1963: 102, text-fig. 218) this lineage continues into the Maastrichtian with *B. lomaensis*. Some of the Campanian baculitids from France described by Kennedy (1986*b*, text-fig. 8f–h) have a similar suture and probably also belong to this group, as may specimens from Israel referred to as *Baculites* sp. cf. *increscens*.

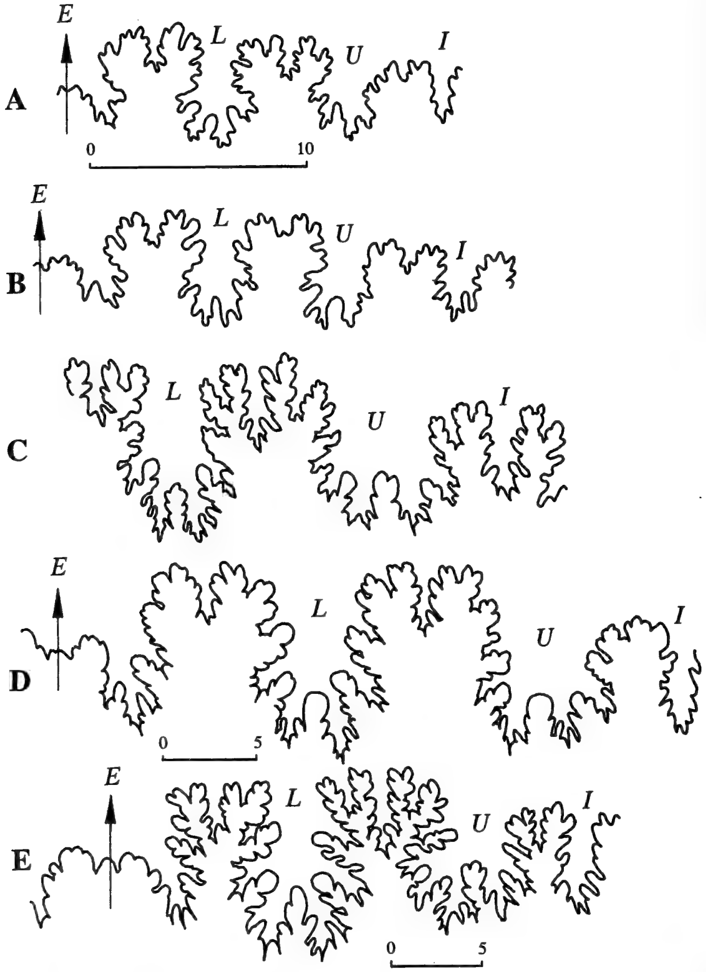


Fig. 31. Suture lines of Campanian and Maastrichtian *Baculites* and *Eubaculites*. A. *B. anceps* Lamarck, 1822. After Kennedy (1986*c*, text-fig. 11d). B. *B. vertebralis* Lamarck, 1801. After Kennedy (1986*c*, text-fig. 11A). C. *B. lomaensis* Anderson, 1958. After Matsumoto (1959, text-fig. 35). D–E. *Eubaculites occidentalis* (Meek, 1862). After Matsumoto (1959, text-figs 64, 65a). Scale bars for size.

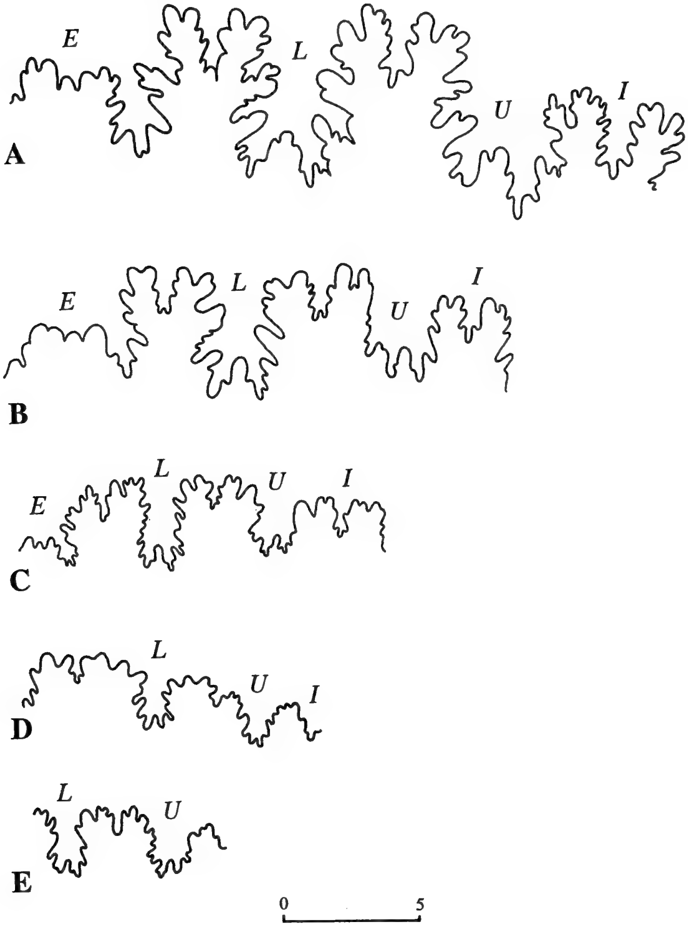


Fig. 32. Suture lines of the lineage *B. yokoyamai* (E, D), *B. capensis* (C), *B. sulcatus* (B), and *B. vanhoepeni* (A) in Zululand to illustrate increasing sutural complexity. Scale bar for size.

The third identifiable lineage consists of smooth *Baculites* with extremely complex sutures. This includes *B. hochstetteri* Liebus, 1902 (Fig. 33A–B), *B. rex*, *B. chicoensis* (Fig. 34A–D) and *B. rectus* (Fig. 33C). This is in part Ward's (1978) 'lytoceratine' group. Unfortunately, the relationship of these species is far from clear. All have an extremely dendritic suture line with narrow-stemmed saddles and lobes. In *B. rex* and *B. chicoensis* the incisions of the lobes and saddles appear to be predominantly pointed, i.e. 'lytoceratine' in the sense of Ward (1978). In contrast, the sutures of *B. hochstetteri* and *B. rectus* are more rounded 'phylloid'. This would suggest that this is not a homogeneous group, but rather a grouping of convergent taxa, but we cannot be sure.

The origins of this group are uncertain. Matsumoto & Obata (1963: 102, text-fig. 218) suggested derivation from *B. bailyi* and *B. uedae* (which we regard as synonyms). Whatever the origins of this group, the increase in complexity of the suture line appears to be sudden: punctuate. In South Africa, a similar sudden jump in sutural complexity occurs in the series presumably originating in *B. yokoyamai*, through *B. bailyi* and ending in *Baculites* cf. *rectus* (Fig. 35).

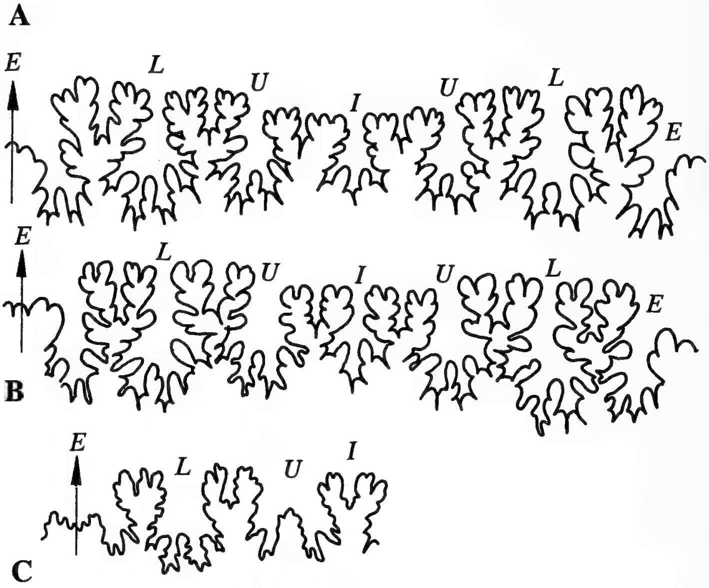


Fig. 33. Complex suture lines of smooth Campanian–?Maastrichtian *Baculites*. A–B. *B. hochstetteri* Liebus, 1902. After Liebus (1902, text-fig. 2). C. *B. rectus* Marshall, 1926. After Henderson (1970, text-fig. 6a).

The sutures of this third lineage, especially those of *B. rectus* are very similar to those of the group of *B. compressus–B. eliasi* of the US Western Interior. Furthermore, they seem to be of more or less similar age. This suggests a parallel development of sutures in the Indo-Pacific and US Western Interior towards the end of the Campanian, and persisting into part of the Maastrichtian. A similar degree of sutural complexity is also achieved in *B. ovatus* (Fig. 36) from the Campanian the Gulf Coast Atlantic Seaboard of the USA.

During the Maastrichtian several small, short-lived baculitid groups appeared in which sutural simplification or modification has taken place.

The sutures of *Fresvillia* are not fully known, but illustrations of *F. constricta* (Fig. 37B) and *F. teres* show subtriangular, but not simplified saddles and lobes, quite unlike those of contemporary *Baculites* or *Eubaculites*.

The specimen described and figured by Pervinquière (1907: 95, pl. 4 (fig. 12a–b), text-fig. 25) (Fig. 38B) as *Baculites* indét. from the Upper Senonian of Pont du Fahs, Tunisia, is minute, with a circular whorl section, smooth surface and a constriction. The suture shows distinct triangular saddles

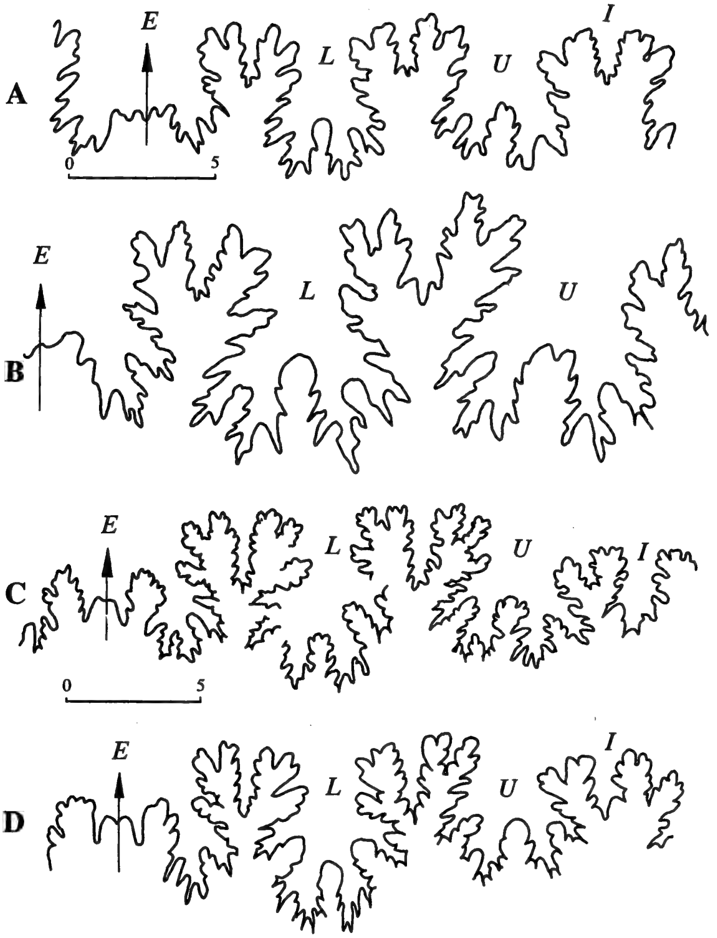


Fig. 34. Complex suture lines of Campanian and Maastrichtian *Baculites*. A–B. *B. chicoensis* Trask, 1856. After Matsumoto (1959, text-figs 62a, 63a). C–D. *B. rex* Anderson, 1958. After Matsumoto (1959, text-figs 45a, 46a). Scale bars for size.

and lobes, which suggest polyptychoceratid rather than baculitid affinities. The suture line and constriction are homoeomorphic with some Cenomanian *Sciponoceras*. *Baculites paradoxus* (Fig. 38A) is another minute, doubtful baculitid from the Maastrichtian of Draa et Tbaga, Tunisia, described by Pervinquière (1907: 94, pl. 4 (figs 10–11), text-fig. 24). According to Pervinquière (1907: 94), this species is unique in allegedly having five saddles and lobes instead of six (around the whole periphery), a feature also noted by Reeside (1927*b*: 9). An alternative interpretation could be that the internal lobe (I) is merely very small, and as large as the median incisions of the saddles E/L and L/U. The triangular shape of the saddles and lobes is similar to that of *Baculites* indet., from which it differs by the lack of constrictions. Both are probably polyptychoceratids rather than baculitids as suggested earlier (Klinger & Kennedy 1997).

Trachybaculites vicentei Stinnesbeck, 1986 (p. 203, pl. 9 (fig. 4), pl. 10 (figs 3–6), text-figs 23a–c) (Fig. 37A) from the Maastrichtian of Quiriquina Island, Chile, has a pseudoceratitic suture line.

In the US Western Interior, the last baculites are *B. larsoni* (Fig. 37E), *Baculites* sp., *Trachybaculites columna* (Fig. 37D) and an endogastrically-coiled baculitid (Fig. 37C), probably referable to *Criobaculites*, all with simplified sutures.

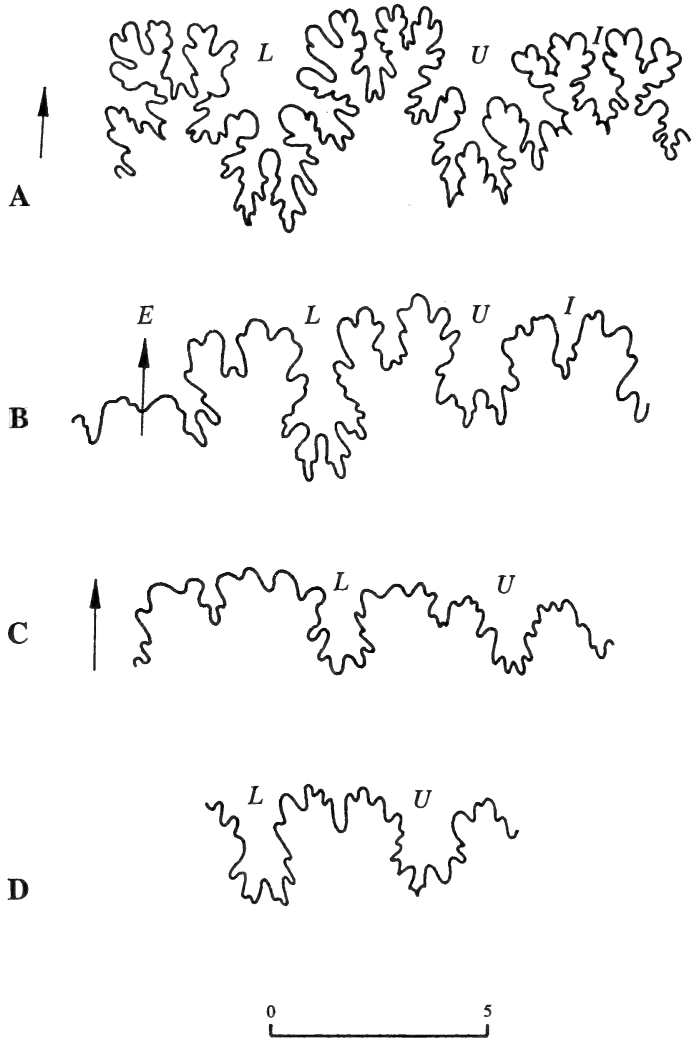


Fig. 35. D–A. Suture lines of Coniacian to Campanian smooth *B. yokoyamai–Baculites* cf. *rectus* lineage in South Africa to illustrate increasing complexity. Scale bar for size.

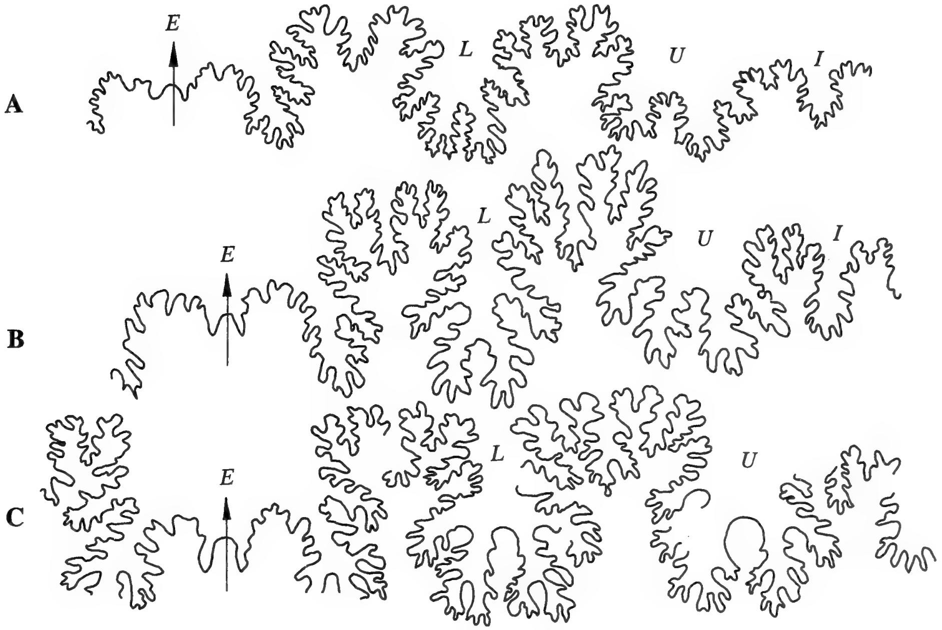


Fig. 36. Complex suture line of Campanian–Maastrichtian *B. ovatus* Say, 1821. After Cobban (1974, text-fig. 4). × 2.8.

ORNAMENTATION

The following elements of ornamentation can be identified in Baculitidae:

1. Growth lines. In near-smooth, non-ornate forms there are growth lines and striae only. These are often only visible on the shell and absent on internal moulds. Some of the striae may be stronger (lirae) than others.
2. Lateral tubercles—mostly only one row, in very rare cases two rows connected by ribs of variable strength. The shape, size and spacing of these tubercles varies widely, and they often grade into:
3. Lateral ribs. These can vary from mere transversely elongated tubercles, to distinct, circumperipheral ribs; either single or often bifurcating or with intercalatories on the venter.
4. Ventral corrugations. These are also very variably developed—in some they are mere undulations on the venter, and only present in shelly preservation—in others distinct undulations; also often associated with ventral bifurcating or intercalated ribs.
5. Constrictions. These may appear regularly, and be of taxonomic importance, or random, sometimes as body-chamber modifications only, and of little significance.
6. Ventral tubercles—these are extremely rare.

Ornamentation in the early representatives of the family, *Lechites* and *Sciponoceras* is very conservative. *Lechites* has simple, albeit variably spaced, circumperipheral ribbing and occasional constrictions. An aberrant offshoot in the Upper Albian, *L. (Tuberolechites)* has minute ventral tubercles on the ribs. Cenomanian and Turonian *Sciponoceras* either retain the simple ribbing of *Lechites* or become smooth, and constrictions become a permanent feature of ornamentation.

In contrast, ornamentation in later, Turonian to Maastrichtian *Baculites* is notoriously variable. The great number of apparently endemic *Baculites* species recognized, as well as gross misidentifications all indicate how variable ornament can be and the extent of homoeomorphy.

Most problematic are the smooth (non-ornate species). Unless they have a very characteristic whorl section, as in e.g. some *B. anceps*, or a distinct sutural

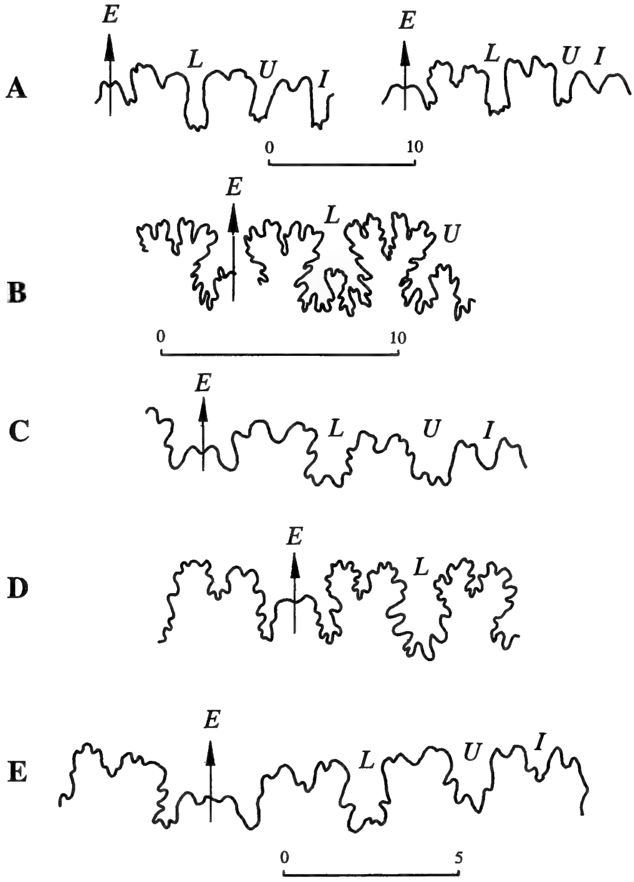
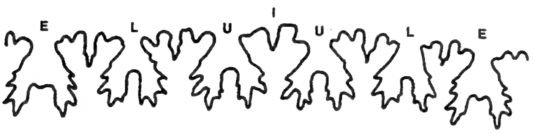
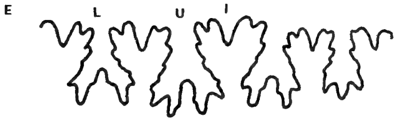


Fig. 37. Suture lines of diverse Maastrichtian baculitids. A. *Trachybaculites vicentei* (Stinnesbeck, 1986). After Stinnesbeck (1986, text-fig. 23a, c). B. *Fresvillia constricta* Kennedy, 1986. After Kennedy (1986*a*, text-fig. 10a). C. *Criobaculites* sp. D. *Trachybaculites columna* (Morton, 1834). E. *Baculites larsoni* Cobban & Kennedy, 1991*b*. C–E. After Cobban & Kennedy (1991*b*, text-fig. 3.1–3.3). Scale bar for size.



Baculites paradoxus PERVINQUIÈRE 1907



Baculites indét.

Fig. 38. Sutures of Maastrichtian *Baculites paradoxus* Pervinquière, 1907, and *Baculites* indet. After Pervinquière (1907, text-figs 24, 25).

pattern, e.g. *B. rectus*, identifying unlocalized smooth *Baculites* is virtually impossible. In addition, some predominantly smooth species, e.g. *B. yokoyamai* or *B. bailyi* (see Klinger & Kennedy 1997) include rare forms with distinct lateral ornament.

Ornamented forms present even more problems. Variation in *Eubaculites vagina*, recently comprehensively figured by Klinger 1976, Kennedy & Henderson (1992) and Klinger & Kennedy (1993) illustrates the point—lateral ornament varies from distinctly bituberculate, through ribbed to smooth (Figs 39–41). Our material of *B. capensis* (Klinger & Kennedy 1997) shows a similar wide range of variation. Apart from simple intraspecific variation, similar forms of ornament appear at different times (heterochronous homoeomorphy), or in apparent unrelated baculitid lineages of more-or-less the same age (synchronous homoeomorphy). Thus the crescentic dorsolateral tubercles of *B. brevicosta* in the Coniacian are virtually identical to those of Maastrichtian *B. lomaensis*. Some Lower Campanian *B. sulcatus* with strong lateral and bifurcating ventral ribbing are indistinguishable from similar Upper Campanian *B. leopoliensis*. Specimens with identical lateral tubercles occur in *B. capensis* and *B. codyensis*, although populations differ markedly. Identical ornament consisting of distinct auricular lateral nodes occurs in the lineages of *B. vanhoepeni* and *B. sulcatus* from the Middle and Lower Campanian of Zululand and Pondoland respectively, *B. asperiformis* Meek, 1876, in the Middle Campanian of the Western Interior, *B. taylorensis* in the Middle Campanian of the Gulf Coast and, in Upper Santonian, *Boehmoceras arculus*. Unlocalized specimens of these species (save the last) would be impossible to separate.

A broad outline of the ornamentation of Turonian to Maastrichtian baculitids, especially of the genera *Baculites* and *Eubaculites* is given in the

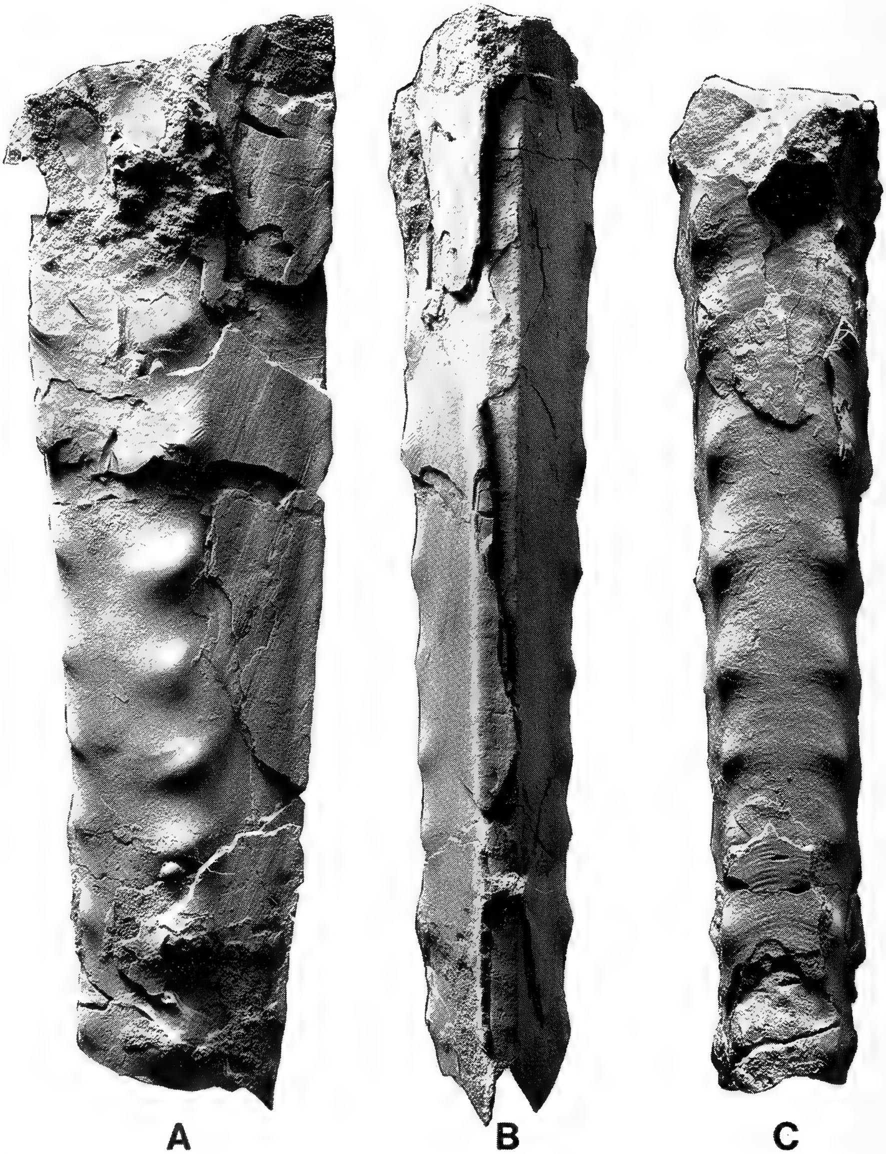


Fig. 39. *Eubaculites vagina* (Forbes, 1846). Variation in lateral ornament. Specimen with typical bituberculate lateral ornament. BMNH C77593 from the Valudavur Formation of southern India. × 1.

sketches in the stratigraphic and geographic distribution charts in Figures 3 to 19. It is impossible to give a detailed description of the ornamentation of each individual species, and only broad outlines are provided.

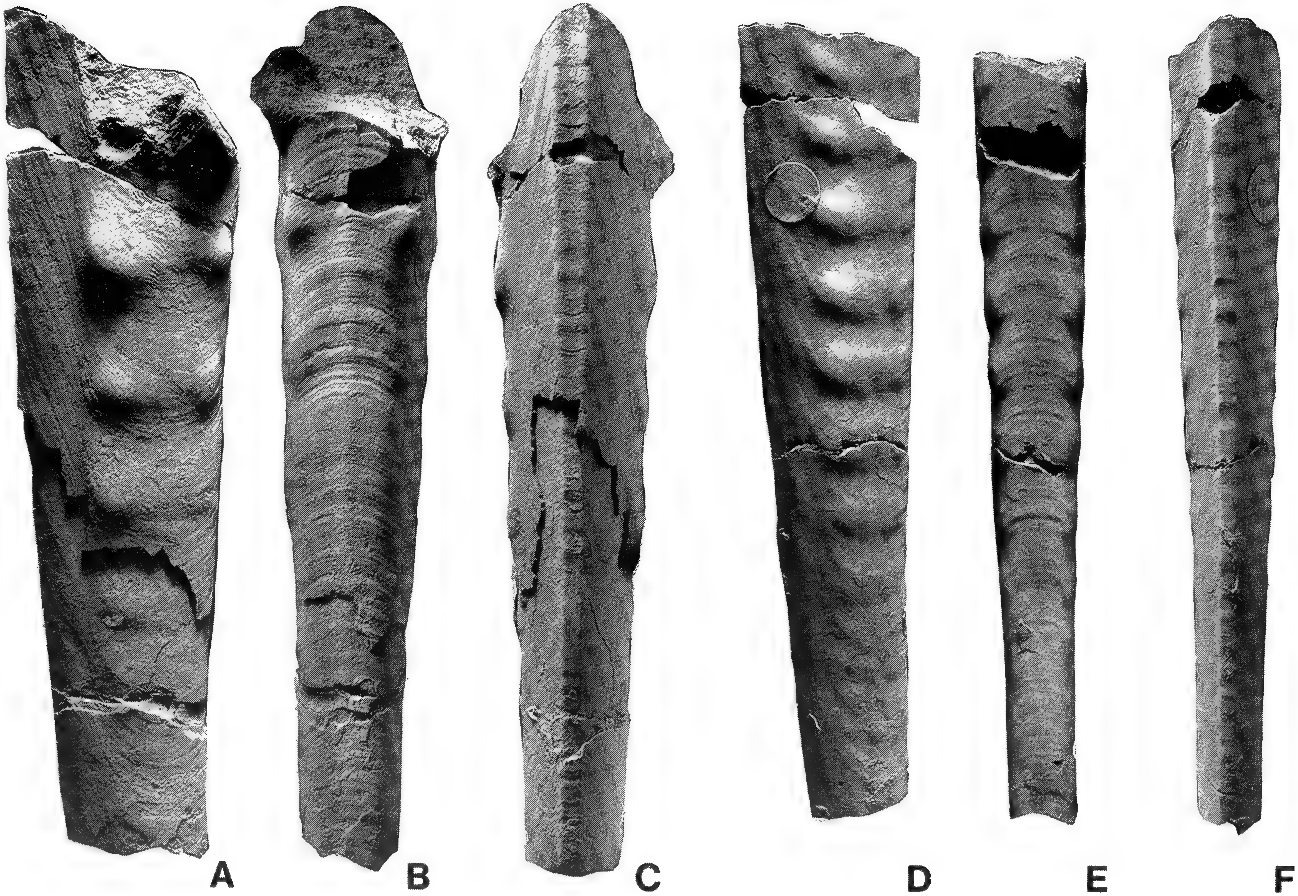


Fig. 40. *Eubaculites vagina* (Forbes, 1846). Variation in lateral ornament. Specimens with rib-like lateral ornament. A–C. BMNH C51141. D–F. BMNH C51149. Both from the Valudavur Formation of southern India. × 1.

The earliest *Baculites*, *B. yokoyamai* and *B. undulatus* are non-tuberculate, but the shell bears fine ribbing; that of *B. undulatus* is coarser than that of *B. yokoyamai*. *Baculites calamus*, poorly known from the Middle Turonian of the US Western Interior only, has ribbing more prominent than that of *B. undulatus*. On the body chamber of both *B. yokoyamai* and *B. undulatus*, coarse, fold-like ribs may appear similar to those of some *Sciponoceras bohemicum* (Fig. 181A–F).

The first dorsolateral ornament in *Baculites* probably arose through thickening of, and/or bundling of sheaves of lirae on the dorsal flanks, giving rise to feebly crescentic or oblique tubercles (Klinger & Kennedy 1997, fig. 55). Tubercles first appear in the uppermost Turonian or basal Coniacian of Angola in *Baculites* sp. as weak dorsolaterally situated crescentic nodes. We assume that the *Baculites codyensis*, *B. capensis* and *B. brevicosta–B. incurvatus* lineages arose independently during the Coniacian from *B. yokoyamai* in the US Western Interior, the Indo-Pacific Region and Europe, respectively, during the Coniacian, albeit at slightly different times.

The baculitid succession in the US Western Interior starts with smooth *B. yokoyamai* in the Lower Turonian. Ornamented *B. sweetgrassensis* and

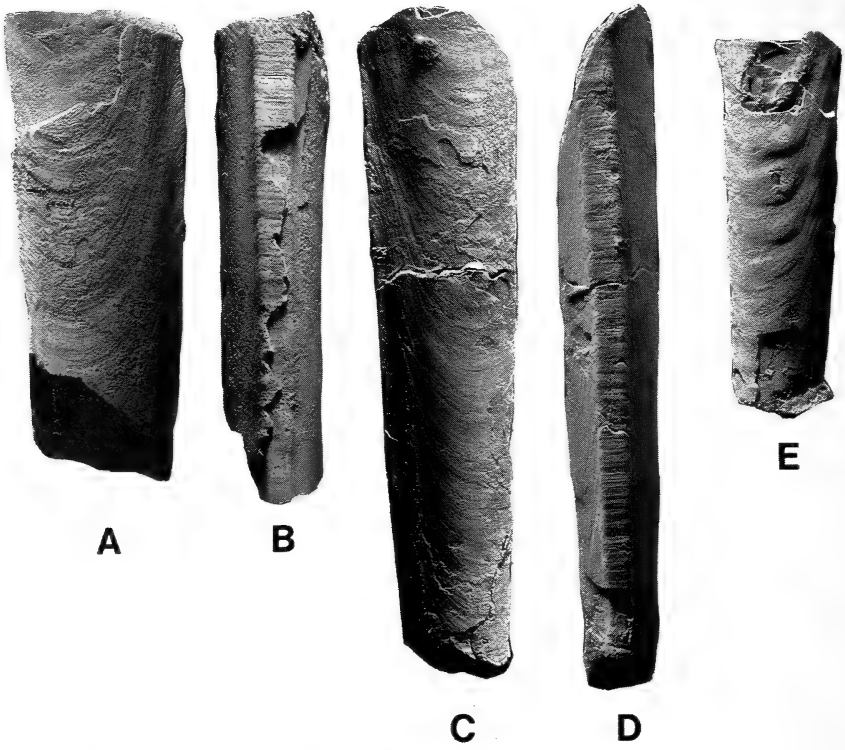


Fig. 41. *Eubaculites vagina* (Forbes, 1846). Variation in lateral ornament. Specimens with lateral striations only. A–B. BMNH C51142. C–D. BMNH C51145. E. BMNH C73569. All from the Valudavur Formation of southern India. × 1.

Fig. 42. A. *Baculites* sp. from the *Baculites compressus* Zone, Pennington County, South Dakota. BHI 4360. B–C. *B. cuneatus* from Elk Creek, Meade County, South Dakota. BHI 4366. Two baculite specimens showing constrictions that appear to indicate old apertures. Both × 1.

B. codyensis appear in the Middle Coniacian. Ornament consists predominantly of lateral ribbing, although some variants of *B. codyensis* have distinct lateral nodes rather than ribs—the *B. 'asper'* of previous authors. Lateral ribbing remains the dominant mode of ornament in the baculitid succession of the US Western Interior; in the Santonian, distinct ventral corrugations are initiated in

B. thomi. *Pseudobaculites nodosus* is an exception, in having lateral ornament, consisting in some specimens of two nodes connected by a rib—a mode of ornament reminiscent of *Eubaculites vagina*. *Pseudobaculites wyomingensis* has weak flank ornament and ventral undulations. Details of the ornament of the US Western Interior baculites are admirably illustrated in Scott & Cobban (1965) and Gill & Cobban (1973). The lineage from *B. codyensis* to *B. eliasi* underwent progressive, sometimes reversed change. Ribbed forms gave rise to smooth ones and vice versa in this lineage, which ends in the Lower Maastrichtian with *B. eliasi*, a smooth species. Later forms arose from *B. baculus*, an immigrant from the Gulf Coast.

The baculitid succession in the Indo-Pacific region most probably also has its origins in *B. yokoyamai*, as suggested by Matsumoto & Obata (1963: 102, text-fig. 218) and by the *Baculites* faunas of Zululand and Madagascar. The first ornamented forms occur in the Middle Coniacian of Zululand as *Baculites capensis*. However, unlike the baculite faunas of the US Western Interior, the dominant form of lateral ornament of the Coniacian, Santonian and Lower Campanian *B. capensis* lineage consists of nodes, rather than ribs. Details of the ornament are shown in Klinger & Kennedy (1997) and only the salient points need to be discussed here. Lateral ornament in *B. capensis* varies from absent, through dorsolateral crescentic '*schencki*', rounded weak dorsolateral '*boulei*', prominent lateral conical or longitudinally elongated, typical *capensis* ornament, to elongated and pinched, oblique '*umsinenensis*' type of ornament. The typical *capensis* type of ornament only occurs up to the Middle Santonian in Zululand and Pondoland, but continues into the Lower Campanian in Madagascar and Hokkaido as *B. menabensis* and *B. tanakae*, with essentially '*umsinenensis*' oblique lateral tubercles.

Strongly ribbed forms occur in the Lower Campanian of Pondoland as *B. sulcatus*, replacing, but probably originating in *B. capensis*. The Middle Campanian baculites of Zululand and Madagascar, represented by *B. increscens* and *B. vanhoepeni* have prominent lateral rib-like ornament, closely resembling the Middle Campanian *B. obtusus–B. asperiformis* lineage of the US Western Interior; a remarkable example of convergence, as mentioned above. Ventral corrugation does occur in some specimens of *B. vanhoepeni*, but, in contrast to the baculitids of the US Western Interior, it is not a consistent feature and of no taxonomic value. A smooth baculite, *B. duharti* occurs more or less at the same level as the first occurrence of *B. vanhoepeni*. The whorl section clearly indicates that it belongs to the predominantly ornamented lineage of *B. capensis–B. vanhoepeni*, and is not a derivative of Coniacian–Lower Campanian smooth *B. bailyi*. The *B. capensis–B. vanhoepeni* lineage ended in the Upper Campanian in Zululand with *B. nibelae* Klinger & Kennedy, 1997, and in the Upper Campanian and/or Lower Maastrichtian of Madagascar with *B. bassei* Besairie, 1930, with trigonal whorl section and lateral ribs. It possibly continued as *B. lomaensis* in the Maastrichtian of California.

As mentioned above, *Baculites* appear rare in Europe and are poorly known from the Coniacian to Campanian. However, Coniacian *B. brevicosta* and Coniacian–Santonian *B. incurvatus* are similar to the *B. capensis* lineage of the Indo-Pacific, if not conspecific. Some of the German Campanian forms figured by Müller & Wolleman (e.g. 1906, pl. 2 (fig. 2)) as *B. incurvatus* have oblique lateral tubercles as in *B. menabensis*; *Baculites* sp. 1 (*pars*) of Kennedy (1986*b*: 110, pl. 17 (figs 7–9, 13–15, 21–23), pl. 18 (figs 18–22), pl. 23 (figs 1, 7), text-fig. 8a, c) resembles *B. vanhoepeni*. *Baculites leopoliensis*, an Upper Campanian (to Lower Maastrichtian?) European baculite has distinct lateral ribbing that splits over the venter.

Apart from *Eubaculites*, the remaining Upper Campanian and Maastrichtian baculites of the different geographic regions are difficult to relate to the above lineages. Ornament in *Eubaculites* is variable, but, as shown in Figure 20 includes consistently smooth, laterally ribbed and bituberculate forms. The ventral keel may be corrugated or smooth in the same species (e.g. *E. vagina*) as in some *Baculites*, and this feature again is of no taxonomic importance. Ornament in the remaining baculitids ranges from smooth to ribbed, and no distinct tuberculate forms occur. The circumperipheral ribbing of *Trachybaculites columna* and *T. ? furcillatus* is conspicuous. *Baculites kegeli* Oliveira, 1957, and *B. lechitides* Brunnschweiler, 1966, probably also belong to the genus *Trachybaculites*. The ornament of *B. anceps* was discussed extensively by Howarth (1965); it includes smooth and laterally ribbed forms, some with, and others without constrictions—the only species of *Baculites* in which constricted individuals occur with some frequency.

ABSOLUTE SIZE, DEGREE OF TAPER, DIMORPHISM AND SHAPE OF THE APERTURE

Before discussing these four closely related aspects, some words of caution. Some species have mature adult apertures that differ in no significant respects from the transient aperture morphology indicated by the growth lines. In others there are distinct modifications that mark the cessation of growth at maturity. But formation of an aperture apparently does not always indicate maturity: Birkelund (1965: 62, pl. 9 (fig. 3a–c)) described and figured a specimen of *B. obtusus* from West Greenland, which is part of a phragmocone, but has a distinct flare, indicating that 'growth does not necessarily stop when a flared aperture has been formed' (Birkelund 1965: 62). Steinmann (1895: 90, pl. 6 (fig. 4b)) illustrated a specimen of *Eubaculites carinatus* (as *B. vagina*) with an old aperture (stehengebliebenen Mundrändern). However, judging by the scarcity of phragmocones with parts of old apertures preserved, this appears to be a rather rare phenomenon in Baculitidae. We figure here (Fig. 42) US Western Interior *Baculites* with what may be transient apertures marked by constrictions.

ABSOLUTE SIZE

Disregarding the possible effects of dimorphism and ecophenotypic variation, the family Baculitidae shows a progressive increase in overall size, reaching a maximum in the late Campanian to early Maastrichtian (Fig. 43). In the Maastrichtian, several dwarfed stocks appear, e.g. *Fresvillia*, *Trachybaculites*, *Baculites larsoni*, etc. *Pseudobaculites*, from the Upper Coniacian of the US Western Interior are small, with a phragmocone whorl height of up to

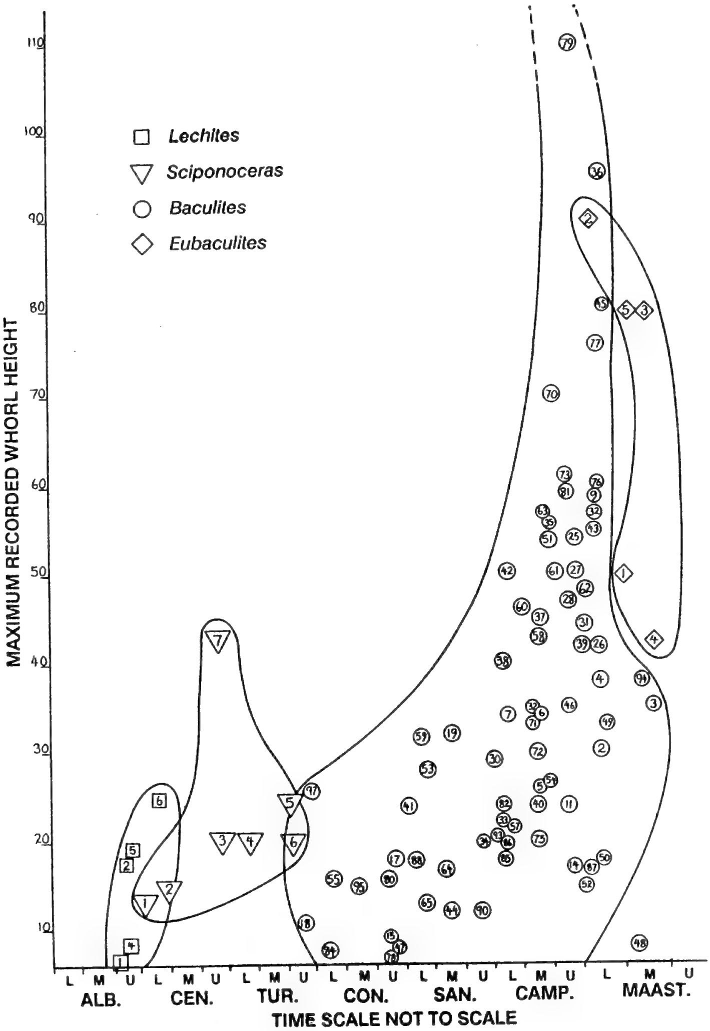


Fig. 43. Diagram illustrating progressive increase in overall size in Baculitidae. Time axis not to scale. Whorl height in millimetres. Data from various sources. Genus *Lechites*. 1. *L. comanchensis*. 2. *L. gaudini*. 3. *L. campichei*. 4. *L. vraconensis*. 5. *L. moreti*. 6. *L. antanimangaensis*. Genus *Sciponoceras*. 1. *S. roto*. 2. *S. baculoide*. 3. *S. kossmati*. 4. *S. orientale*. 5. *S. santacrucense*. 6. *S. intermedium*. 7. *S. gracile*. Genus *Baculites*. 1. *B. albertensis*. 2. *B. ambatryensis*. 3. *B. anceps*. 4. *B. subanceps*. 5. *B. androtsyensis*. 6. *B. ankilizatensis*. 7. *B. antsirasiraensis*. 8. *B. aquilaensis*. 9. *B. argentinicus*. 11. *B. asperiformis*. 12. *B. baculus*. 13. *B. bailyi*. 14. *B. bassei*. 15. *B. 'besairiei'*. 16. *B. borealis*. 17. *B. boulei*. 18. *B. calamus*. 19. *B. capensis*. 20. *B. chicoensis*. 21. *B. claviformis*. 22. *B. coagmentatus*. 23. *B. codyensis*. 24. *B. robinsoni*. 25. *B. corrugatus*. 26. *B. reesidei*. 27. *B. compressus*. 28. *B. crickmayi*. 29. *B. cuneatus*. 30. *B. delvallei*. 31. *B. duharti*. 32. *B. eliasi*. 33. *B. falcatus*. 34. *B. fuchsi*. 35. *B. gilberti*. 36. *B. grandis*. 37. *B. gregoryensis*. 38. *B. haresi*. 39. *B. huenickeni*. 40. *B. increscens*. 41. *B. incurvatus*. 42. *B. inornatus*. (*continued on facing page*)

46 mm; the Upper Campanian–Lower Maastrichtian *P. natosini* is a giant with a whorl height of up to 240 mm on the body chamber.

True giants seem to occur in separate lineages of the family, but not necessarily at the ends of these. In *Sciponoceras*, *S. gracile* is a true giant in comparison with other contemporary Cenomanian, or younger, Turonian members of the genus, or *Baculites*.

In *Baculites*, early Turonian and Coniacian species are all relatively small in comparison with the majority of later, especially Campanian, species.

In the US Western Interior, a lineage can be followed from *B. yokoyamai* in the Lower Turonian to Lower Coniacian, through *B. codyensis* in the Middle Coniacian to Middle Santonian, then through a series of species in the Campanian, starting with *B. obtusus*, reaching maximum size in *B. rugosus* in the Upper Campanian, with whorl heights of 110 mm. Thereafter, there is a decrease in size, ending with *B. eliasi* in the Lower Maastrichtian with whorl heights of up to 57 mm.

In South Africa, a similar progressive increase in size can be traced in two separate lineages. The first is predominantly nodose, starting with the group of *B. capensis* in the Middle Coniacian to Middle? Santonian, probably through *B. sulcatus* and *B. increscens* in the Lower Campanian, reaching maximum size in the Middle Campanian in *B. vanhoepeni* and *B. duharti*, and followed by a decrease in size in *B. nibelae*. The other, smooth lineage started with *B. bailyi* in the Middle Coniacian, possibly ending in *B.* aff. *rectus* in the Campanian. Both lineages probably had their origins in *B. yokoyamai*.

In the Campanian–Maastrichtian of the Gulf Coast region of the USA, *B. claviformis* may reach gigantic proportions (Stephenson 1941, pl. 1) with lengths in excess of 170 cm. (Neal Larson informed us that Stephenson's figured specimen, is, in fact, composite, consisting of eight to ten individuals. The largest baculite they have seen is a *B. obtusus* with an aperture, and is 113.5 cm long, missing 20 cm of phragmocone).

Baculites rex, from the Maastrichtian of California is another giant with whorl heights greater than 60 mm.

Even larger are giant *Eubaculites latecarinatus* and *E. carinatus* with estimated total lengths of two metres, known from the Maastrichtian of Zululand and Neuquén Basin of Argentina, respectively.

Fig. 43 *(continued)*. 43. *B. jenseni*. 44. *B. kirki*. 45. *B. knorrianus*. 46. *B. kotanii*. 47. *B. latelobatus*. 48. *B. lechitides*. 49. *B. leopoliensis*. 50. *B. libyensis*. 51. *B. mclearni*. 52. *B. lomaensis*. 53. *B. malagasyensis*. 54. *B. mamillatus*. 55. *B. mariasensis*. 56. *B. meeki*. 57. *B. menabensis*. 58. *B. natosini*. 59. *B. nugssuaquensis*. 60. *B. obtusus*. 61. *B. occidentalis*. 62. *B. ovatus*. 63. *B. perplexus*. 64. *B. princeps*. 65. *B. pseudobaculus*. 70. *B. pseudovatus*. 71. *B. rectangulatus*. 72. *B. rectus*. 73. *B. reduncus*. 74. *B. reesidei*. 75. *B. regina*. 76. *B. rex*. 77. *B. rioturbioensis*. 78. *B. roedereri*. 79. *B. rugosus*. 80. *B. schencki*. 81. *B. scotti*. 82. *B. sparsinodosus*. 83. *B. subcircularis*. 84. *B. sweetgrassensis*. 85. *B. subtilis*. 86. *B. tanakae*. 87. *B. teicherti*. 88. *B. thomi*. 89. *B. trifidilobatus*. 90. *B. uedae*. 91. *B. undatus*. 92. *B. undulatus*. 93. *B. ventroplanus*. 94. *B. vertebralis*. 95. *B. yokoyamai*. Genus *Eubaculites*. 1. *E. vagina*. 2. *E. latecarinatus*. 3. *E. carinatus*. 4. *E. labyrinthicus*. 5. *E. simplex*. *Pseudobaculites natosini* (Robinson, 1945) with maximum whorl height of 260 mm (see Cobban & Kennedy 1994*a*) is not included in the diagram.

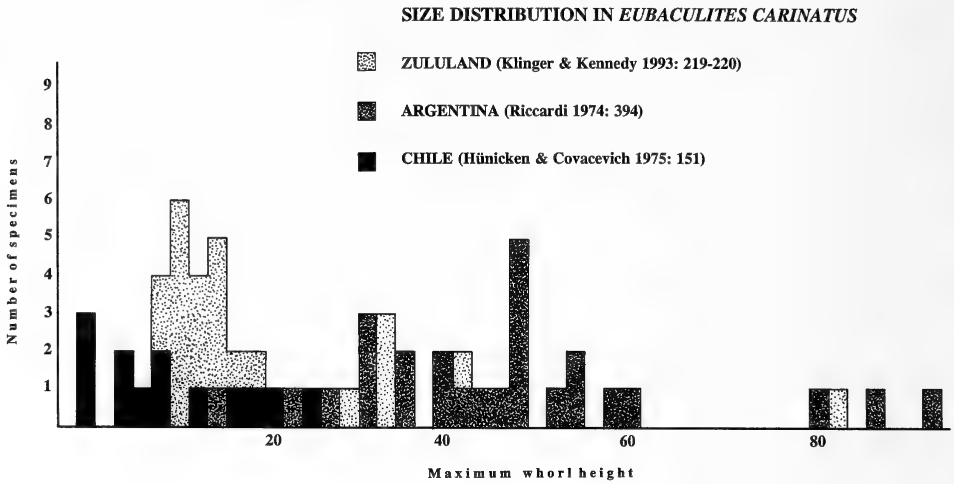


Fig. 44. Histogram showing distribution in size of *Eubaculites carinatus* (Morton, 1834) from Zululand (South Africa), Neuquén (Argentina), and Quiriquina (Chile). Whorl height in mm.

Matsumoto (1959: 141) mentioned size differences in *B. rex* from different localities in California, but could not decide whether these were due to simple 'variation in size or . . . ecological difference between immature and mature shells' (i.e. ontogenetic separation). Matsumoto & Obata (1963: 67) mentioned a similar difference in size between *B. chicoensis* from California and Hokkaido respectively; those from the latter region are distinctly smaller than those from California.

We (Klinger & Kennedy 1993: 235) noticed a similar difference in size in *Eubaculites carinatus*. This is one of the few baculitid species with a near world-wide distribution (see p. 6), and it is possible to compare the size distribution from different geographic localities (Fig. 44). Giants with whorl heights of 80 to 90 mm, and estimated lengths of 2 metres are known from the Neuquén Basin (Argentina) and Zululand. In contrast, all the specimens recorded from North America and Europe are much smaller. This may, however, be due to the fact that the species is less common in these areas than in Argentina and in Zululand, to their occurrence in facies where small fossils predominate (e.g. phosphatic beds in the Prairie Bluff Chalk in the U.S. Gulf Coast Region, and, in part due to collecting failure. *Eubaculites carinatus* is, however, very common in southern Chile (see especially Hünicken & Covacevich 1975; Klinger & Kennedy 1993, fig. 37). None of these Chilean specimens is as large as the Neuquén and Zululand giants, and the whole known population seems to consist of individuals which are smaller than those from Zululand and Argentina.

A similar situation may occur in *B. capensis*. This species is well known from Zululand, Pondoland, California and Hokkaido, but is apparently rare in Madagascar. All the recorded specimens from California and Hokkaido are small compared to the average size recorded from Zululand (Fig. 45).

Furthermore, most specimens from Pondoland appear to be smaller than those from Zululand.

For the present, we are unable to interpret these data. We can only note that there appear to be distinct differences in maximum size within the same baculitid species from different geographic areas and/or depositional environments. We suspect it may somehow be connected with different nutrient supplies.

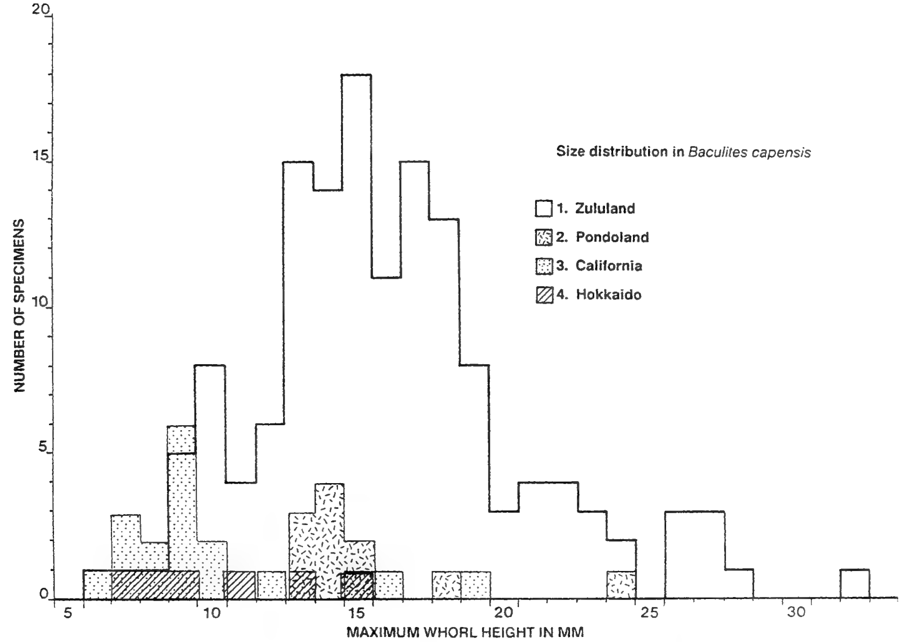


Fig. 45. Histogram showing distribution in size of *Baculites capensis* Woods, 1906, from Zululand and Pondoland (South Africa), California (USA), and Hokkaido (Japan).

DEGREE OF TAPER

The taper index (Matsumoto & Obata 1963: 4) is the difference in whorl height at two successive points on a shell divided by the distance measured between them x 100. A taper index of less than 5 is considered low, between 5 and 10 moderate, and above 10 high, according to these authors. Converted into the apical angle of the baculitid shell, these three categories of taper index correspond to less than 3 degrees, 3–6 degrees and more than 6 degrees.

As Birkelund (1965: 44) has already noted, the taper index changes between different ontogenetic stages; there is a considerable difference between juvenile and adult stages, as well as individual variation. In addition, the degree of taper differs between large and small populations of the same species as well as between macro- and microconchs. Unless the taper index is very high, as in e.g.

Pseudobaculites or very low as in e.g. *B. thomi*, we have found this feature to be of very limited taxonomic significance. In addition, because of the generally fragmentary nature of baculitids in South Africa, it is very difficult to determine satisfactorily in the material we have studied.

DIMORPHISM AND SHAPE OF THE APERTURE

Dimorphism in the Baculitidae, especially in the genus *Baculites* has only recently been demonstrated and/or suggested for some taxa, but as a whole, remains more or less unexplored. In the major descriptions of the Baculitidae from the US Western Interior (Reeside 1927*a*, 1927*b*; Cobban 1951 onwards), California (Matsumoto 1959), Hokkaido (Matsumoto & Obata 1963), Honshu (Obata & Matsumoto 1963), and Greenland (Birkelund 1965), dimorphism is hardly mentioned—but in due fairness to these authors, dimorphism *per se* in Cretaceous ammonites has only recently been recognized and investigated. Matsumoto & Obata (1963: 52) did, however, note disparate sizes of adult *B. tanakae* as did Obata & Matsumoto (1963: 90) in *B. regina*.

According to Cooper & Kennedy (1977), the earliest representative of the family, the genus *Lechites* is distinctly dimorphic, as demonstrated by *Lechites gaudini* from the Upper Albian Cambridge Greensand of England. Dimorphism is manifested by differences in size, as well as shape of the aperture. A size-frequency histogram (Cooper & Kennedy 1977, fig. 3) shows two size groupings. Macro- and microconchs appear to have different apertures: microconchs have an oblique down-turned, collared aperture, whereas macroconchs have an expanded, trumpet-shaped aperture (Fig. 46). Recent observations by Kennedy (1996 in Gale *et al.* 1996: 577–578) show that in microconchs of *L. (L.) gaudini* the apterture is oblique to the long axis of the shell, and preceded by weakening ribs. Macroconch apertures appear to have a final sector of delicate, wiry ribs.

According to Wright & Kennedy (1981: 112) dimorphism is wide-spread in *Sciponoceras*. In contrast to *Lechites*, numerous specimens of *Sciponoceras* with apertures are known.

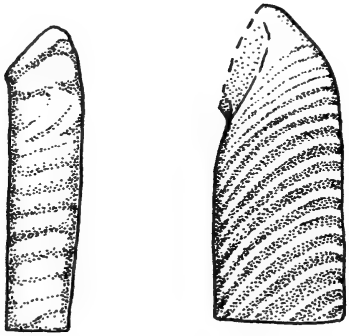


Fig. 46. Apertures of microconch and macroconch of *Lechites gaudini* (Pictet & Campiche, 1861). After Cooper & Kennedy (1977, fig. 7).

These show that some apertures are simple, others have a long ventral rostrum, broad folds and a high collar, others have lappets, and some are recurved (Figs 47–50). It appears that some of these apertural features are of sexual as well as specific significance, but there is still disagreement on details. Two examples illustrate the point:

1. *Sciponoceras gracile* (Shumard, 1860) (Fig. 46). Kennedy (1988: 108) described the species as highly dimorphic. Microconchs develop a hooded aperture at whorl heights of between 7.3 and 11.7 mm, ribs strengthen on the venter towards the aperture, a dorsal constriction develops and the aperture itself may be distinctly flared (see e.g. Cobban & Scott 1972, pl. 17 (figs 23–24)). Macroconchs are much larger, up to four times the size of microconchs with whorl heights of up to 41.4 mm; complete apertures of macroconchs have not yet been found. A specimen figured by Kennedy (1988, pl. 20 (figs 17–20)) shows part of a macroconch aperture without a hood.
2. *Sciponoceras baculoides* (Mantell, 1822). Marcinowski (1980: 253) described four body chambers of *S. baculoides* from the same bed; all are of the same size, but with two different types of aperture. Three have well-developed latero-ventral lappets (Fig. 50B), with the apertural constriction most pronounced on the venter. The fourth specimen has a simple aperture with the margin more or less parallel to the last rib, and no lappets. Marcinowski's (1980: 253) interpretation is that this is a special type of dimorphism; the micro- and macro-conchs are indistinguishable in shell size and ornamentation, but differ in the shape of the aperture. Marcinowski's interpretation has still to be tested on other species; certainly none of the other figured specimens of *S. baculoides* with apertures show this type of dimorphism (see e.g. Mantell 1822, pl. 23 (figs 6–7); Sowerby 1822, pl. 592 (figs 2–3); D'Orbigny, 1842, pl. 138 (figs 6, 8, 9); Crick 1896, figs a–e; Noetling 1885, pl. 8 (fig. 7); Matsumoto & Obata 1963, pl. 2 (figs 1, 3); Juignet & Kennedy 1976, pl. 1 (figs 3–4, 6), pl. 2 (fig. 1) (Fig. 47); Kennedy & Juignet 1983, figs 11a–b, d–e, 13a–b; Thomel 1992, pl. 10 (fig. 2), pl. 11 (figs 1, 3); Wright & Kennedy 1995); instead they clearly show size-related dimorphism (Fig. 49).

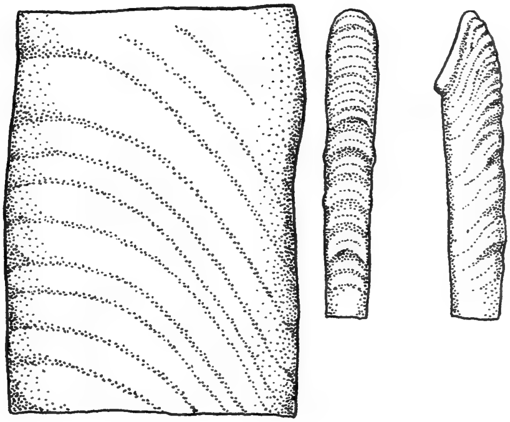


Fig. 47. Macro- and microconch of *Sciponoceras gracile* (Shumard, 1860). After Kennedy (1988, pl. 20 (figs 5, 14)).

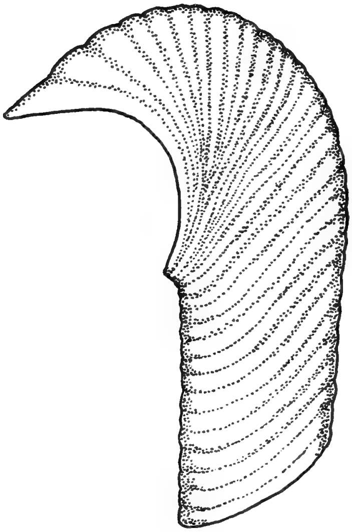


Fig. 48. Aperture of *Sciponoceras cucullatum* Collignon, 1964, based on cast of holotype.

Some examples of *Sciponoceras* with well-preserved apertures include:

Sciponoceras sp.—Marcinowski (1980: 254, pl. 3 (fig. 16)), from the Middle Cenomanian of Dagestan with a pronounced pair of ventrolateral lappets (Fig. 50A).

Sciponoceras cucullatum Collignon (1964: 38, pl. 320 (fig. 1458)) from the Lower Cenomanian of Madagascar, with a distinctly recurved aperture (Fig. 48).

Sciponoceras kossmati (?*non* Nowak, 1908). Matsumoto & Obata (1963, pl. 3 (fig. 2), pl. 4 (fig. 1)) from the Middle Cenomanian of Hokkaido, with a distinct collar along the apertural margin.

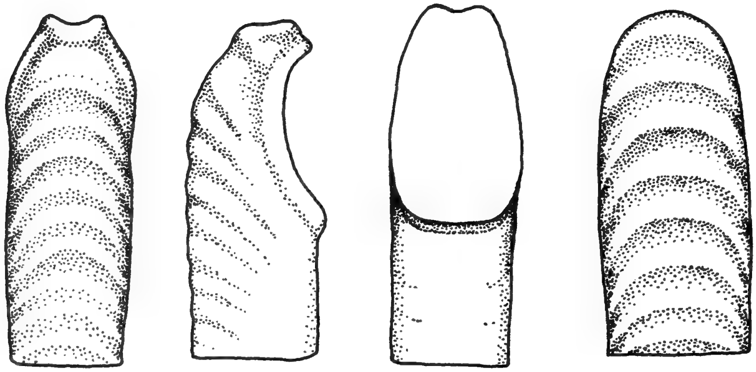


Fig. 49. Aperture of *Sciponoceras baculoide* (Mantell, 1822). After Juignet & Kennedy (1976, pl. 1 (fig. 3)).

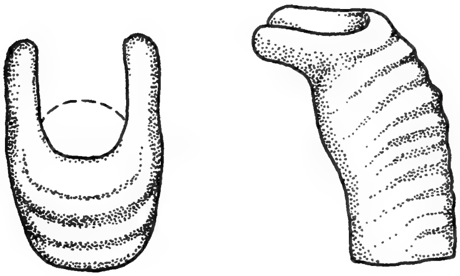


Fig. 50. A. Aperture of *Sciponoceras* sp. with distinct lappets. After Marcinowski (1980, pl. 3 (fig. 16)). B. *Sciponoceras baculoide* (Mantell, 1822), alleged microconch with lappets. After Marcinowski (1980, pl. 3 (fig. 17)).

Sciponoceras orientale Matsumoto & Obata (1963, pl. 7 (fig. 3)) from the Lower and Middle Turonian of Hokkaido. It has a hooded aperture with trigonal ventral rostrum and acute apex.

Sciponoceras intermedium Matsumoto & Obata (1963, pl. 8 (fig. 1), pl. 11 (fig. 6)) from the Upper Turonian of Hokkaido—the aperture is oblique, facing dorsally, the ventral rostrum is gently curved, the dorsal rostrum very short.

Sciponoceras matsumotoi Inoma (1980, text-fig. 4c, pl. 21 (figs 14, 16)) from the Cenomanian of Hokkaido—the aperture is oblique and the ventral rostrum slightly curved.

To summarize, apertures in microconch *Sciponoceras* are quite diverse, but generally form a slight hood, or may even recurve, some with prominent ventrolateral lappets, others without. Size and development of the dorsal rostrum varies. In some, possibly macroconchs the aperture is simple and oblique. With the possible exception of the case discussed by Marcinowski (1980) dimorphism is also manifested by marked differences in size.

Apertures are quite commonly preserved in *Baculites*. Figured examples include:

B. anceps Lamarck. Howarth (1965, pl. 5 (fig. 4)); Kennedy (1986*c*, pl. 20 (fig. 2)).
B. androtsyensis Collignon (1970, pl. 607 (fig. 2272)).
B. aquilaensis Reeside (1927*a*, pl. 8 (figs 1, 4, 7, 12); Reeside (1927*b*, pl. 2 (figs 1, 4, 7, 12)).
B. asperiformis Meek. Cobban (1962*b*, pl. 106 (figs 14–16)).
B. capensis Woods. Matsumoto & Obata (1963, pl. 19 (fig. 2)); Klinger & Kennedy (1997, figs 46, 48A, 51–52).
B. codyensis Reeside (1927*a*, pl. 2 (figs 1–3) as *B. asper*); Kennedy & Cobban (1991*a*, pl. 15 (figs 13–15)).
B. mariasensis Cobban—Kennedy & Cobban (1991*a*, pl. 14 (figs 6–9)).
B. inornatus Meek—Obata & Matsumoto (1963, pl. 24 (fig. 6)).
B. obtusus Meek—Birkelund (1965, pl. 9 (fig. 3), pl. 13 (fig. 2)).
B. occidentalis Meek—Matsumoto (1959, pl. 35 (fig. 2)).
B. ovatus Say—Cobban (1974, pl. 2 (figs 13–14)).
B. rectangulatus Collignon (1970, pl. 611 (fig. 2281)).

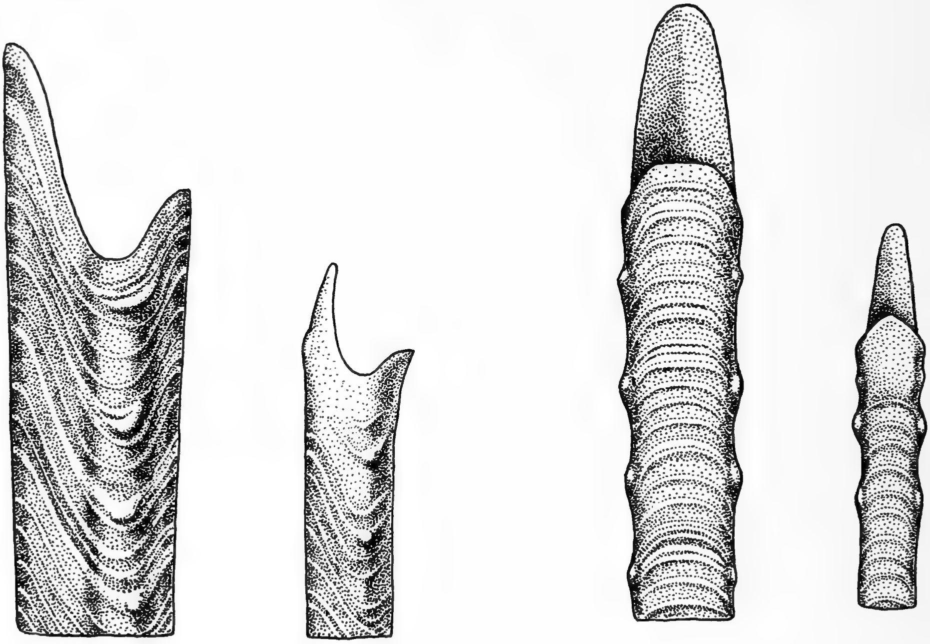


Fig. 51. Apertures of macro- and microconchs of *Baculites capensis* Woods, 1906. Both × 0.9.

B. subanceps Haughton—Matsumoto (1959, pl. 35 (fig. 1) as *B.* aff. *anceps*); Klinger & Kennedy (1997, fig. 130g).
B. sulcatus Baily—Klinger & Kennedy (1997, figs 67h–j, 75a–c).
B. tanakae Matsumoto & Obata—Matsumoto & Obata (1963, pl. 16 (fig. 4)).
B. thomi Reeside—Cobban & Kennedy (1991*a*, pl. 1 (figs 7–10)).
B. undulatus d'Orbigny—Matsumoto & Obata (1963, pl. 11 (figs 2–3)).
B. vanhoepeni Venzo—Klinger & Kennedy (1997, fig. 92d, g–h).
B. ventroplanus Collignon—(1969, pl. 520 (fig. 2050).
B. yokoyamai Tokunaga & Shimizu—Matsumoto & Obata (1963, pl. 11 (fig. 1), pl. 14 (fig. 4); Renz (1982, pl. 34 (fig. 4)) (as *B. inornatus*); Cobban 1990, pl. 9 (figs 21–22).

In our South African material (Klinger & Kennedy 1997), apertures are preserved in *B. bailyi*, *B. capensis*, *B. sulcatus*, *B. vanhoepeni*, *B. nibelae* and *B.* aff. *rectus*.

The known apertures in all *Baculites* have a short dorsal rostrum, a longer ventral rostrum, and lateral sinuses, but the relative proportions and orientation vary considerably. In the earliest, Turonian, *Baculites*, e.g. *B. undulatus* and *B. yokoyamai* the ventral rostrum is short, the dorsal one poorly developed, and the aperture may face slightly upward, very much as in some *Sciponoceras*. In later *Baculites* the ventral and dorsal rostra are more prominent. In some, the ventral rostrum is very long and lingoid to spoon-shaped, with a distinct lateral sinus (e.g. *B. sulcatus* in Klinger & Kennedy 1997, fig. 67h–j; *B. thomi* in

Cobban & Kennedy 1991*a*, pl. 1 (figs 7–10). In some *Baculites*, the aperture is distinctly flared, e.g. *B. obtusus* in Birkelund (1965, pl. 13 (fig. 2a–c)); *B. asperiformis* Meek in Cobban (1962*b*, pl. 106 (figs 14–16)) and some *B. vanhoepeni*, or associated with a slight constriction, e.g. *B. rex* Anderson in Matsumoto (1959, pl. 40 (fig. 1a–c)) or *B. subanceps* Haughton (as *B.* aff. *anceps* in Matsumoto 1959: 140). According to Birkelund (1965: 62), there seems to be some variation in the aperture of *B. obtusus*; some specimens, e.g. Birkelund (1965, pl. 10 (fig. 1a–c)) have less-inflated apertures; others, as mentioned above (p. 59), retain traces of an early flared aperture on the phragmocone.

In the South African material, the disparate sizes at which apertures are formed in *B. capensis* (Fig. 51), *B. sulcatus* and *B. vanhoepeni* (Fig. 53) is striking. In small specimens the apertures are usually slightly flared, whereas in larger specimens this is less apparent, but this feature does not seem to be consistent.

Where large samples are available, e.g. in *B. capensis* (Fig. 52) and *B. vanhoepeni* (Fig. 53), there seems to be a gradation from large to small specimens with apertures, with no distinct, separate double peaks, indicating micro- and macroconchs. This shows that there is a considerable degree of overlap in size at which micro- and macroconchs form apertures. However, the difference in size between the largest macroconch and the smallest microconch is impressive.

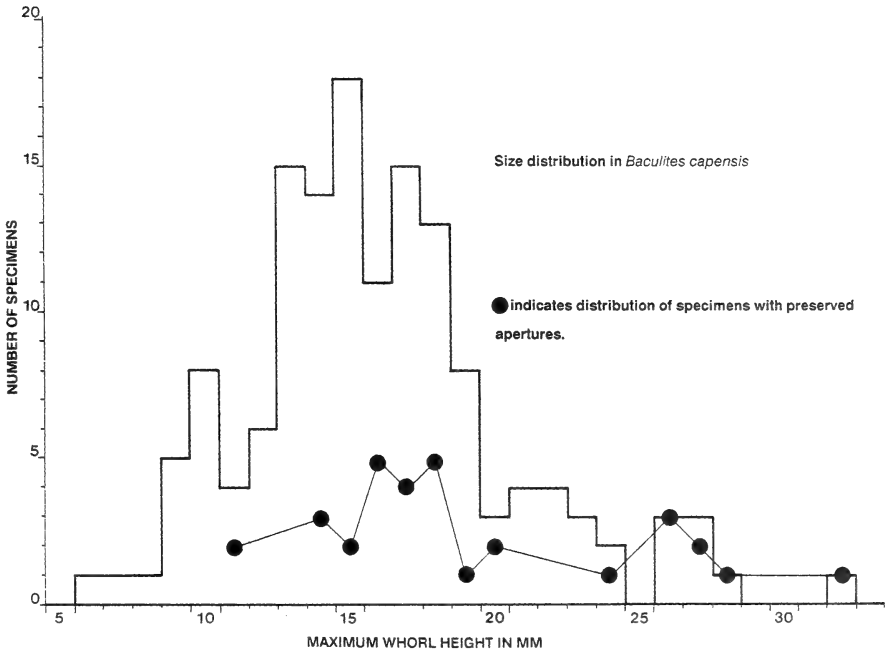


Fig. 52. Histogram illustrating size distribution in *Baculites capensis* Woods, 1906, to illustrate dimorphism.

To summarize, the aperture in *Baculites* is relatively simple, parallel to the long axis of the shell, with a short dorsal and a long ventral rostrum and a lateral sinus of variable depth. In some it may be distinctly flared, but this is not a very common feature. In general, dimorphism in *Baculites* seems to be only size related. There is a large range of overlap in size between micro- and macroconchs, and distinct separation into two size groupings is not clear in some species, e.g. *B. capensis* and *B. vanhoepeni*.

Boehmoceras is thus far only known by two Upper Santonian species, *B. arculus* (= *B. loescheri* Riedel, 1931) and *B. krekeleri*. These two species co-occur in Austria, and Summesberger (1979) suggested that the two 'species' are in fact a dimorphic pair—*B. arculus* the microconch, and *B. krekeleri* the macroconch. In the Gulf Coast Region of the USA, *Boehmoceras* is only represented by *B. arculus*. Kennedy & Cobban (1991*b*: 183) regard specimens of *B. arculus* with whorl heights of 15–17 mm at the base of the body chamber as macroconchs, and small specimens with whorl heights of about 10 mm as microconchs.

The aperture of *Eubaculites* is not as well-known as that of *Baculites*, but seems to follow the same pattern, except that the whorl section does not expand. Figured examples include:

E. vagina (Forbes)—Klinger & Kennedy (1993, fig. 12a–c) (Fig. 54A).

E. latecarinatus (Brunnschweiler)—Klinger & Kennedy (1993, fig. 46) (Fig. 54B).

?*E. simplex* (Kossmat)—Klinger & Kennedy (1993, fig. 53b).

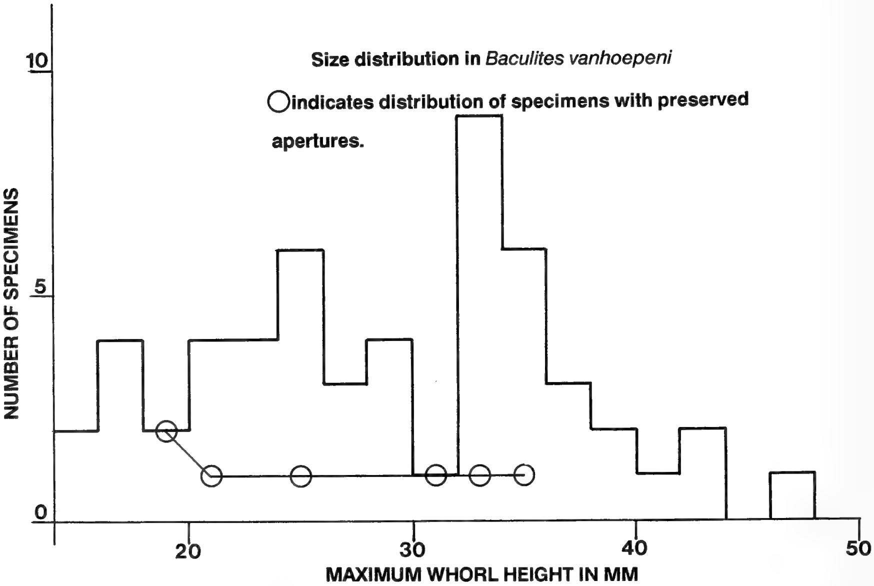


Fig. 53. Histogram illustrating size distribution in *Baculites vanhoepeni* Venzo, 1936, to illustrate dimorphism.

The pattern of distribution of maximum whorl height in *E. carinatus* (Fig. 44) from Neuquén, Zululand and Quiriquina, already mentioned above, is interesting. The Zululand and Neuquén specimens respectively show a bimodal distribution, suggesting size-related dimorphism, but the peaks do not fully coincide. The Quiriquina specimens all occur within the size range of the Zululand microconchs. We admit that these data are far from complete, but they do suggest that differences in size occur between populations from different localities, as suggested above, in addition to sexual differences.

The apertures of the remaining Maastrichtian baculitid lineages, e.g. *Fresvillia*, are unknown but judging by the general pattern in the rest of the Baculitidae, we assume that these genera are also dimorphic.

SUMMARY

1. Geographic distribution

Early representatives of the family, *Lechites* and *Sciponoceras* had a wide north-south distribution, but appear absent or very rare in West Africa. *Baculites* appears to have separated into distinct endemic lineages from the Coniacian onwards; that of the US Western Interior is most conspicuous, and persisted until the early Maastrichtian. In the Maastrichtian, *Eubaculites* dominated the Gondwanan regions and *Baculites* was scarce. In contrast, in the Northern Hemisphere, *Eubaculites* was a rarity and *Baculites* dominant. *Eubaculites* shows distinct latitudinally restricted distribution; it is absent from high northern and southern latitudes and equatorial regions, as well as from West Africa, North Africa and the Middle East.

2. Coiling

Lechites and *Sciponoceras* are straight, except at the aperture. Some Coniacian–Santonian *Baculites* may have curved body chambers, but this feature is not consistent. Others are either completely straight or the whole shell may be curved. Except in endogastric *Boehmoceras* and exogastric *Criobaculites* where the whole shell is a coiled criocone, curvature appears of little taxonomic value.

3. Whorl section

Lechites and *Sciponoceras* have circular or elliptical whorl sections. Early, Turonian *Baculites* have elliptical whorl sections; in later forms it varies between species, but seems to be rather consistent within the same species. Ventral keels first appear in the Santonian, but are not common, and only dominate in the Maastrichtian. Near the Campanian–Maastrichtian boundary a number of baculitid lineages acquire a cuneiform or trigonal whorl section. The predominantly Maastrichtian genus *Eubaculites* has a distinct pyriform whorl section with tabulate venter or trigonal whorl section with narrow venter. Late, Maastrichtian aberrant baculitids have circular whorl sections.

4. Suture line

Early *Baculites* have a simple suture with quadrate saddles and lobes. *Pseudobaculites* has a complex suture compared to contemporary *Baculites*. A progressive increase in complexity of suture line took place in all *Baculites* lineages from the Coniacian onwards. In the Campanian, several lineages with very complex sutures appeared suddenly. In the Maastrichtian, several small lineages with simplified suture occur.

5. Ornament

Ornament in *Lechites* and *Sciponoceras* is simple: circumperipheral ribbing or smooth with constrictions is a constant feature in the latter. In contrast, ornament in *Baculites* is extremely variable. Some ornamented species have rare smooth variants, and some smooth species have rare irregularly ornamented forms. Also, smooth species may occur in otherwise ornamented lineages. Lateral tubercles first occur in the Upper Turonian, and become dominant in the Coniacian and Santonian, but persist to the Lower Campanian in the Indo-Pacific. Prominent lateral ribbing is conspicuous in the Middle Campanian in the US Western Interior and the Indo-Pacific.

6. Size, dimorphism and apertures

Early *Baculites* are small, but show a gradual increase in size, reaching maximum size in the Upper Campanian–Lower Maastrichtian. True giants also occur in some *Eubaculites* in the Maastrichtian. The family as a whole is dimorphic. In *Lechites* apertures are different in macro- and microconchs. Those of *Sciponoceras* are more varied, and of specific as well as of sexual significance. Early *Baculites* have slightly curved apertures with short ventral and dorsal rostra; later forms are straight, with longer rostra and may be expanded. *Eubaculites* has a short dorsal and long ventral rostrum that is not flared.

GENERAL COMMENTS ON BACULITIDAE

APTYCHI

Aptychi of Baculitidae are rarities. These are calcitic objects and would be expected to have a high preservation potential. The best known occurrences are in European chalk facies where original aragonitic shells are lost, but even here, aptychi are absent from levels of abundant baculitids, as in the Middle Cenomanian of Southern England. There is little doubt that development of calcitic aptychi was limited to certain species only, as in the Scaphitaceae, and perhaps only in some individuals, and that most species had unmineralized jaw apparatus.

Thus far only two known occurrences of aptychi in *Sciponoceras* are known: the first by Fritsch (1895: 78, text-fig. 63c) from Bohemia; the second by Breitkreutz *et al.* (1991, figs 6–7) from the Upper Cenomanian *Neocardioceras juddii* Zone of Ostwestfalendamm, near Bielefeld in the Münster Basin in Germany. This specimen is shown as Figure 56 and

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Fig. 54 *(see facing page)*. Apertures in *Eubaculites*. A. *E. vagina* (Forbes, 1846). BMNH C51146 from the Valudavur Formation of southern India. B. *E. latecarinatus* (Brunnschweiler, 1966). SAS–H60H/1 from bed H, locality 133, Zululand, St Lucia Formation, Maastrichtian I. Both × 1.

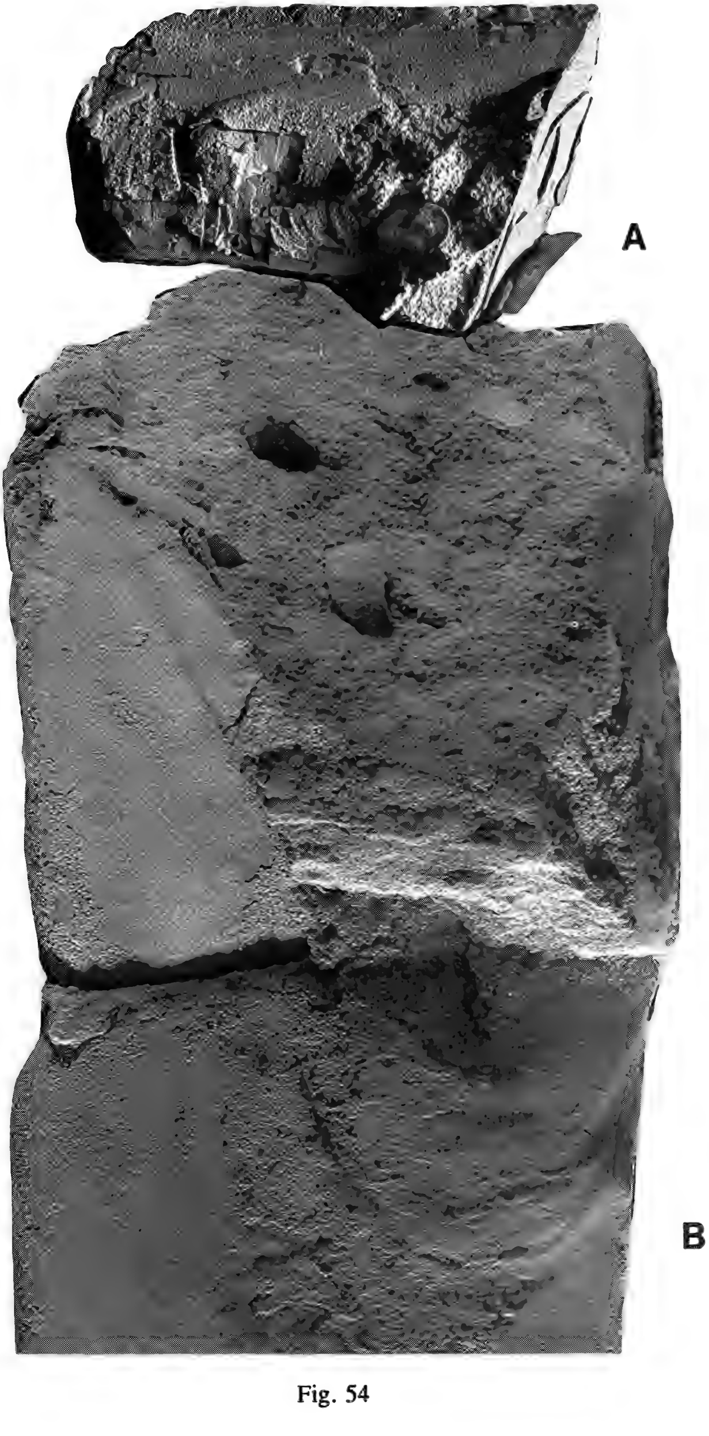

Fig. 54

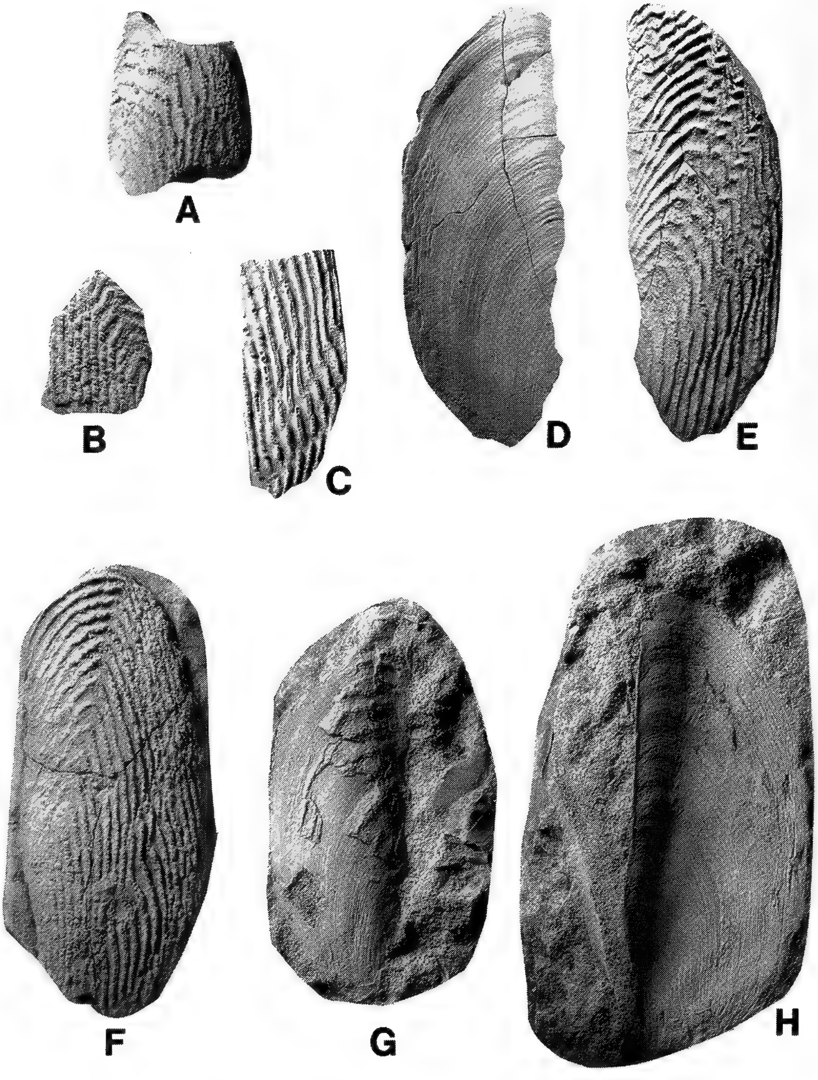

Fig. 55. A. *Rugaptychus flexus* (Moberg, 1885). Syntype, Lund University Collection, the original of Moberg (1885, pl. 1 (fig. 19)) from the Campanian of Köpinge, Sweden. B–H. *Rugaptychus insignis* (Hébert, 1856) (= *R. rugosus* (Sharpe, 1857)). B–C. Lund University Collections, the original of Moberg (1885, pl. 1 (figs 16–17)). D–E. Natuurhistorisch Museum, Maastricht Collections no. 6309, from the lower third of the Upper Campanian Zeven Wegen Chalk of Haccourt, Belgium. F. Syntype of *R. rugosus* Norwich Castle Museum collections no. 3519 from the Upper Campanian Chalk of Norwich, the original of Sharpe (1857, pl. 24 (fig. 31)). G. Lund University Collections, the original of Moberg (1885, pl. 1 (fig. 15)) from the Campanian of Köpinge, Sweden. H. Lund University Collections, the original of Moberg (1885, pl. 1 (fig. 14)), also from Köpinge. All × 1.

photographs were kindly supplied by Dr Büchner (Bielefeld) via Mr R. Metzdorf. The *Sciponoceras* is ill-preserved but compares to the early subspecies *anterius* Wright & Kennedy, 1984, of *S. bohemicum* (Fritsch & Schlönbach, 1872). The specimen is 105 mm long, with a maximum preserved whorl height of 7 mm. The adapertural 60 mm of the composite mould is body chamber, lacking the adapertural part, the aptychus lies 23 mm from the last septum, and is exposed as a convex mould of the inner, concave surface. There are traces of what appears to be the original calcite material of the jaw, suggesting it to be an aptychus rather than anaptychus. The partial exposure of the specimen means that it is not clear if two plates are represented, or a single fused plate. Ornament is of relatively coarse ridges and grooves that appear to parallel the outer and lateral margins; the structure is 5 mm in maximum length, the two halves 3.5 mm in maximum width. The specimen agrees with material from the Upper Cenomanian *Metoicoceras geslinianum* Zone of southern England described by Wright & Kennedy (1981: 118, pl. 31 (fig. 19)) as being possibly associated with *Scaphites*, although *Sciponoceras* occurs in the same interval and the latter assignation now seems more likely.

The form genus *Rugaptychus* Trauth belongs to the genus *Baculites* (Trauth 1927: 245; Arkell 1957*b*: L440). Records of *Baculites* with *Rugaptychus* are nearly all from Campanian Boreal Chalk facies in Europe (Fig. 55).

Trauth (1927: 245) recognized the following species in *Rugaptychus*:

R. rugosus (Sharpe, 1853). Upper Campanian (Sharpe 1853: 57, pl. 24 (figs 8a–b, 9); Binckhorst 1861: 33 (said to be Maastrichtian); Lundgren 1874: 70, *et seq.*, pl. 3 (fig. 14); Moberg 1885: 41, pl. 1 (figs 14–18), pl. 6 (fig. 26); Blackmore 1896: 532–3, pl. 16 (fig. 16); De Grossouvre 1908: 39, pl. 10 (figs 7–13)).

R. rugosus insignis (Hébert, 1856). Upper Campanian (Hébert 1856: 367, pl. 28 (fig. 6).

R. knorrianus Trauth, 1927. Upper Campanian (Schlüter 1876: 147, pl. 39 (fig. 16)).

R. flexus (Moberg, 1885). Upper Campanian (Schlüter 1876: 144, pl. 40 (fig. 8); Moberg 1885: 43, pl. 1 (fig. 19), pl. 6 (fig. 25)).

Rugaptychus form 1 Sharpe. Upper Campanian (Sharpe 1853: 58, pl. 26 (fig. 10a–b)).

Rugaptychus form 2. Maastrichtian (Ravn 1902: 259). This specimen was not figured and the identification is questionable.

The only possible older species of *Rugaptychus* is the specimen figured by Fritsch (1893: 80, fig. 63c–e) from the Coniacian of Bohemia.

To these may also be added: *B. leopoliensis* with aptychus in Nowak (1908: 339, pl. 14 (fig. 11)) and *B. vertebralis* Giers *non* Lamarck with aptychus in Giers (1964: 256). Giers (1964: 256, text-fig. 2) also figured some problematic structures in *B. vertebralis*, which he tentatively interpreted as jaw apparati

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Fig. 56 *(see overleaf)*. *Sciponoceras bohemicum anterius?* Wright & Kennedy, 1984. Specimen with aptychus from the Upper Cenomanian *Neocardioceras juddi* zone of Ostwestfalendamm near Bielefeld in the Münster Basin, Germany, the original specimen figured by Breitkreutz *et al.* (1991: 42, text-fig. 6). A × 4; B × 1.5.

Fig. 56

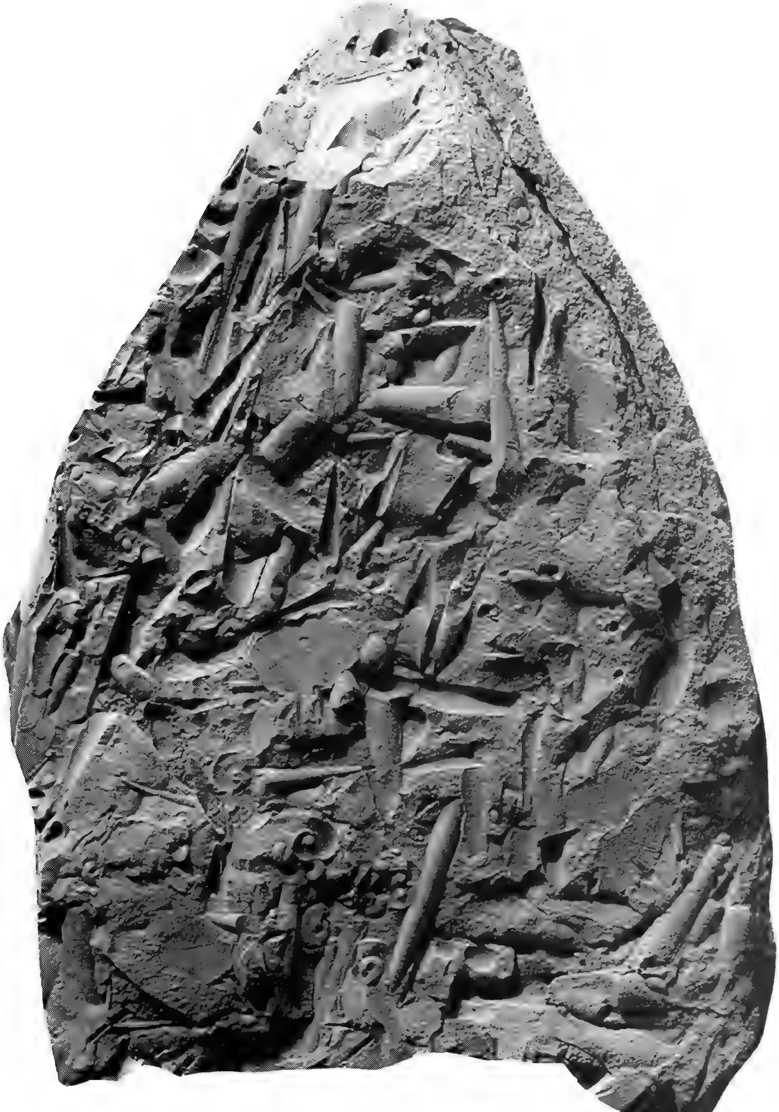

Fig. 57. Ammonitella of *Baculites* (small) and *Scaphites* (large) associated with juvenile *Baculites codyensis* Reeside, 1927*a*. USNM 507252, from USGS Mesozoic locality 21425, Santonian, Marias River Shale on east bank of Marias River, 18.5 km (11 miles) south-west of Shelby in the W½ NE¼ SE¼ sec. 14, T. 31 N., R. 4 W., Toole County, Montana. × 2.

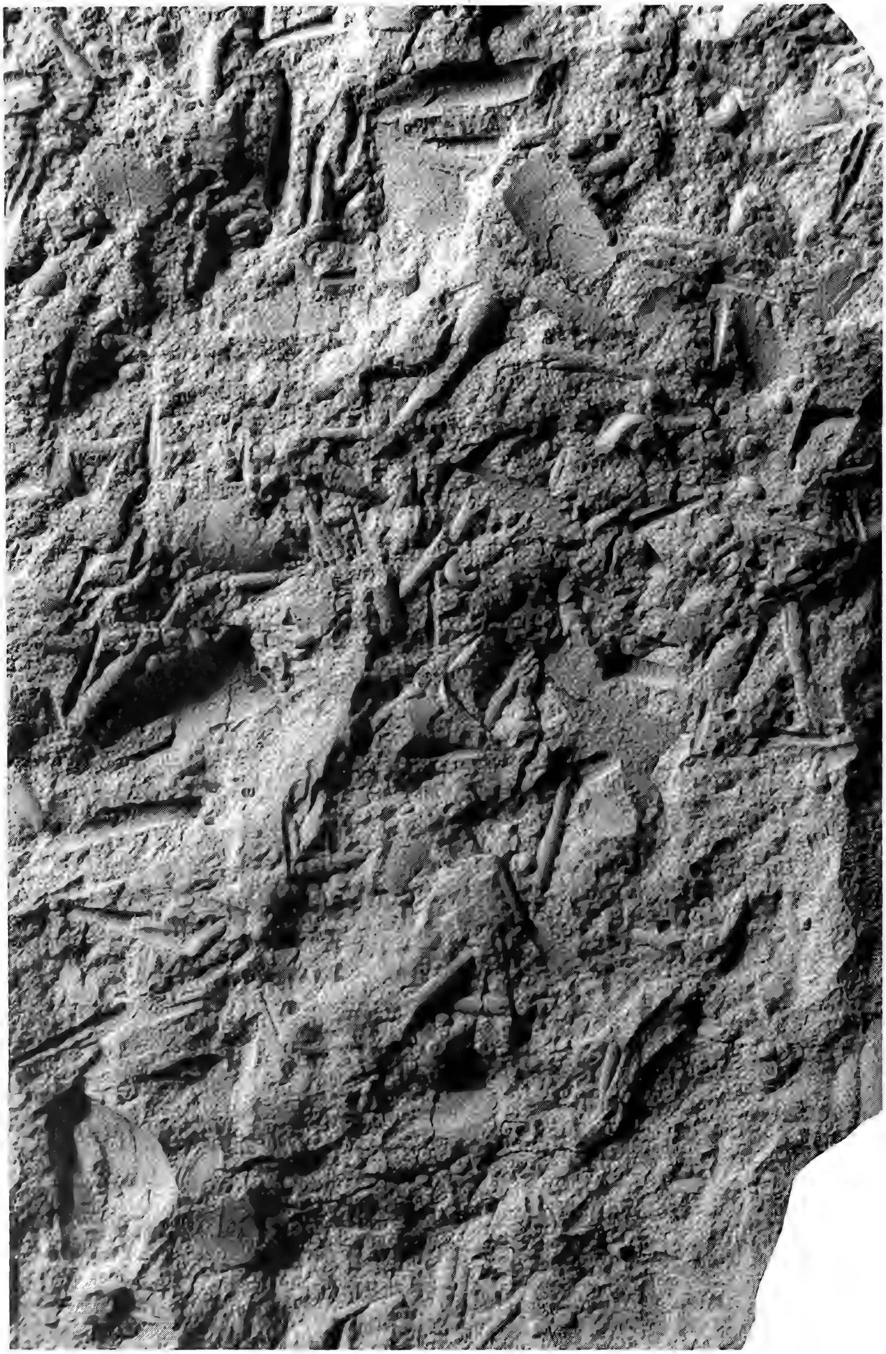

Fig. 58

(Mundwerkzeuge). One of us (WJK) has examined the specimen and concluded that the structures do not belong to the baculite. Picard (1929: 436) recorded an aptychus in the same layer as *B. vertebralis*. Kennedy (1986*c*: 192, pl. 16 (figs 1–22)) figured numerous specimens of *R. rugosus* from the Campanian of Folx-les-Caves, Belgium (previously figured by De Grossouvre 1908, pl. 10 (figs 7–13)), and later (Kennedy 1993: 114, pl. 7 (figs 18–25)) from Mons, Belgium. Kennedy & Christensen (1997, fig. 31a–h) figured some aptychi from southern Sweden, including some of Moberg's original specimens.

Given the large number of Baculitidae, especially *Baculites* and *Eubaculites*, often well-preserved in concretions, it is very surprising that neither aptychi nor anaptychi associated with these genera have been recorded from the US Western Interior, West Greenland, the Gulf Coast and Atlantic Seaboard regions of the USA, Hokkaido, Madagascar, Zululand, Australia, India, Argentina and Chile.

MASS OCCURRENCES

Baculitidae, especially *Baculites* often occur in great monospecific concentrations in single concretions, on single bedding planes and in limited intervals such as individual concretions or layers of concretions, e.g.*B. 'ovatus'* (Reeside 1927*b*, pl. 7 (figs 1–2)); *B. asperiformis* (Cobban 1962*b*: 708); *B. mclearni* (Cobban 1962*b*: 712); *B. perplexus* (Cobban 1962*b*: 714; Gill & Cobban 1966, pl. 11 (fig. 3)); *B. cuneatus* (Cobban 1962*a*: 128); *B. jenseni* (Cobban 1962*a*: 130); *B. perplexus* (Kennedy & Cobban 1976, pl. 8 (fig. 2)); *B. yokoyamai* (Cobban & Hook 1983: 7); *Sciponoceras gracile* (Kennedy 1988: 109, text-fig. 38; herein Fig. 60); *Eubaculites carinatus* (Klinger & Kennedy 1993, fig. 37); and *Baculites bailyi*, *B. capensis* and *B. duharti* (Klinger & Kennedy 1997).

In the US Western Interior, concretion layers filled with *Baculites* extend over many hundreds of square kilometres. In southern England, *Sciponoceras baculoides* occurs in profusion in a sequence of three limestone/marl couplets (Kennedy 1969) in the Middle Cenomanian part of the Lower Chalk over an area of more than 20 000 square kilometres. Gale (1989, 1995) has shown these couplets to represent an 18 000–23 000 Milankowitch cyclicity; for 72 000–92 000 years, *Sciponoceras* was the dominant organism preserved as body fossils, but is very rare or absent in the Lower Cenomanian Chalk below. It is equally abundant in contemporary phosphatized remanié faunas in condensed units resting on hard grounds in Dorset (Kennedy 1970), Haute Normandie (Juignet & Kennedy 1976) and Sarthe (Kennedy & Juignet 1983). Similar brief flood abundances on single bedding planes can be recognized in southern France with the Lower Cenomanian *Sciponoceras* sp. at Dieulefit (Drôme) or *Sciponoceras bohemicum anterius* in the Upper Cenomanian *Neocardioceras juddii* Zone in Devon, England.

Fig. 58 *(see facing page)*. USNM 507253, from the Niobrara Shale, Santonian, with mass occurrence of juvenile *Baculites codyensis* Reeside, 1927*a*, and rare ammonite jaws, from USGS Mesozoic locality D6619, Seminoe Dam south-west quadrangle in NW¼ SW¼ sec. 23, T. 25 S., R. 85 W., Carbon County, Wyoming. × 5.

Fig. 59. U.S. Geological Survey Collections, Denver, from the Niobrara Shale, Santonian with mass occurrence of juvenile *Baculites codyensis* Reeside, 1927*a*, and rare ammonite jaws, from USGS Mesozoic locality D6619, Seminoe Dam south-west quadrangle in NW¼ SW¼ sec. 23, T. 25 S., R. 85 W., Carbon County, Wyoming. × 5.

Fig. 60. Mass occurrence of *Sciponoceras gracile* (Shumard, 1860). J. P. Conlin Collection no. 7490, from 1.5 to 1.8 miles south-east of Britton, Ellis County, Texas. × 1.

Mass occurrences are generally made up of whole or fragmentary adult or subadult individuals and may sometimes show size-sorting. In the US Western Interior, there are also rare occurrences with associated ammonitella and juveniles (Figs 57–59), or laminae with abundant juveniles may occur in concretions dominated by adults. Much rarer are mass occurrences of juveniles only, as have been figured from Zululand (Klinger & Kennedy 1997) of *Baculites bailyi*.

In most of these occurrences, including our Zululand material, these *Baculites* show subparallel alignment, suggesting post-mortem drifting and current alignment. However, the preservation and attachment to the rest of the shell of the very delicate ammonitellas in some of these assemblages seems to contradict current alignment of the shells. The very fine silty lithology of these concretions suggests a low energy sedimentary environment. A detailed analysis of the accompanying invertebrate faunas might throw more light on the sedimentary environment of these mass occurrences of baculitids. The mass occurrences suggest that, for part of their life-cycles at least, baculites were gregarious.

AMMONITELLA AND EARLY ONTOGENY

In contrast to normally coiled ammonites where the ammonitella is partially covered and protected by the succeeding planispiral whorls, the ammonitella of the baculitids is very vulnerable, being totally exposed and attached to the rest of the straight shell by a slender shaft. Notwithstanding these unfavourable conditions, ammonitellas, often still attached to the early shaft have been recorded on several occasions in *Baculites*—see e.g. Bandel *et al.* (1982, text-figs 1c, 2d); Birkelund (1979, text-fig. 3a–c, g–h); 1981, text-fig. 4a–b?, c; 1993, text-fig. 6a–b, d–i)); Brown (1891: 159–160; 1892: 136–141, pl. 9 (figs 1–11)) (*B. compressus*); Cobban (1962*b*: 708–709); Landman (1982: 1235–1241, text-figs 1–2; 1987: 158, fig. 25c–d, p. 160, fig. 26); (1994); Landman & Bandel (1985, figs 16–26); Reeside (1927*b*, pl. 7 (figs 6–8)) (*B. ovatus*), Reyment (1958: 7, fig. 1a–d) (*B. yokoyamai*? as *B. 'ovatus'* Say?) and Smith (1901: 39–49). Our own material of *B. bailyi* (Klinger & Kennedy 1997) from the Coniacian also shows several specimens with the ammonitella still attached to the early shaft. In some cases assemblages are dominated by, or consist exclusively of such juveniles, suggesting age segregation of adults and juveniles.

Unfortunately, it is not possible to dissect our Zululand specimens to determine the early sutural ontogeny, nor is the preservation good enough to show the early micro-ornament. For detailed discussions on these features the reader is referred to Brown (1892), Smith (1901), Landman (1982) and Bandel *et al.* (1982).

Dr W. A. Cobban (U.S. Geological Survey, Denver) has kindly allowed us to illustrate a series of well-preserved *Baculites codyensis* Reeside, 1927*a*, from the Santonian Colorado Shale (now Marias River Shale) of Toole County, Montana (Figs 61–65). Specimens include ammonitella (Fig. 62A, B) and ammonitella with juvenile phragmocone and, perhaps, body chamber (Fig. 61A–B). Ammonitella with shell preserved (Fig. 63A–B) show the lack of

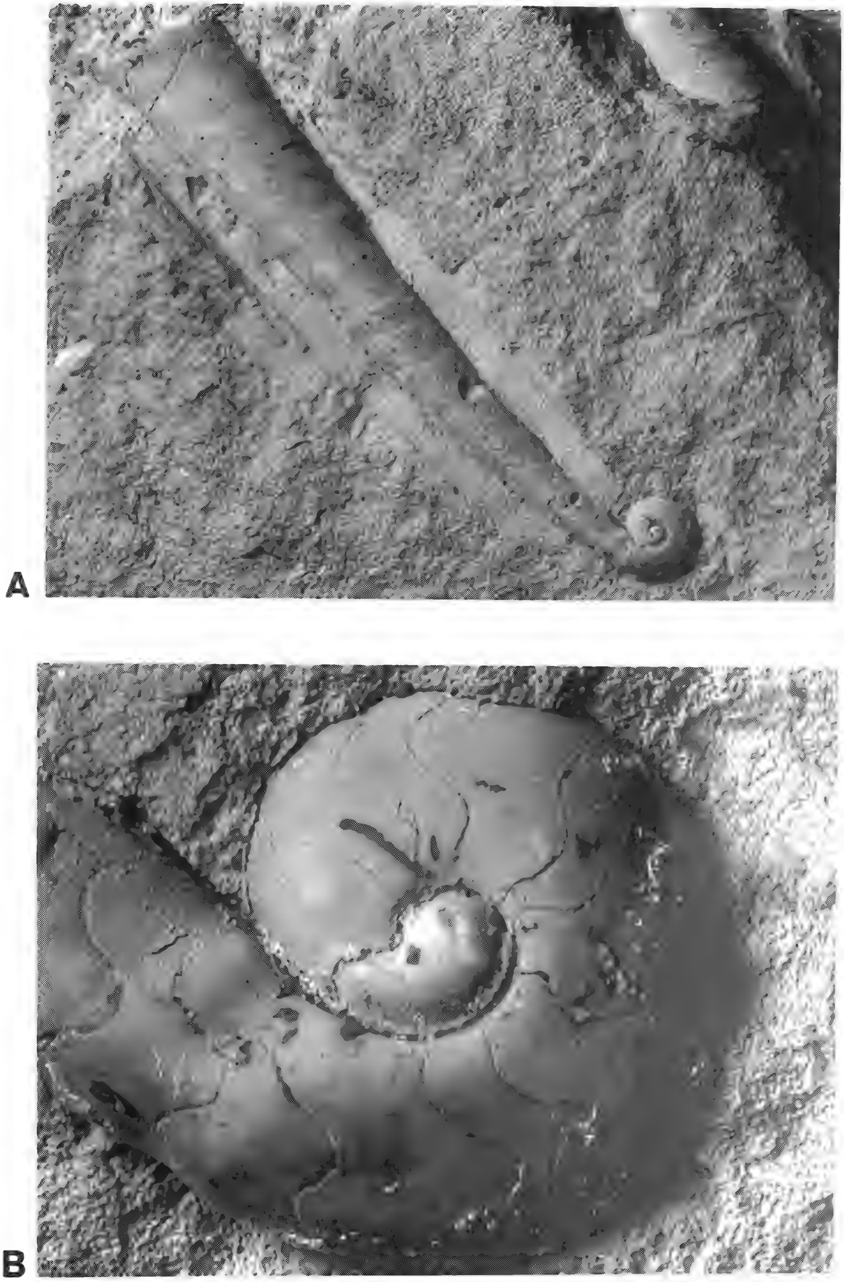

Fig. 61. *Baculites codyensis* Reeside, 1927*a*, USNM 507254, from USGS Mesozoic locality 21425, the Santonian Marias River Shale on the east bank of the Marias River, 18.15 km (11 miles) south-west of Shelby, in the W½ NE¼ SE¼ sec. 14, T. 31 N., R. 4 W., Toole County, Montana. A × 15; B × 100.

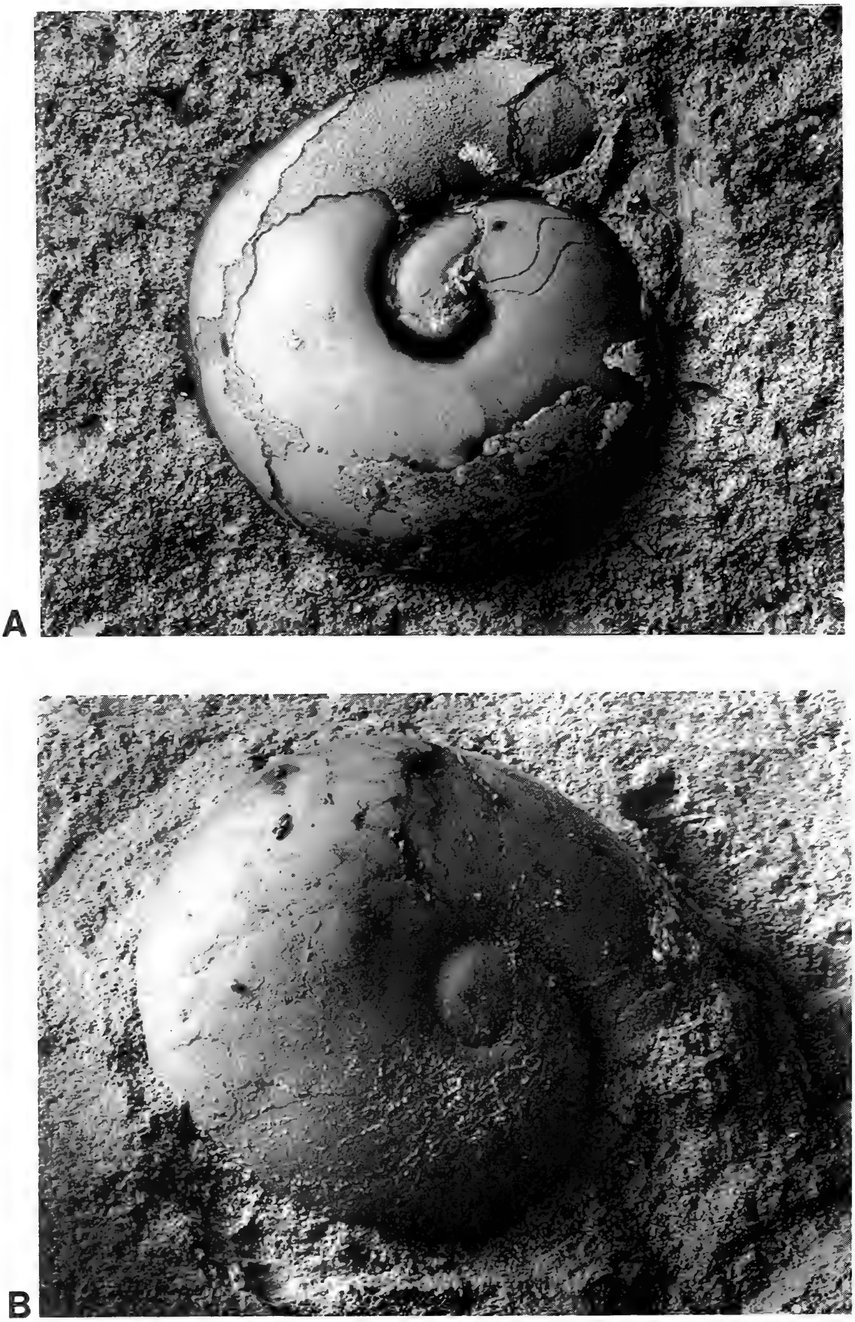

Fig. 62. *Baculites codyensis* Reeside, 1927*a*. A. USNM 207255. B. USNM 507256. Both from USGS Mesozoic locality 21425, the Santonian Marias River Shale on the east bank of the Marias River, 18.15 km (11 miles) south-west of Shelby, in the W½ NE¼ SE¼ sec. 14, T. 31 N., R. 4 W., Toole County, Montana. A × 90; B × 120.

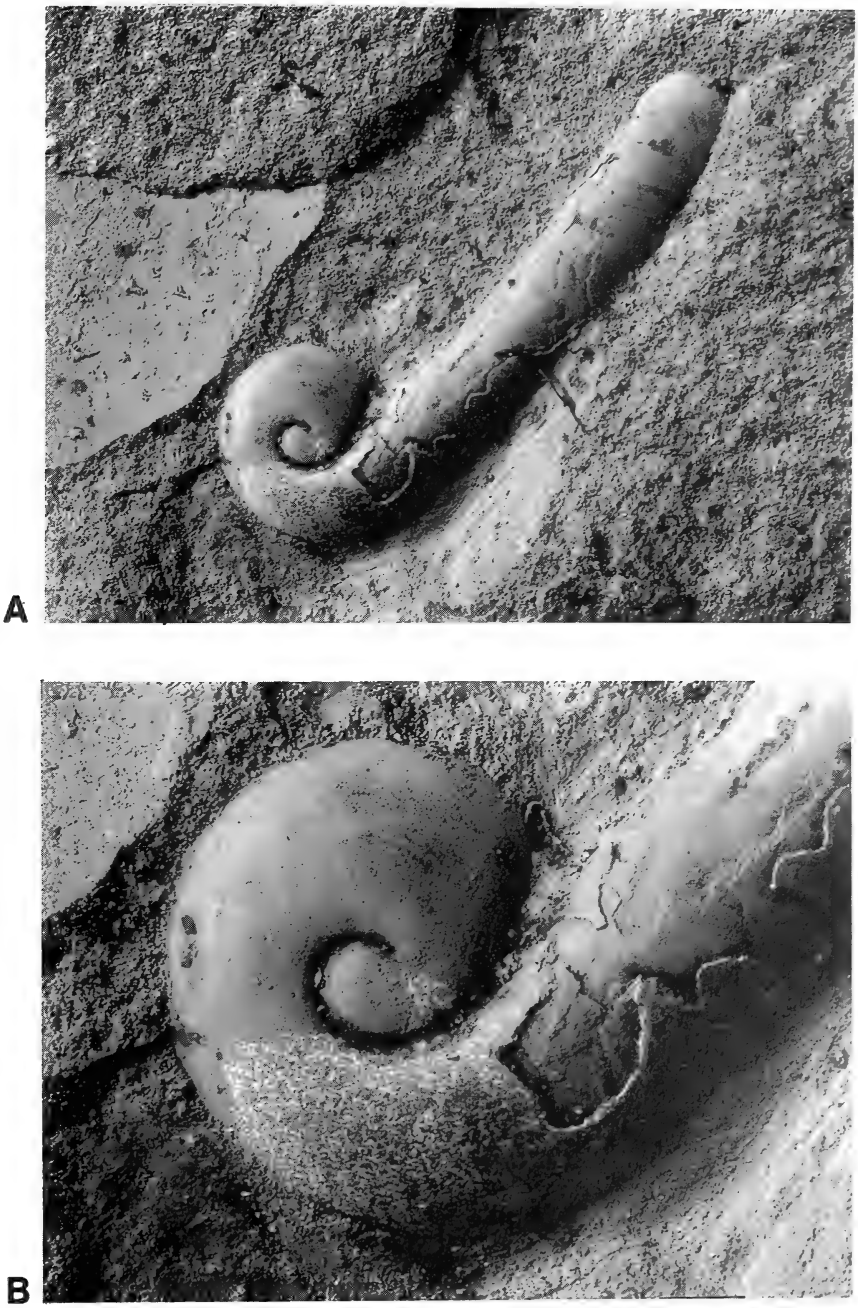

Fig. 63. *Baculites codyensis* Reeside, 1927*a*, USNM 507257, from USGS Mesozoic locality 21425, the Santonian Marias River Shale on the east bank of the Marias River, 18.15 km (11 miles) south-west of Shelby, in the W½ NE¼ SE¼ sec. 14, T. 31 N., R. 4 W., Toole County, Montana. A × 40; B × 90.

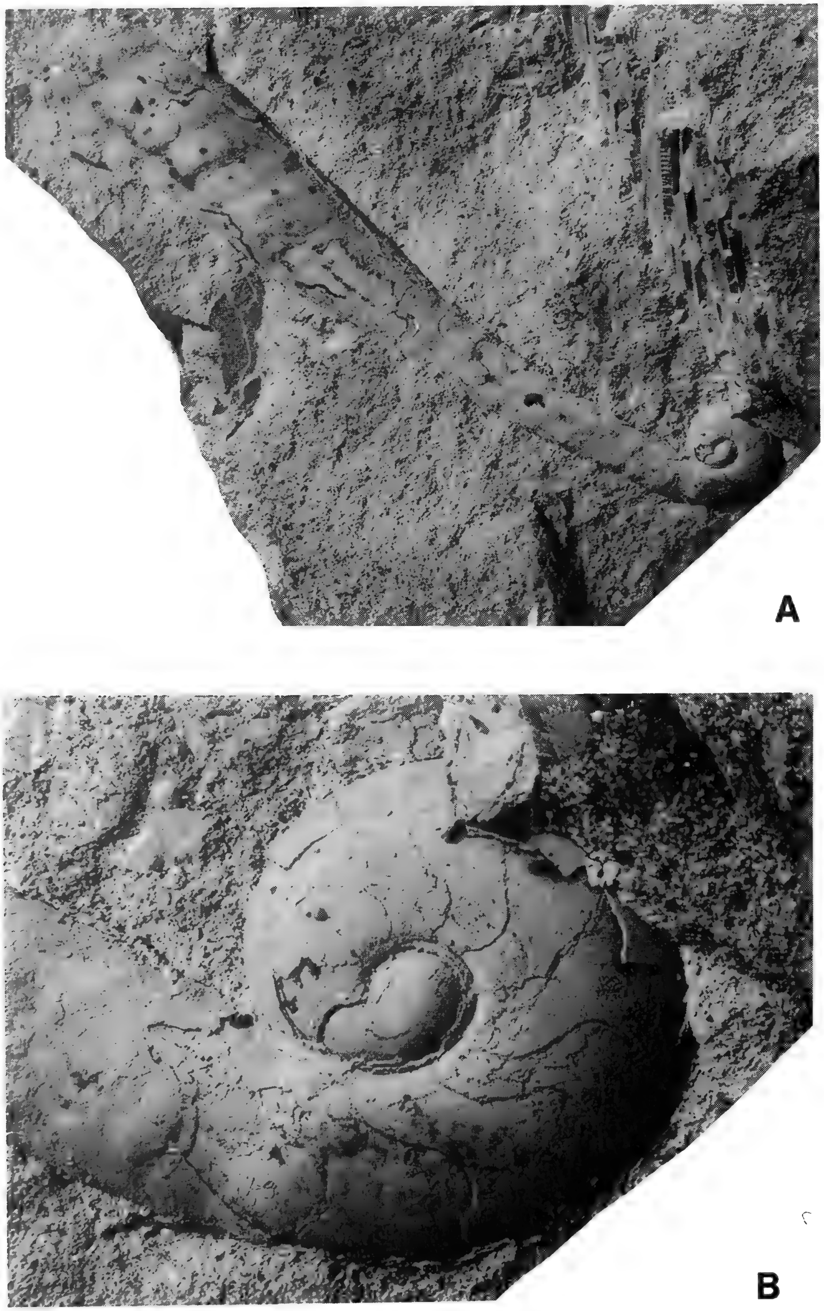

Fig. 64. *Baculites codyensis* Reeside, 1927*a*, USNM 507258, from USGS Mesozoic locality 21425, the Santonian Marias River Shale on the east bank of the Marias River, 18.15 km (11 miles) south-west of Shelby, in the W½ NE¼ SE¼ sec. 14, T. 31 N., R. 4 W., Toole County, Montana. A × 22; B × 110.

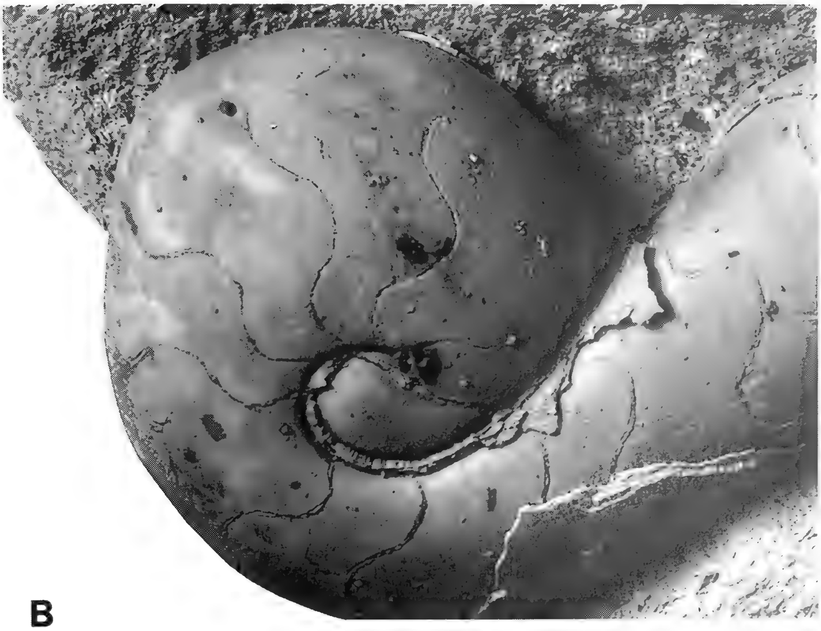

Fig. 65. *Baculites codyensis* Reeside, 1927*a*, USNM 507259, from USGS Mesozoic locality 21425, the Santonian Marias River Shale on the east bank of the Marias River, 18.15 km (11 miles) south-west of Shelby, in the W½ NE¼ SE¼ sec. 14, T. 31 N., R. 4 W., Toole County, Montana. A × 14; B × 110.

growth lines and microtuberculation as described by Bandel *et al.* (1982), Landman (1982) and Landman & Bandel (1985), whereas internal moulds show details of early suture ontogeny (Figs 61B, 62A, 64B, 65B) and the nepionic constriction (Figs 61A, 64A–B).

MUSCLE SCARS

Records of muscle scars in Baculitidae are rare. In a pioneering study nearly a century ago, Crick (1898) described and figured muscle scars in *Baculites ovatus* (1898: 77, pl. 17 (figs 1–4)) and *Eubaculites vagina* (1898: 78, pl. 17 (fig. 1)). Kennedy & Cobban (1976, pl. 2 (fig. 1a–b)) figured paired dorsal muscle scars in *Baculites codyensis*. Klinger & Kennedy (1980: 299, figs 3d, 4b, 5b) recorded a slight, median dorsal ridge in *Eubaculites latecarinatus* and in *E. vagina*. They suggested that this structure might be associated with the muscular attachment of the animal to the shell. Henderson (1984), in contrast, suggested that subepithelial muscle attachment in ammonites was along the line of contact of the septum and shell wall, and that the 'muscle scars' of previous workers perhaps represented the 'imprint of internal organs', although they could be viewed as 'additional sites of muscle attachment, separated from those

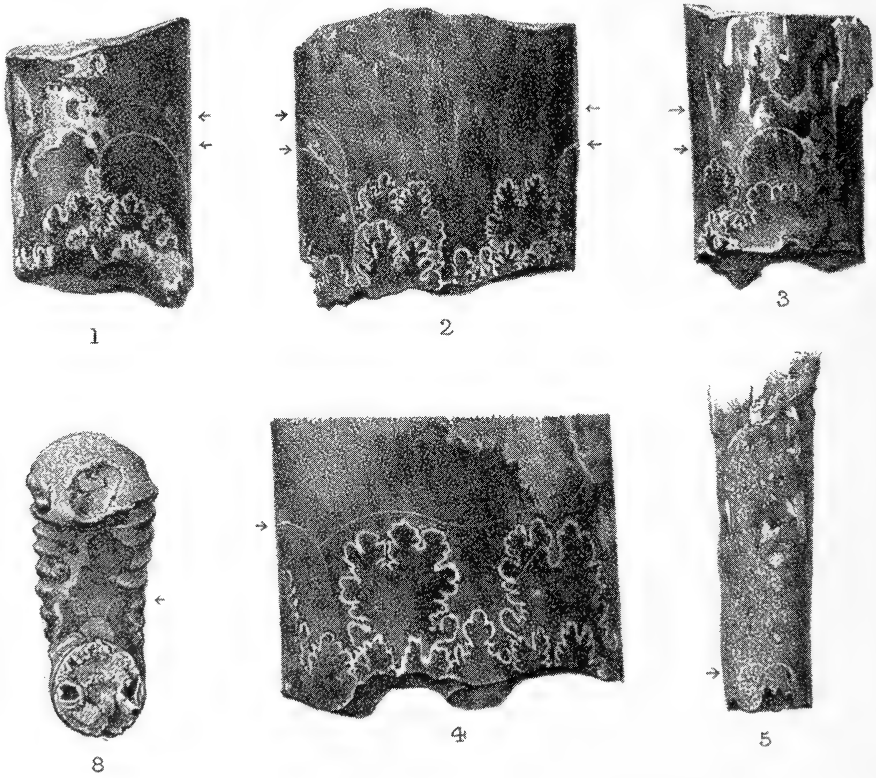

Fig. 66. Copy of part of Crick's (1898) plate 17. Figs 1–4 are labelled as *Baculites ovatus* Say, Fig. 5 as *Baculites vagina* Forbes, and Fig. 8 as *Hamites maximus* J. Sowerby.

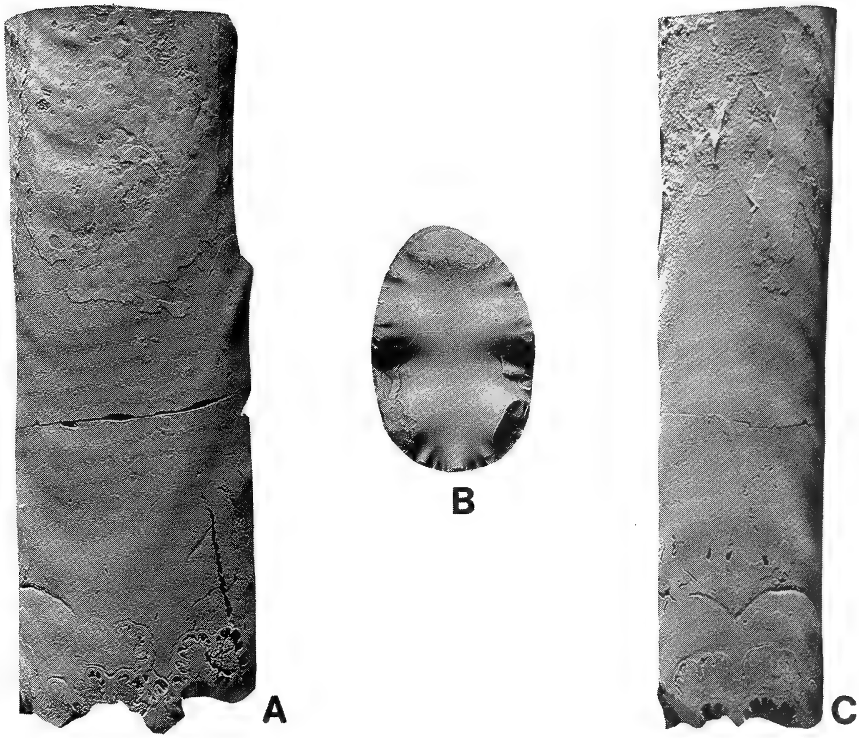

Fig. 67. *Baculites* sp. A–C. U.S. Geological Survey collections, Denver, locality D2140, from the Pierre Shale, Campanian, 12.2–21.3 m above the top of the Groat Sandstone at Mesozoic locality D2140, 25.6 km north of Belle Fourche in SW¼ SE¼ sec. 22, T. 11 N., R. 2 E., Butte County, South Dakota. The specimen has been coated with ammonium chloride and shows the narrow groove on the internal mould that corresponds to the ridge on the inside of the adapical end of the body chamber that defines the adapertural edge of the bilobed dorsal muscle scar. The groove adapertural to the final septum corresponds to the position of the postseptal prismatic zone of Henderson (1984). × 1.

of the subepithelial sheath' (1984: 480). Henderson illustrated and described pre- and post-septal prismatic zones, the latter in his view the site of muscle attachment (1984, text-fig. 9).

Through the courtesy of Dr W. A. Cobban (U.S. Geological Survey, Denver), we have been able to examine a series of rare and exceptionally preserved *Baculites* from the US Western Interior that show detail of muscle scars and related features with great clarity. Only a tiny percentage of generally adult *Baculites* show muscle scars; development is variable even in individuals from a single concretion. The post-septal prismatic zone of Henderson forms a distinct groove, adapertural to the septa (Fig. 67). There is a well-developed adaperturally biconvex groove on the mould (Figs 67–71), corresponding to a ridge of shell material on the inside of the body chamber, that follows the general line of the U/I saddle on the dorsum, and runs back towards the trace of the post-septal prismatic zone. This bilobed trace is presumed to represent the fused dorsal muscle scars described in other ammonites. Much rarer, and generally fainter, is an adaperturally convex groove that defines a single, ventral muscle scar (Figs 69–70). Rare specimens show two sets of successive scars in the adapical part of the body chamber, and one specimen (Figs 70–71) has a series of successive scars on the walls of the last few chambers of the phragmocone and the adapical part of the body chamber. These traces presumably mark the adapertural boundary of the muscle scar associated with temporary attachment following the pause in forward movement of the body that coincided with the secretion of the last few septa.

Some internal moulds show delicate longitudinal ridges on both dorsum and venter of moulds of phragmocone and body chamber, corresponding to ridges of shell material on the inside of the shell. These may occur on specimens with the muscle scar present (Fig. 69) or where they are not developed (Fig. 70). On the dorsum there is a faint median groove, plus a lateral groove, corresponding to lobe I and the outer flank of saddle U/I (Figs 69C, 70A). A pair of closely spaced median grooves may be present on the venter (Fig. 70), and there may also be faint parallel striations.

None of the specimens studied showed any trace of an 'annulus' as described by Crick (1898), and we accordingly re-examined his material. The original of Crick's *Baculites ovatus* are examples of one of the feebly ornamented Campanian–Maastrichtian *Baculites* from the Pierre Shale; the locality is given as 'Fox Hills beds (Upper Cretaceous) of Horse Head Creek, South Dakota'. The original of Crick's pl. 17 (figs 1–3) is BMNH C54150. It is illustrated here as Figure 73D–H, and Crick's original drawings are reproduced as Figure 73A–C. It will be seen that the reported dorsal and ventral muscle scars shown by Crick are indeed present. The original of his pl. 17 (fig. 4), is shown here as Figure 74A and 74E; his original drawing is reproduced as Figure 74B. We were unable to detect the annulus he described and illustrated. We also examined the specimen of *Eubaculites vagina* (Forbes, 1846) described and illustrated by Crick (1898, pl. 17 (fig. 5)), BMNH C73570) but were unable to convince ourselves that a bilobed groove delineating a dorsal muscle scar was indeed present (Fig. 74C, D, F).

DRAG BANDS AND RELATED FEATURES

Rare *Baculites* from the US Western Interior show longitudinal markings on internal moulds of the chambers of the phragmocone (Fig. 75). Similar structures have been discussed most recently by Zaborski (1986) and Hewitt *et al.* (1991), and variously interpreted. In our view, they record the forward movement of the tissues between successive pauses associated with septum formation. The markings correspond to slight irregularities on the mould, and variation in surface texture. The siphonal region of one specimen (Fig. 75B)

Fig. 68 *(see facing page)*. ***Baculites haresi*** Reeside, 1927*b*, USNM 507260, from USGS locality D1587, from the Gammon Member of the Pierre Shale, sec. 3, T. 10 N., R. 4 E., Butte County, South Dakota. A–B. Flanks (uncoated). C–D. Dorsum (coated in C, uncoated in D). The bilobed dorsal muscle scar accompanied by a groove (C) with traces of the original shell material (D). × 1.

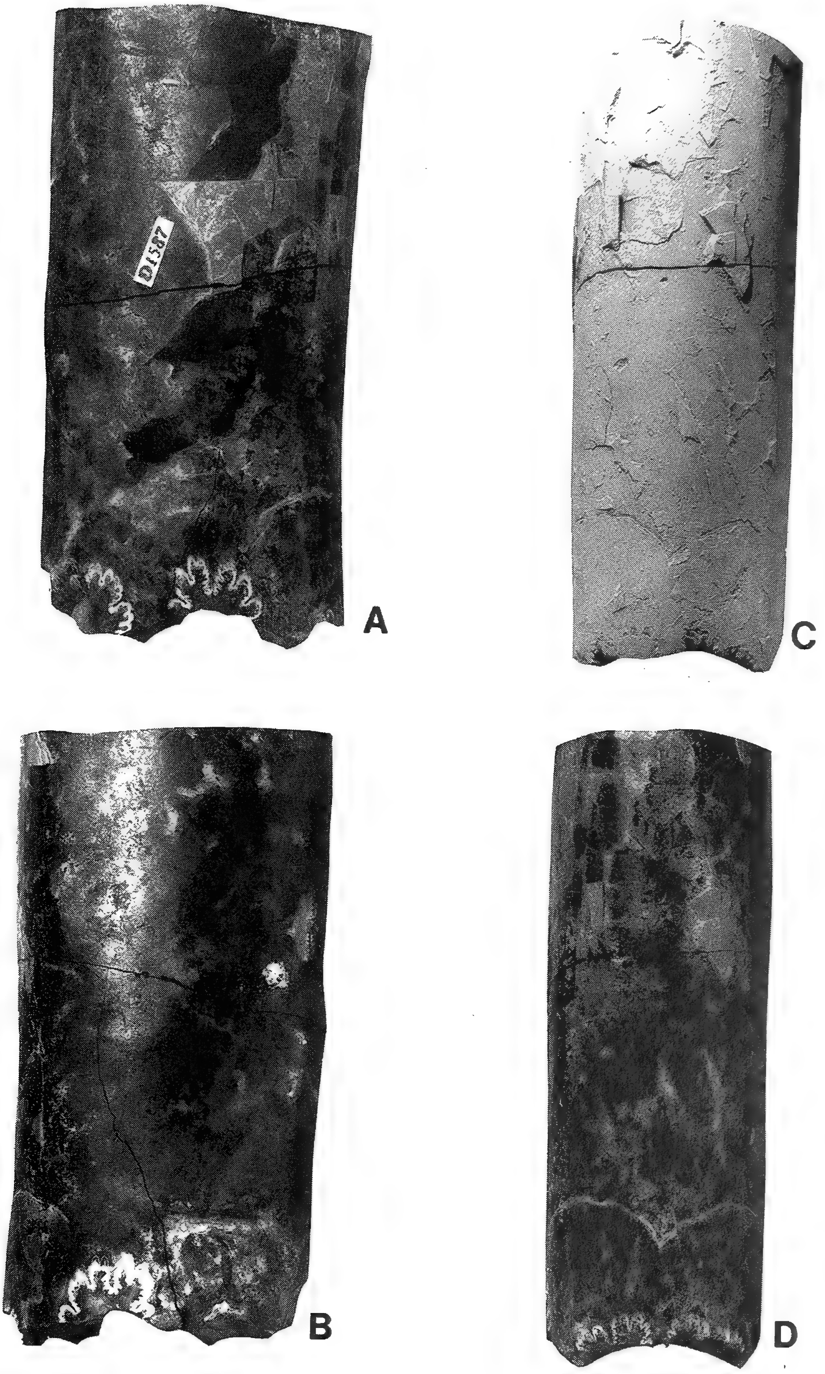

Fig. 68

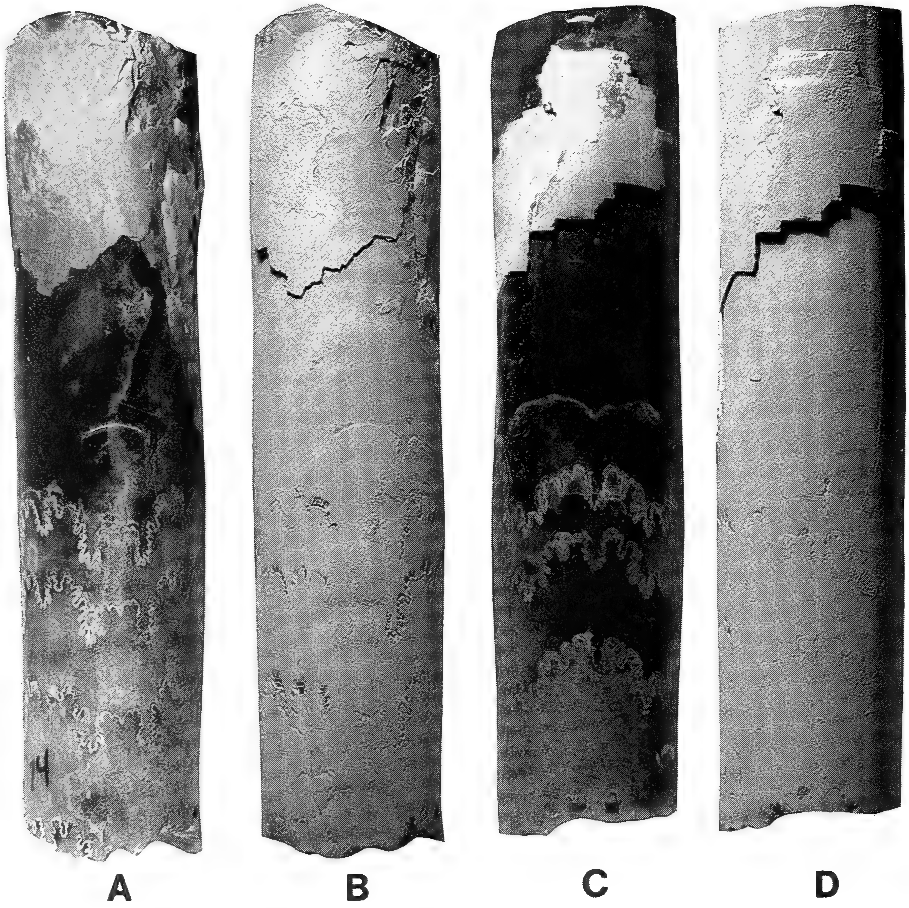

Fig. 69. *Baculites codyensis* Reeside, 1927*a*. U.S. Geological Survey Collections, Denver; from the Marias River Shale, Santonian, USGS Mesozoic locality 21425, near Shelby, Montana. A and C are uncoated; B and D are coated with ammonium chloride. The venter (A, B) shows a single incomplete adaperturally convex groove marking the adapertural edge of the ventral muscle scar. The dorsum (C, D) shows the bilobed trace of the adapertural edge of the dorsal muscle scar. In D, a median and a pair of lateral grooves (corresponding to ridges on the inside of the shell) are present on both phragmocone and body chamber. Their function is uncertain. × 2.

Fig. 70 *(see facing page)*. *Baculites codyensis* Reeside, 1927*a*. A–C. USNM 507261. B. USNM 507262. From the Colorado Shale, Santonian, USGS Mesozoic locality 21425, 18.15 km (11 miles) south-west Shelby, in W½ NE¼ SE¼ sec. 14, T. 31 N., R. 4 W., Toole County, Montana. A, E, show the dorsum; G, the venter of specimens showing well-developed grooves on internal moulds that correspond to ridges on the inside of the shell. × 1.

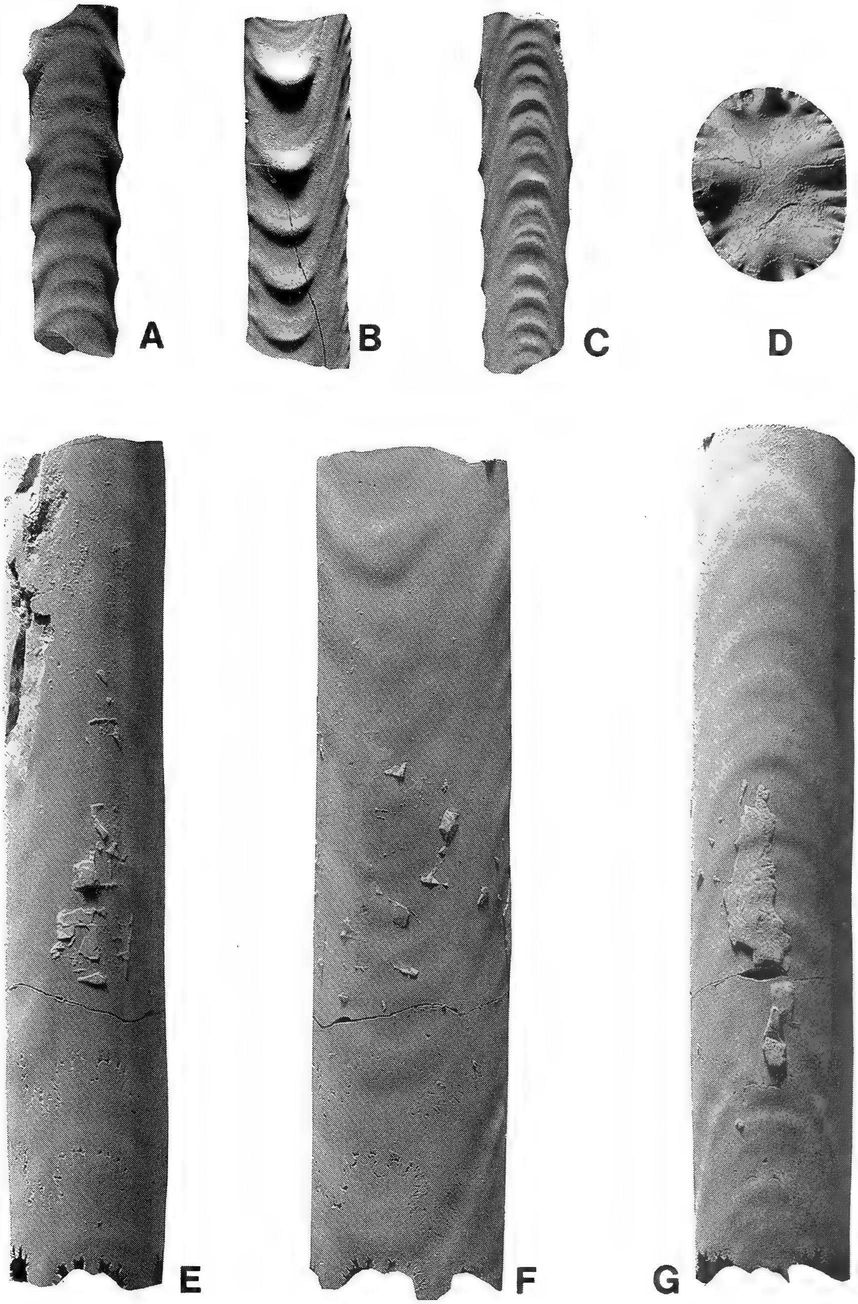

Fig. 70

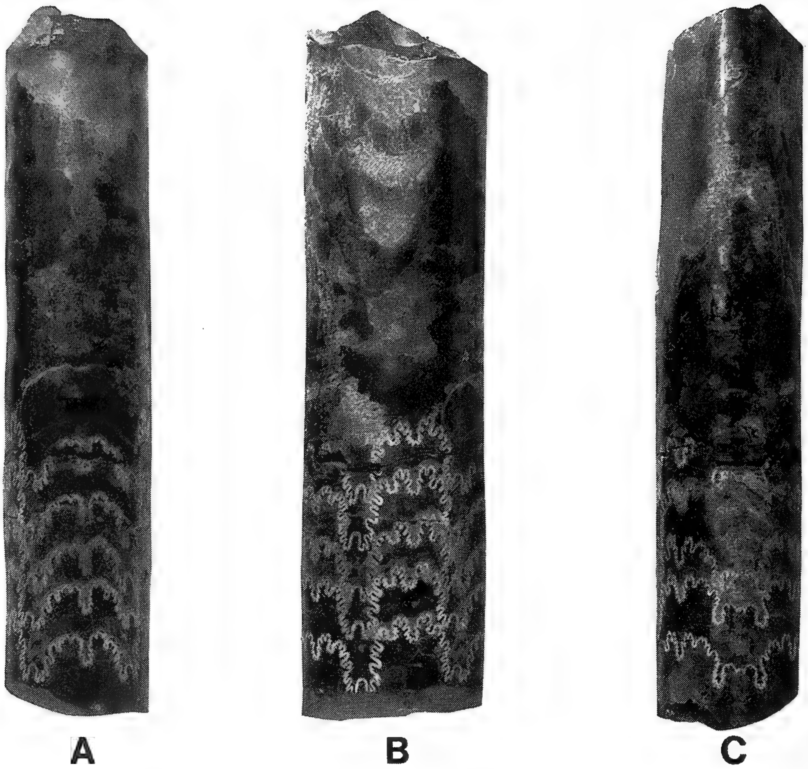

Fig. 71. *Baculites haresi* Reeside, 1927*b*, USNM 507263, from the Gammon Member of the Pierre Shale, Campanian, USGS Mesozoic locality D1587, sec. 3, T. 10 N., R. 4 E., Butte County, South Dakota. Dorsum (A) shows traces of four successive positions of the bilobed dorsal muscle scar. Two are overlain by the final two septa of the phragmocone, and two are visible at the adapical end of the body chamber. Flank (B) shows final dorsal muscle scar at adapical end of body chamber clearly. Venter (C) shows traces of four successive ventral muscle scars. × 2.

shows well-developed longitudinal lines, in part picked out by traces of shell, in the siphonal region. These features were described by a number of previous workers (see review in Kennedy & Cobban 1976), and interpreted as traces of the ligaments supporting the siphuncle. The width of the structure figured here suggests that it may be the trace of the adapertural migration of the ventral muscle.

MICROSCULPTURES

Checa (1995) recognized eight morphological types of 'microsculpture' on the outer surface of a range of well-preserved Jurassic and Cretaceous ammonites, and interpreted them as having been produced by compressive stresses acting on a free, uncalcified periostracum, and consequently preserved by mineralization of the wrinkled surface. Structures of this type are quite common in US Western Interior *Baculites*, both where the outer shell layer is

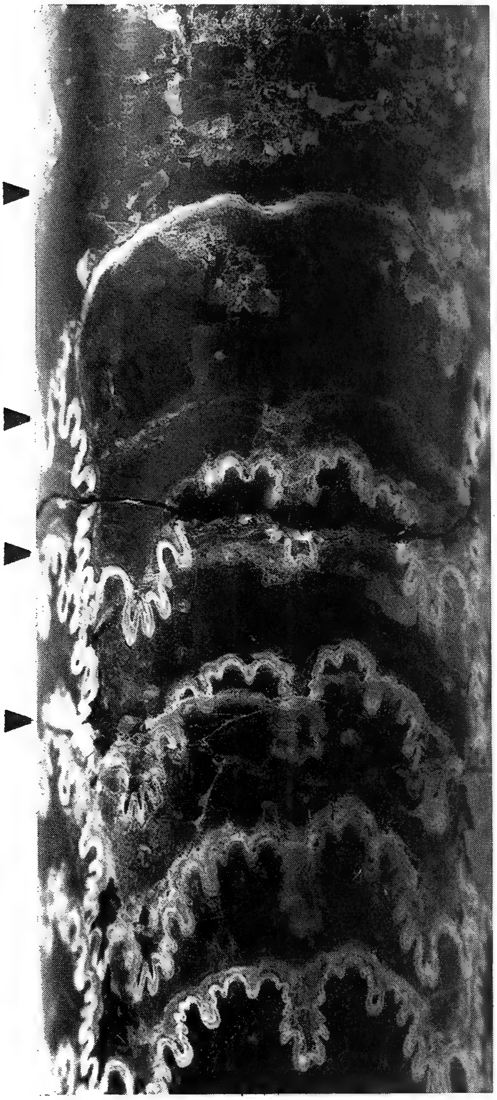

Fig. 72. *Baculites haresi* Reeside, 1927*b*, USNM 507263, from the Gammon Member of the Pierre Shale, USGS Mesozoic locality D1587, sec. 3, T. 10 N., R. 4 E., Butte County, South Dakota. Details of dorsum of specimen shown in Fig. 71A, with positions of four successive dorsal muscle scars indicated. × 6.

preserved, and on partially exfoliated surfaces within the nacreous layer (Figs 76–78, 79A–C, E). Some of the most striking examples extend through on to the internal mould (Fig. 76D–F).

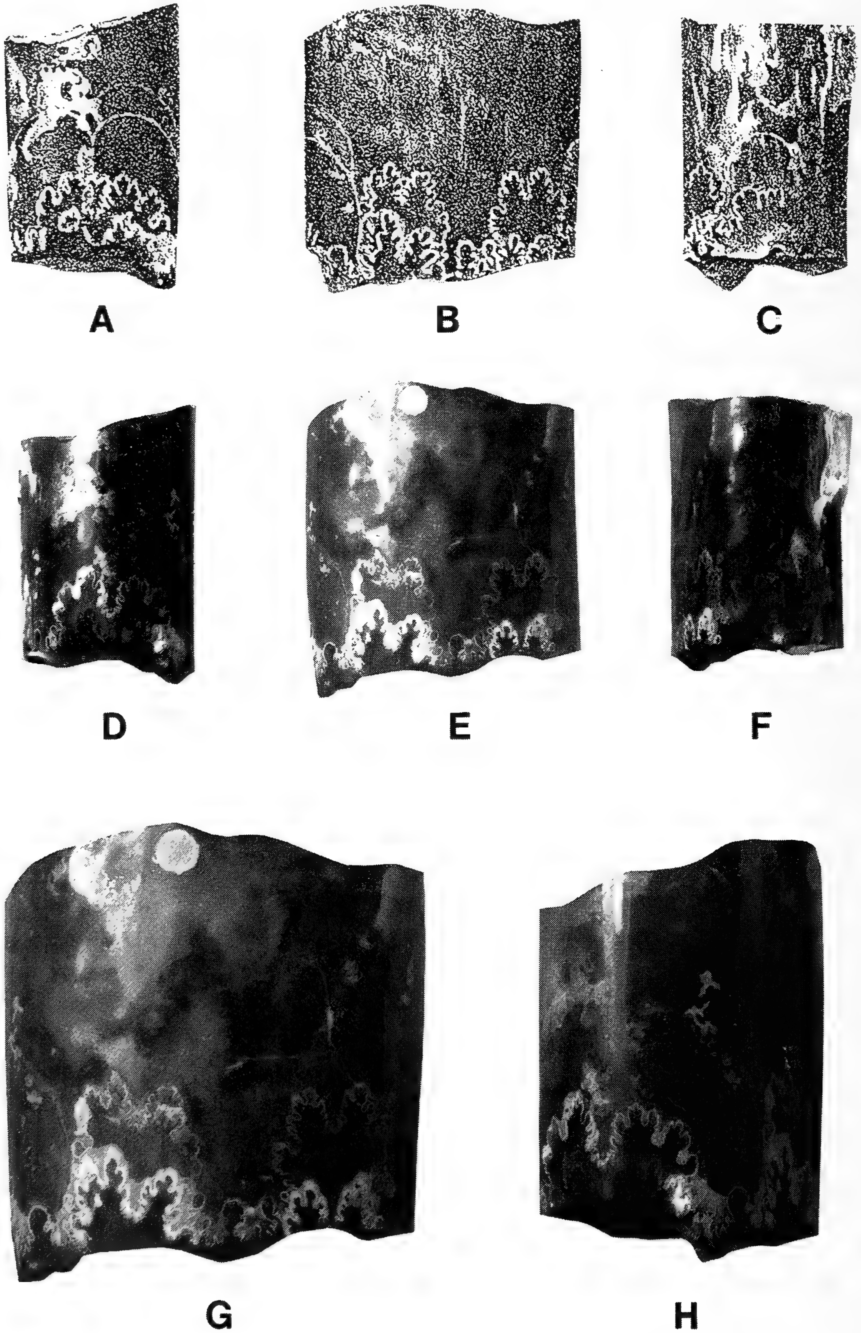

Fig. 73

We are uncertain as to the origin of these structures, the best developed of which may disrupt ornament and appear to record a pathological condition (Fig. 76D–F, 77–78) rather than the exceptional preservation of normal structures produced in an unmineralized periostracum.

FEATHER STRUCTURE

Arkell (1957*a*) used the term 'feather structure' for the low-relief adapically diverging chevrons described from a range of generally oxycone or very compressed feebly ornamented ammonites of Jurassic and Cretaceous age.

Wepfer (1920) referred to these structures as 'Streifenbüschel' and noted their presence in what he termed *Baculites compressus* from the US Western Interior. Feather structure is in fact relatively common in US Western Interior *Baculites* (Fig. 79D). Well-preserved specimens show this structure to be present on the outer surface of the outer shell layer (on rare occasions where this is preserved), but is typically seen on exfoliated surfaces within the thick nacreous layer, and is also present on the internal mould. Wepfer (1920) thought this structure could possibly be the impression of the nidamental gland.

Kessler (1923) thought the structure to be associated with muscle attachment, as did Seilacher (1988) who interpreted it as reflecting the successive sites of attachment of the retractor muscle to the wall of the body chamber. In an alternative interpretation Checa (1995: 885) regarded feather structure as a variant of what he described as 'adoral convergent wrinkles' produced in unmineralized periostracum. He dismissed the muscle attachment hypothesis on the basis that the feather structure was external rather than internal. The present material shows it to be both (for further discussion of feather structure see Enay & Dominjon 1964, 1967, and references therein).

PARASITISM

Distortion and irregular section of shell has been interpreted as the result of parasitism by some workers (Keupp 1984, 1995; Keupp & Dietze 1987; Hengsbach 1990, 1991, and reviews therein). Through the courtesy of Dr W. A. Cobban and Messrs P. and N. Larson (Black Hills Institute of Geological Research, Hill City, South Dakota) we have seen *Baculites* showing two conditions that may be the result of parasitism. The most spectacular example (Fig. 80) is a specimen of *B. eliasi* Cobban, 1958, from the Maastrichtian Pierre Shale of Garfield County, Montana.

A partially exfoliated fragment from the adapical end of the body chamber bears a large, asymmetric blister-like swelling on the venter (Fig. 80). A possible interpretation of this specimen is that the mantle at the aperture of the shell was either parasitized or infected, producing a tumour-like growth, but

Fig. 73 *(see facing page)*. *Baculites* sp., BMNH C54150, from the 'Fox Hills beds (Upper Cretaceous) of Horse Head Creek, South Dakota', the original of Crick (1898, pl. 17 (figs 1–3)). Crick's figures are reproduced as A–C; photographs of the corresponding views as D–F. A–F × 1; G, H × 1.5.

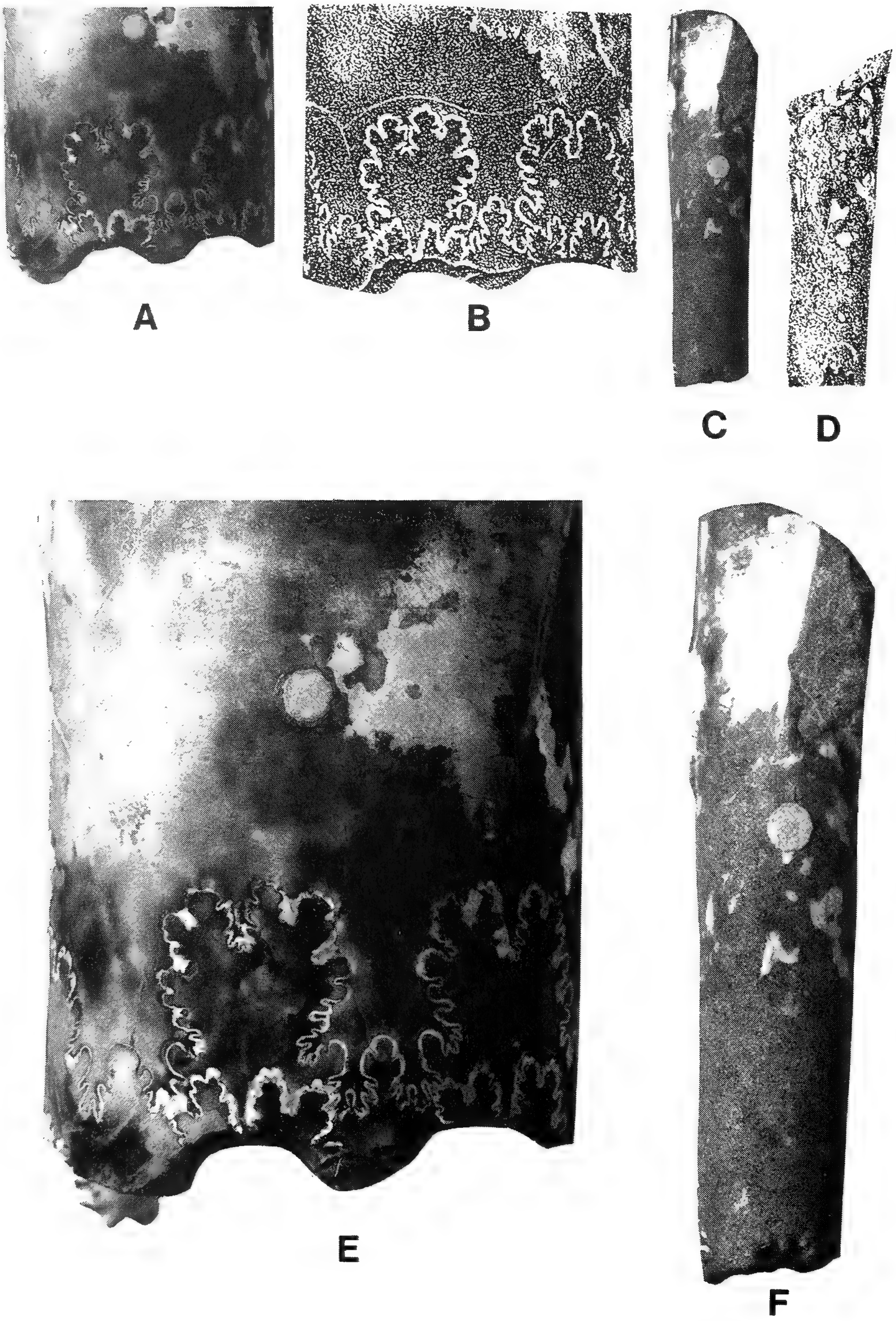

Fig. 74

Fig. 75. Drag bands in *Baculites* sp. A. USNM 507264. B. USNM 507265. From the Pierre Shale, Campanian, 12.2–21.3 m above the top of the Groat Sandstone at USGS Mesozoic locality D2140, 25.6 km north of Belle Fourche, in SW¼ SE¼ sec. 22, T. 11 N., R. 2 E., Butte County, South Dakota. A shows drag markings associated with movement of mantle on dorsolateral surface of mould. B shows drag markings on the venter associated with the ventral muscle. A × 3; B × 2.

Fig. 74 *(see facing page)*. A, B, E. *Baculites* sp. BMNH C54150, from the 'Fox Hills beds (Upper Cretaceous) of Horse Head Creek, South Dakota', the original of Crick (1898, pl. 17 (fig. 4)). Crick's original figure is reproduced as B, photographs of the corresponding view as A and E. C, D, F. *Eubaculites vagina* (Forbes, 1846). BMNH C73570, Valudavur Group, Maastrichtian, Pondicherry, South India, the original of Crick (1898, pl. 17 (fig. 5)). Crick's original figure is reproduced as D, photographs of the corresponding views as C and F. A–D × 1; E, F × 2.

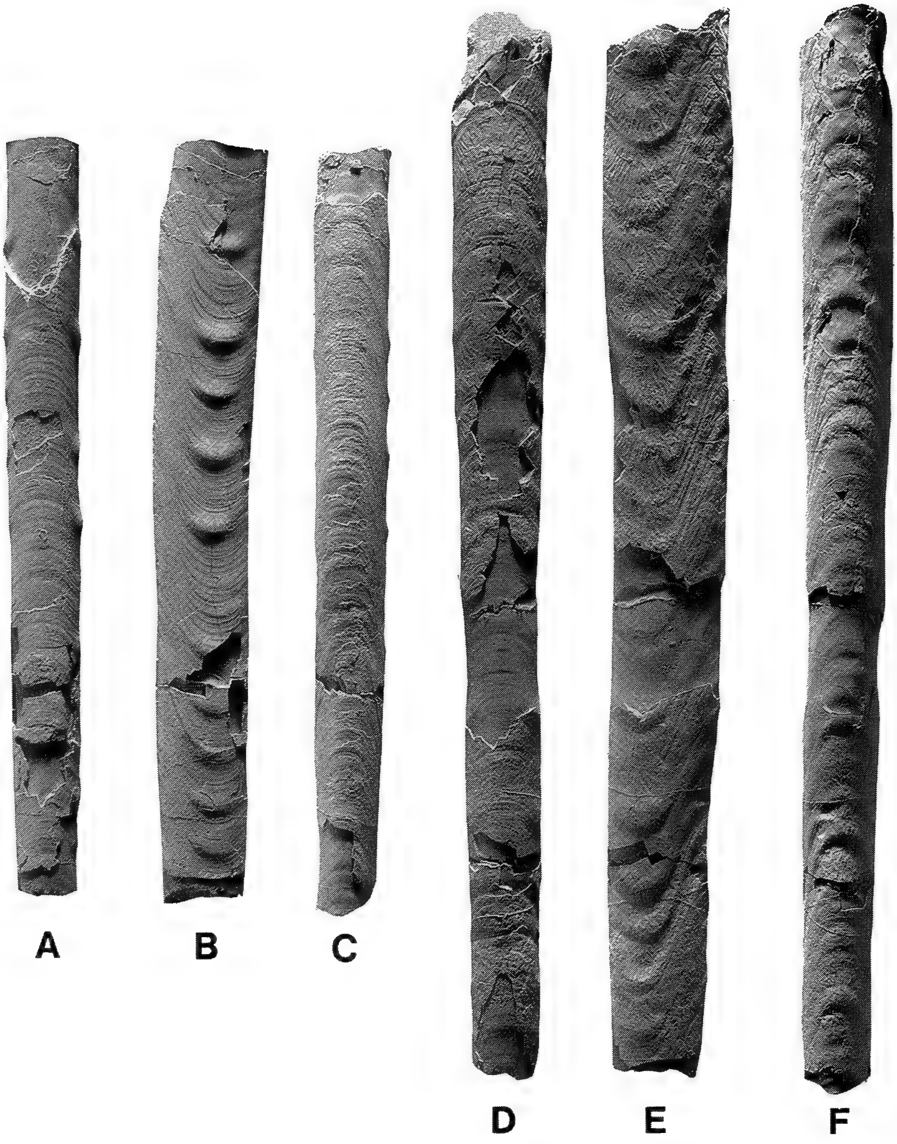

Fig. 76. *Baculites codyensis* Reeside, 1927*a*. From Marias River Shale, Santonian, USGS Mesozoic locality 21425, east bank of Marias River, 18.15 km (11 miles) south-west of Shelby in W½ NE¼ SE¼ sec. 14, T. 31 N., R. 4 W., Toole County, Montana. A–C. USNM 506266, well-preserved individual with shell present, showing normal ornament and growth lines. D–F. USNM 507267, example with well-developed wrinkles affecting whole of shell surface, and also present on internal mould in a more subdued form. All × 1.

Fig. 77 *(see facing page)*. *Baculites codyensis* Reeside, 1927*a*. USNM 507267, Marias River Shale, Santonian, USGS Mesozoic locality 21425, east bank of Marias River, 18.5 km (11 miles) south-west of Shelby in W½ NE¼ SE¼ sec. 14, T. 31 N., R. 4 W., Toole County, Montana. Detail of specimen shown in Fig. 76D–F, showing well-developed wrinkles. × 4.

Fig. 77

not affecting normal secretory processes, as a result of which the shell was secreted around the growth, beyond which the mantle returned to its normal shape, and a simple tubular shell, without growth irregularities, was secreted. Keupp (1984, fig. 4; 1995, fig. 2) illustrated and described a similar blister-like growth anomaly in a Jurassic (Kimmeridgian) *Orthosphinctes*.

The second distinctive growth anomaly that may be the result of parasitism is shown by specimens of *Baculites scotti* Cobban, 1958, and *Baculites* sp. from the Campanian Pierre Shale of South Dakota. In the case of the latter, 3 per cent of a total of 300 specimens showed the abnormality. Gill & Cobban (1966: A27, 40, pl. 10 (figs 1–9)) had previously described and illustrated these structures on moulds of *Baculites gregoryensis* Cobban, 1951, from the Pierre Shale of Wyoming, and interpreted them as marking the attachment areas of some unknown organism.

The structures are restricted to the body chambers and on internal moulds take the form of crudely elliptical pits 0.3–0.8 mm across and approximately 0.1 mm deep (Figs 81, 82). They may affect the whole of the body chamber as preserved (Fig. 82) part of the length only (Fig. 81A) or be restricted to parts of the flanks, dorsum or venter only. Where the *Baculites* retain traces of shell, this may be differentially preserved within the pits. In other cases, where traces of shell extend over the surface of the mould, the pits appear to have been originally hollow, rather than solid pillars of shell material. That they appear to have been hollow suggests that they record the presence of some foreign body between the shell interior and mantle surface that irritated the mantle cells and led to the secretion of shell material that sealed off the source of irritation and hence secretory stimulus. These structures do **not** extend through the shell, and are thus not a response to external borings through the shell that stimulated mantle activity to repair damage.

PREDATION

There is an extensive literature on shell damage to ammonites that has been interpreted as a result of predation, in some cases with subsequent and successful shell repair. Previous workers have attributed damage to predatory

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Fig. 78 *(see facing page)*. ***Baculites codyensis*** Reeside, 1927*a*. Marias River Shale, Santonian, USGS Mesozoic locality 21425, east bank of Marias River, 18.15 km (11 miles) south-west of Shelby in W½ NE¼ SE¼ sec. 14, T. 31 N., R. 4 W., Toole County, Montana. A–C, F, G–I. Internal moulds of body chambers showing ribbing interrupted by wrinkles of the type shown in Figs 76–77. A–C. USNM 507268. F. USNM 507269. G–I. USNM 507270. D–E and G show the dorsal muscle scar, whereas D also shows longitudinal dorsal grooves, corresponding to ridges on the inside of the shell. All × 1.

Fig. 79 *(see overleaf)*. A–C. Microsculpture wrinkles in *Baculites texanus* Kennedy & Cobban, 1999. From the Pierre Shale, Campanian, USGS Mesozoic locality D1411, west-facing bluff, 1.6 km (1 mile) north-north-east of Oral in NW¼ NW¼ sec. 26, T. 7 S., R. 8 E., Fall River County, South Dakota. A–B. USNM 507271. C. USNM 507272. D. Feather structure in *Baculites scotti*, USNM 507273, horizon and locality as for A–C. E. Microsculpture wrinkles in *Baculites rugosus* Cobban, 1962*a*, USNM 507274, Pierre Shale, Campanian, *Exiteloceras jenneyi* Zone, SE¼ NE¼ sec. 17, T. 7 S., R. 8 E., Fall River County, South Dakota. All × 1.

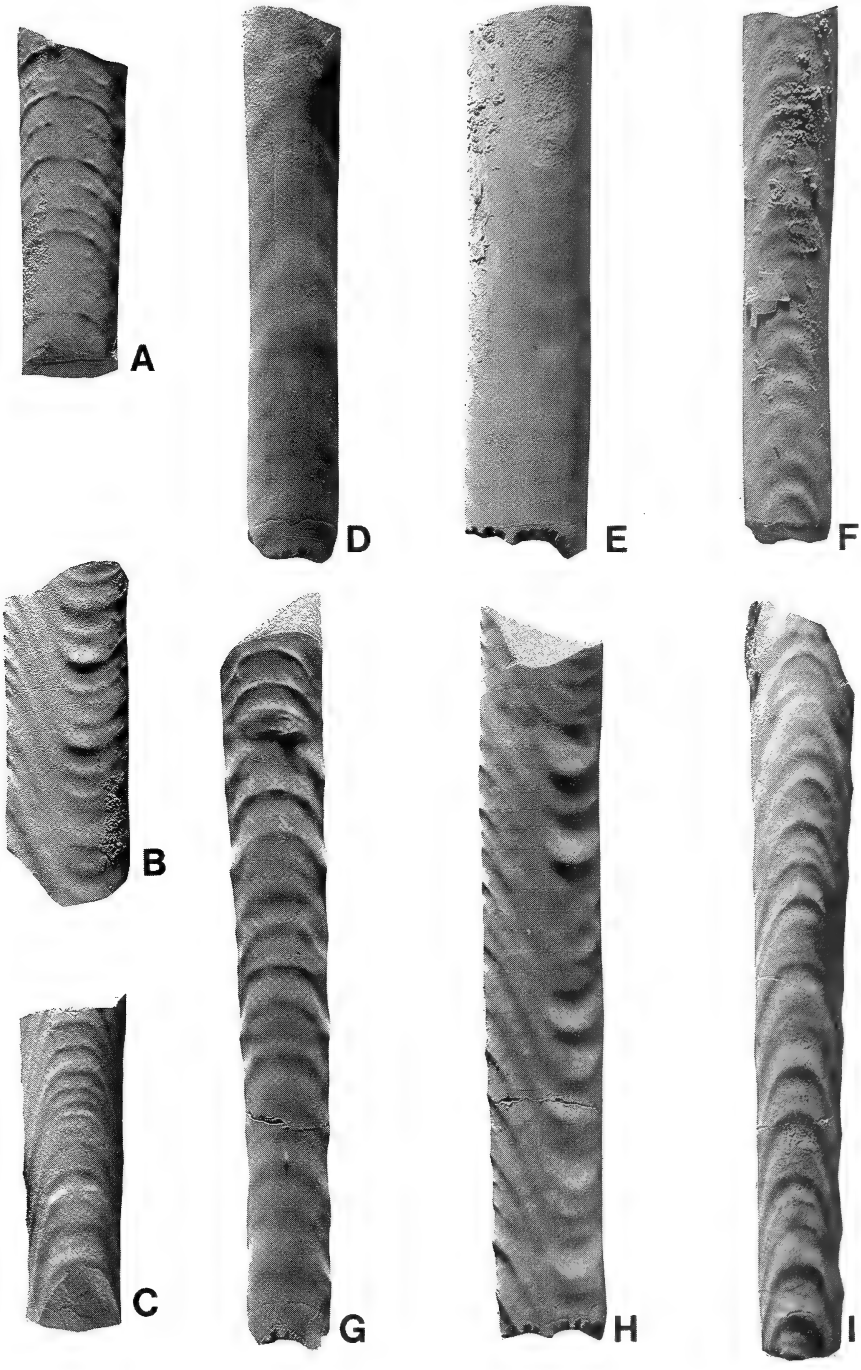

Fig. 78

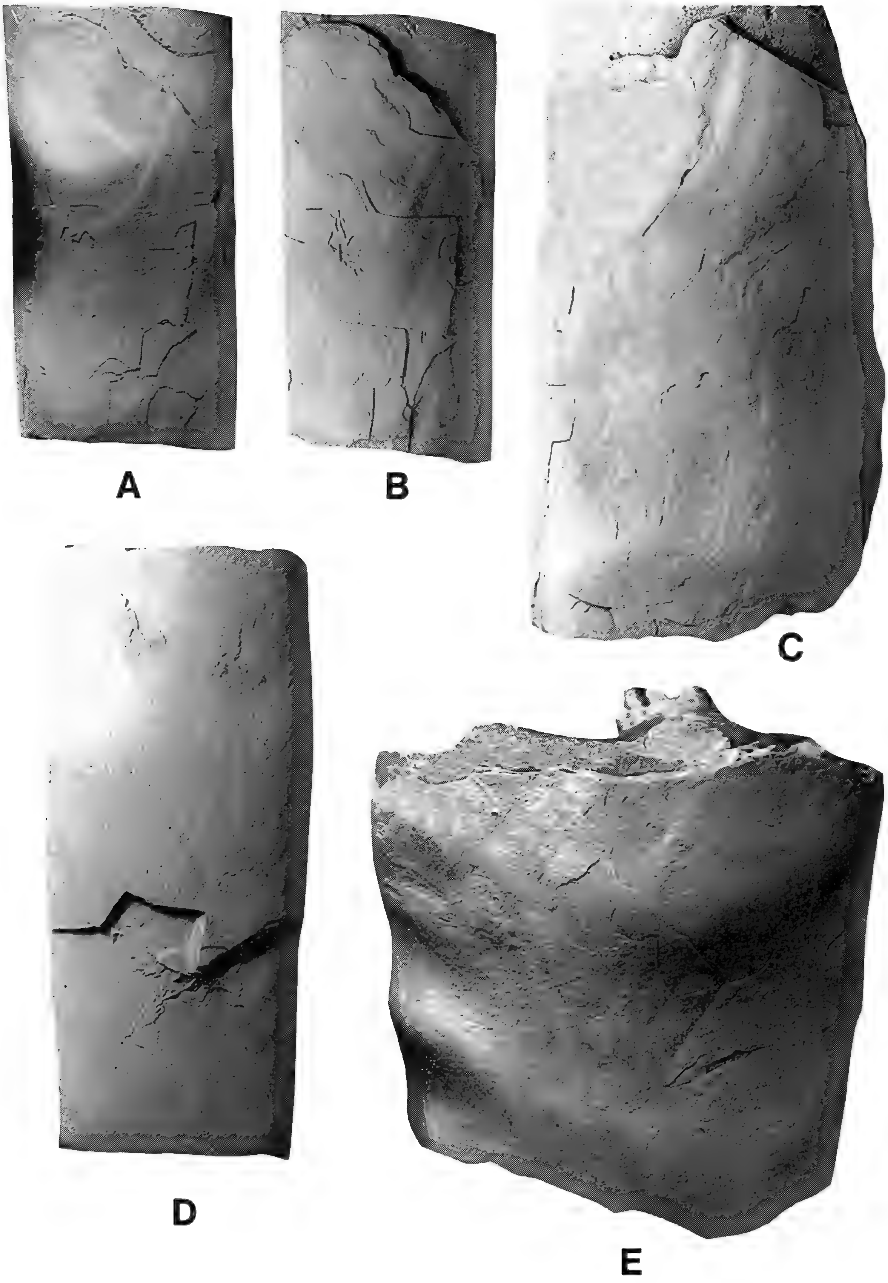

Fig. 79

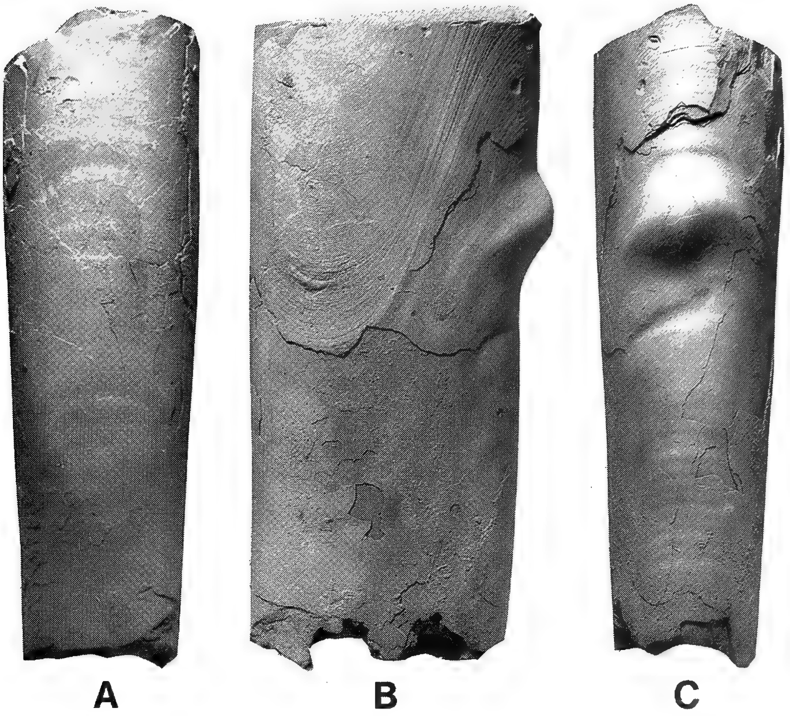

Fig. 80. *Baculites eliasi* Cobban, 1958. BHI4362, Pierre Shale, Maastrichtian, Garfield County, Montana. Blister-like protuberance on venter of partially exfoliated specimen is interpreted as the result of parasitism, corresponding to the 'Volumensanomalie' of Keupp (1984, 1994). × 1.

decapods, fish and mosasaurs (see reviews in Kennedy & Cobban 1976; Keupp 1984, etc.). See also Seilacher (1998) for a different interpretation of alleged mosasaur predation on *Placenticeras*. The only previous record of predation in *Baculites* is by Kauffman (*in* Kennedy & Cobban 1976: 18) of mosasaur tooth marks. We have not ourselves seen evidence of such predation, but through the

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Fig. 81 *(see overleaf)*. A, C. *Baculites scotti* Cobban, 1958. USNM507273, from the Pierre Shale, Campanian, USGS Mesozoic locality D1411, west-facing bluff 1 mile north-east of Oral in NW¼ NW¼ sec. 26, T. 7 S., R. 7 E., Fall River County, South Dakota. Specimen is uncoated in A and coated with ammonium chloride in C. The specimen has lost most of its shell, but traces survive in the pits on the surface of the mould as shown in A. Detailed inspection suggests that these pits correspond to hollow blisters on the inside of the body chamber, interpreted as a result of infestation by an unknown parasitic organism. B. *Baculites* sp., USNM507275, from the Pierre Shale, Campanian, 12.2–21.3 m above the top of the Groat Sandstone at USGS Mesozoic locality D2140, 25.6 km north of Belle Fourche in SW¼ SE¼ sec. 22, T. 11 N., R. 2 E., Butte County, South Dakota. Specimen is an uncoated internal mould, and shows drag markings associated with the ventral muscle scar on the phragmocone, and intense pitting, regarded as a response to the same type of parasitism as shown in A and C. A–B × 1; C × 4.5.

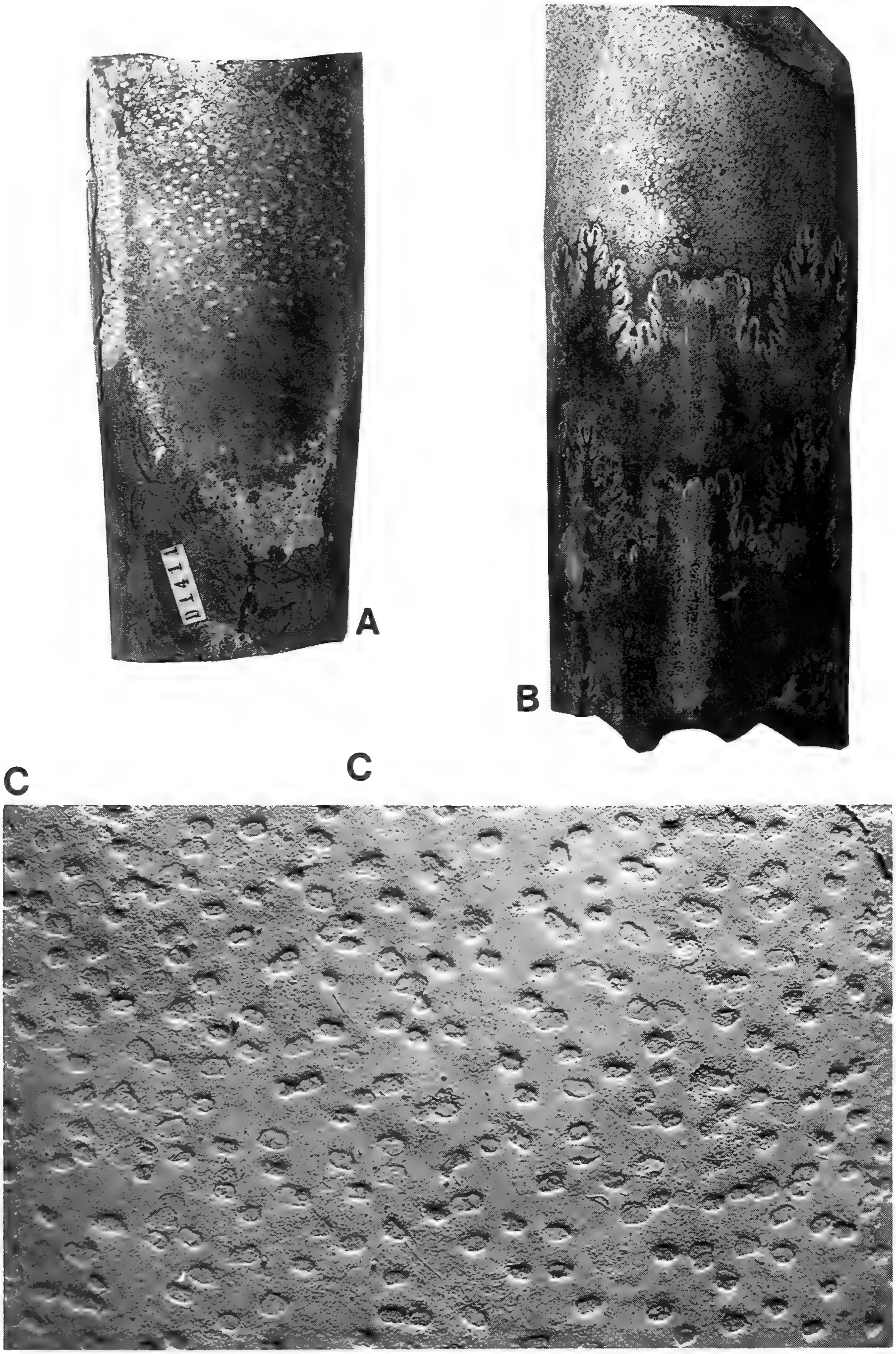

Fig. 81

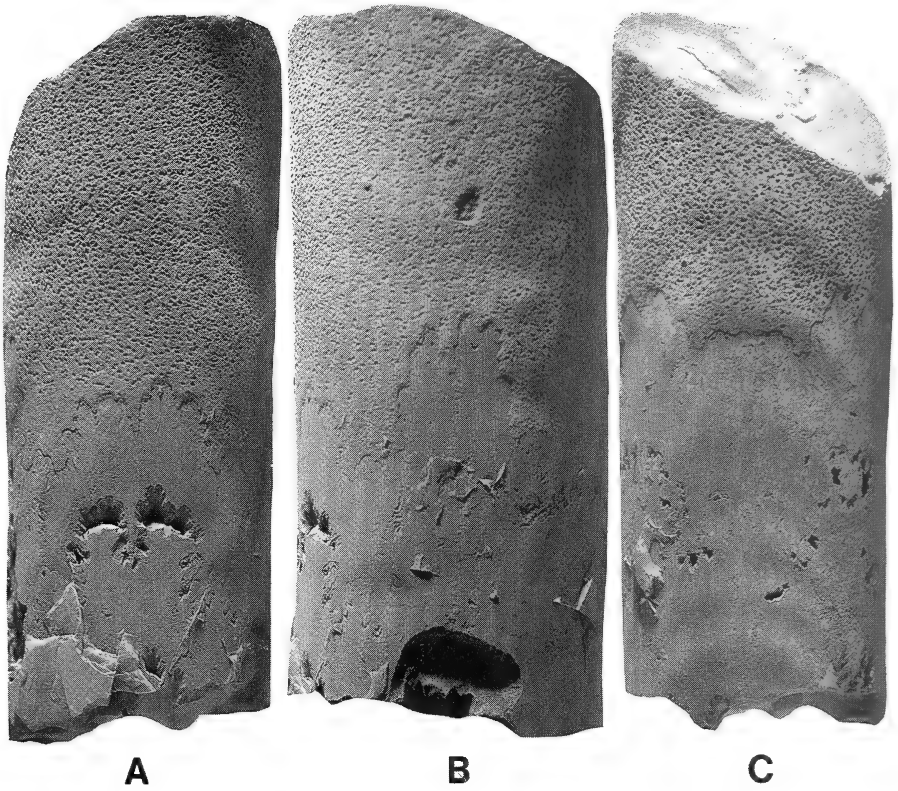

Fig. 82. *Baculites* sp., USNM 507275, from the Pierre Shale, Campanian, 12.2–21.3 m above top of Groat Sandstone at USGS Mesozoic locality D2140, 25.6 km north of Belle Fourche in SW¼ SE¼ sec. 22, T. 11 N., R. 2 E., Butte County, Montana. A. Dorsum. B. Flank. C. Venter. All of an internal mould coated with ammonium chloride, showing dense pitting, corresponding to blisters on the inside of the shell of the body chamber, interpreted as a response to infestation by an unknown parasite. × 1.

courtesy of Messrs P. and N. Larson (Black Hills Institute of Geological Research, Hill City, South Dakota), we have been able to study a number of spectacular examples of predation on *Baculites*. The most frequent evidence of predation is traumatic damage to the body chamber in which the end of the shell, part or all of the dorsum, venter or flank have been broken-off, followed by subsequent repair, irregular growth and, eventually a return to normal shell development (Fig. 83).

In some cases shells retain dents and depressions, as though significant amounts of tissue had been bitten out and subsequently regenerated. Such damage affects individuals with whorl height of up to 50 mm, and may possibly be the result of attacks by pycnodont fish.

A second striking type of healed shell damage that appears to record predation takes the form of a 'V'-shaped break to the shell on both flanks (Fig. 84), tapering away from the adapertural end. The outline of the inferred

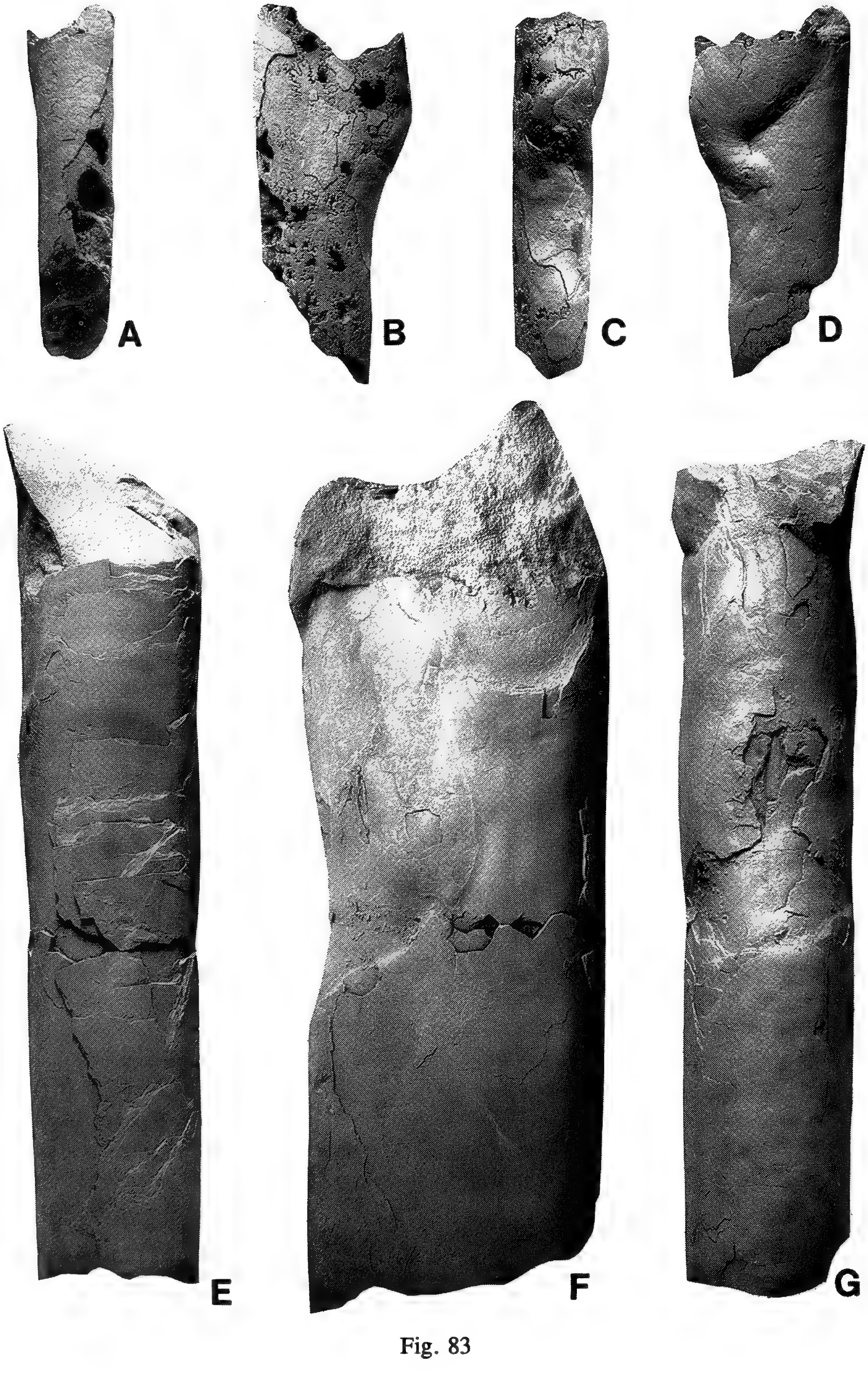

Fig. 83

break is irregular, with one side of the 'V' feebly curved towards the apex, the apex rounded, and the other side of the 'V' with a minor embayment at the apical end. The healed area may bulge out, or be irregularly impressed and folded, presumably recording the morphology of the healed tissue that bulged out of the shell locally. If it is assumed that *Baculites* lived with the dorso-ventral plane vertical, damage was clearly produced by a lateral closing movement of an approximately mirror image pair of structures. Three possibilities come to mind—a fish that rotated the jaws and head through 90 degrees before striking, a large cephalopod that captured the *Baculites* and rotated it before biting, or a decapod that simply snapped at the shell, the direction of movement of the closing claw being normal to the dorso-ventral plane of the ammonite. We believe the last to be the most likely culprit on the basis of the clear asymmetry of the damage, and the minor differences in outline and size of the opposing flanks of the specimens. Large decapods are known from the Pierre Shale and equivalent rocks in the Western Interior, and are described by Whitfield (1907), Feldman *et al.* (1977), Kammer & Raff (1978), and others.

A third indicator of possible predation is shown by BHI 4377 (Fig. 85), a specimen of *Baculites texanus* Kennedy & Cobban, 1999, from the Campanian Pierre Shale, *Baculites scotti* Zone of Lyman County, South Dakota. The specimen is a phragmocone 53.5 mm long, with a maximum preserved whorl height of 17 mm. The adapical end of the fragment shows a prominent healed 'V'-shaped area of damage on both flanks, of the type attributed above to decapod attack. The fragment also shows five prominent circular to elliptical holes in one flank, and a further hole in the venter. These are borings, and penetrate through the full thickness of the nacreous layers. The borings are subcircular, elliptical, tear-shaped or bilobate, with maximum external diameters of 1.8–3.5 mm. In some cases, a distinct groove leads to the boring, or a pair of borings may be partially superimposed. There are also suggestions of incomplete borings with associated, sometimes linking grooves, mere depressions in the outer surface of the nacre. The borings taper slightly with a countersunk appearance. These holes look like octopus borings. Closely comparable borings of undoubted octopus origin are discussed by Bromley (1993), and others (e.g. Saunders *et al.* 1987; Saunders *et al.* 1991) all of whom provide references to earlier accounts. The present examples are drilled into the phragmocone, and, in the absence of evidence of damage to the body chamber

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Fig. 83 *(see facing page).* A–D. *Baculites gregoryensis* Cobban, 1951. BHI collections, from the Pierre Shale, Campanian, Lyman County, South Dakota. Specimen retains partially exfoliated shell, and is a section of the phragmocone. The individual appears to have suffered traumatic damage to the venter and one flank, interpreted as the result of a bite by a vertebrate, possibly a pycnodont fish. The swollen portion records regeneration and shell repair by the damaged mantle tissues. E–G. *Baculites reesidei* Elias, 1933. BHI collections, from the Pierre Shale, Campanian, Meade County, South Dakota. Specimen retains partially exfoliated shell and is part phragmocone, part body chamber. The individual has suffered massive damage in life, with removal of the venter and most of the flanks as a result of a bite by a vertebrate, possibly a pycnodont fish, followed by extensive regeneration of the shell. × 1.

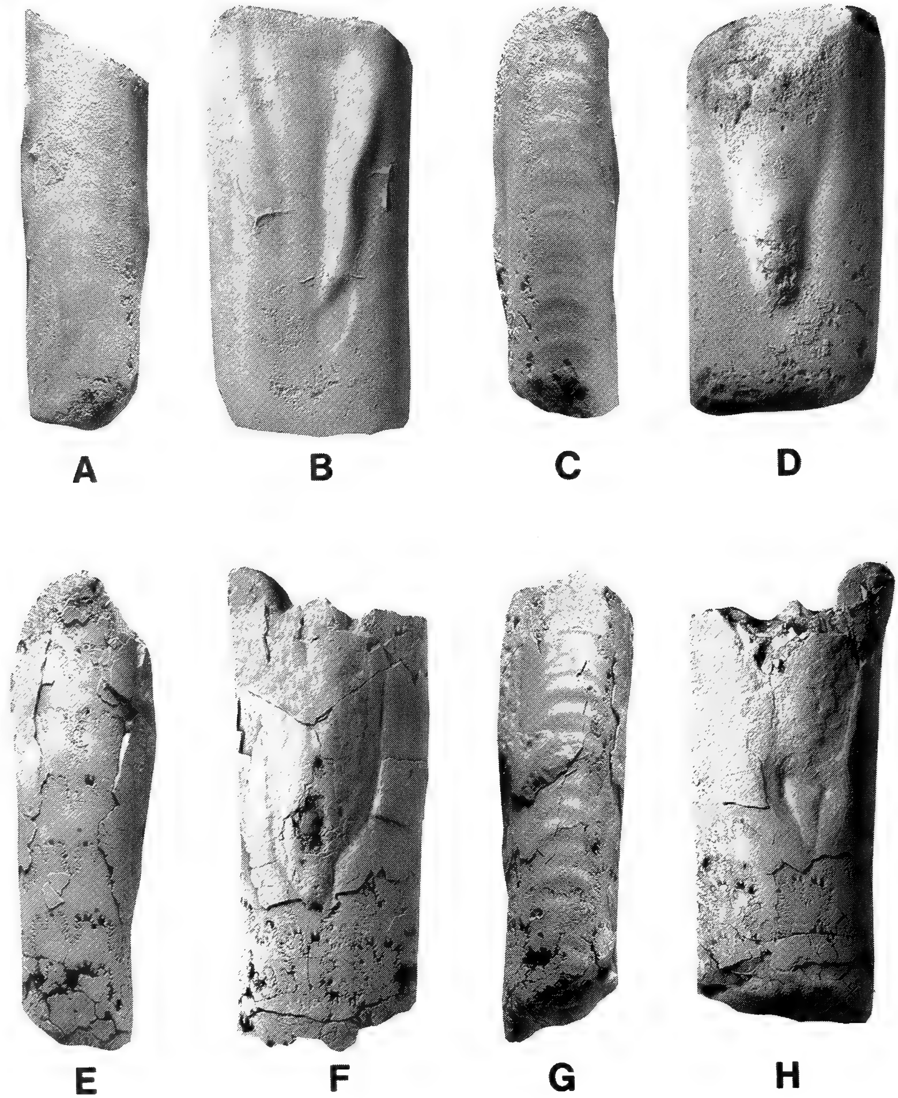

Fig. 84. *Baculites* showing healed asymmetric V-shaped bites to both flanks, interpreted as a result of a decapod attack. A–D. *Baculites* sp., BHI 4358, *Baculites compressus* or *B. cuneatus* zone, Campanian, Meade County, South Dakota. Specimen is an internal mould of part of the body chamber. E–H. *Baculites gregoryensis* Cobban, 1951, BHI 4370, Pierre Shale, Campanian, Lyman County, South Dakota. Specimen is a phragmocone, with partially exfoliated shell. × 1.

(which is not preserved), it cannot be shown that this represents attack on a living animal. Professor R. Bromley (Copenhagen, telefax 07.02.96) has examined this specimen, and does not think that the holes were made by octopi; rather he suggests them to be due to diagenetic processes. He has seen similar holes in aragonite developed by chemical diagenesis around pyrite grains.

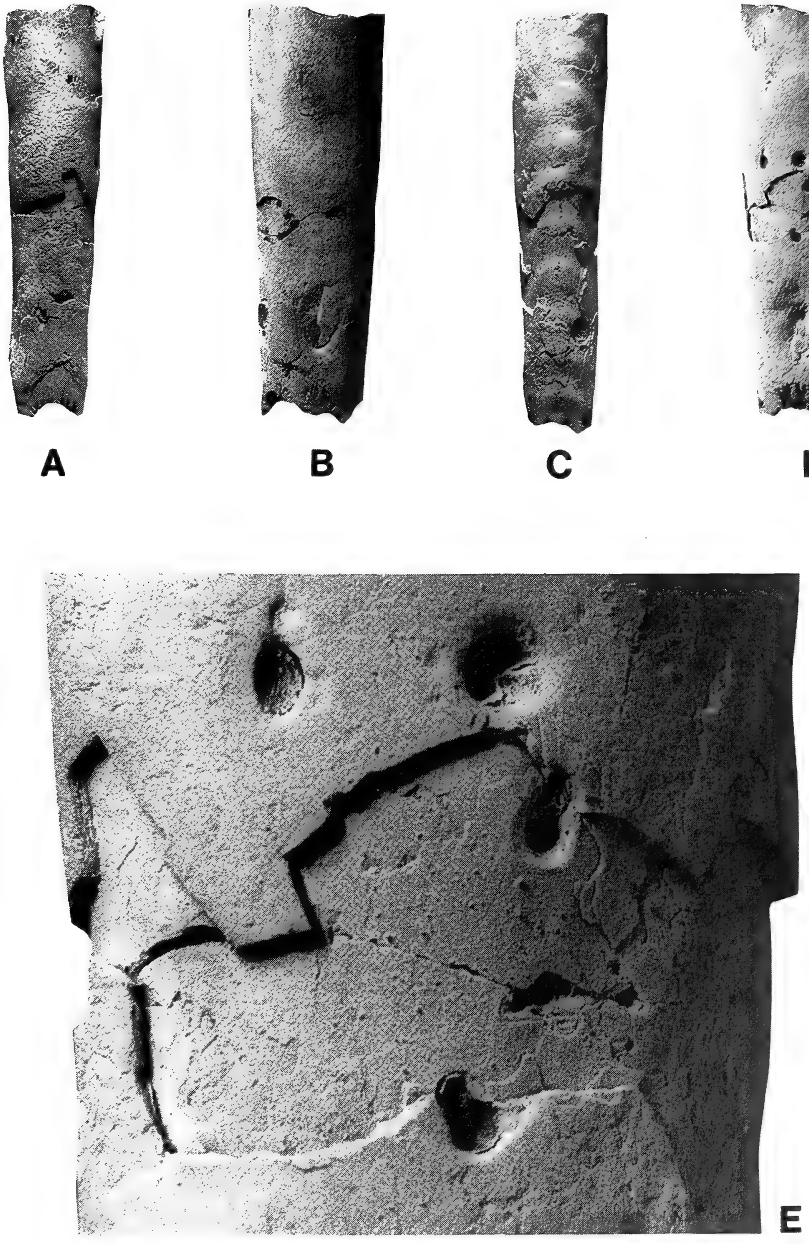

Fig. 85. *Baculites texanus* Kennedy & Cobban, 1999. BHI 4377 from the Pierre Shale, Campanian, Lyman County, South Dakota. Specimen is a phragmocone, with partially exfoliated shell preserved. The organism responsible for the borings is unknown.
A–D × 1; E × 5.5.

ANNOTATED LIST OF SPECIES REFERRED TO THE FAMILY BACULITIDAE

The most important references for each species are given, but we do not claim these to be complete synonymies.

The symbol * preceding an entry indicates species figured photographically herein. For photographic illustrations of most of the type specimens of *Baculites* from Madagascar and South Africa, and *Eubaculites* in general, readers are referred to Klinger & Kennedy (1993) and Klinger & Kennedy (1997).

The following abbreviations are used to indicate the repositories of material referred to in the text and appendix:

ANSP	Academy of Natural Sciences, Philadelphia
ASUE	Ain Shams University, Egypt
BEG	Bureau of Economic Geology at Austin, Texas
BGS	British Geological Survey, Keyworth, Nottingham
BHI	Black Hills Institute of Geological Research, Hill City, South Dakota
BMNH	Natural History Museum, London
CAS	California Academy of Sciences (type collection), San Francisco
CBC	Commonwealth Bureau of Mineral Resources, Geology and Geophysics, Canberra
CPC	Facultad de Ciencias Exactas, Fisicas y Naturales, Universidad Nacional de Cordoba, Argentina
CTB	Collection Klauman
DSGUB	Department of Geology, University of Bologna
GD	Institut des Sciences de la Terre de l'université Dijon (ex Collignon collection)
GDUA	Department Geology, University of Adelaide
GK	Department of Geology, Kyushu University, Fukuoka
GLKU	Geological Laboratory, Kagawa University, Tamatsu
GMUA	Geology Museum, University of Alberta
GMUK	Geology Museum, University of Kansas
GPIB	Institut für Geologie der Friedrich-Wilhelms Universität, Bonn
GSC	Geological Survey, Canada
GSI	Geological Survey of India
GSNZ	Geological Survey, New Zealand
GT	Geological Institute, University of Tokyo
HTW	Henryk Teisseyre Geological Museum, Wrocław
HU	Hebrew University, Department Geology, Jerusalem
IGG	Institute Geology-Geophysics, Bucarest
IGP	Instituto di Geologia, Padova
IRSNB	Institut Royal des Sciences Naturelles, Brussels
LSJU	Stanford University, California
KU	Kansas University
MGL	Museé Géologique, Lausanne
MLP	Museo de Ciencias Naturales de La Plata
MNHP	Museum Histoire Naturelle, Paris
MMH	Mineralogical Museum, University Copenhagen (Museum Mineralogicum Hafniense)
NHMW	Naturhistorisches Museum, Vienna
NMB	National Museum, Bloemfontein (presently in the South African Museum)
OUM	Oxford University Museum
SAM	South African Museum, Cape Town
SAS	Geological Survey of South Africa, Pretoria
SMC	Sedgewick Museum, Cambridge
SP	Collections Sorbonne, now Université Pierre et Marie Curie, Paris

TMM	Texas Memorial Museum, Austin
UAB	Geology Department, Universitat Autonoma, Barcelona
UCLA	University California, type collection
UCS	Geology Department, University Chile, Santiago
USGS	United States Geological Survey
UPST	Université Paul Sabatier, Toulouse
USNM	United States National Museum, Washington
YPB	Peabody Museum, Yale

Genus *Baculites* Lamarck, 1822

Baculites acuminatus Glazunova, 1960

Glazunova 1960: 162, pl. 36 (figs 6–7), text-fig. 26.

Type. ?

Occurrence. Asiatic Russia.

Baculites alavaensis Santamaria Zabala, 1996

Santamaria Zabala 1996: 14, pl. 3 (figs 7–9). Klinger & Küchler 1998: 287–295, figs 1, 2a–f, 3–4, 5i–l.

Type. Holotype is the original of Santamaria Zabala (1996, pl. 3 (fig. 8)) from the Campanian of Ullibarri-Jauregui, northern Spain. UAB–1979.

Occurrence. Lower Campanian, Alava Province, northern Spain.

* ***Baculites albertensis*** Warren, 1930 Fig. 117D–E

(= *B. codyensis* Reeside, 1927*a*, fide Kennedy & Cobban 1991*a*: 72).

Warren 1930: 64, pl. 5 (figs 5–8, 10, 13).

Type. Lectotype here designated is the original of Warren (1930, pl. 5 (figs 7–8)), from the Coniacian Smoky River Shale, Little Smoky River, Peace River District, Alberta, Canada. GMUA Ct458.

Occurrence. Coniacian, Canada.

Baculites alonsoi Santamaria Zabala, 1996

Santamaria Zabala 1996: 13, pl. 3 (figs 3–6).

Type. Holotype is the original of Santamaria Zabala (1996, pl. 3 (fig. 6)) from the Campanian of Ullibarri-Jauregui, northern Spain. UAB–1069.

Occurrence. Lower Campanian, Alava Province, northern Spain.

Baculites ambatryensis Collignon, 1971

Collignon 1971: 15, pl. 645 (fig. 2392). Klinger & Kennedy 1997: 128, fig. 62a. Fatmi & Kennedy 1999: 657, figs 13.1–13.18, 13.23–13.28, 16.1, 16.4, 16.5.

Type. Holotype by monotypy is the original of Collignon (1971, pl. 645 (fig. 2392)) from the Lower Maastrichtian of gisement 400, Côte d'Ambatry (Betioky), Madagascar. GD 12392.

Occurrence. Lower Maastrichtian, Madagascar; Upper Maastrichtian, Baluchistan and India.

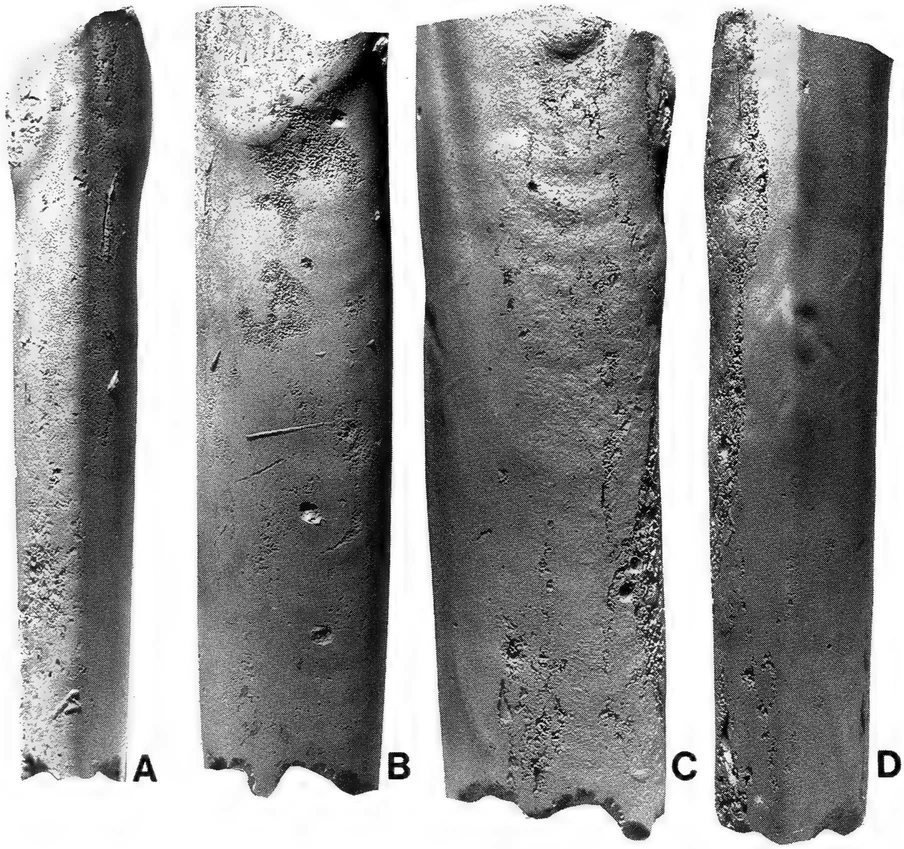

Fig. 86. *Baculites anceps* Lamarck, 1822. A–B. Musée d'Histoire Naturelle, Genève, unregistered specimen, ex Pictet Collection. C–D. NHMW 7482. Both from the Upper Maastrichtian Calcaire à *Baculites* of Valognes, Manche, France. × 1.

Baculites ambiguus Eichwald, 1868

Eichwald 1868: 1176, pl. 37 (fig. 3a–c). = ?*B. claviformis* Stephenson, 1941 (*fide* Cobban 1974: 8).

* ***Baculites anceps*** Lamarck, 1822 Figs 86–89

Lamarck 1822: 648. Schlüter 1876, *non* p. 145, pl. 40 (figs 2, 6) only. *non* Johnson 1903: 132, pl. 11 (fig. 30a–c). *non* Müller & Wolleman 1906: 5. Łopuski 1911: 122, pl. 4 (fig. 4). *non* Spengler 1923: 55, pl. 4 (fig. 8a, b) (as *B*. cf. *anceps*). ?Basse 1931: 21, pl. 2 (fig. 5) ?Haas 1943: 13, figs 15–19. ?Mikhailov 1951: 44, pl. 2 (figs 11–12), text-fig. 13. *non* Hägg 1954: 55. Naidin & Shimanskij 1959: 183, text-fig. 17–20. *non* Young 1963: 42, pl. 2 (figs 18, 20–22) (as *B*. cfr. *anceps*). *non* Giers 1964: 257, text-fig. 3. Howarth 1965: 363, pl. 4 (fig. 4), pl. 5 (figs 4–5), pl. 6 (figs 1–5), text-figs 2–3, 5–12. *non* Atabekian & Khakimov 1976: 94, pl. 2

Fig. 87. *Baculites anceps* Lamarck, 1822. SMC F2822 from the Upper Maastrichtian of Maastricht, The Netherlands. × 1.

(figs 3–4), pl. 11 (figs 8–10). Matsumoto & Obata 1963: 59. Naidin 1974: 163, pl. 53 (fig. 1), ?*non* pl. 53 (figs 2–4), text-figs 22.3–22.5, 23a (as *B. anceps anceps* hamarck) [*sic*]. ?Martinez 1982: 169, pl. 30 (figs 1–2)

(= ?*E. simplex*). Balan 1982: 209, pl. 19 (figs 5–7). Kennedy 1986*a*: 58, pl. 11 (figs 12–14), pl. 12 (figs 7–11), text-figs 3e–h, 7a–c. Kennedy 1986*c*: 189, pl. 20 (fig. 2), pl. 28 (figs 3, 11–13, 19–23), text-fig. 11c–d. Kennedy 1986*d*, fig. 10n–o. Ward & Kennedy 1993: 52, fig. 45.2.

Type. Neotype, designated by Howarth (1965: 365, pl. 5 (fig. 5)) from 'Normandy', BMNH C32573.

Occurrence. Upper Maastrichtian, Denmark (as *B. valognensis* by Birkelund 1979: 53), Cotentin Peninsula, France, Belgium, Poland, Commonwealth Independent States, and possibly Spain. At Zumaya (Spain), *B. anceps* is recorded from the Lower Maastrichtian (Ward *et al.* 1991: 1183, fig. 2; Ward & Kennedy 1993: 52); herein also possibly from the Lower Maastrichtian of Angola.

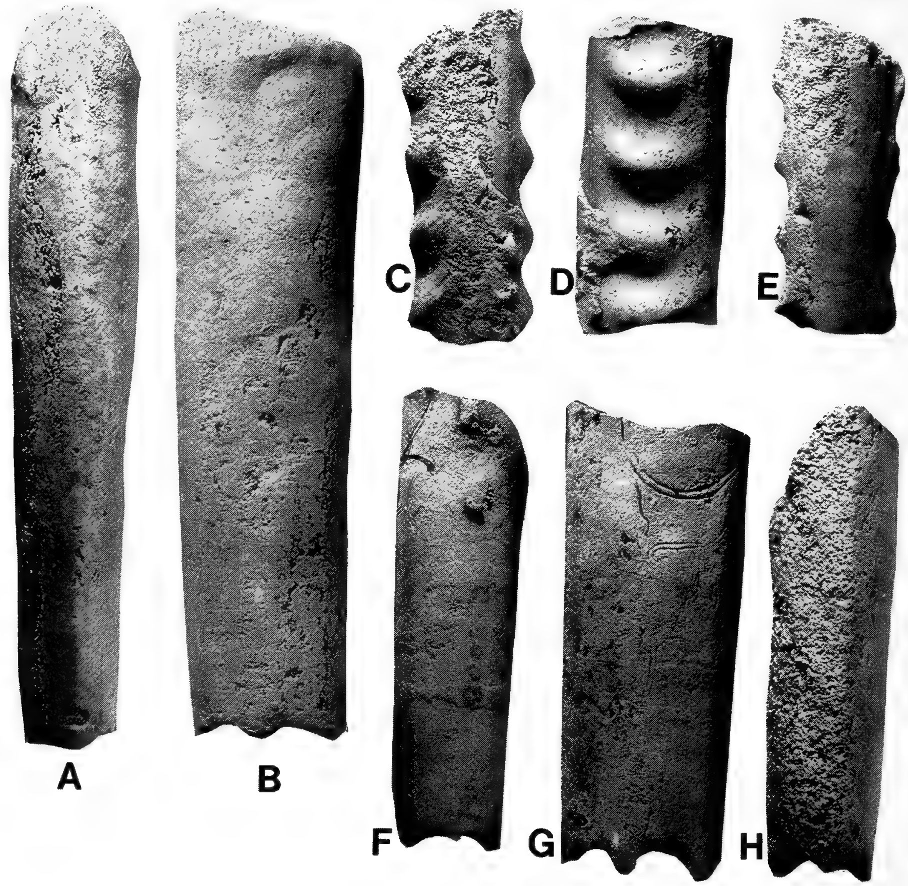

Fig. 88. *Baculites anceps* Lamarck, 1822. Muséum Nationale d'Histoire Naturelle Collections, Paris, ex D'Orbigny collections no. 7204, from the Upper Maastrichtian of Néhou, Manche, France.
All × 1.

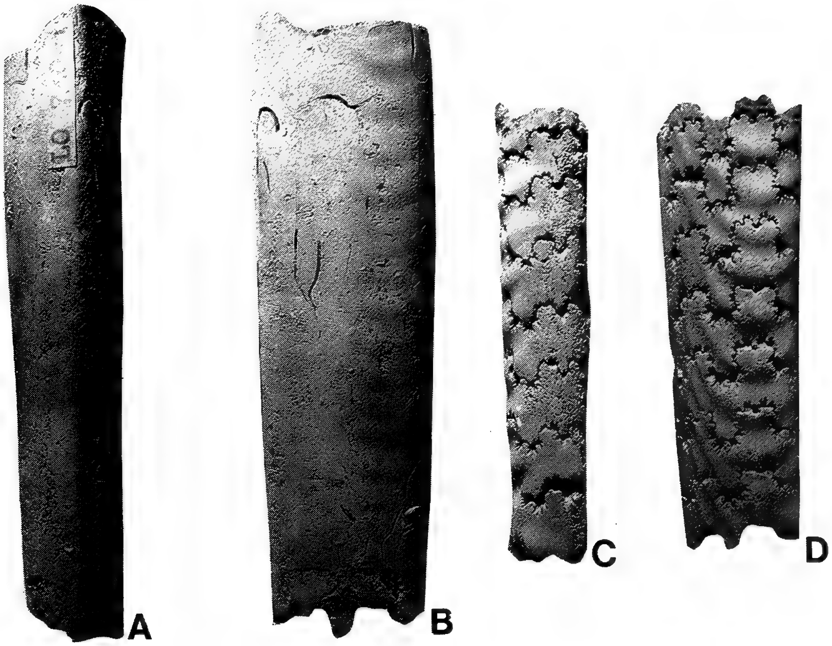

Fig. 89. *Baculites anceps* Lamarck, 1822. From Piconville, Manche, France. Lund University Collections. The original of *Baculites schlüteri* n. sp. of Moberg (1885, pl. 4 (fig. 13)). × 1.

Baculites anceps **var.** ***angustisellata*** Łopuski, 1911

Łopuski 1911: 124, 139. (= *B. anceps* s.s. fide Kennedy 1986*c*: 190).

Type. Łopuski only figured the suture; lectotype designation must await study of the original material.

Occurrence. Maastrichtian, Poland.

Baculites anceps **var.** ***latisellata*** Łopuski, 1911

Łopuski 1911: 124, 139.

Type. Łopuski only figured the suture; lectotype designation must await study of the original material.

Occurrence. Maastrichtian, Poland.

Baculites anceps **var.** ***leopoliensis*** Nowak, 1908

See *B. leopoliensis*.

Nowak 1908: 328, pl. 14 (figs 1–5), text-figs 1–5 (p. 329), text-figs 5–10 (p. 331).

Baculites anceps **var.** ***obtusa*** Meek, 1876

See *B. obtusus*.

Meek 1876: 406, text-figs 57–60.

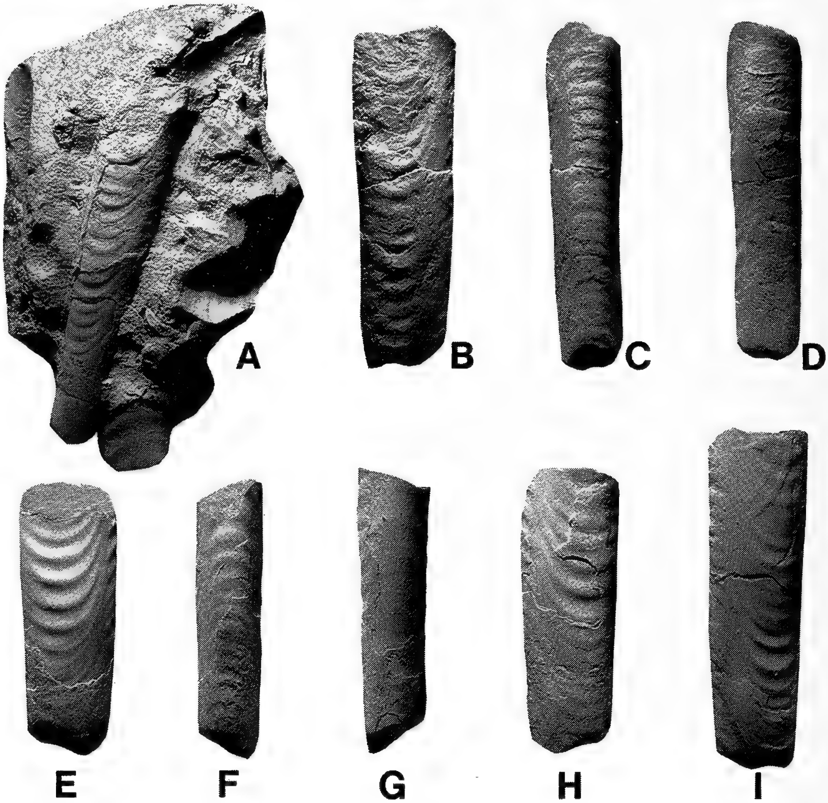

Fig. 90. *Baculites anceps pacificus* Matsumoto, 1959. A–I. CAS-31245.01, all from Alameda County, Arroyo del Valle, from creek south of Aqueduct tunnel, SE¼ of NW¼ of sec. 13, T. 3 S., R. 2 E., California.
All × 1.

* ***Baculites anceps pacificus*** Matsumoto & Obata, 1963 Fig. 90
(= *B. subanceps*)

Matsumoto & Obata 1963: 59, pl. 20 (fig. 3), text-figs 145–146, 156.

Baculites anceps **var.** ***sublaevis*** Griepenkerl, 1889
(= *nom. nud.* fide Howarth 1965: 366; non *anceps*, *nom. dub.* fide Kennedy 1986*c*: 191).

Baculites anceps **var.** ***valognensis*** Böhm, 1891
See *B. valognensis*.

Baculites androtsyensis Collignon, 1970
(= *B. increscens*)

Collignon 1970: 5, pl. 608 (figs 2270–2272). Klinger & Kennedy 1997, figs 83, 85c.

Type. Holotype by original designation is the original of Collignon (1970, pl. 608 (fig. 2270)), from the Middle Campanian at Gisement 329, Coupe Ampolypoly-Antsirasira-Behamotra (Belo sur Tsiribihina), Madagascar. GD 12270.

Occurrence. Middle Campanian, Madagascar.

* ***Baculites angustus*** Moberg, 1885 Fig. 91E–G

Moberg 1885: 39, pl. 4 (fig. 10). Hägg 1954: 55. Kennedy & Christensen 1997: 110, fig. 27, pl. 13 (figs 5–8), text-fig. A–E. *Nomen dubium* fide Kennedy & Christensen (1997: 110).

Baculites ankilizatensis Collignon, 1970

Collignon 1970: 13, pl. 612 (figs 2282–2284). Klinger & Kennedy 1997, figs 85b, 89.

Type. Holotype by original designation is the original of Collignon (1970, pl. 612 (fig. 2282)), from the Middle Campanian, of Gisement 153 Coupe d'Ankilizato (Belo sur Tsiribihina), Madagascar, GD 12282.

Occurrence. Middle Campanian, Madagascar.

?***Baculites annulatus*** Conrad, 1856

Conrad 1856: 265.

Baculites antsirasiraensis Collignon, 1969
(= *B. menabensis*)

Collignon 1969: 18, pl. 519 (figs 2040–2041). Klinger & Kennedy 1997, figs 59a–c, 62b.

Type. Holotype by original designation is the original of Collignon (1969, pl. 519 (fig. 2040)) from the Lower Campanian of Gisement 304, Coupe Ampolypoly-Antsirasira-Behamotra (Belo sur Tsiribihina), GD 12040.

Occurrence. Lower Campanian, Madagascar.

* ***Baculites aquilaensis*** Reeside, 1927*b* Figs 92–96, 139–140

Reeside 1927*b*: 12, pl. 6 (figs 11–13), pl. 8 (figs 1–14). Landes 1940: 167. Young 1963: 41, pl. 1 (figs 1–4, 9) (as *B.* sp. cfr *B. aquilaensis*). Cobban & Kennedy 1992*a*: 82, pl. 5 (figs 1–6, 10–15), pl. 6 (figs 3–4), pl. 7 (figs 3–4), text-fig. 4d (as *Baculites* sp. group of *aquilaensis*). Kennedy 1993: 110, pl. 4 (figs 22–24). Kennedy & Christensen, 1997: 110, fig. 26f–g, h, j–k (as *B.* cf. *aquilaensis*. Larson *et al.* 1997: 20.

Type. Holotype is the original of Reeside (1927*b*, pl. 8 (figs 7–11)), from the Lower Campanian, sandstone in the Steele Shale, Sheridan County, Wyoming, USNM 73298.

Occurrence. Lower Campanian, US Western Interior (Wyoming, Montana, Utah, South Dakota, Colorado, New Mexico), Alberta, Canada; questionably Middle Campanian, Texas; Campanian, Belgium and perhaps Sweden.

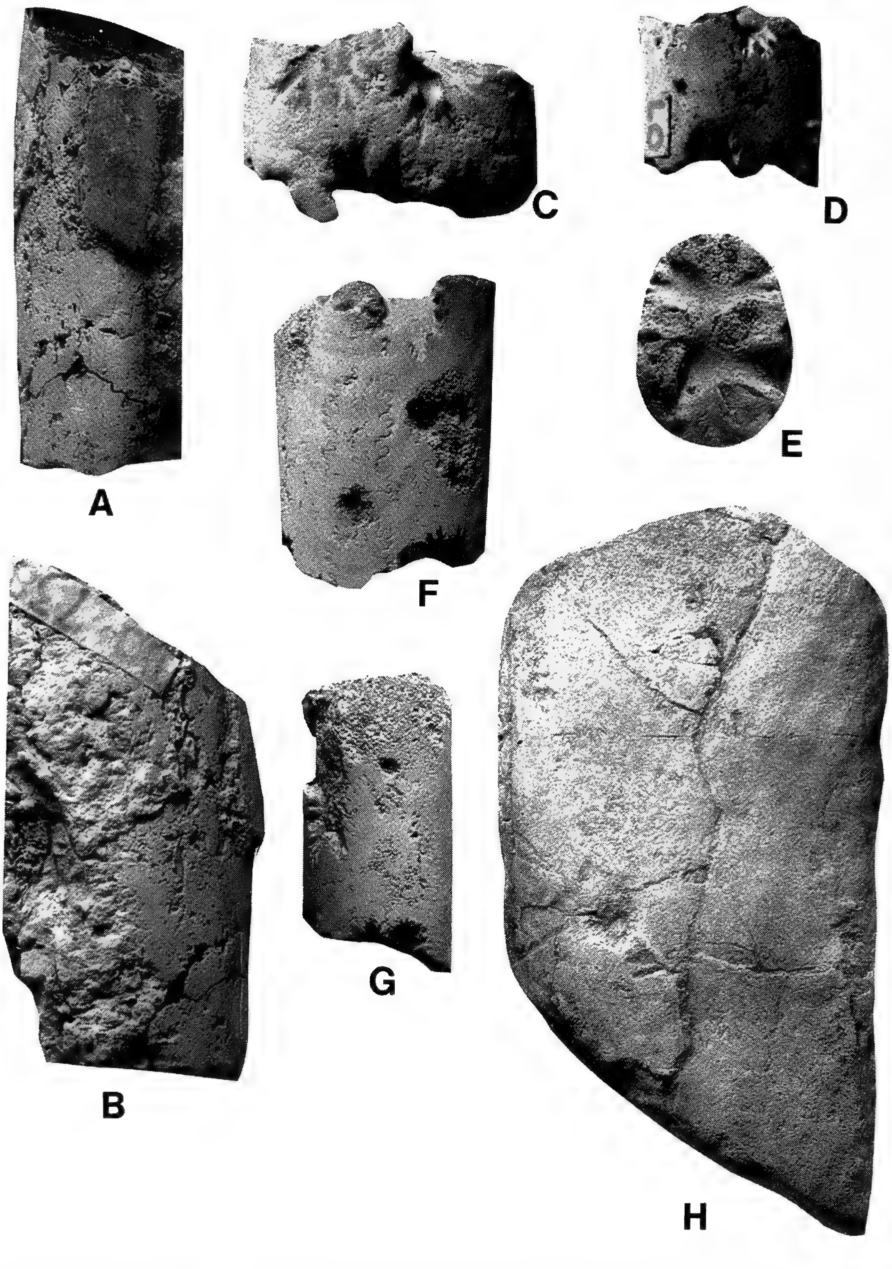

Fig. 91. *Baculites* sp. A–B. The original of *Baculites vertebralis* Lamarck of Moberg (1885, pl. 4 (fig. 9)) from the Campanian of Balsberg, Sweden. C–D. *Baculites* sp., the original of *Baculites vertebralis* Lamarck of Moberg (1885, pl. 4 (fig. 8)), from a loose block at Åhus, Sweden. E–G. *Baculites angustus* Moberg, 1885, the original of Moberg (1885, pl. 4 (fig. 10)), from the Campanian of Köpinge, Sweden. H. *Baculites suecicus* Moberg, 1885, the original of Moberg (1885, pl. 4 (fig. 1)), from the Lower Campanian of Kåseberga, Sweden. All from Lund University Collections. All × 1.

Fig. 92. *Baculites aquilaensis* Reeside, 1927*b*. USNM 73298 from sandstone in Steele Shale, 900 ft below top, 2 miles north-west of Slack, Sheridan County, Wyoming. × 1.

Fig. 93 *(see overleaf)*. A–D. *Baculites aquilaensis* Reeside, 1927*b*. Collections of the U.S. Geological Survey, Denver, from USGS Mesozoic locality 23639 lower Gammon Shale Member of Pierre Shale along west-facing scarp at head of Owl Creek in SE¼ sec. 12, T. 9 S., R. 61 E., and N½ sec. 13, T. 9 S., R. 16 E., Carter County, Montana. Lower Campanian Zone of *Scaphites hippocrepis* sensu lato.

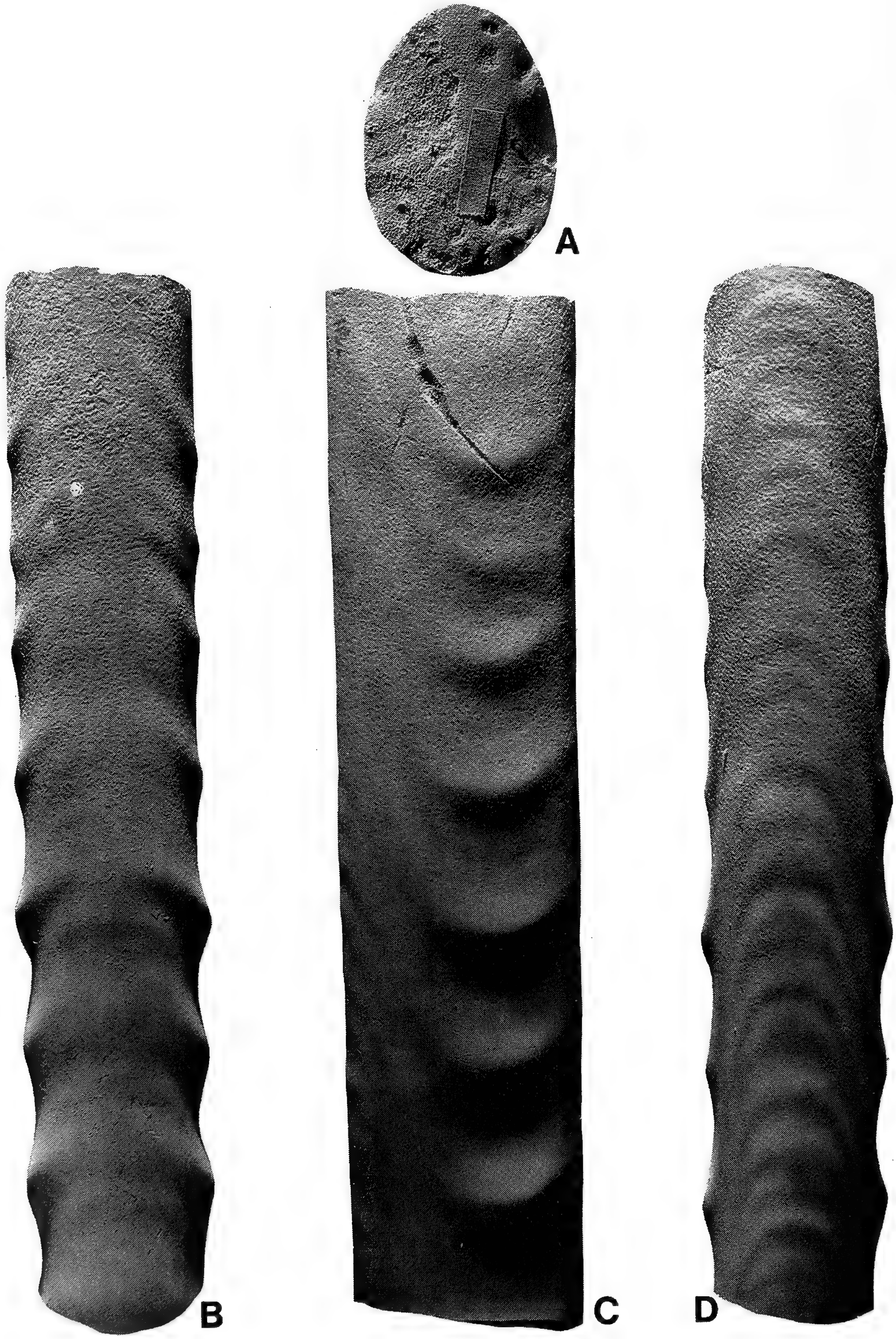

Fig. 93

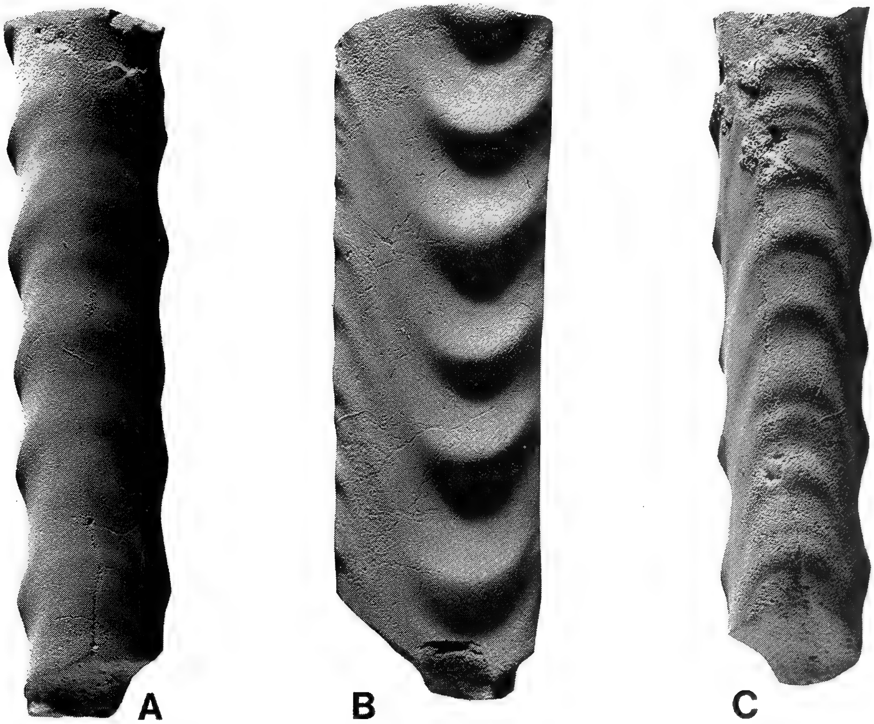

Fig. 94. A–C. *Baculites aquilaensis* Reeside, 1927*b*. Collections of the U.S. Geological Survey, Denver, from USGS Mesozoic locality 23639 lower Gammon Shale Member of Pierre Shale along west-facing scarp at head of Owl Creek in SE¼ sec. 12, T. 9 S., R. 61 E., and N½ sec. 13, T. 9 S., R. 16 E., Carter County, Montana. Lower Campanian Zone of *Scaphites hippocrepis* sensu lato.

Fig. 95 *(see overleaf)*. *Baculites aquilaensis* Reeside, 1927*b*. Collections of the U.S. Geological Survey, Denver, from USGS Mesozoic locality 23639 lower Gammon Shale Member of Pierre Shale along west-facing scarp at head of Owl Creek in SE¼ sec. 12, T. 9 S., R. 61 E., and N½ sec. 13, T. 9 S., R. 16 E., Carter County, Montana. Lower Campanian Zone of *Scaphites hippocrepis* sensu lato. × 1.

Fig. 96 *(see overleaf)*. *Baculites* sp. gr. of *aquilaensis* Reeside, 1927*b*. A. USNM 441411. B–C. USNM 441410. D–E. USNM 441407. F–G. USNM 441406. All from the *Trachyscaphites spiniger* zone of the Ozan Formation, 46 m above the base at USGS Mesozoic locality D10154, Fannin County, Texas. All × 1.

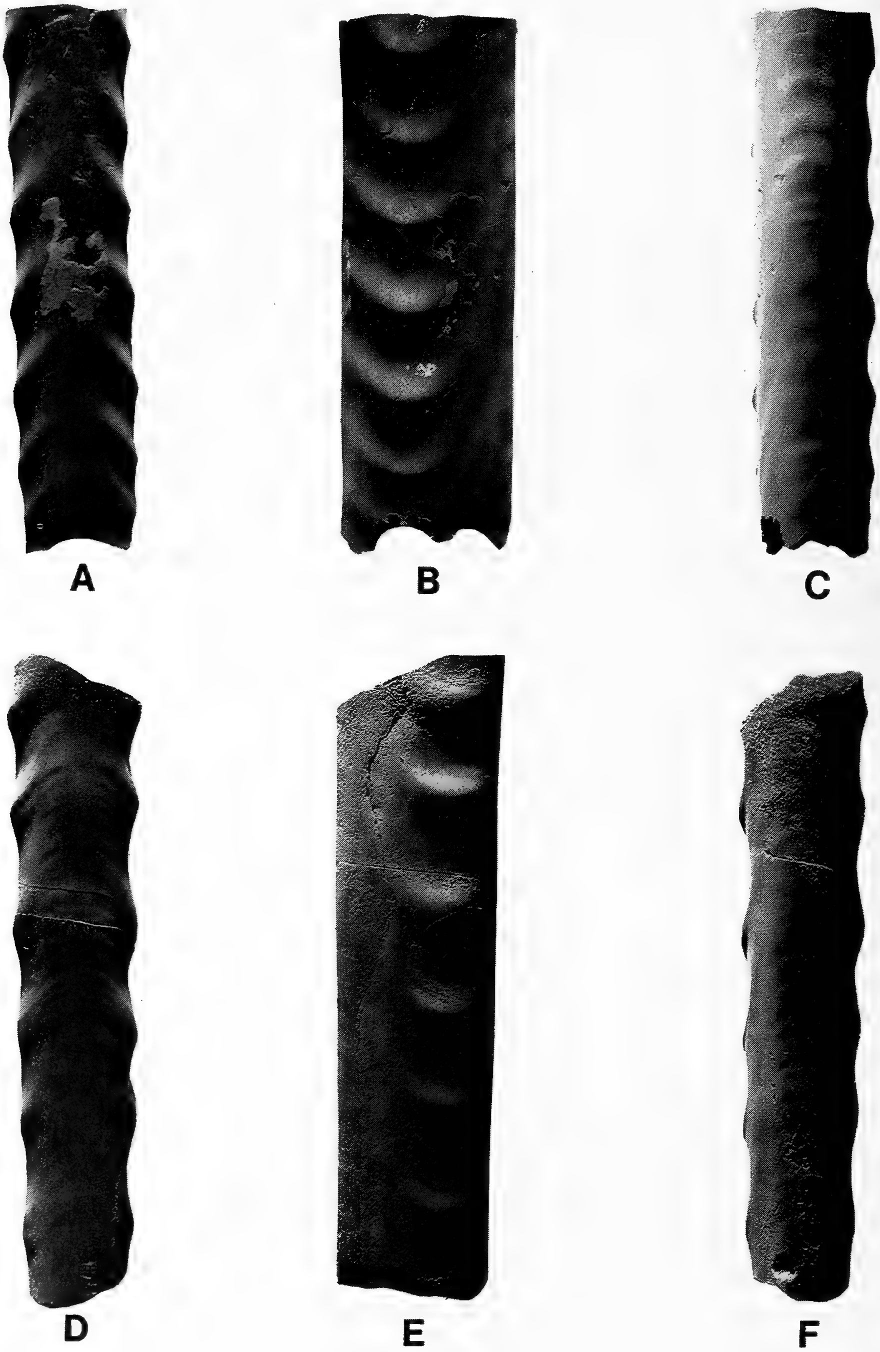

Fig. 95

Fig. 96

* ***Baculites aquilaensis*** **var.** ***obesus*** Reeside, 1927*b* Fig. 97A

Reeside 1927*b*: 12, pl. 10 (figs 1–8).

Type. Holotype is the original of Reeside (1927*b*, pl. 10 (figs 1–6)), from the Lower Campanian, sandstone in the Steele Shale, Wyoming, USNM 73305.

Occurrence. Lower Campanian, US Western Interior (Wyoming, Montana, New Mexico).

* ***Baculites aquilaensis*** **var.** ***separatus*** Reeside, 1927*b* Fig. 97E–F, 98

Reeside 1927*b*: 12, pl. 8 (figs 15–21), pl. 9 (figs 6–15), pl. 45 (figs 5–6). Landes 1940: 168.

Type. Holotype is the original of Reeside (1927*b*, pl. 8 (figs 18–21) from the Lower Campanian, sandstone in the Steele Shale, Wyoming, USNM 73302.

Occurrence. Lower Campanian, US Western Interior (Montana, Wyoming, New Mexico), Alberta, Canada.

Baculites **sp. (nov.?) cf.** ***Aquilaensis*** (*non* Reeside) Collignon

Collignon 1970: 81, pl. 639 (fig. 2358). Klinger & Kennedy 1997, fig. 121a–c.

Occurrence. Upper Campanian, Madagascar.

Baculites argentinicus Weaver, 1927

(? = *Eubaculites simplex* (Kossmat); *nom. dub. Eubaculites* fide Riccardi 1974)

Weaver 1927: 429, fig. 2.

Type. Weaver based his description on the figured specimen from 'The Roca beds at locality no. 115 on the western side of Sierra de Huantraico in the north-western part of Gobernacion del Neuquén, Argentina', but also mentioned another poorly preserved specimen from Los Ramblones. The former is here designated lectotype. Allegedly housed in the collections of University of Washington, Seattle.

Occurrence. Upper Campanian or Maastrichtian, Neuquén Province, Argentina.

Fig. 97 *(see facing page)*. A. *Baculites aquilaensis obesus* Reeside, 1927*b*. USNM 73305 from sandstone in Steele Shale, 1 000 ft below top in SW¼ sec. 19, T. 58 N., R. 87 W., Sheridan County, Wyoming. B–D. *Baculites ovatus* var. *haresi* Reeside, 1927*b*. USNM 73296 from Elk Basin sandstone member of Telegraph Creek Formation in sec. 2, T. 7 S., R. 23. E., Carbon County, Montana. E–F. *Baculites aquilaensis separatus* Reeside, 1927*b*. USNM 73302 from sandstone in Steele Shale, 1 040 ft below top, in sec. 32, T. 58 N., R. 87 W., Sheridan County, Wyoming. H–I. *Baculites thomi* Reeside, 1927*b*. Specimen with complete aperture in the U.S. Geological Survey Collections, Denver. From USGS Mesozoic locality 21419, 8 miles west of Shelby, Montana, in the NE¼ sec. 31, T. 32 N., R. 3 W., Marias River Shale, Kevin Member. × 1.

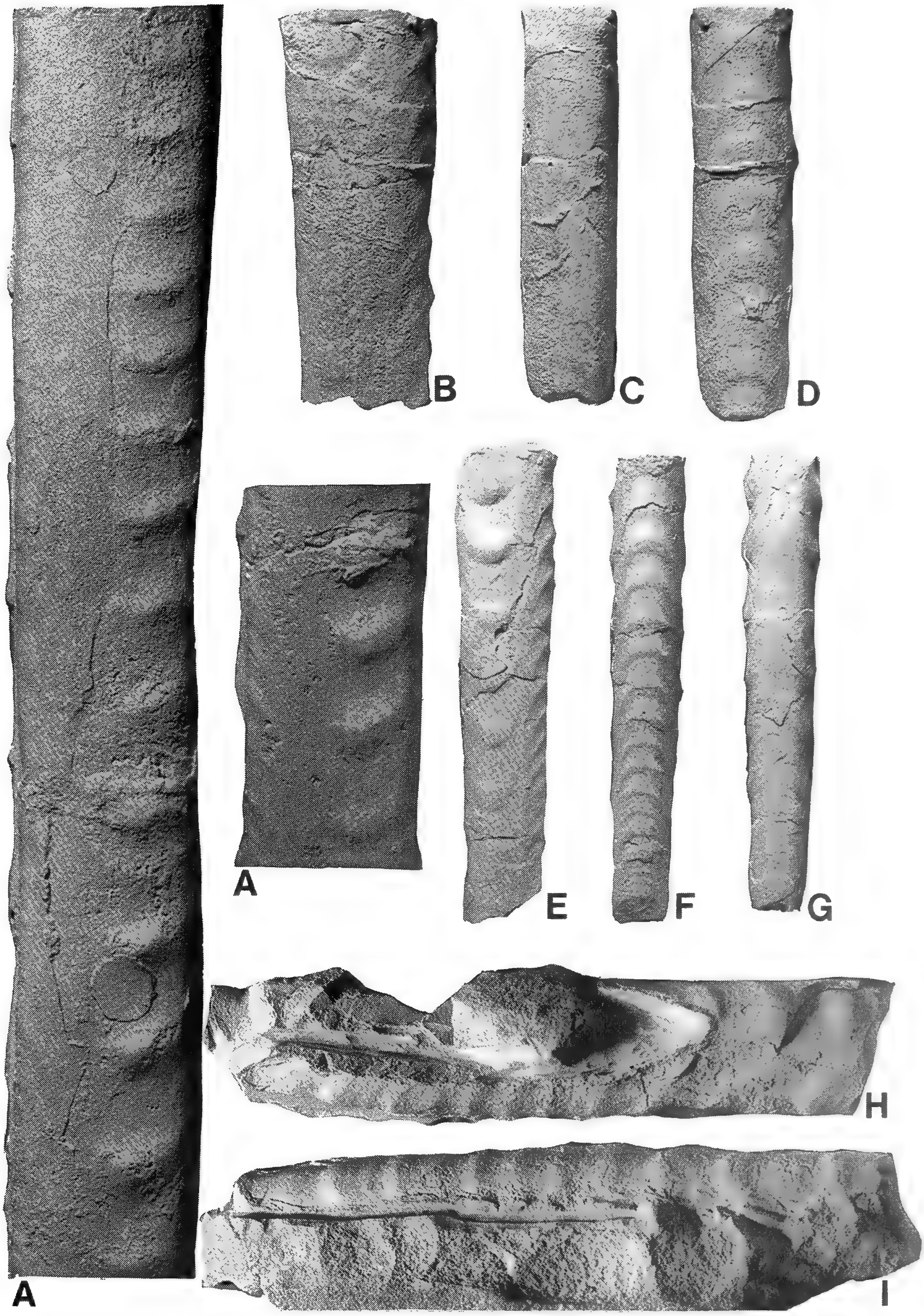

Fig. 97

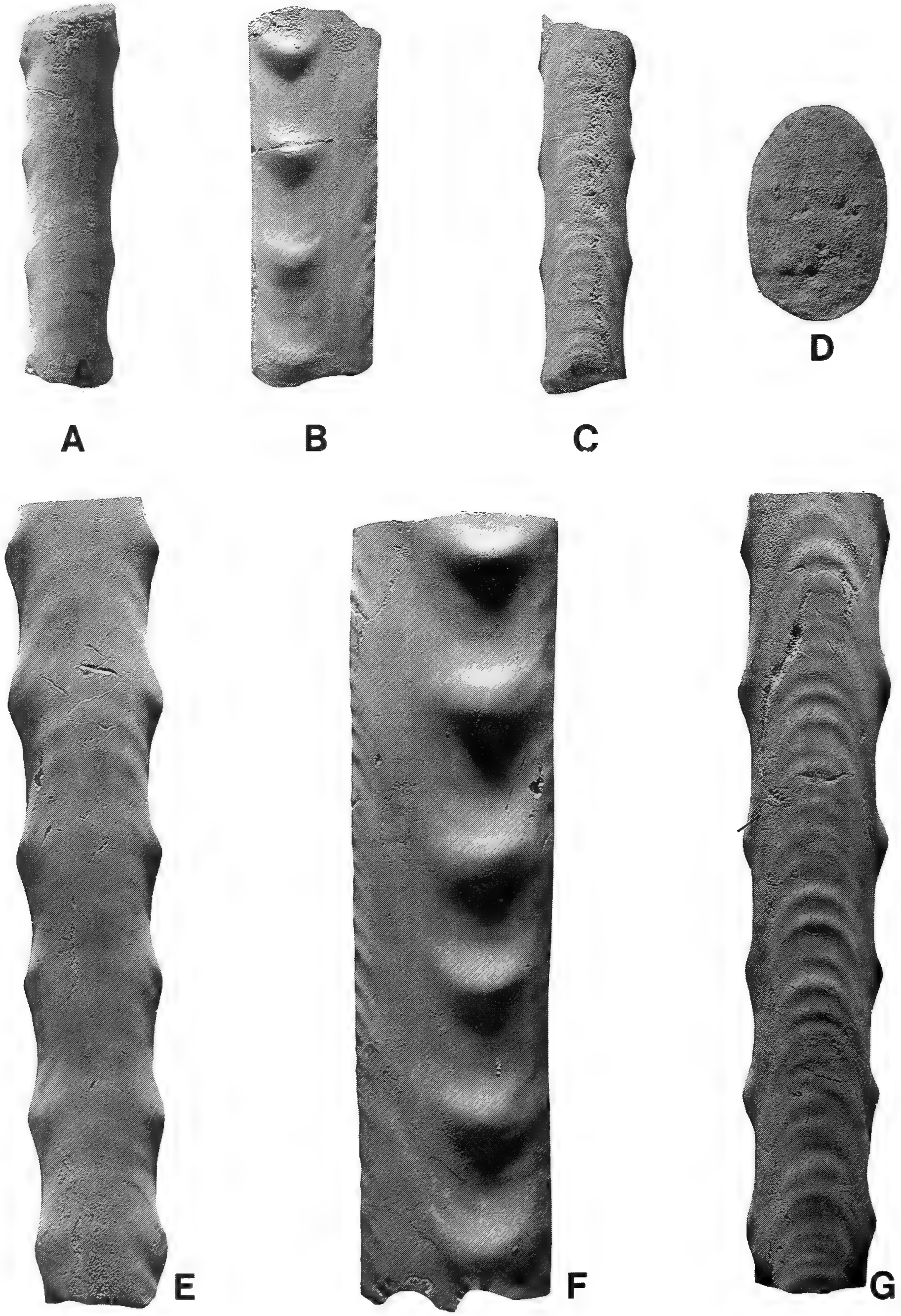

Fig. 98

* ***Baculites asper*** Morton, 1830 Fig. 99H–K

Morton 1830: 291. Morton 1834: 43, pl. 1 (figs 12–13), pl. 13 (fig. 2). *non* Roemer 1852: 36, pl. 2 (fig. 2). Johnson 1905: 26. *non* Reeside 1927*a*: 4, pl. 1 (figs 19–24), pl. 2 (figs 1–5). *non* Reeside 1927*b*: 13 (*pars*), pl. 11 (figs 5–16). *non* Picard 1929: 442, pl. 10 (fig. 8). Reeside 1962: 116 (*pars*). *non* Scott & Cobban 1964, pl. 3 (fig. 5), pl. 4 (fig. 3), pl. 7 (figs 5–6). *non* Kennedy 1977, text-fig. 17.5–17.6. *non* Kauffman 1977: 268, pl. 28 (fig. 6).

Type. According to Reeside (1962: 117), only one of Morton's syntypes (Morton 1834, pl. 1 (figs 12–13)) survives in the Academy of Natural Sciences, Philadelphia, ANSP 19878, allegedly from Prairie Bluff, Alabama.

Occurrence. Upper Campanian, Selma Chalk, Cahawba, Lower Maastrichtian. Prairie Bluff. All records of *B. asper* subsequent to Morton's original descriptions seem to be misidentified *B. codyensis* (*fide* Kennedy & Cobban 1991*a*: 72).

Baculites asper* var. *larteti Blanckenhorn, 1905

See *B. larteti*

Blanckenhorn 1905: 111.

****Baculites asperiformis*** Meek, 1876 Figs 100–101

Meek 1876: 405, pl. 39 (fig. 10a, d). Landes 1940: 168. Cobban 1962*b*: 708, pl. 106 (figs 1–16). Gill & Cobban 1973: 5, fig. 2j. Larson *et al.* 1997: 23.

Type. Lectotype by subsequent designation of Cobban (1962*b*: 708) is the original of Meek (1876, pl. 39 (fig. 10a, d)), from the Middle Campanian, allegedly from 'near mouth of Judith River, Montana' (see Cobban 1962*b*: 711 for locality data), USNM 178a.

Occurrence. Middle Campanian, US Western Interior (New Mexico, South Dakota, Wyoming, Kansas, Montana, Colorado), Alberta and Saskatchewan, Canada.

Baculites asperoanceps Lasswitz, 1904

Lasswitz 1904: 16, pl. 3 (15) (fig. 1a–b). ?Roemer 1852: 36, pl. 2 (fig. 2). *non* Taubenhaus 1920: 10, pl. 6 (fig. 3) (= *B. palestinensis*). Adkins 1928: 206. *non* Collignon 1938: 89, pl. 6 (fig. 7) (as *B.* cf. *aspero-anceps*). Klinger *et al.* 1996: 100, pl. 1; Klinger & Kennedy, 1997, fig. 129.

Fig. 98 *(see facing page)*. *Baculites aquilaensis separatus* Reeside, 1927*b*. Collections of the U.S. Geological Survey, Denver, from USGS Mesozoic locality 23639 lower Gammon Shale Member of Pierre Shale along west-facing scarp at head of Owl Creek in SE¼ sec. 12, T. 9 S., R. 61 E., and N½ sec. 13, T. 9 S., R. 16 E., Carter County, Montana. Lower Campanian Zone of *Scaphites hippocrepis* sensu lato. × 1.

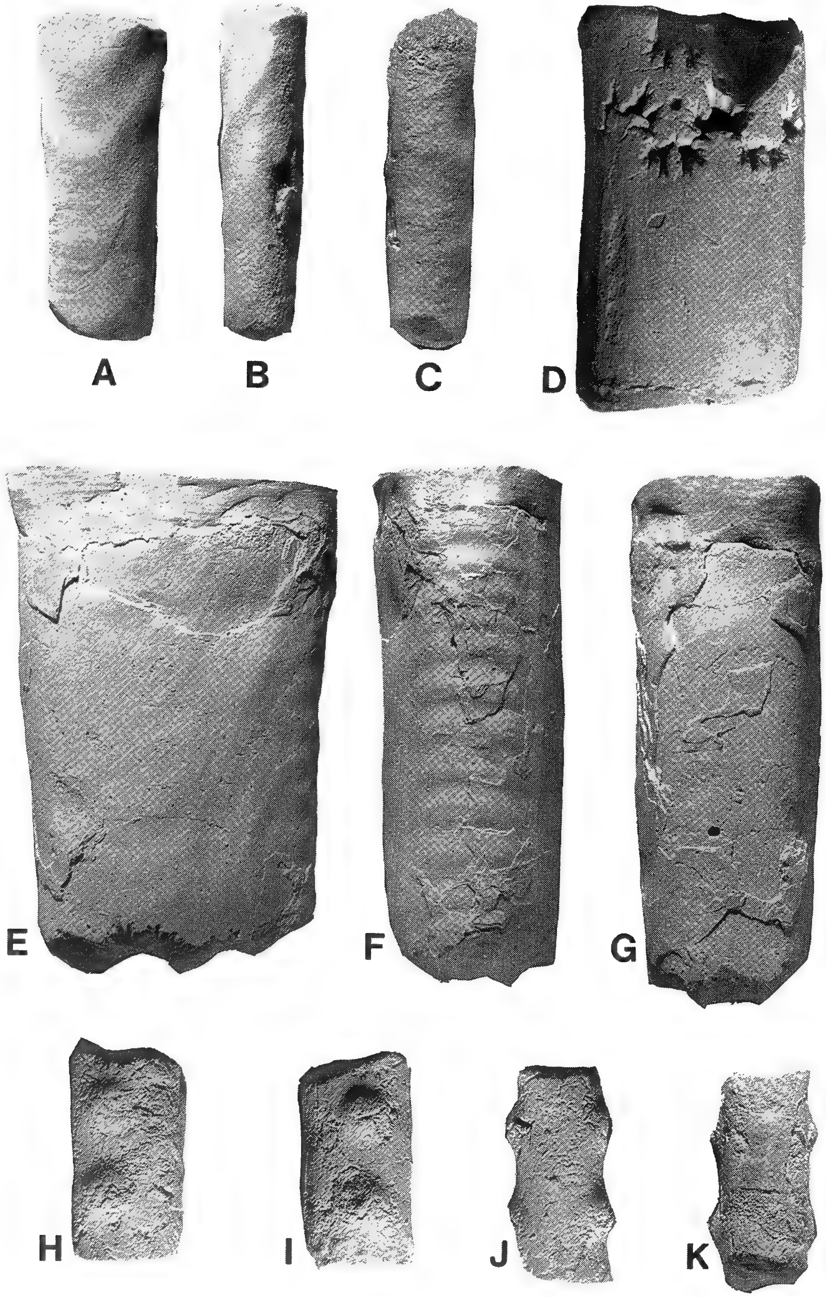

Fig. 99

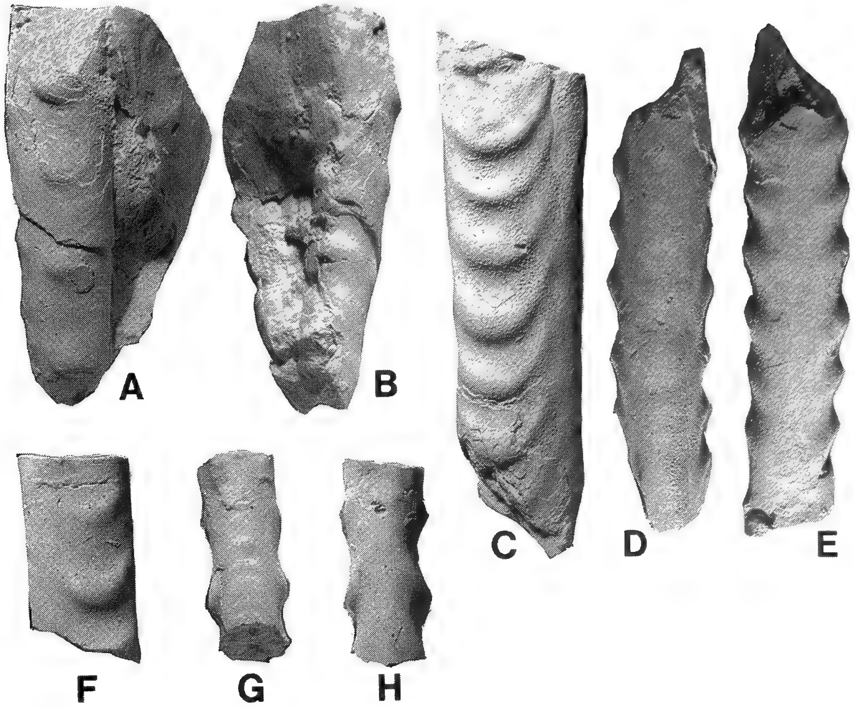

Fig. 100. A–B. *Baculites asperiformis* Meek, 1876. USNM 178 from the mouth of Judith River, Montana; the specimen figured by Meek (1876, pl. 39 (fig. 10a, 10d)). C–H. *Baculites obtusus* Meek, 1876. C–E. USNM 1934, from Deer Creek, North Platte River, Wyoming; the specimen figured by Meek (1876, text-fig. 57). F–H. USNM 1934 from the same locality, the specimen figured by Meek (1876, text-figs 59–60). All × 1.

Type. Lectotype by subsequent designation of Klinger *et al.* (1996, pl. 1) is the original of Lasswitz (1904, pl. 3 (15) (fig. 1a–b)) from Austin, Texas. HTW 3045s (k), MGUWr.

Occurrence. Coniacian–?Santonian, Texas.

Fig. 99 *(see facing page)*. A–C. *Baculites meeki* Elias, 1933. KU 1702A1, the holotype, from KU locality 1702-1, Beecher Island Shale Member, Pierre Formation, 2 miles north-west of Beecher Island, Yuma County, Colorado. D. *Baculites pseudovatus* var. A. Elias, 1933. KU 1662A1, the holotype, from KU locality 1662-1, Salt Grass Shale Member (*Baculites* zone), Pierre Formation, sec. 2, T. 12 S., R. 42 W., Wallace County, Kansas. E–G. *Baculites reesidei* Elias, 1933. USNM 73304, the holotype, from the Bearpaw Shale, sec. 34, T. 16 N., R. 28 E., Fergus County, Montana, the specimen figured by Reeside (1927b, pl. 9 (figs 1–5)). H–K. *Baculites asper* Morton, 1830. ANSP 19878, according to data on original label in Morton's handwriting 'one of cotypes . . . Prairie Bluff Alabama'.
All × 1.

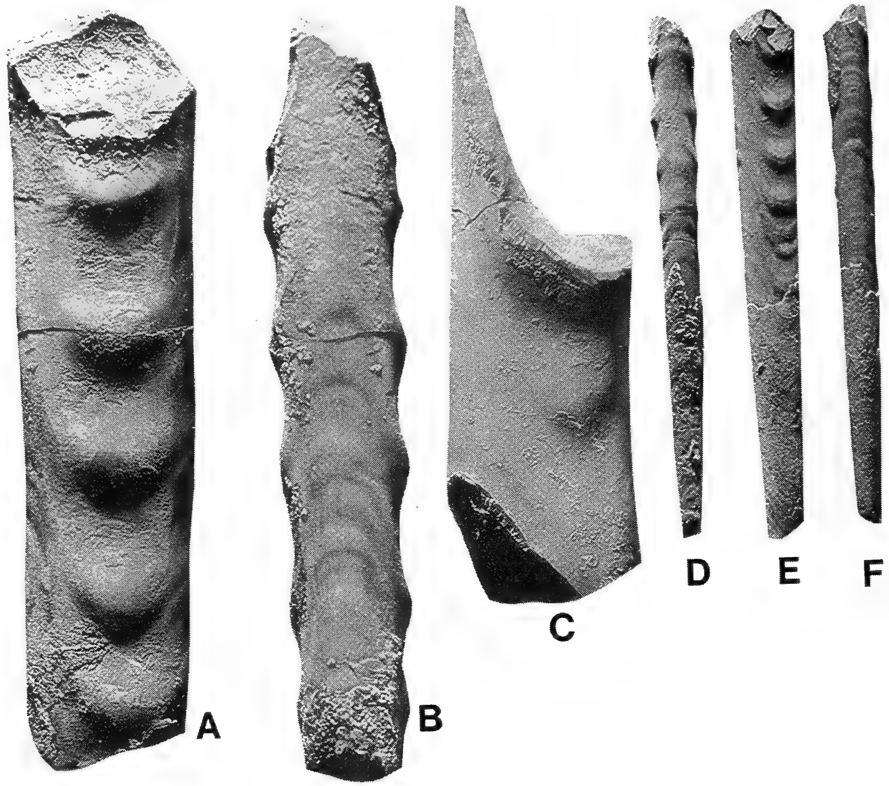

Fig. 101. *Baculites asperiformis* Meek, 1876. A–B. USNM 131015e. C. USNM 131015f. D–F. USNM 131015a. All from 40 ft below the top of the Sharon Springs Member of the Pierre Shale at USGS Mesozoic locality D2951, 1 mile north-east of McAllaster, Logan County, western Kansas. Copy of Cobban (1962*b*, pl. 106 (figs 12–14, 1–3)). All × 1.

Baculites asperoides Meek & Hayden, 1861

Meek & Hayden 1861: 421. (= *nom. nud.* fide Cobban 1962*b*: 708).

* ***Baculites baculus*** Meek, 1862 Fig. 102

Meek & Hayden 1861: 445. Meek 1876: 397, text-figs 51–52. Scott & Cobban 1965: 3, map I-439. Gill & Cobban 1973: 10, fig. 3d, 7a. Riccardi 1983, pl. 26 (figs 6–10). Kennedy 1993: 110, pl. 4 (figs 10, 20–21). Larson *et al.* 1997: 34.

Type. Holotype is from the 'Fox Hill Sandstone near Glenrock, Wyoming' (Meek 1876, text-figs 51–52).

Fig. 102 *(see facing page)*. *Baculites baculus* Meek, 1862. U.S. Geological Survey Collections, Denver. From the Pierre Shale near Midland, South Dakota. × 1.

Fig. 102

Occurrence. Maastrichtian, US Western Interior (Wyoming, Colorado, South Dakota, Montana), Saskatchewan, Alberta, Canada, U.S. Gulf Coast and Belgium.

Baculites bailyi Woods, 1906

Baily 1855: 457 (*pars*), pl. 11 (fig. 5a–b only, *non* 5c). ?Etheridge 1904: 90. Woods 1906: 341, pl. 44 (fig. 5). ?Van Hoepen 1921: 18, pl. 3 (figs 9–10). *non* Spath 1921: 261. Spath 1922: 146. *non* Besairie 1930: 223, pl. 21 (figs 6–7). Glazunova 1955: 186, pl. 3 (fig. 7) (as *B.* cf. *bailyi*). Matsumoto & Obata 1963: 35, pl. 20 (figs 1–2), pl. 21 (fig. 5), text-figs 88–89, 116–120, 140–142. Collignon 1969: 21, pl. 520 (fig. 2051). Klinger & Kennedy 1977: 75, fig. 5d. Ward 1978: 1148, pl. 1 (figs 5–7), text-fig. 5. Olivero 1984: 57, pl. 1 (figs 1–5), text-fig. 1a–b. Klinger 1985: 5, fig. 4e–h. Klinger & Kennedy 1997, figs 13–23, 67k–q, 78a–b.

Type. Holotype by original designation of Woods (1906: 342) is the original of Baily (1855, pl. 11 (fig. 5a–b)), from an unspecified horizon in the Mzamba Formation at the Mzamba River Estuary, BMNH C11372..

Occurrence. Upper Santonian–Lower Campanian, Pondoland, Zululand, Natal offshore, Madagascar, James Ross Island, Antarctica, British Columbia.

Baculites bassei Besairie, 1930

Besairie 1930: 222, pl. 22 (fig. 8, 8a), text-fig. 17. Klinger & Kennedy 1997, fig. 121d–e.

Type. Holotype, by monotypy? is the original of Besairie (1930, pl. 22 (fig. 8, 8a)) from the Upper Campanian or Lower Maastrichtian, Maintirano, Madagascar. The repository of the type is not known to us.

Occurrence. Upper Campanian or Lower Maastrichtian, Madagascar.

Baculites besairiei Collignon, 1931
(= *B. yokoyamai* Tokunaga & Shimizu)

Collignon 1931: 37, pl. 5 (figs 6–9), pl. 9 (fig. 16). Collignon 1965: 18, pl. 420 (figs 1745–1746).

Type. Lectotype, here designated is the original of Collignon (1931, pl. 5 (fig. 6)) from the Upper Coniacian of Mahagaga, Madagascar, GD unregistered.

Occurrence. Upper Coniacian, Madagascar.

Fig. 103 *(see facing page)*. A–L, R–S. *Baculites* sp. NHMW 1890.xiii.209, labelled *Baculites faujasi* Lam. var. *bohem.* Frič, Priesener Schichten, Priesen, Bohemia. Probably Coniacian. T–W. *Baculites* sp., NHMW 1890.xiii.210, from the same locality and horizon as A–L, R–S. (= *B. brevicosta* Schlüter). M–P. *Sciponoceras bohemicum* (Fritsch, 1872). NHMW 1893.iii.10. The original of Jahn (1895, pl. 8 (fig. 7)). All × 1.

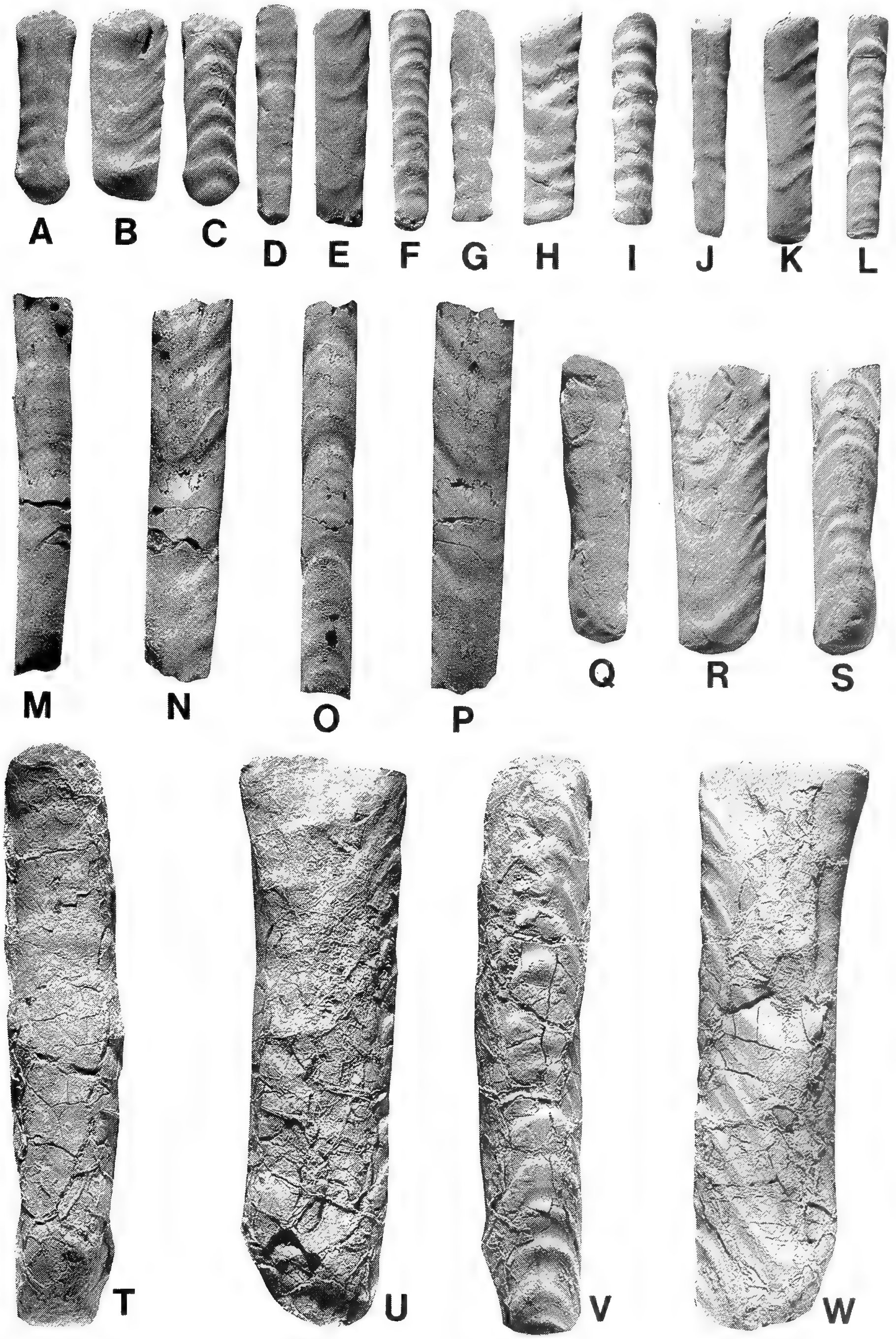

Fig. 103

* ***Baculites borealis*** Warren, 1930 Fig. 117A–C
(= *B. codyensis* Reeside, 1927*a*, fide Kennedy & Cobban 1991*a*: 72)

Warren 1930: 65, pl. 5 (figs 3–4, 9, 14).

Type. Lectotype here designated is the original of Warren (1930, pl. 5 (figs 3–4), from the Smoky River Shale, Little Smoky River, Alberta, Canada. GMUA Ct465.

Occurrence. Middle Coniacian to Middle Santonian, Alberta, Canada.

* ***Baculites boulei*** Collignon, 1931
(= *B. capensis*)

Collignon 1931: 35, pl. 5 (fig. 2), pl. 9 (fig. 14). *non* Collignon 1938: 88, pl. 6 (fig. 6, 6a, 6b). Matsumoto 1959: 118, pl. 32 (fig. 7a–c), pl. 33 (fig. 4a–c, 5a–b, 6a–d, 7a–b), text-figs 27a–b, 28–32. Matsumoto & Obata 1963: 43, pl. 13 (figs 3, 5), pl. 15 (fig. 6), text-figs 93, 152–155. *non* Förster 1975: 168, pl. 4 (figs 3, 9), text-fig. 37. ?*non* Haggart & Ward 1989: 226, fig. 3.7–3.10 (as *Baculites* cf. *boulei*).

Type. Lectotype by the subsequent designation of Matsumoto (1959: 118) is the original of Collignon (1931, pl. 5 (fig. 2, 2a), pl. 9 (fig. 14)) from the Upper Coniacian of Mahagaga, Madagascar, GD unregistered.

Occurrence. Upper Coniacian–Lower Santonian Madagascar, Zululand, California, Hokkaido. (Neal Larson informed us that *Baculites* cf. *boulei* occurs in the Turner Sand Member of the Carlile Formation from South Dakota, Wyoming, and questionably New Mexico).

* ***Baculites brevicosta*** Schlüter, 1876 ?Figs 103R–S, 128Q–S

Schlüter 1876: 141, pl. 39 (figs 9–10). *non* Moberg 1885: 37, pl. 4 (figs 5–6). Wegner 1905: 207. *non* Spath 1921: 260, pl. 24 (fig. 5) (as *B.* cf. *brevicosta*). *non* Hägg 1930: 58. *non* Collignon 1931: 34, pl. 5

Fig. 104 *(see facing page)*. A–C. ***Baculites schencki*** Matsumoto, 1959. CAS-67731.01, paratype from Fresno County, Panoche Quadrangle, *c.* 1 100 feet of south-east corner of sec. 28, T. 14 S., R. 11 E., Panoche Hills, California. D. *Baculites* aff. ***B. capensis*** Woods, 1906. CAS-31289.01; from Yolo County, 3 miles north-west of Rumsey on Lake Co. highway, on Cache Creek, a little above the concrete bridge, California. The original figured by Anderson (1958: 192, pl. 48 (fig. 8, 8a)). E–G. *Baculites buttensis* Anderson, 1958. CAS-27835.01, the holotype, from Butte County, from bluff on south-east side of Big Chico Creek at Frank Mickey's place, California. H–K. *Baculites subcircularis* Anderson, 1958. CAS-28442.01, the holotype, from Contra Costa County, 4 miles south of Brentwood, Marsh Creek, at the mouth of Briones Creek, *c.* 1 250 feet south-west of the old John Marsh House, from large concretion, S½ SW¼ NW¼ sec. 35, T. 1 N., R. 2 E. L–N. *Baculites lomaensis* Anderson, 1958. CAS-2361.03, a paratype, from Fresno County, north-west of Oil City, 11 miles north of Coalinga, Joaquin Ridge, California, the specimen figured by Anderson (1958, pl. 48 (fig. 6)). A–G, J–N × 1; H–I × 2.

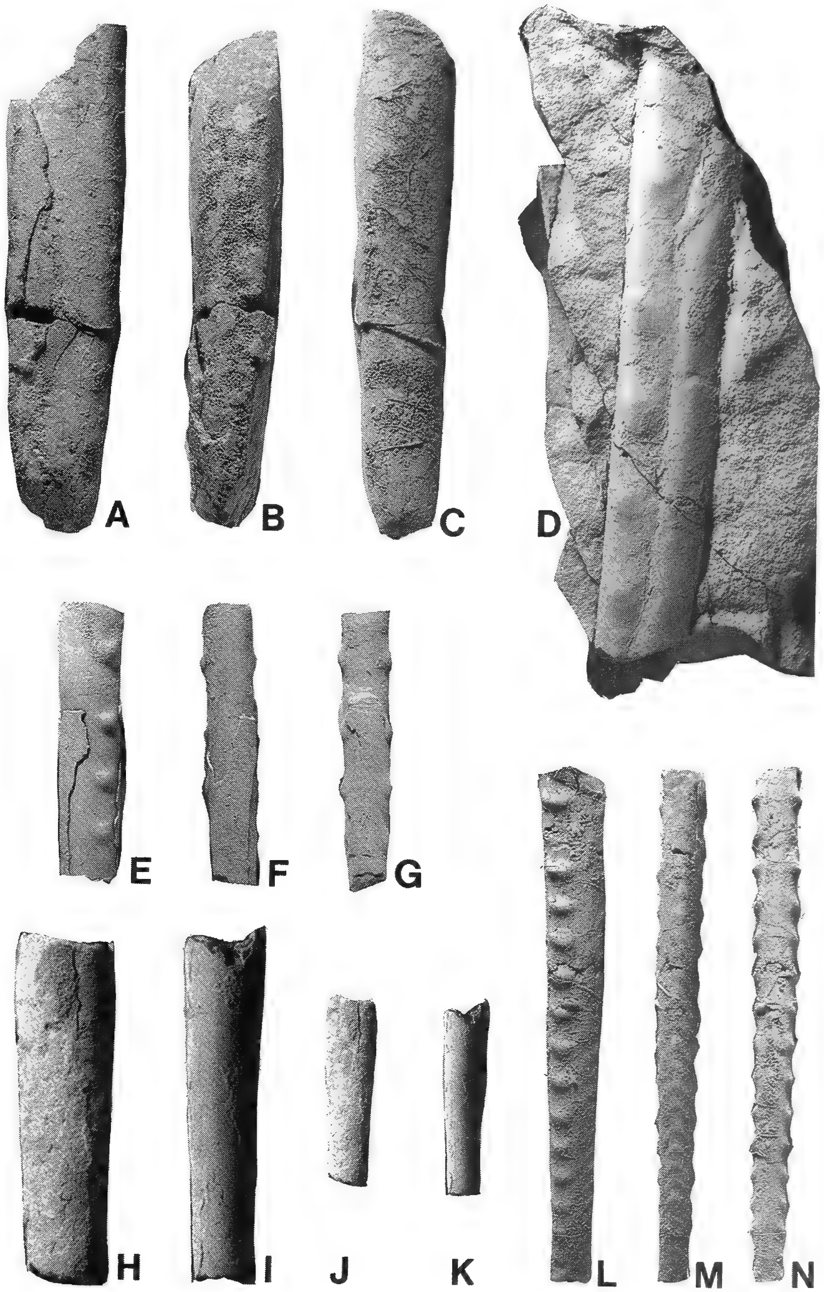

Fig. 104

(fig. 1), pl. 9 (fig. 13) (as *B.* cf. *brevicosta*). Kennedy 1984: 146, pl. 33 (figs 23–25) (as *B.* cf. *brevicosta*). Kaplan & Kennedy 1994: 59, pl. 40 (figs 15–19). ?Kennedy & Christensen 1997: 109.

Type. Lectotype by the subsequent designation of Kennedy (1984: 146), is the original of Schlüter (1876, pl. 39 (figs 9–10)) from the Emscher Marls of Horst in Westphalia, Germany. The lectotype could not be located by us in the collections in Bonn and has to be assumed lost.

Occurrence. Coniacian of Germany and possibly France.

***Baculites buttensis** Anderson, 1958 Fig. 104E–G

(= uninterpretable; probably *B. capensis*; see also Matsumoto 1959: 121–2)

Anderson 1958: 191, pl. 49 (fig. 6).

Type. Holotype (by monotypy?) is the original of Anderson (1958, pl. 49 (fig. 6)) from the Upper Cretaceous of Chico Creek, California, CAS type collection.

Occurrence. ?Santonian, California.

* **Baculites calamus** Morrow, 1935 Fig. 105A

Morrow 1935: 473, pl. 49 (fig. 8a, b). Cobban & Scott 1972: 49, pl. 34 (fig. 7).

Type. Holotype is the original of Morrow (1935, pl. 49 (fig. 8a, b)) from the Upper Turonian, Bridge Creek Member of the Greenhorn Formation, Hamilton County, Kansas. GMUK.

Occurrence. Upper Turonian, Kansas and Colorado.

Baculites capensis Woods, 1906

Woods 1906: 342, pl. 44 (figs 6–7). ?Boule *et al.* 1907: 65 (45), pl. 15 (fig. 3, 3a) (as *B. vagina*). Crick 1907: 240 (as *Baculites* sp.). Spath 1921: 257, pl. 24 (figs 6–7). Spath 1921: 259, pl. 24 (fig. 4, 4a) (as *B.* cf. *aspero-anceps*); 1921: 260, pl. 24 (fig. 5, 5a) (as *B.* cf. *brevicosta*); 1921: 258 (as *B.* sp. aff. *capensis*); 1921: 260 (as *B.* cf. *sulcatus*). Spath 1922: 146. ?Spath 1925: 31, pl. 1 (fig. 1) (as *Baculites* sp. ind.). Collignon 1931: 22, pl. 3 (fig. 6) (as *B.* aff. *capensis*). Besairie 1930: 620. Venzo 1936: 116 (58). Venzo 1936: 116 (58), pl. 10 (6) (fig. 13) (as *B. capensis* var. *umsinenensis*). ?Anderson 1958: 191, pl. 49

Fig. 105 *(see facing page)*. A. *Baculites calamus* Morrow, 1935. From the Middle Turonian Bridge Creek Member of the Greenhorn Formation, Hamilton County, Kansas. B–R. *Baculites yokoyamai* Tokunaga & Shimizu, 1926. B–E. USNM 433862 from USGS Mesozoic locality 20611. F–G. USNM 433867 from USGS Mesozoic locality 23438. H–I. USNM 433858 from the same locality as F–G. J–L. USNM 433861, from the same locality. M–O. USNM 438857, from the same locality. P–R. USNM 433863, from the same locality. All from the Lower Coniacian *Inoceramus erectus* zone. All × 1.

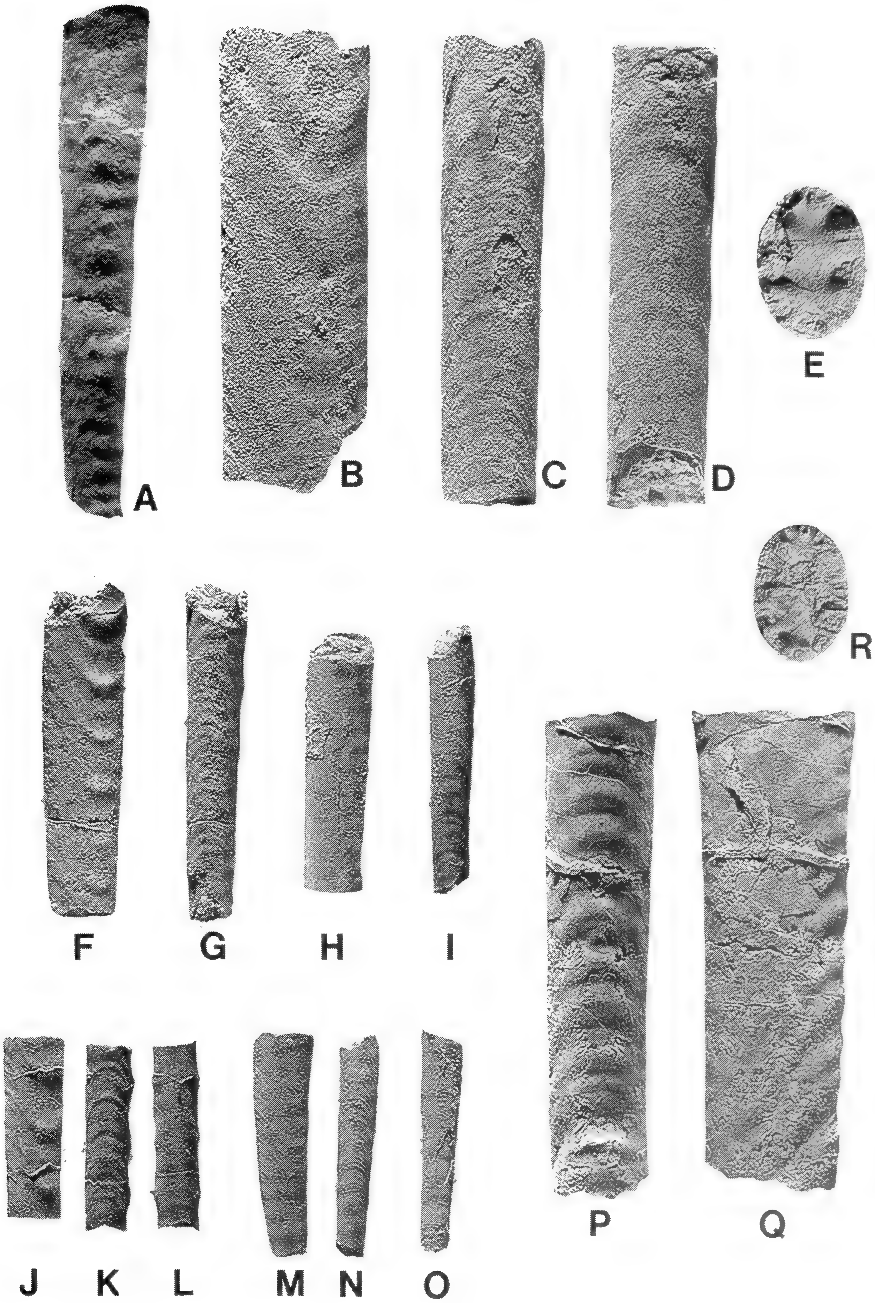

Fig. 105

(fig. 6, 6a, 6b) (as *B. buttensis*). Anderson 1958: 192, pl. 48 (fig. 8, 8a) (as *B.* aff. *capensis*). Matsumoto 1959: 121, pl. 33 (fig. 1a–d, 2a–c, 3a–b), pl. 45 (fig. 1a–d, 2a–d, 3a–d, 4a–d), text-figs 33a–b, 34a–b. Matsumoto & Obata 1963: 47, pl. 14 (fig. 2), pl. 15 (figs 3–5), pl. 19 (fig. 2), text-figs 95–96, 147–151. Collignon 1966: 6, pl. 457 (fig. 1862). Collignon 1966: 6, pl. 457 (figs 1863–1864) (as *B. capensis* var. *tenuetuberculata*). Collignon 1966: 7, pl. 457 (fig. 1865) (as *B. malagasyensis*). *non* Kennedy & Klinger 1973: 100, pl. 4 (figs 1–5), pl. 5 (fig. 1a–d), pl. 6 (figs 4–5) (as *Baculites* sp. group of *B. capensis* Woods). Klinger & Kennedy 1977: 71, figs 2a–f, 3g. Haggart 1984: 233, fig. a–d. ?Cooper 1988: 210, fig. 1g–i. Kennedy & Cobban 1991*b*: 182, figs 6: 4; 8: 1–8; 10: 7–10, 12–14; 12: 2, 5. ?Kennedy & Christensen 1993: 152, fig. 4a (as *Baculites* sp. group of *capensis*). Klinger & Kennedy 1997: 53, figs 12m–o, 27–55.

Type. Lectotype by subsequent designation of Matsumoto & Obata (1963: 48) is the original of Woods (1906, pl. 44 (fig. 6a–b)) from the Santonian of the Mzamba Formation, Mzamba River Estuary, Pondoland, SAM–4823.

Occurrence. Middle Coniacian to Middle Santonian, Pondoland, Zululand, Madagascar, Santonian California and Hokkaido, Texas and Mississippi in the USA, doubtfully Campanian of Angola and Sweden.

Baculites capensis* var. *tenuetuberculata Collignon, 1966
(= *B. capensis* s.s.)

Collignon 1966: 6, pl. 457 (figs 1863–1864), p. 22, pl. 463 (figs 1894–1895).

Type. Holotype, by original designation is the original of Collignon (1966, pl. 457 (fig. 1863)) from the Lower Santonian of Gisement 270, Coupe Ampolypoly-Antsirasira-Behamotra (Belo sur Tsiribihina), Madagascar, GD 11865.

Occurrence. Lower Santonian, Zone of *Texanites oliveti*, Madagascar.

Baculites capensis* var. *umsinenensis Venzo, 1936
(= *B. capensis* s.s.)

Venzo 1936: 116 (58), pl. 10 (6) (fig. 13).

Type. Lectotype, here designated is the original of Venzo (1936, pl. 10 (fig. 13)) from the Upper Coniacian or Lower Santonian, Mzinene River, Zululand.

Occurrence. Upper Coniacian or Lower Santonian, Zululand.

Baculites carinatus Morton, 1834
(see *Eubaculites*)

Morton 1834: 44, pl. 13 (fig. 1).

Fig. 106 *(see facing page)*. ***Baculites chicoensis*** Trask, 1856. CAS–61997.08 (Stanford University collection) from Butte County, east bank of Chico Creek, 3.6 miles along country road to Big Chico Creek from Humboldt Road at the '10 mile House', California. The specimen figured by Matsumoto (1959: 146, pl. 37 (fig. 1a–d), text-fig. 59a–d). × 1.

Fig. 106

Baculites carinatus Binckhorst, 1861, *non* Morton, 1834
(= presumably an atypical *B. vertebralis* fide Kennedy 1986*c*: 192)

Binckhorst 1861: 43, pl. 5d (fig. 2).

Type. Holotype by monotypy is the original of Binckhorst (1861, pl. 5d (fig. 2a–d).

Occurrence. Maastrichtian, Belgium.

Baculites cazadorianus Paulcke, 1907
(= ?*B. anceps* or *Eubaculites simplex*)

Paulcke 1907: 11 (177), pl. 16 (fig. 5), text-fig. 2. (as *B. vagina* var. nov. *cazadorianus*).

Type. Lectotype here designated is the original of Paulcke (1907, pl. 16 (fig. 5a–c)) from the Upper Campanian? of Cerro Cazador, Patagonia, Argentina. The type, originally housed in the Albert-Ludwigs Universität, Freiburg im Breisgau, Germany, appears to be lost (letter Dr U. Leppig 13.07.1992).

Occurrence. Upper Campanian?, Patagonia.

* ***Baculites chicoensis*** Trask, 1856 Figs 106, 107G–I, 108D–F

Trask 1856: 92, pl. 2 (fig. 2). Gabb 1864: 80, pl. 14 (fig. 27), pl. 17 (fig. 27, 27a). Usher 1952: 96, pl. 26 (figs 1–4), pl. 31 (fig. 18), text-fig. 3. Matsumoto 1959: 145, pl. 36 (fig. 2), pl. 37 (fig. 1), text-figs 59a–d, 60a, 61a–b, 62a–b, 63a–b. Matsumoto & Obata 1963: 66, pl. 21 (figs 2, 4), text-figs 159, 163–164. Ward 1978: 1148, pl. 1 (figs 3–4, 8–9), text-fig. 5. Matsumoto & Miyauchi 1984: 69. ?Grabovskaja 1984: 86 (as *B.* cf. *chicoensis*). Haggart 1984: 233, fig. 7e–h. Haggart 1991, pl. 2 (figs 6–7).

Type. Trask's original material is lost (see Taff *et al.* 1940: 1321, Matsumoto 1959: 145). Taff *et al.* 1940 designated two 'neosyntypes'. Matsumoto (1959: 146) has selected a better specimen in the collections of Stanford University, LSJU 8537 (Matsumoto 1959, pl. 36 (fig. 2a–d), text-fig. 60a–b) from Chico Creek, and indicated that an application would be made to the International Commission of Zoological Nomenclature to designate the latter as the neotype, and to invalidate the designation of Taff *et al.* 1940.

Occurrence. Lower Campanian, California (see Ward 1978: 418), British Columbia, Hokkaido, and tentatively southern Saghalin.

Fig. 107 *(see facing page)*. A–F. *Baculites occidentalis* Meek, 1862. A–B. CAS-66773.02 from Fresno County, Coalinga Quadrangle from *c.* 50 ft above contact with massive sandstone, west of Los Gatos Creek, California. C–F. CAS-66769.01 from Fresno County, Los Gatos Creek, from the SE¼ of sec. 4, T. 20 S., R. 14 E., from the upper part of the Panoche Formation, California. G–I. *Baculites chicoensis* Trask, 1856. CAS-61997.11; from Butte County, east bank of Chico Creek, 3.6 miles along country road to Big Chico Creek from Humboldt Road at the '10 mile House', California. All × 1.

Fig. 107

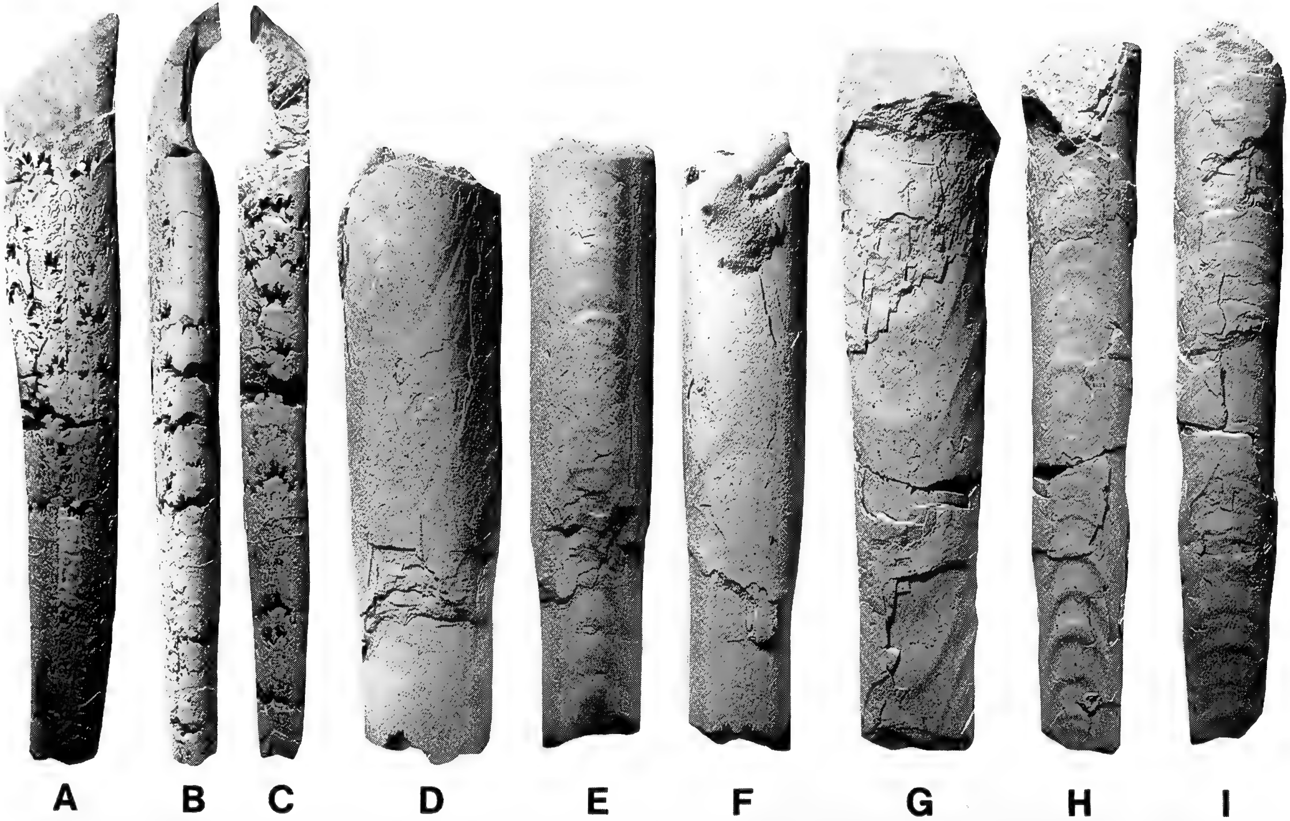

Fig. 108. A–C. *Baculites rex* Anderson, 1958. CAS–66781.01; locality data given by Matsumoto (1959: 136) and CAS are conflicting. D–F. *Baculites chicoensis* Trask, 1856. CAS–61997.07, from Butte County, east bank of Chico Creek, 3.6 miles along country road to Big Chico Creek from Humboldt Road at the '10 mile House', California. G–I. *Baculites inornatus* Meek, 1862. CAS–228.02, from Strait of Georgia, San Juan Islands, Sucia Island, Washington State. All × 1.

Baculites chicoensis Waring, 1915, *non* Trask, 1856
(= uninterpretable)

Waring 1915, map, fig. 6. See also Matsumoto 1959: 130.

Occurrence. Upper Campanian, Baha California, Mexico.

Baculites chicoensis yezoensis Matsumoto & Miyauchi, 1984

Matsumoto & Miyauchi 1984: 70, pl. 25 (figs 1–5), text-fig. 11b–c.

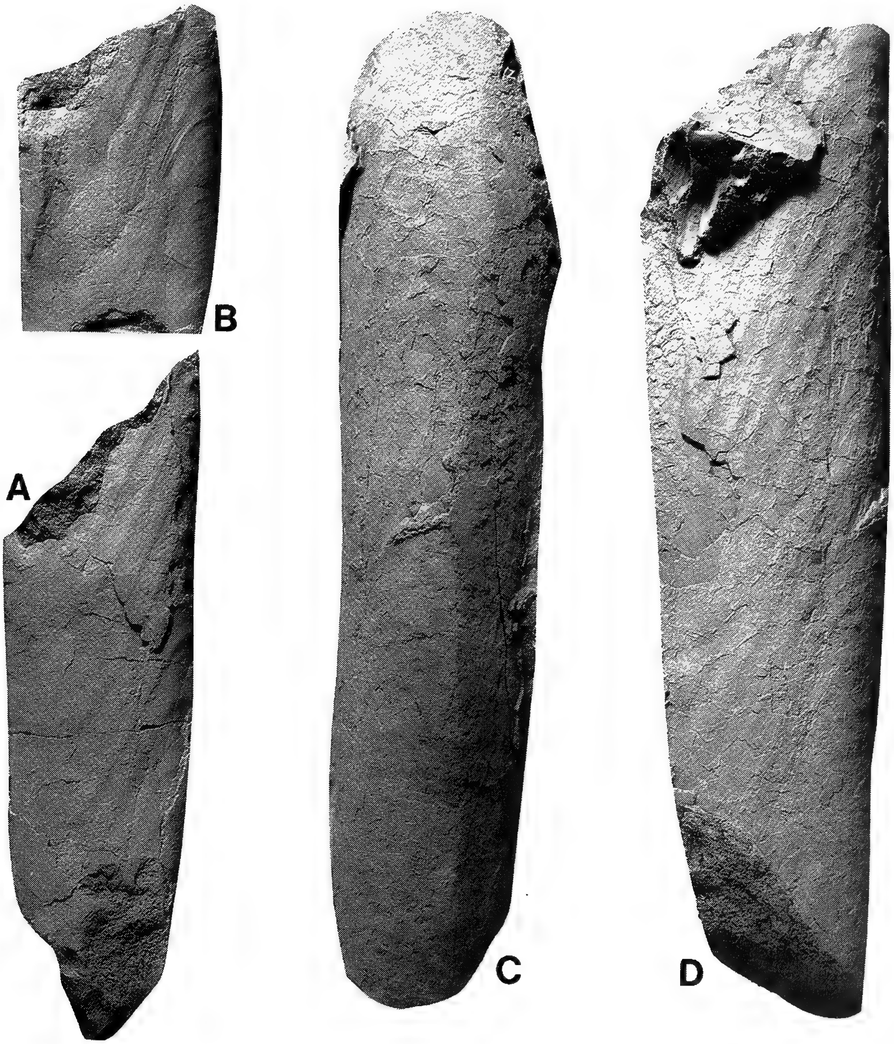

Fig. 109. *Baculites claviformis* Stephenson, 1941. A. USNM 44940. B. USNM 44943. C–D. USNM 449431. All from the Upper Campanian, *Nostoceras hyatti* zone fauna of the Coon Creek Tongue of the Ripley Formation, Coon Creek, McNairy County, Tennessee. All × 1.

Fig. 110. *Baculites clinolobatus* Elias, 1933. USNM 507276, from the Pierre Shale near Wasta, South Dakota. × 1.

Type. Holotype is the original of Matsumoto & Miyauchi 1984, pl. 25 (fig. 1)), from the lower Campanian Fukiyose Bed of Kiyohama II of northern Hokkaido, GK H5975.

Occurrence. Lower Campanian, northern Hokkaido.

Fig. 111. *Baculites clinolobatus* Elias, 1933. USNM 507276, from the Pierre Shale near Wasta, South Dakota. × 1.

* ***Baculites claviformis*** Stephenson, 1941 Fig. 109

Stephenson 1941: 403, pl. 1, pl. 77 (figs 6–8), pl. 78 (figs 1–6). Cobban 1974: 5, pl. 3 (figs 7–8, 12–14). Cobban & Kennedy 1991*b*: E4, pl. 3 (figs 1–9). Cobban & Kennedy 1994*c*: B8, pl. 8 (figs 1–8), pl. 11, text-fig. 3.

Type. Holotype is the original of Stephenson (1941, pl. 77 (figs 6–8)) from the Upper Campanian, Nacatoch Sand Kaufman County, Texas, USNM 77241.

Occurrence. Upper Campanian–?Maastrichtian, Texas, New Jersey, Arkansas, Alabama, Mississippi, Tennessee, and possibly Colorado.

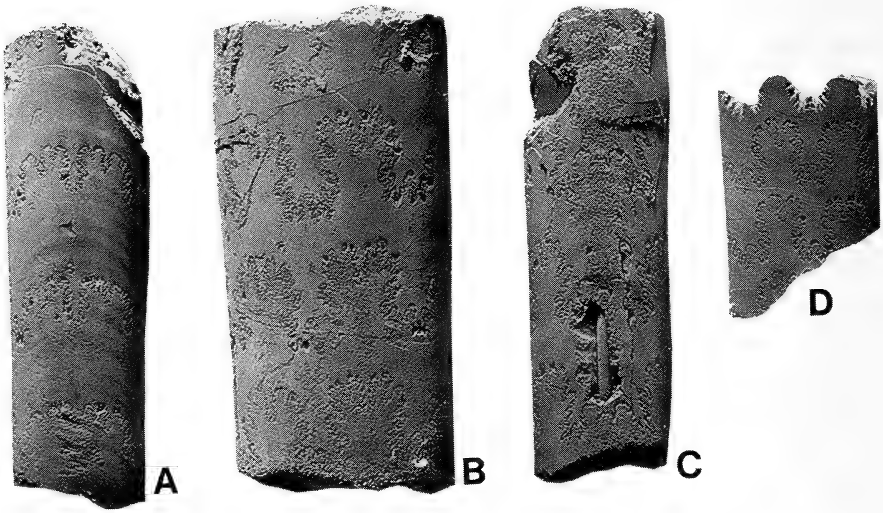

Fig. 112. *Baculites* sp. (smooth). A–C. USNM 131014a. D. USNM 131014b. Both from the Pierre Shale, USGS Mesozoic locality D2102 near Red Bird, Wyoming. Copy of Cobban (1962*b*, pl. 108 (figs 1–4)). Both × 1.

* ***Baculites clinolobatus*** Elias, 1933 Figs 110–111

Elias 1933: 310, pl. 30 (figs 1–2), pl. 34 (figs 1, 2a–b, 3). Scott & Cobban 1965: 3, map I–439. Gill & Cobban 1973: 11, fig. 7c. Larson *et al.* 1997: 36.

Type. Lectotype, here designated is the original of Elias (1933, pl. 30 (fig. 1)) from Beecher Island, Yuma County, Colorado. GMUK 59709.

Occurrence. Maastrichtian, US Western Interior (Wyoming, Colorado, South Dakota, Kansas and Nebraska).

Baculites coagmentatus Collignon, 1970
(= ?*B. increscens*)

Collignon 1970: 7, pl. 609 (figs 2275–2276). Klinger & Kennedy 1997: 136, fig. 88.

Type. Holotype is the original of Collignon (1970, pl. 609 (fig. 2275)) from the Middle Campanian of Gisement 177, Coupe d'Ankilizato (Belo sur Tsiribihina), Madagascar, GD 12275.

Occurrence. Middle Campanian, Zone of *Pachydiscus grossouvrei*, top of subzone of *Pachydiscus bassae*, Madagascar.

* ***Baculites cobbani*** Khakimov, 1976 Fig. 112

Cobban 1962*b*: 714, pl. 108 (figs 1–4), text-fig. 1i–j (as *Baculites* smooth species). Atabekian & Khakimov 1976: 98, pl. 11 (figs 2–7). Kennedy 1993: 111, pl. 5 (figs 1–12), pl. 6 (figs 5–10), text-fig. 6 (as *Baculites* sp. (smooth). Larson *et al.* (1997), however, think that the Central Asian material is different from that of the US Western Interior; Dr W. A. Cobban (pers. comm.) agrees that the sutures are different.

Type. According to Khakimov (1976: 99, *in* Atabekian & Khakimov), the holotype is number 45/1168; however, none of their figured specimens bears this number.

Occurrence. Lower Campanian, Central Asia; ?Middle Campanian, U.S. Western Interior; ?Campanian, Belgium.

* ***Baculites codyensis*** Reeside, 1927 Figs 113–117

Reeside 1927*a*: 4, pl. 2 (figs 6–19). Reeside 1927*b*: 13, pl. 10 (figs 9–12), pl. 11 (figs 5–16) (as *B. asper*). Reeside 1927*a*: 4 ,pl. 1 (figs 19–24), pl. 2 (figs 1–5) (as *B. asper*). Warren 1930: 64, pl. 5 (figs 5–8), 10, 13) (as *B. albertensis*). Warren 1930: 65, pl. 5 (figs 3–4, 9, 14) (as *B. borealis*). Warren 1930: 65, pl. 5 (figs 1–2, 11–12) (as *B. trifidilobatus*). Cobban 1955: 204, pl. 2 (fig. 2). Scott & Cobban 1964, pl. 5 (fig. 4), pl. 7 (figs 3–4). Scott & Cobban 1964, pl. 3 (fig. 5), pl. 5 (fig. 3), pl. 7 (figs 5–6) (as *B. asper*). Birkelund 1965: 52, pl. 6 (figs 3–5), pl. 7 (fig. 1), text-figs 42–45. Cobban 1976: 4, pl. 2 (figs 6–19). Kennedy & Cobban 1976, pl. 2 (fig. 1). Kennedy 1977, text-fig. 17.3–17.4. Kennedy 1977, text-fig. 17.5–17.6 (as *B. asper*). Kauffman 1977: 268, pl. 28 (fig. 7). Scott *et al.* 1986, figs 12d, 13f. Kennedy & Cobban 1991*a*: 72, pl. 15 (figs 1–30), pl. 16 (figs 1–13), pl. 17 (figs 1–8), text-fig. 25f.

Type. Holotype is the original of Reeside (1927*a*, pl. 2 (figs 6–10)) from the Coniacian Cody Shale, Park County, Wyoming. YPB 6408.

Occurrence. Middle Coniacian to Middle Santonian, predominantly in the western half of the US Western Interior, from north-western Alberta in the north to central New Mexico in the south, Middle Santonian, West Greenland.

Baculites collignoni Klinger & Kennedy, 1997

B. leopoliensis Collignon *non* Nowak in Collignon (1970: 10, pl. 610 (figs 2277–2278)) (= *?B. increscens*)

Klinger & Kennedy 1997, fig. 86.

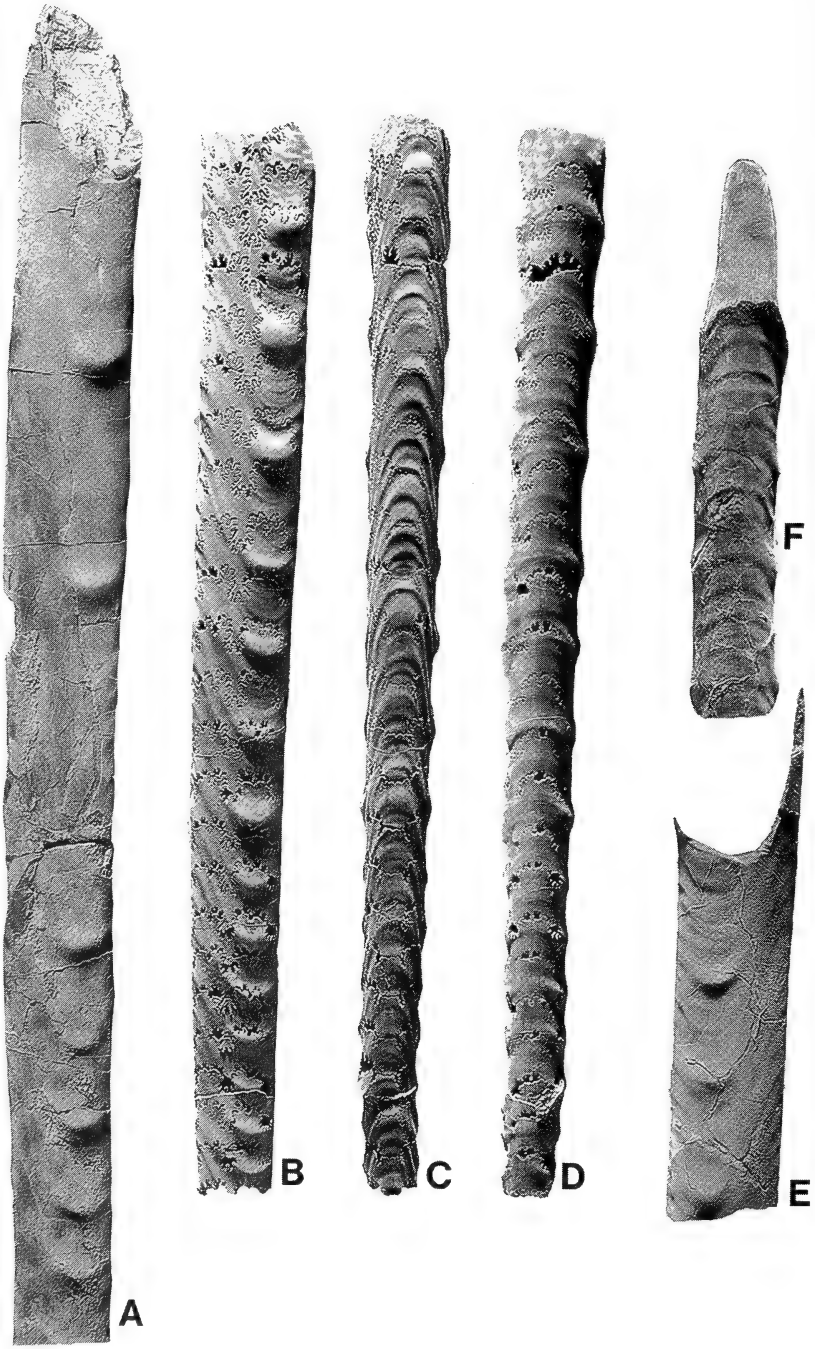

Fig. 113

Type. Holotype is the original of Collignon (1970, pl. 610 (fig. 2277)) from the Middle Campanian of Gisement 156, Coupe d'Ankilizato (Belo sur Tsiribihina), Madagascar, GD 12277.

Occurrence. Middle Campanian, Madagascar.

Baculites columna Morton, 1834
= *Trachybaculites columna* (Morton, 1834).

Baculites complex Say
Matsumoto 1959: 112. (= *?lapsus B. compressus*).

*****Baculites compressus*** Say, 1821 Fig. 118
Say, 1821: 41. Morton 1834: 43, pl. 9 (fig. 1). Meek 1876: 400, pl. 20 (fig. 3a–c), text-figs 55–56. Brown 1892, pl. 9 (figs 1–11). Johnson 1905: 26. Dowling 1917: 31, pl. 30 (fig. 1). *non* Reeside 1927*b*: 10, pl. 9

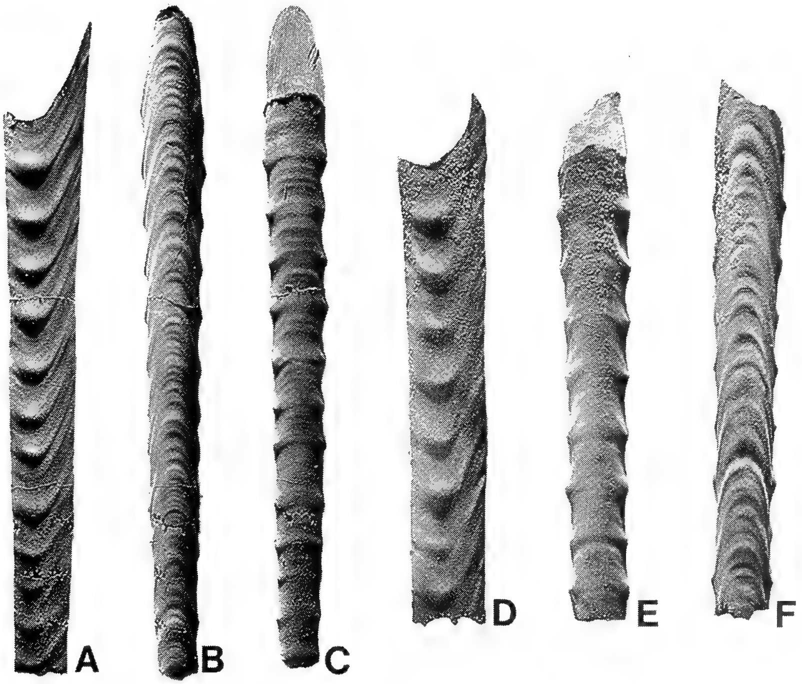

Fig. 114. *Baculites codyensis* Reeside, 1927*a*. A–C. USNM 433895. D–F. USNM 433896, both from the Coniacian, USGS Mesozoic locality 21097, of the Cody Shale, shore of Ray Lake, Fremont County, Wyoming. Both × 1.

Fig. 113 *(see facing page)*. *Baculites codyensis* Reeside, 1927*a*. A. USNM 433886 from the Coniacian, USGS Mesozoic locality D3797, of the Cody Shale, Oregon Basin, Park County, Wyoming. B–D. USNM 433984 from the Coniacian, USGS Mesozoic locality 21097, of the Cody Shale, shore of Ray Lake, Fremont County, Wyoming. E–F. USNM 433890 from the Coniacian, USGS Mesozoic locality D1655, of the Cody Shale, Hot Springs County, Wyoming. All × 1.

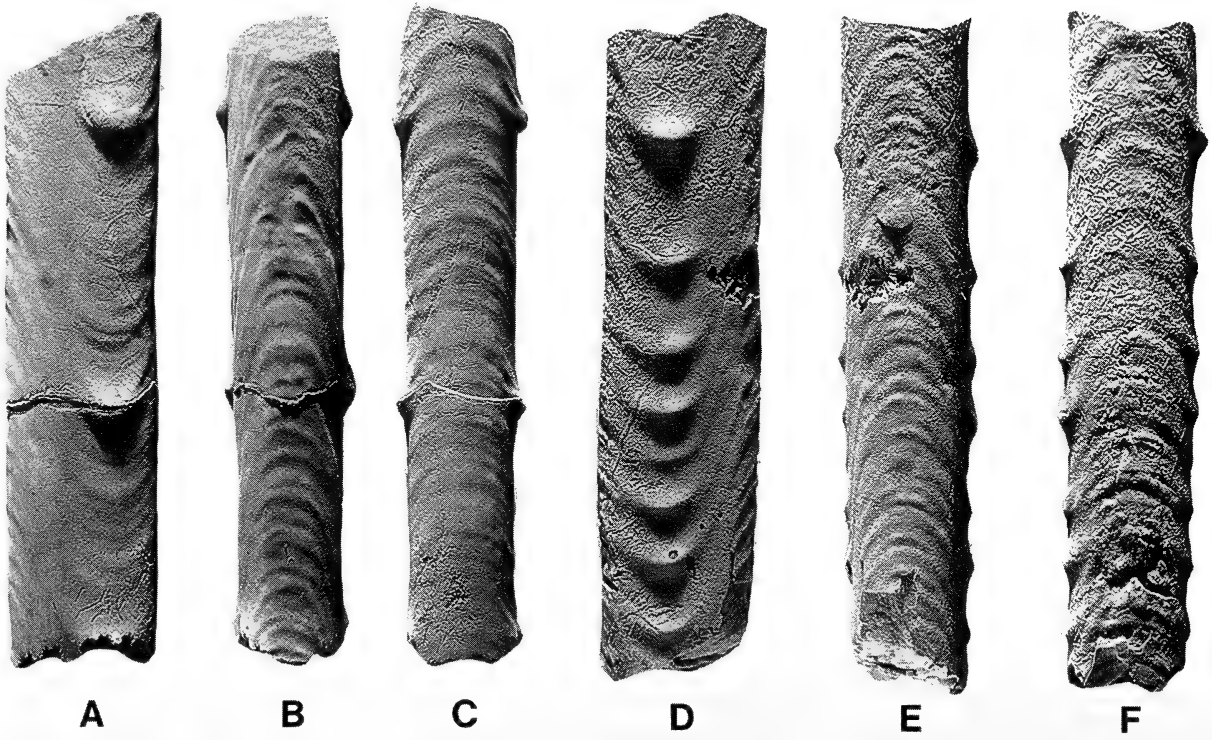

Fig. 115. *Baculites codyensis* Reeside, 1927*a*. A–C. USNM 433897. D–F. USNM 433899. Both from the Coniacian, USGS Mesozoic locality 17956, of the Cody Shale, Park County, Wyoming. Both × 1.

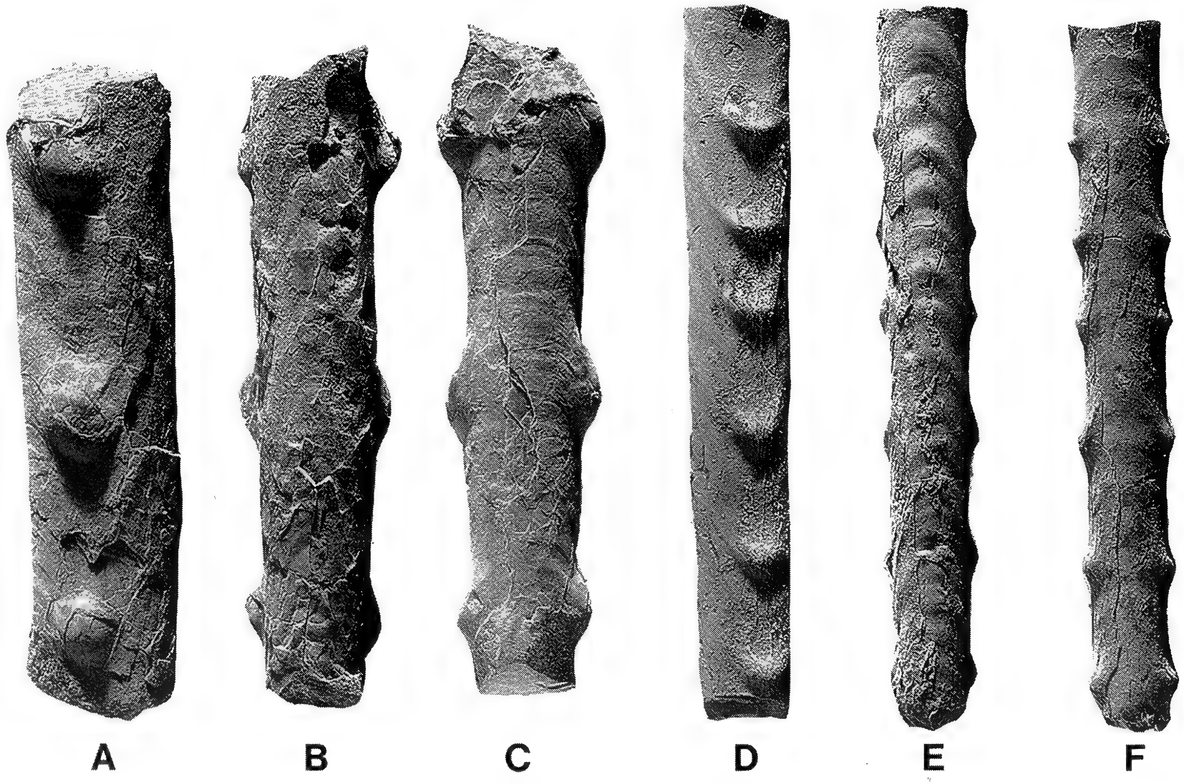

Fig. 116. *Baculites codyensis* Reeside, 1927*a*. A–C. USNM 433898 from the Coniacian, USGS Mesozoic locality 17954, of the Cody Shale, Park County, Wyoming. D–F. USNM 433900 from the Coniacian of USGS Mesozoic locality D940, of the Marias River Shale, Glacier County, Montana. Both × 1.

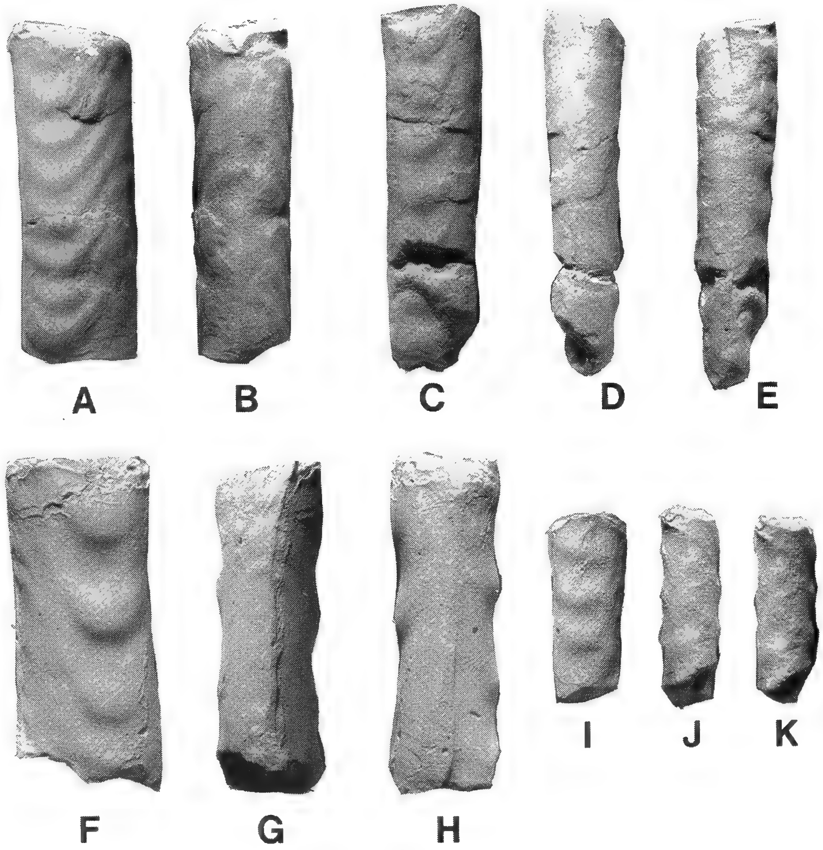

Fig. 117. *Baculites codyensis* Reeside, 1927*a*. A–C. GMUA Ct465, a specimen labelled as '*Baculites borealis*, topotype used as cotype' from the Middle Coniacian to Middle Santonian of the Smoky River Shale, Little Smoky River, Alberta, Canada. D–E. GMUA Ct459, labelled 'topotype, *Baculites albertensis* Warren' from the same locality. F–H. GMUA Ct448, data as for D–E. I–K. GMUA Ct464, specimen labelled '*Baculites trifidilobatus* topotype used as cotype'. Locality as for A–C.
All × 1.

(figs 1–5) (= *B. compressus robinsoni*, W. A. Cobban pers. comm.). Warren 1931, pl. 2 (figs 1–2). Elias 1933: 299. Elias 1933: 300, pl. 28 (fig. 4), pl. 32 (figs 3a–b, 4a–c, 5a–b). Landes 1940: 172. Gill & Cobban 1973: 10, fig. 2n. Nelson 1975, pl. 65 (figs 3–4). Cobban *et al.* 1992: A7, pl. 2 (figs 1–12), pl. 3 (fig. 1) (with complete synonymy). Larson *et al.* 1997: 29.

Type. According to Elias (1933: 294) and Landes (1940: 172) the types are lost. Neotype designation is desirable.

Occurrence. Upper Campanian, US Western Interior.

Baculites compressus* var. *corrugatus Elias, 1933
(= *B. corrugatus* Elias, 1933)

Elias 1933: 303, pl. 28 (fig. 3), pl. 30 (fig. 3), pl. 32 (fig. 1a–c).

Baculites compressus* var. *ornatus Robinson, 1945
(= *B. compressus robinsoni* Cobban, 1962*a*)

Robinson 1945: 51, pl. 1 (figs 1–4). Cobban 1962*a*: 128.

Baculites compressus* var. *reesidei Elias, 1933
(= *B. reesidei* Elias)

Elias 1933: 302, pl. 28 (fig. 1), pl. 31 (fig. 3), pl. 32 (fig. 2a–c), pl. 33 (figs 1a–c, 2a–c).

* ***Baculites compressus robinsoni*** Cobban, 1962*a* Fig. 119

Robinson 1945: 51, pl. 1 (figs 1–4) (as *B. compressus* var. *ornatus*). Cobban 1962*a*: 128 *nom. nov.* Larson *et al.* 1997: 30 (as var. *robinsoni*). Jerzykiewicz 1996: 99 (fig. 2).

Type. Holotype is the original of Robinson (1945, pl. 1 (figs 1–2)), from the Bearpaw Formation of southern Saskatchewan, Canada, GSC 9070.

Occurrence. Upper Campanian, Canada (Alberta), US Western Interior (Montana, South Dakota).

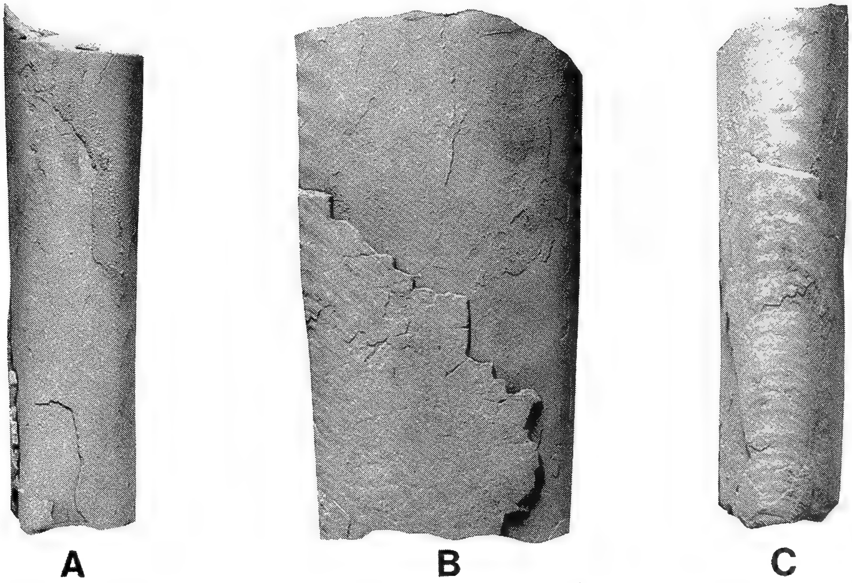

Fig. 118. *Baculites compressus compressus* Say, 1821. USNM 507277, from USGS Mesozoic locality 23349, Pierre Shale, near Wasta, South Dakota. × 1.

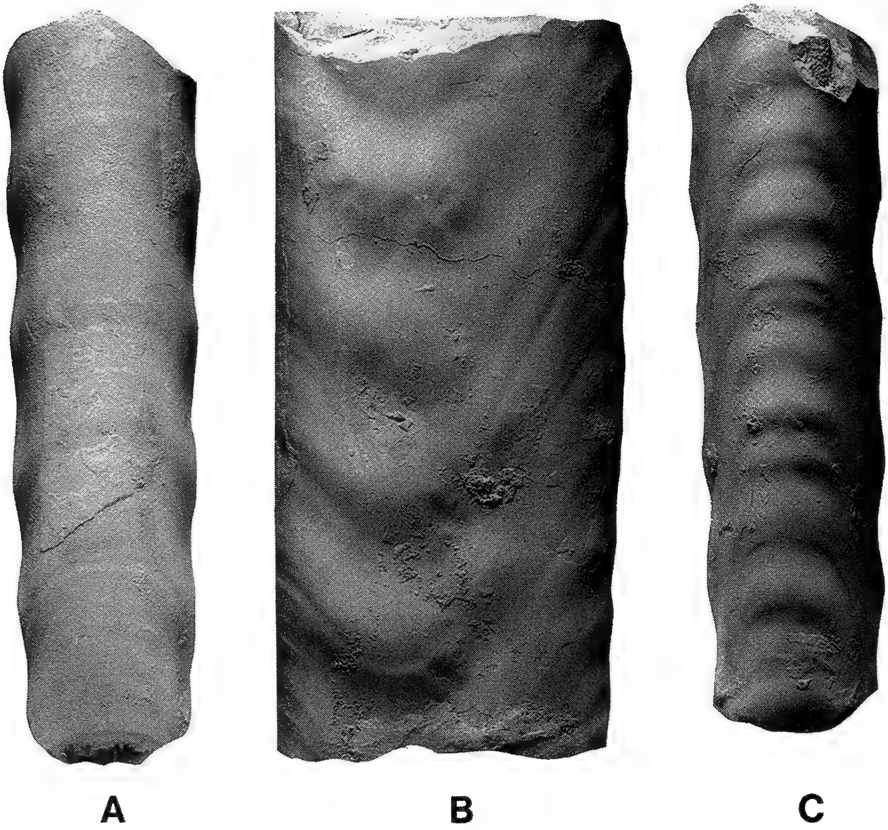

Fig. 119. *Baculites compressus robinsoni* Cobban, 1962*a*. USNM 507278, from USGS Mesozoic locality D4133, Bearpaw Shale, near Lavina, Montana. × 1.

* ***Baculites corrugatus*** Elias, 1933 Figs 120–121

Elias 1933: 303, pl. 28 (fig. 3), pl. 30 (fig. 3), pl. 32 (fig. 1) (as *B. compressus* var. *corrugatus*). Cobban 1962*a*: 134. Larson *et al.* 1997: 28.

Type. Holotype is the original of Elias (1933, pl. 28 (fig. 3)), from the Campanian Lake Creek Shale Member, Pierre Shale, Wallace County, Kansas. GMUK 50164.

Occurrence. Upper Campanian, US Western Interior.

Baculites crickmayi Williams, 1930

Williams 1930: 3, pl. 1 (fig. 1), pl. 2 (figs 1–3). Landes 1940: 173; Kennedy & Cobban 1993*a*: 95, figs 10.10, 10.13–10.15, 10.17, 10.20–10.27; 12.5. Larson *et al.* 1997: 27.

Type. Lectotype here designated is the original of Williams (1930, pl. 1, pl. 2 (figs 1–3)) from the Upper Campanian, Bearpaw Formation of Alberta. No repository data were given.

Fig. 120. *Baculites corrugatus* Elias, 1933. OUM KT7445, from the Pierre Shale, *Didymoceras cheyennense* zone, Upper Campanian, Indian Creek in SW¼ sec. 22, R. 12 E., T. 3 S, Pennington County, South Dakota. × 1.

Occurrence. Upper Campanian, Bearpaw Formation, Alberta, Canada, Campanian, US Western Interior (Arkansas, Montana, Wyoming and Colorado).

* ***Baculites cuneatus*** Cobban, 1962*a* Fig. 122

Meek 1876, text-figs 55–56 (as *B. compressus*). Warren 1930, pl. 2 (figs 1–2) (as *B. compressus*). Cobban 1962*a*: 127, pl. 25 (figs 1–8), text-fig. 1b. Scott & Cobban 1965: 2, map I–439. Gill & Cobban 1973: 10, fig. 2o. Riccardi 1983, pl. 25 (figs 1–3). Larson *et al.* 1997: 31.

Fig. 121. *Baculites corrugatus* Elias, 1933. KU 1566A1, the holotype, from upper part of Lake Creek Shale Member, Pierre Formation, NW¼ SW¼ sec. 5, T. 15 S., R. 41 W., Wallace County, Kansas. × 1.

Type. Holotype is the original of Cobban (1962*a*, pl. 25 (figs 6–8)) from the Upper Campanian, near Hardin, Montana, USNM 108966.

Occurrence. Upper Campanian, US Western Interior (Montana, South Dakota, Colorado, Kansas, Wyoming), Canada (Alberta, Saskatchewan).

Baculites delvallei Riccardi, 1980

Riccardi 1980: 324, pl. 1 (figs 1–2), text-fig. 1.

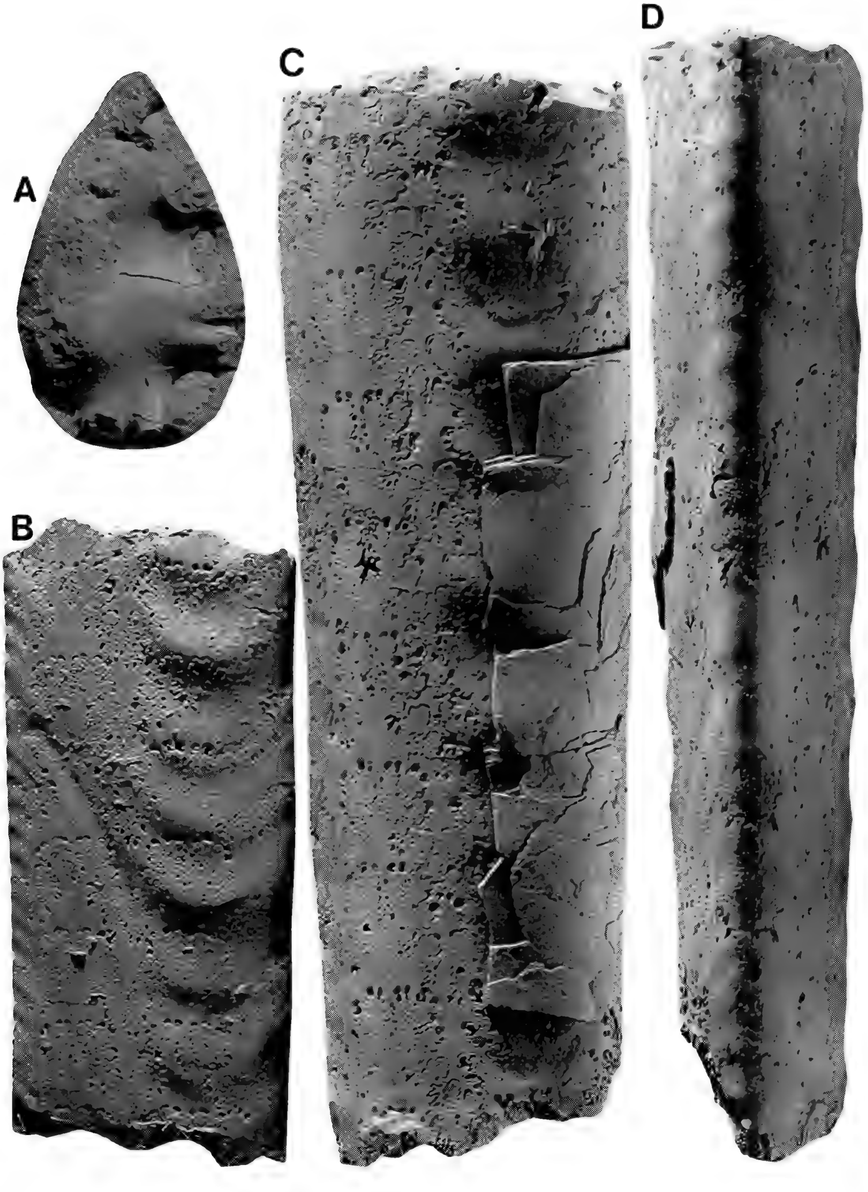

Fig. 122. *Baculites cuneatus* Cobban, 1962*a*. A, C–D. USNM 108966, the holotype. B. USNM 108967a, paratype. Both from the Upper Campanian *Baculites cuneatus* zone of the Bearpaw Shale, from USGS Mesozoic locality 21363 near Hardin, Montana. Copy of Cobban (1962*a*, pl. 25 (figs 4, 6–8)). Both × 1.

Type. Holotype by monotypy is the original of Riccardi (1980, pl. 1 (figs 1–2), text-fig. 1) from the Upper Santonian or Lower Campanian of Seymour (Vicecomodoro Marambio) Island, Antarctica. MLP 12248.

Occurrence. Upper Santonian–Lower Campanian, Seymour Island, Antarctica.

Baculites dissimilis Desmarest, 1817

Desmarest 1817: 49, pl. 2 (figs 4–6) (= *B. vertebralis fide* Kennedy 1986*c*: 187).

Baculites distans De Grossouvre, 1901

De Grossouvre 1901, table 35 (in zone of *Pachydiscus neubergicus*) (= *nom. nud.* fide Kennedy 1986*b*: 112).

Baculites duharti Hünicken, 1975

Hünicken (*in* Hünicken *et al.*) 1975: 116, pl. 1 (figs 1–4), pl. 2 (figs 1–2), pl. 3 (figs 5–8), text-figs 2a–d, 3a–c, 4–5. Hünicken *et al.* 1980: 224, pl. 1 (figs 1–2), pl. 2 (figs 1–6), text-figs 3–9. Klinger & Kennedy 1997: 178, figs 80c–d, 117e, 121–127.

Type. Holotype is the original of Hünicken (1975, pl. 1 (figs 1–4), text-figs 2c–d, 4) from the Middle–Upper Campanian Cerro Matero Formation, at Rio Sur, at the confluence with the Rio Condor, Chile. UCS D–1127.

Occurrence. Middle–Upper Campanian, southern Chile, Middle Campanian, Zululand.

* ***Baculites eliasi*** Cobban, 1958 Fig. 123

Elias 1933: 306, pl. 28 (fig. 2), pl. 33 (fig. 5a–b) (as *B. pseudovatus* Elias var. A.). Cobban 1958: 663, pl. 91 (figs 1–11), text-figs 1f–g, i–j. Scott & Cobban 1965: 3, map I–439. Gill & Cobban 1973: 10, fig. 2r. Kennedy & Cobban 1976, pl. 6 (fig. 3). Riccardi 1983, pl. 25 (figs 4–6). Larson *et al.* 1997: 33.

Type. Holotype is the original of Cobban (1958, pl. 91 (figs 9–11), text-fig. 1i)) from the Lower Maastrichtian Bearpaw Shale, near Fort Peck, Montana, USNM 108969.

Occurrence. Lower Maastrichtian, US Western Interior (Montana, Wyoming, Colorado, South Dakota, Kansas and Nebraska) and Alberta and Saskatchewan, Canada.

Baculites embaensis Balan, 1982

Balan 1982: 210, pl. 19 (fig. 4).

Type. Holotype is the original of Balan (1982, pl. 19 (fig. 4)) from the Upper Turonian of Kazakstan. PIN 3766/18.

Occurrence. Upper Turonian, Kazakstan.

Fig. 123 *(see facing page)*. ***Baculites eliasi*** Cobban, 1958. A–B, F. USNM 108972, paratype from the Bearpaw Shale, 1.7 miles north of Oswego, Montana. C–E. USNM 108969, the holotype from the Bearpaw Shale, near Fort Peck, Montana. Copy of Cobban (1958, pl. 91 (figs 4–6, 9–11)). Both × 1.

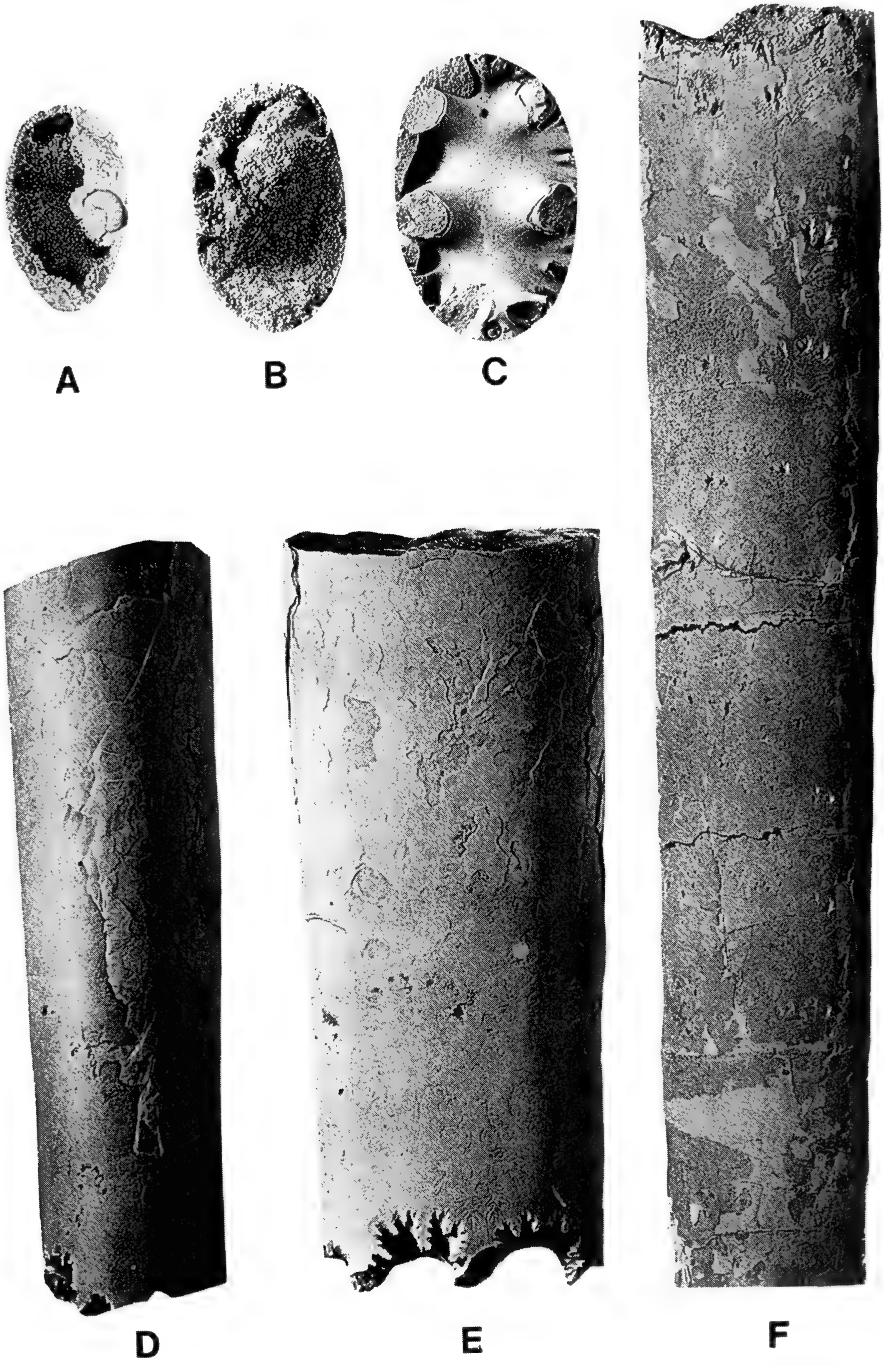

Fig. 123

Baculites fairbanksi Anderson, 1902

(= uninterpretable *fide* Matsumoto 1959: 135, Howarth 1965: 370)

Anderson, 1902: 92, pl. 7 (figs 152–153), pl. 10 (fig. 194). Anderson 1958: 190, pl. 48 (fig. 4), pl. 49 (fig. 4).

Type. Anderson did not designate a type in his original (1902): 92) description. Anderson (1958: 190) referred to the largest specimen as the 'holotype'—this may be taken as lectotype designation. The lectotype was recorded from Silverado Canyon, Orange County and dated as Turonian in the plate description. UCLA collections.

Occurrence. The lectotype was dated as Turonian, another specimen (1958, pl. 49 (fig. 4, 4a) as Coniacian, in the text (1958: 190) it is recorded as being associated with *Metaplacenticeras pacificum*, which would date it as late Campanian.

Baculites fairbanksi germanicum Lommerzheim, 1976

(probably a *Sciponoceras*)

Lommerzheim 1976: 222, pl. 1 (fig. 1a–c), text-fig. 5.

Type. Holotype is the original of Lommerzheim (1976, pl. 1 (fig. 1b), text-fig. 5b, d) from the Turonian of the Becker Brickworks, Mülheim-Broich, Westphalia, Germany, Collection Klauman, CTB 1.

Occurrence. Turonian, northern Germany.

Baculites falcatus Collignon, 1969

(= *B. menabensis*)

Collignon 1969: 20, pl. 520 (figs 2045–2047). Klinger & Kennedy 1997: 94, figs 58a–c, 61b.

Type. Holotype is the original of Collignon (1969, pl. 520 (fig. 2045)) from the Lower Campanian, Gisement 303, Coupe Ampolypoly-Antsirasira-Behamotra (Belo sur Tsiribihina), Madagascar, GD 12045.

Occurrence. Lower Campanian, Madagascar.

Baculites faujasii Lamarck, 1822

(= *B. vertebralis* Lamarck, 1801, *fide* Schlüter 1876: 143; Kennedy 1986*a*: 57)

Lamarck, 1822: 647. Favre 1869: 29.

Baculites fuchsi Redtenbacher, 1873

Redtenbacher 1873: 134, pl. 30 (fig. 15). Summesberger 1979: 113, pl. 1 (figs 2–4), text-figs 2–3. Summesberger 1979: 115, pl. 1 (figs 5–7), text-fig. 4 (as *B.* cf. *fuchsi*). Immel *et al.* 1982: 28, pl. 11 (fig. 8). Immel 1987: 129. Kennedy & Christensen 1991: 217, pl. 7 (fig. 1a–b) (as *B.* cf. *fuchsi*). Santamaria Zabala 1991: 269, pl. 18 (fig. 9), 1992: 239.

Type. Holotype by monotypy is the original of Redtenbacher (1873, pl. 30 (fig. 15)) from the Santonian of the Gosau Beds at Tiefengraben, Austria, NHMW 1865/I/138.

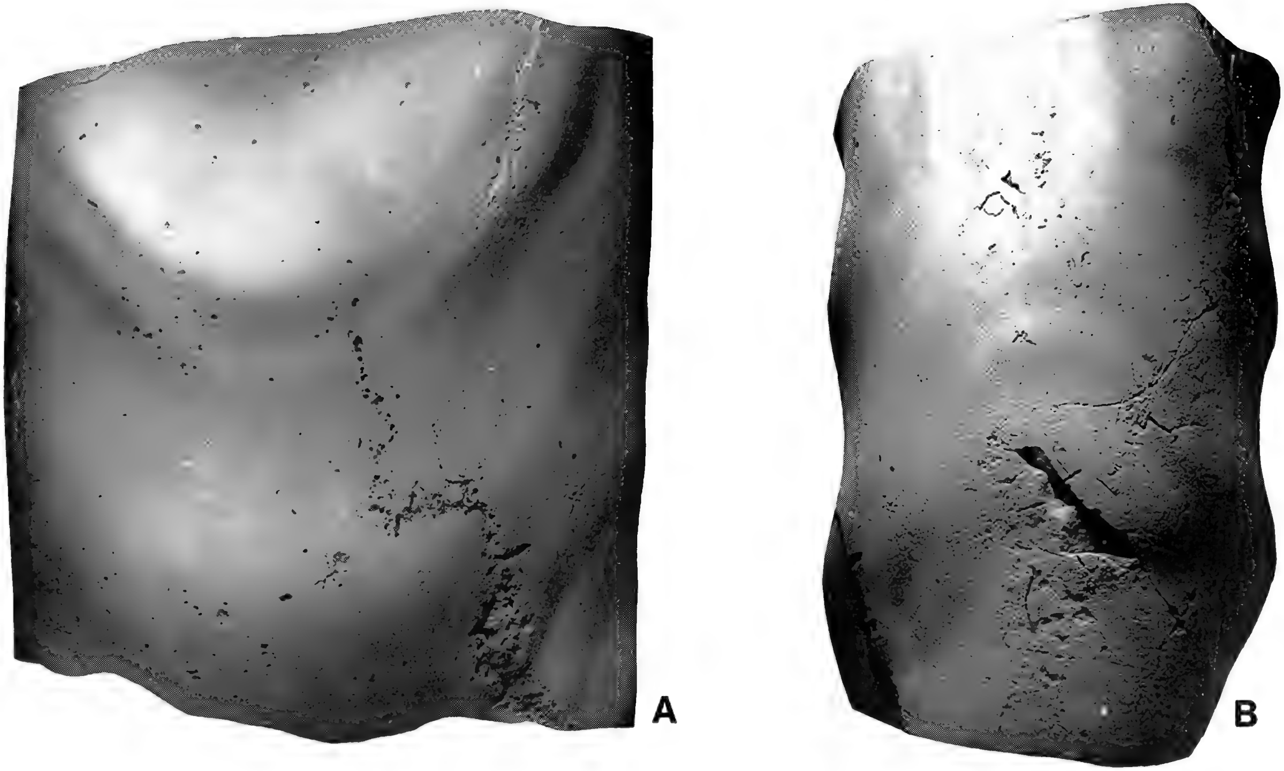

Fig. 124. *Baculites grandis* Meek, 1876. OUM KT7158, from the Pierre Shale, Lower Maastrichtian *Baculites grandis* zone, USGS Mesozoic locality D11783, in SE¼ NW¼ sec. 17, T. 48 N., R. 64 W., Weston County (Newcastle Quadrangle), Wyoming. × 1.

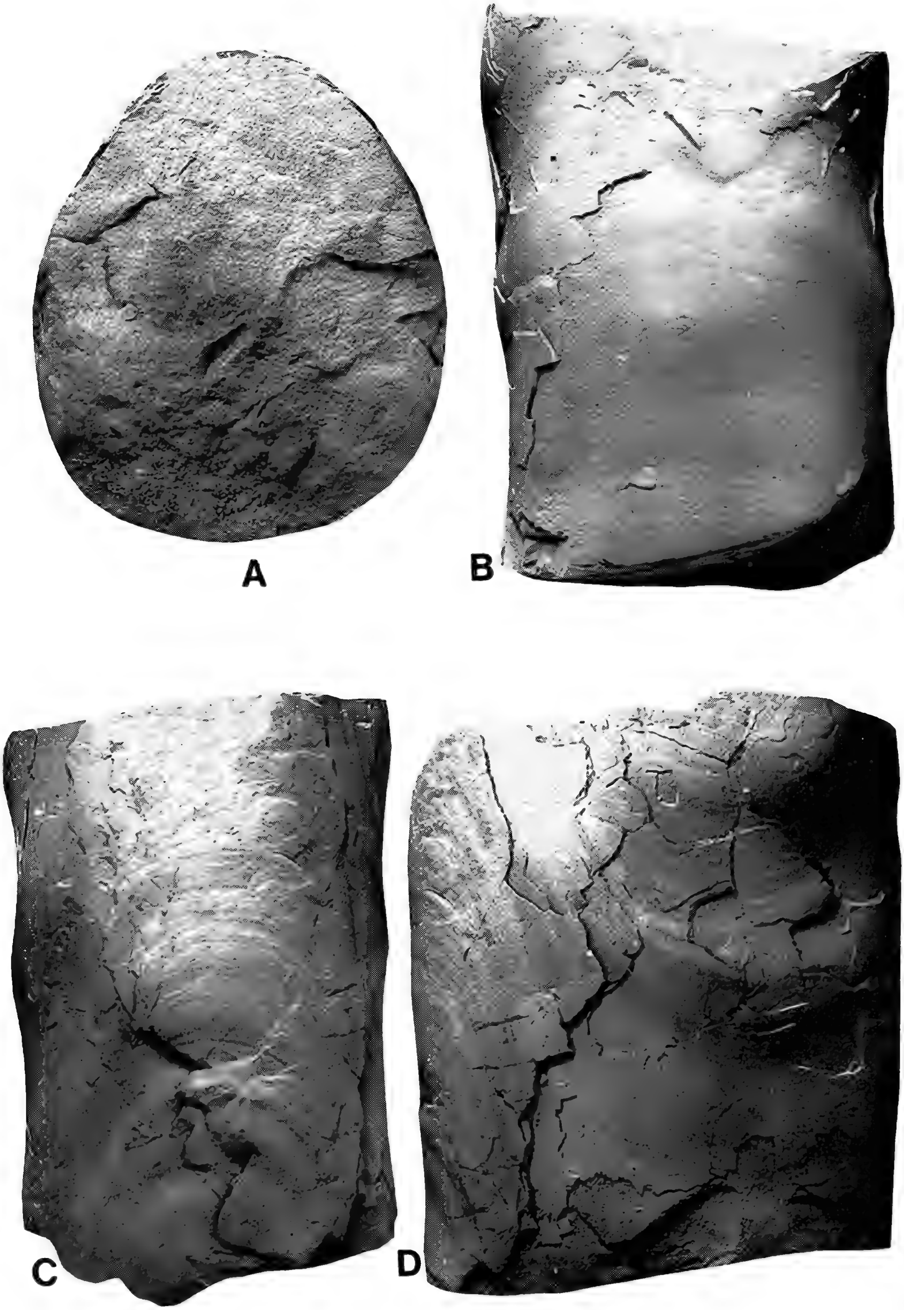

Fig. 125. *Baculites grandis* Meek, 1876. OUM KT7201, from the Pierre Shale, Lower Maastrichtian *Baculites grandis* zone, USGS Mesozoic locality D11783, in SE¼ sec. 17, T. 48 N., R. 64 W., Weston County (Newcastle Quadrangle), Wyoming. × 1.

Occurrence. Lower to Upper Santonian, Austria and Spain.

* ***Baculites furcillatus*** Blanckenhorn?, 1905 Fig. 194A–C
(= ?*Trachybaculites*)

Taubenhaus 1920: 10, pl. 6 (fig. 2). (According to Picard (1929: 441), possibly only a more strongly ribbed form of *B. palestinensis*.)

Type. Lectotype here designated is the original of Taubenhaus (1920, pl. 6 (fig. 2)) from West of Es-Salt, Palestine, Upper Campanian. Blanckenhorn's material was originally deposited in Breslau (Wrocław) in the care of Frech (see Taubenhaus 1920: 2). The material appears lost, and neotype designation may be desirable.

Occurrence. Upper Campanian, Israel.

Baculites gallischi Fritsch, 1897
(= indeterminable *fide* Diener 1925: 60)

Fritsch 1897: 40.

Baculites gigantea Desmarest, 1817
(= *Diplomoceras cylindraceum* Defrance) (*fide* Schlüter 1876: 148 footnote; also Kennedy 1986*c*: 181)

Baculites gigas Sinzow, 1888
(= ?*B. claviformis* fide Cobban 1974: 8)

Sinzow 1888: 126.

* ***Baculites gilberti*** Cobban, 1962*b* Fig. 126

Cobban 1962*b*: 716, pl. 108 (figs 5–13), text-fig. 1d–f. Gill & Cobban 1973: 8, fig. 3a. Larson *et al.* 1997: 24.

Type. Holotype is the original of Cobban (1962*b*, pl. 108 (figs 11–13)) from the Middle Campanian Pierre Shale, just below Hygiene Member, north of Boulder, Colorado, USNM 108911.

Occurrence. Middle Campanian, US Western Interior (Colorado, Wyoming, South Dakota).

* ***Baculites grandis*** Hall & Meek, 1854 Figs 124–125

Hall & Meek 1854: 402, pl. 6 (fig. 10), pl. 7 (figs 1–2), pl. 8 (figs 1–2). Meek 1876: 398, pl. 33 (fig. 1a–c), text-figs 53–54. Wade 1926: 182, pl. 60 (figs 8, 12). Elias 1933: 307, pl. 31 (figs 1a–b, 2a–b), pl. 34 (figs 4, 5a–c). Scott & Cobban 1965: 3, map I–439. Gill & Cobban 1973: 10, fig. 7b. Larson *et al.* 1997: 35.

Type. ?

Occurrence. Maastrichtian, US Western Interior (Colorado, Wyoming, Montana, Nebraska, South Dakota).

* ***Baculites gregoryensis*** Cobban, 1951 Fig. 127

Cobban 1951: 820, pl. 118 (figs 1–5), text-figs 8–13. Scott & Cobban 1965: 2, map I–439. Gill & Cobban 1973: 7, figs 2l, 3b. Larson *et al.* 1997: 25.

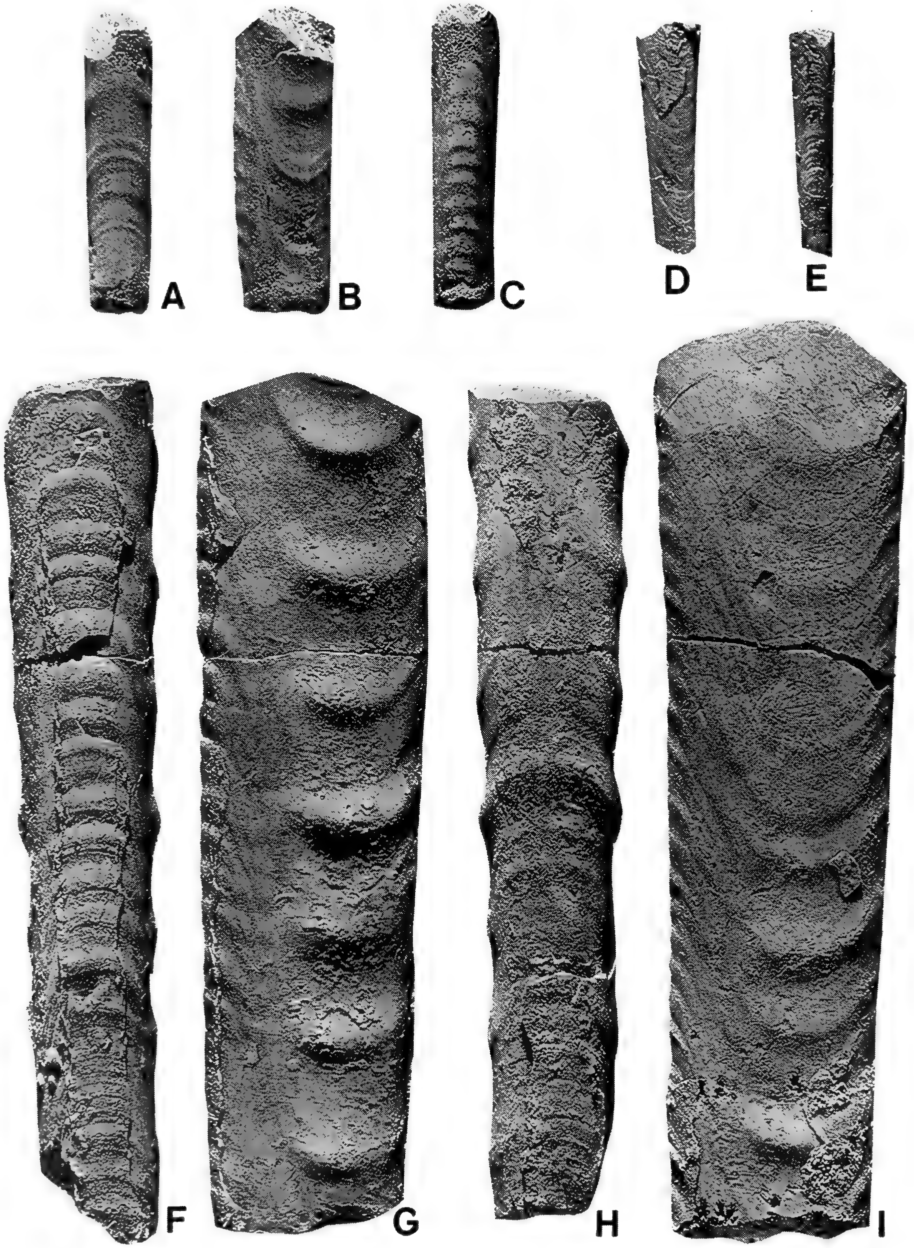

Fig. 126. *Baculites gilberti* Cobban, 1962*b*. A–C. USNM 108912b, paratype. D–E. USNM 108912a, paratype. F–H. USNM 108911, the holotype. I. USNM 108912c, paratype. All from the Pierre Shale just below the Hygiene Member at USGS Mesozoic locality D236, north of Boulder, Colorado. Copy of Cobban (1962*b*, pl. 108 (figs 5–13)). All × 1.

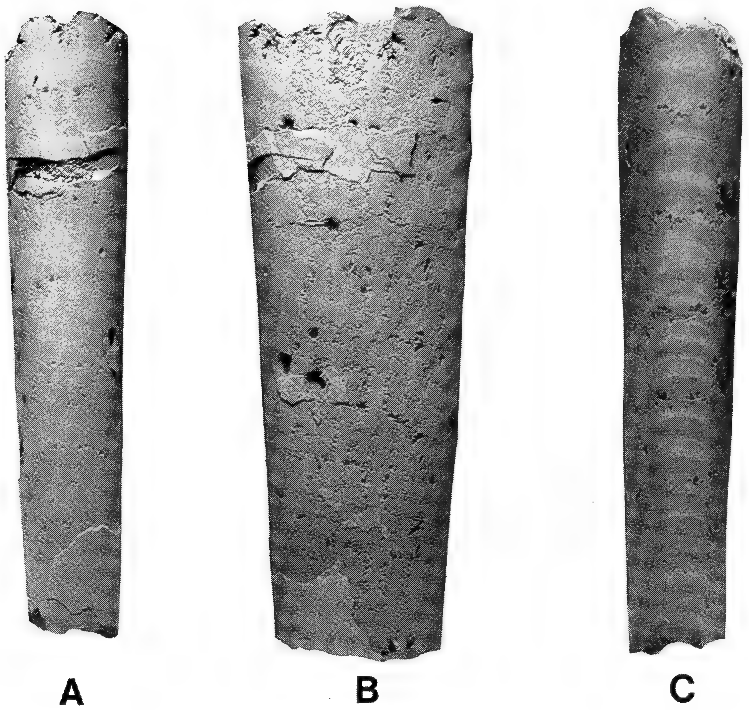

Fig. 127. *Baculites gregoryensis* Cobban, 1951. USNM 507279. From the Pierre Shale near Fort Thompson, South Dakota. × 1.

Type. Holotype is the original of Cobban (1951, pl. 118 (fig. 1), text-figs 12–13), from the Middle Campanian Gregory Member of the Pierre Shale, west of Oacama, Lyman County, South Dakota, USNM 106987.

Occurrence. Middle Campanian, US Western Interior (Montana, Wyoming, South Dakota, Colorado, New Mexico).

* ***Baculites haresi*** Reeside, 1927 Fig. 97B–D

Reeside 1927*b*: 10, pl. 6 (figs 5–10), pl. 7 (figs 9–10) (as *B. ovatus* var. *haresi*). Elias 1933: 298, pl. 35 (figs 3a–b, 4a–b) (as *B. ovatus* var. *haresi*). Landes 1940: 170. ?Birkelund 1965: 56, pl. 7 (fig. 2), text-fig. 46 (as *B.* cf. *haresi*). Cobban & Kennedy 1992*b*: 449, figs 6.5–6.8, 6.11–6.13, 6.16–6.24, 7.1. Kennedy & Cobban 1993*e*: 844, figs 14.18–14.35, 14.37, 15.2, 16.1–16.6. Larson *et al.* 1997: 20.

Type. Lectotype by subsequent designation of Cobban & Kennedy (1992*b*: 449) is the original of Reeside (1927*b*, pl. 6 (figs 5–6)), from the Lower Campanian, Elk Basin Sandstone Member of the Telegraph Creek Formation, Carbon County, Montana, USNM 73296.

Occurrence. Widely distributed in the Lower Campanian, US Western Interior (Montana, Wyoming, Utah, New Mexico, Kansas, South Dakota);

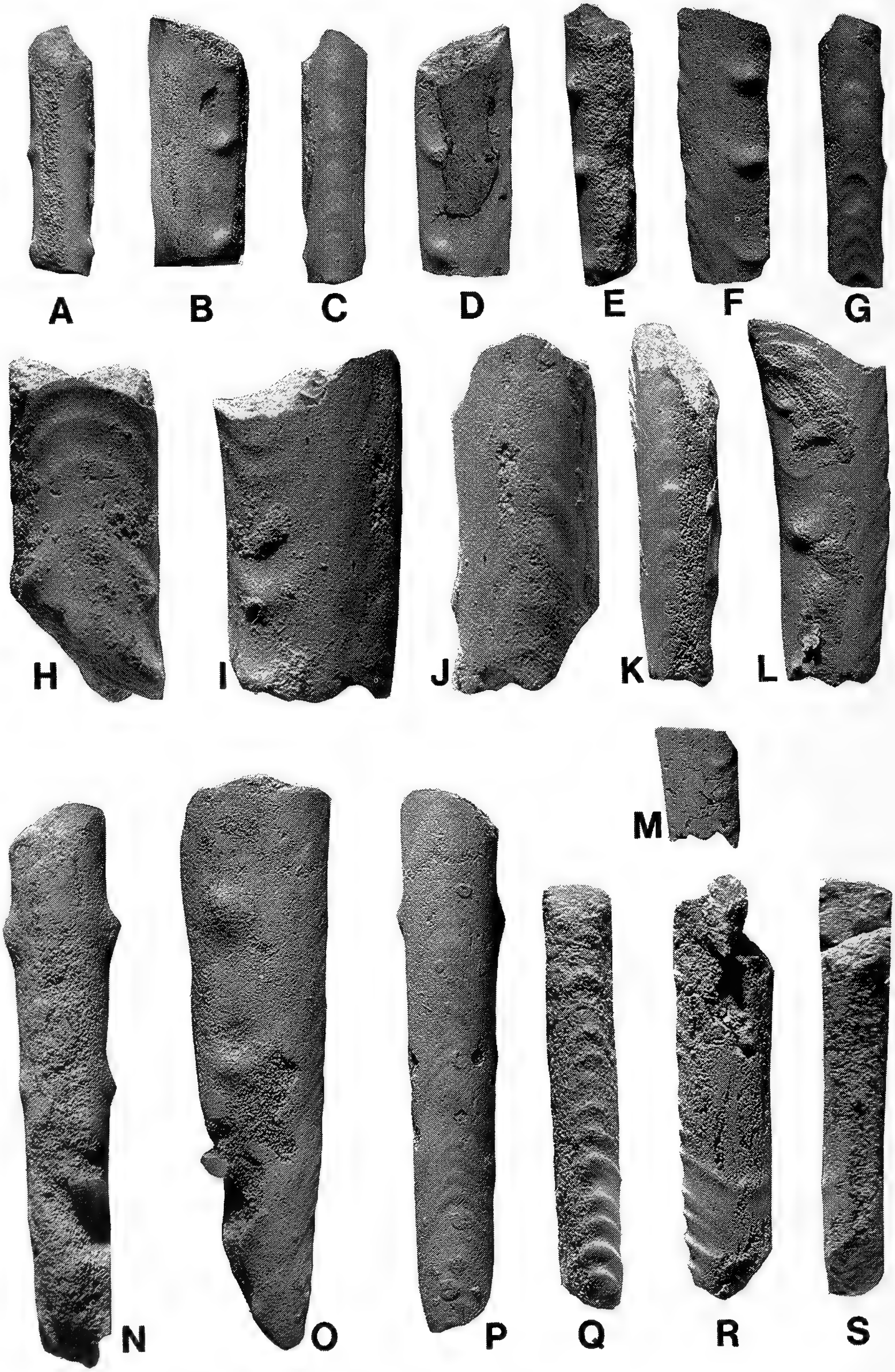

Fig. 128

Gober Chalk of Texas, U.S. Atlantic Seaboard (New Jersey),and possibly West Greenland.

Baculites hochstetteri Liebus, 1902

Liebus 1902: 119 [7], pl. 6 (figs 4–6). Nowak 1908: 331, fig. 11. *non* ?Naidin 1974: 164, pl. 53 (figs 6–7), text-figs 22.6–7, 23.v (as *B. anceps hochstetteri*).

Type. Lectotype by subsequent designation of Matsumoto & Obata (1963: 63) is the original of Liebus (1902, pl. 6 (figs 5a, 6) text-fig. 2b) from the Senonian Friedekar Baculite Marls of the Silesian Carpathians. The types could not be located in Munich and are presumed destroyed during WW II (letter of Prof. H. Immel 25.5.1992).

Occurrence. Senonian, Galicia.

Baculites huenickeni Stinnesbeck, 1986

Stinnesbeck 1986: 201, pl. 8 (figs 7–8), pl. 9 (figs 1–2), text-fig. 24b–c.

Type. Holotype is the original of Stinnesbeck (1986, pl. 8 (fig. 7)), from the Maastrichtian of La Gloria, San Vicente near Talcahuano, Chile, GPIB VO/96.

Occurrence. Maastrichtian, southern Chile.

Baculites increscens Collignon, 1970

Collignon, 1970: 3, pl. 607 (figs 2266–2268), p. 5, pl. 608 (fig. 2269). Klinger & Kennedy 1997: 124, figs 79a–l, n–o, 80a–b, 82.

Type. Holotype is the original of Collignon (1970, pl. 607 (fig. 2266)) from the Middle Campanian, Gisement 177, Coupe d'Ankilizato (Belo sur Tsiribihina), Madagascar, GD12266.

Occurrence. Middle Campanian, Madagascar, Zululand, ?Israel.

* ***Baculites incurvatus*** Dujardin, 1837 Fig. 128A–P

Dujardin 1837: 232, pl. 17 (fig. 13a–d). D'Orbigny 1842: 564, pl. 139 (figs 8–10). D'Orbigny 1842: 565 (as *B. tuberculata*). Geinitz 1843: 9, pl. 1 (fig. 5). Fritsch & Schlönbach 1872: 51, pl. 13 (fig. 21). Schlüter 1876: 142, pl. 39 (figs 6–7), pl. 40 (fig. 3). *non* Moberg 1885: 36, pl. 4 (figs 2–4). *non* Holzapfel 1887: 64, pl. 4 (figs 5–6), pl. 5 (fig. 10). Wegner 1905: 206.

Fig. 128 *(see facing page)*. A–P. *Baculites incurvatus* Dujardin, 1837. A–D. MNHP R1052, paralectotype; locality as for K–L. E–G. MNHP R1044b, D'Orbigny collection no. 7208, the original of D'Orbigny (1842, pl. 139 (figs 8–10)) from Tours. H–J. OUM KZ16643, Upper Coniacian *Gauthiericeras margae* zone, 30–50 cm above the Calcaire Durs de la Ribochère of St Paterne-Racan (Indre-et-Loire). K–L. Lectotype, MNHP R1025a; the locality is simply given as Touraine. M. Paralectotype, MNHP R1025ci; locality as for K–L. N–P. MNHP R1044a, D'Orbigny collection no. 7208, the original of D'Orbigny (1842, pl. 139 (figs 8–10)), from 'Tours'. Q–S. *Baculites* cf. *B. brevicosta* Schlüter, 1876. OUM KZ17023, from the same locality and horizon as H–J. All × 1.

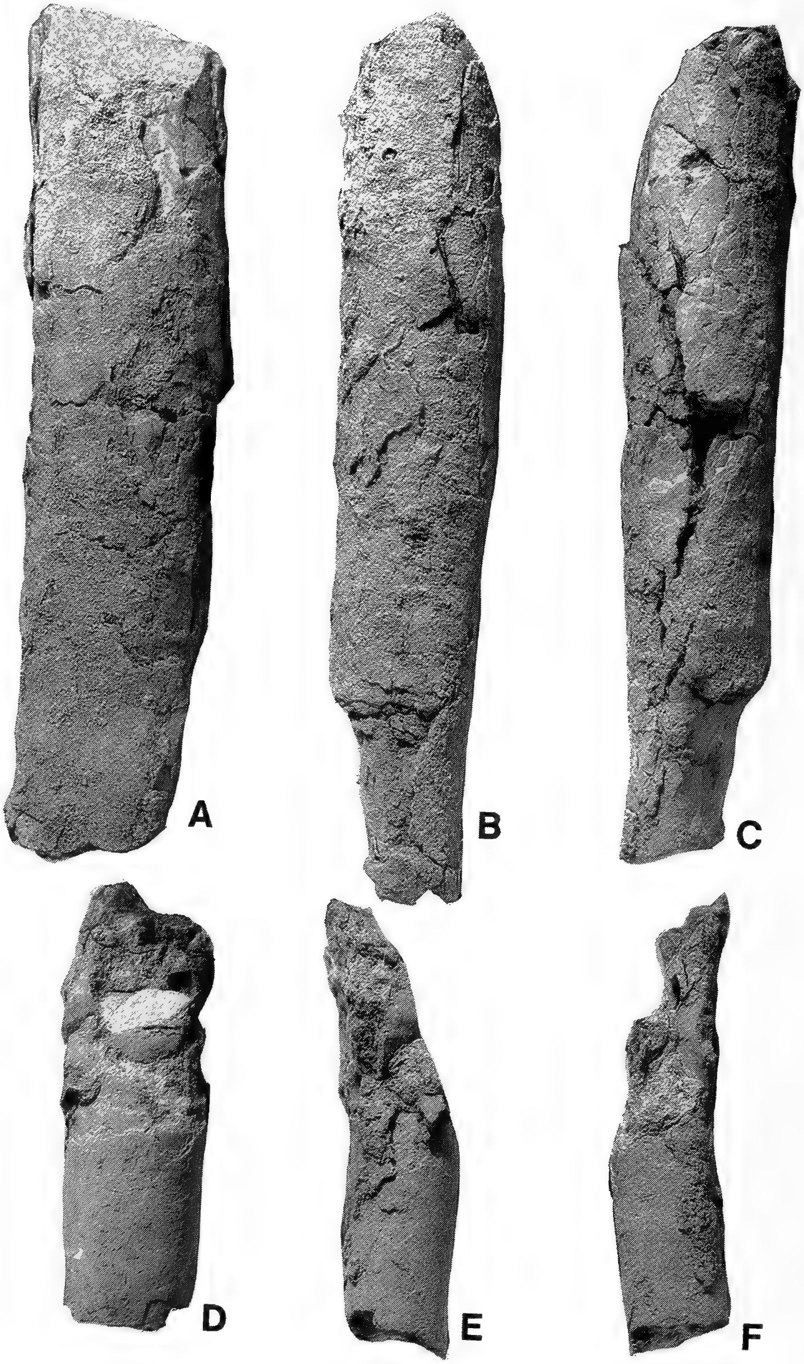

Fig. 129

non Müller & Wolleman 1906: 4, pl. 2 (figs 2–5). ?Scupin 1913: 102, pl. 3 (figs 1, 8). *non* Hägg 1930: 58. *non* Hägg 1935: 58. *non* Collignon 1938: 88, pl. 6 (figs 4–5). Wright 1957: L218, fig. 245.3. Immel *et al.* 1982: 27, pl. 11 (figs 5–7). Kennedy 1984: 143, pl. 32 (figs 12, 15–19), pl. 33 (figs 1–22), text-figs 41, 42f–m. Immel 1987: 128. ?Alizade *et al.* 1988: 378, pl. 27 (figs 2–5) (as *B. incervatus* [*sic.*]). Thomel 1988: 18. Kennedy & Christensen 1991: 217, pl. 1 (fig. 2a–b) (as *Baculites* cf. *incurvatus*). Santamaria Zabala 1991: 267, pl. 18 (fig. 8). Vašiček 1993: 182, pl. 3 (fig. 4), text-figs 10–11. Santamaria Zabala 1992: 238, pl. 2 (fig. 8). Klinger & Kennedy 1997, fig. 56.

Type. Lectotype by the subsequent designation of Immel *et al.* (1982: 27), is the original of Dujardin (1837, pl. 17 (fig. 13a)), imprecisely located as 'Craie Tufau', MNHP R1025a.

Occurrence. Middle Coniacian to Santonian France, Germany, Spain, Czechoslovakia, Austria, ?Sweden, ?Azerbaijan.

Baculites incurvatus Moberg, 1885 *non* Dujardin, 1837

Kennedy & Christensen 1997: 108, fig. 20c–e.

Occurrence. Upper Middle Santonian of Eriksdal, Sweden.

* ***Baculites inornatus*** Meek, 1862 Fig. 108G–I, 129

Meek, 1862: 316. Anderson & Hanna 1935: 24, pl. 8 (figs 1–2). Anderson 1958: 190, pl. 48 (figs 2–3). Matsumoto 1959: 155, pl. 38 (fig. 1a–c), pl. 43 (fig. 5a–c), text-figs 72a–b, 73a–d, 74–79. Obata & Matsumoto 1963: 78, pl. 22 (fig. 1), pl. 24 (fig. 6), pl. 26 (figs 4–6), text-figs 169–170, 187–190. Ward 1978: 1151, pl. 1 (figs 1–2), text-fig. 5. *non* Renz 1982: 105, pl. 34 (figs 3–6), text-fig. 80. Matsumoto & Miyauchi 1984: 72, pl. 25 (fig. 6), text-fig. 12. Morozumi 1985: 45. Haggart 1991, pl. 3 (fig. 3–4).

Type. Lectotype by the subsequent designation of Matsumoto (1959: 155), is one of Meek's unfigured syntypes, figured by Matsumoto (1959, pl. 43 (fig. 5a–c), text-fig. 72a–b) from Sucia Island, Washington, USNM 1259.

Occurrence. Middle to Upper Campanian, California, Baha California (Mexico), British Columbia and Washington State, and Lower Campanian of Honshu.

* ***Baculites jenseni*** Cobban, 1962*a* Figs 130–131

Cobban 1962*a*: 129, pl. 26 (figs 1–12), text-fig. 1a. Scott & Cobban 1965: 3, map I–439. Gill & Cobban 1973: 10, fig. 2q. Larson *et al.* 1997: 32.

Type. Holotype is the original of Cobban (1962*a*, pl. 26 (figs 1, 11–12)) from the Upper Campanian, upper part of the Bearpaw Formation, northeast of Melstone, Montana, USNM 131117.

Fig. 129 *(see facing page)*. *Baculites inornatus* Meek, 1862. A–C. CAS-66772.03; from Fresno County, Coalinga Quadrangle, from bottom of Copper Canyon, in lens of boulder conglomerate near bottom of Joaquin Ridge Sandstone. D–F. CAS-66772.02; from the same locality as A–C. Both × 1.

Fig. 130. *Baculites jenseni* Cobban, 1962*a*. USNM 131118b, paratype, from the *Baculites jenseni* zone of the Bearpaw Shale, USGS Mesozoic locality D915, 12 miles north-east of Melstone, Montana. Copy of Cobban (1962*a*, pl. 26 (figs 7–8)). × 1.

Occurrence. Upper Campanian, US Western Interior (Montana, South Dakota, Colorado, Wyoming, Kansas), Alberta and Saskatchewan, Canada.

Baculites kegeli Oliveira, 1957
(= ?*Trachybaculites*)

Oliveira 1957: 22, pl. 2 (figs 6–7).

Type. Holotype by monotypy is the original of Oliveira (1957, pl. 2 (figs 6–7), text-fig. 1) from the Maastrichtian, Gramame Formation, Olinda State, Brazil, Nr 4486, Cat. de Inv. da Divisão de Geologia e mineralogia do departamento Nacional da Produção Mineral, Rio de Janeiro.

Occurrence. Maastrichtian, Brazil.

Baculites kirki Matsumoto, 1959

Matsumoto 1959: 143, pl. 43 (figs 1a–c, 2a–c, 3a–c), text-figs 53a–b, 54–57, 58a–b. Matsumoto & Obata 1963: 65, pl. 18 (fig. 2), text-fig. 114

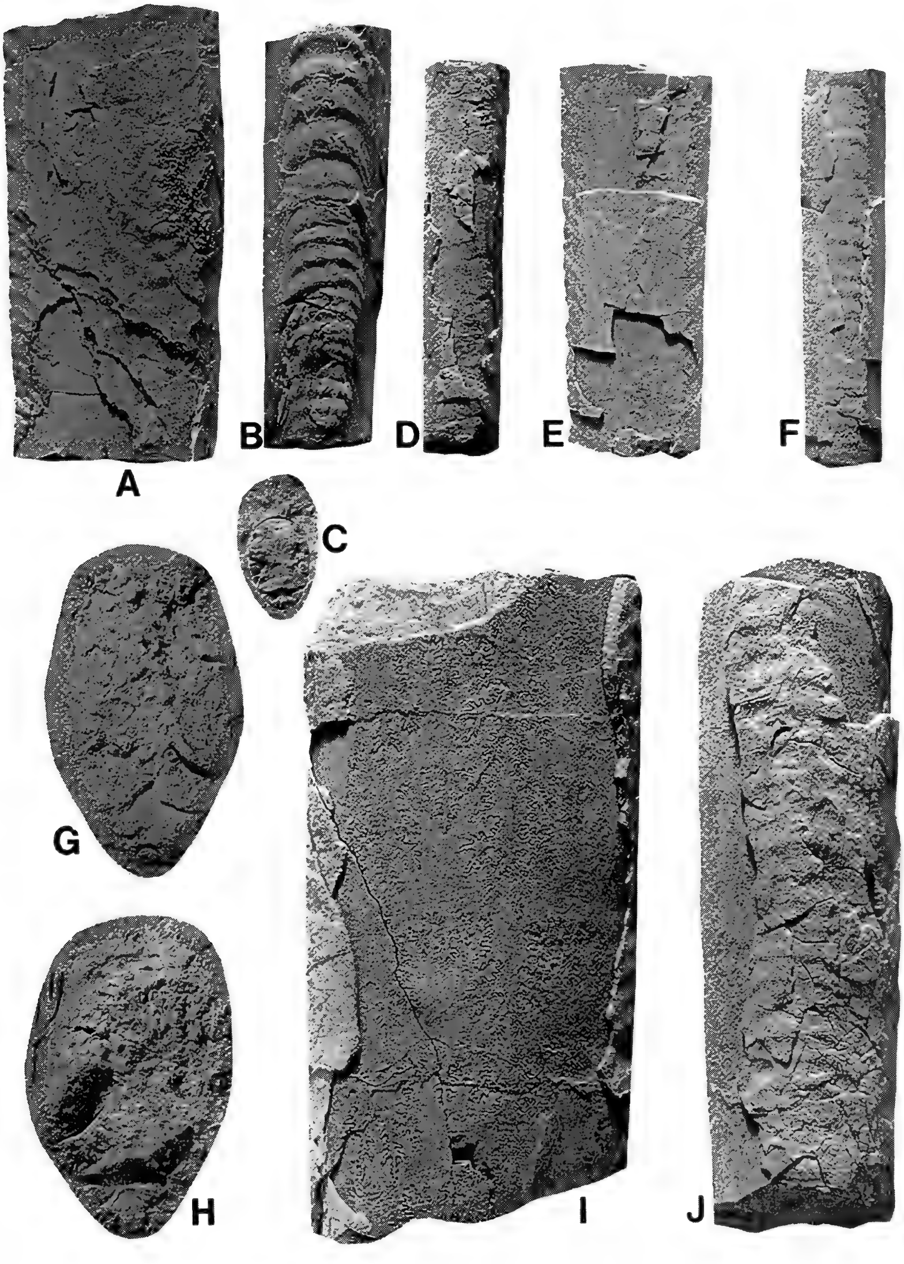

Fig. 131. *Baculites jenseni* Cobban, 1962*a*. A–B. USNM 131119b, paratype. C–F. USNM 131119a, paratype. G. USNM 131118a, paratype. H–J. USNM 131117, the holotype. All from the upper part of the Bearpaw Shale, USGS Mesozoic locality D915, 12 miles north-east of Melstone, Montana. Copy of Cobban (1962*a*, pl. 26 (figs 1–6, 11–12)). × 1.

(as *B.* cf. *kirki*). ?Riccardi & Aguirre Urreta 1988, pl. 3 (figs 4–8) (as *B.* cf. *kirki*). Olivero 1992: 51, pl. 1 (figs 1–3) (as *B.* aff. *kirki*).

Type. Holotype is the original of Matsumoto (1959, pl. 43 (fig. 1a–c), text-fig. 53a–b) from the Santonian of Hooten Gulch in the Redding Area, California, UCLA UC 35693.

Occurrence. Santonian s.l., California, doubtfully Santa Cruz Province, Argentina and James Ross Island, Antarctica.

Baculites knorrianus Desmarest, 1817 Figs 132–133

Desmarest 1817: 48, pl. 1 (fig. 3). Favre 1869: 27, pl. 7 (figs 2–4). Schlüter 1876: 146 (*pars*), pl. 39 (figs 16–18, 20 *non* 19). Mikhailov 1951: 46, pl. 3 (fig. 15) (as *B. anceps* var. *leopoliensis*). Birkelund 1979: 53. Kennedy & Summesberger 1987: 32, pl. 4 (figs 4–6), pl. 5 (figs 1–14), text-fig. 2 (*cum. synon.*). Vašiček 1988: 77, pl. 1 (fig. 4), text-fig. 2. Birkelund 1993: 52, pl. 13 (figs 12–14). Kennedy 1993: 109, pl. 5 (figs 13–22), pl. 6 (figs 11–13, 18–23), text-fig. 5a–c. Kennedy & Christensen 1997: 111, fig. 29.

Type. Desmarest based this species on a figure in Knorr & Walch (1755, pl. 12), which he reproduced as pl. 1 (fig. 3); the type is lost. Neotype designated by Kennedy & Summesberger (1987: 33) is the original of Kennedy & Summesberger (1987, pl. 5 (figs 5, 7–8) from the Lower Maastrichtian of the Ukraine, NHMW 7459a.

Occurrence. Lower Maastrichtian Ukraine, Belgium and northern Germany; in Denmark it spans the Lower–Upper Maastrichtian boundary; also Poland and Czechoslovakia.

Baculites kotanii Matsumoto, Hashimoto & Furuichi, 1980

Matsumoto *et al.* 1980: 408, figs 1–2. Matsumoto & Miyauchi 1984: 73, pl. 25 (fig. 7).

Type. Holotype is the original of Matsumoto *et al.* (1980, figs 1a–b, 2a)) from the Upper Campanian of Gesho, Shikoku, Japan, Geological Laboratory, Kagawa University, Takamatsu, GLKU IZ 80001.

Occurrence. Upper Campanian (see also Bando & Hashimoto 1984), Shikoku, Japan.

Baculites labyrinthicus Morton, 1834
(see *Eubaculites*)

Morton 1834: 44, pl. 13 (fig. 10).

Baculites latelobatus Collignon, 1931
(= *B. yokoyamai* Tokunaga & Shimizu, 1926 = *B. besairiei* Collignon, 1931)

Collignon 1931: 38, pl. 5 (figs 11, 11a, 12, 12a), pl. 9 (fig. 18).

Type. Lectotype here designated is the original of Collignon (1931, pl. 5 (fig. 11)) from the Upper Coniacian of Mahagaga, Madagascar, GD unregistered.

Occurrence. Upper Coniacian, Madagascar.

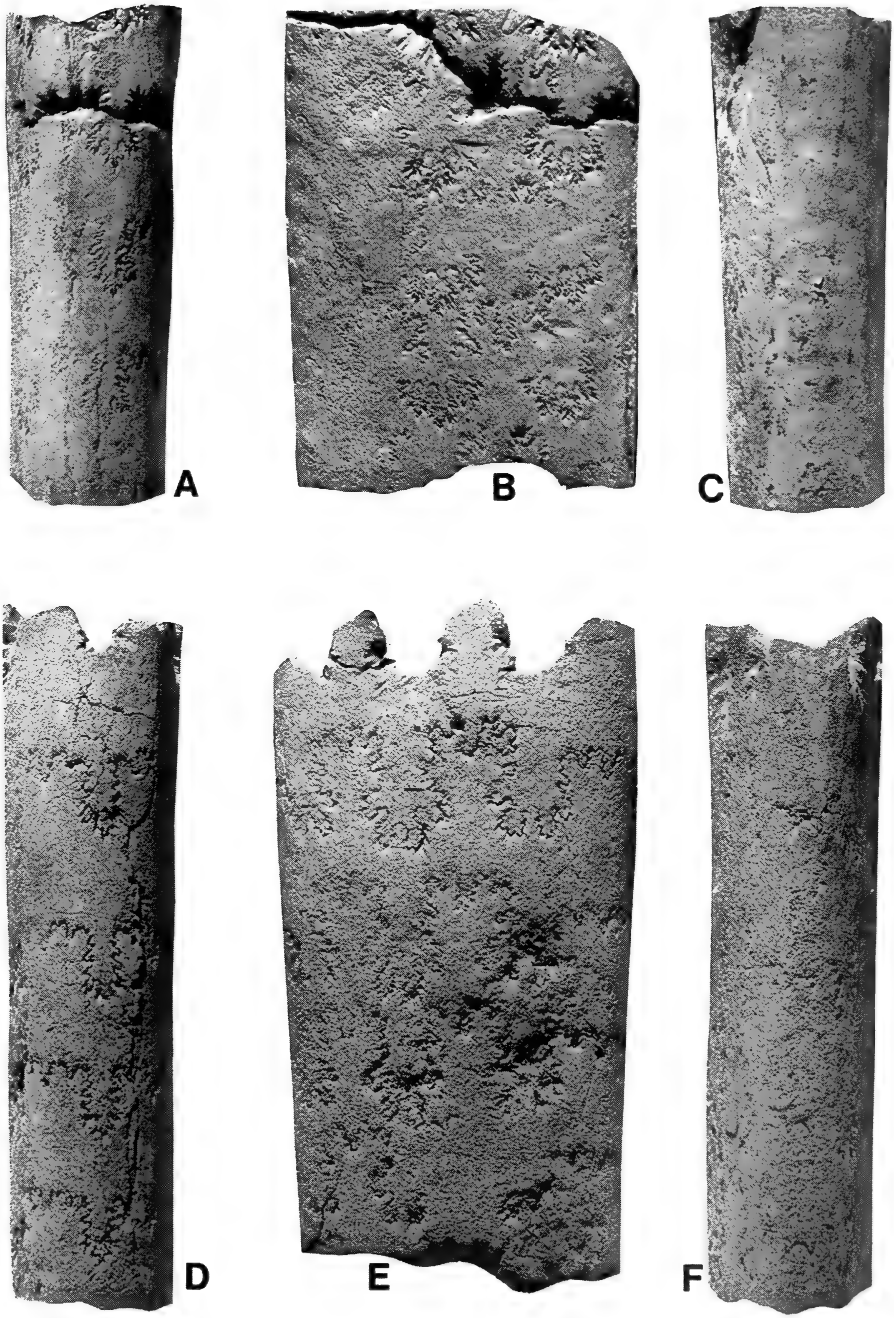

Fig. 132. *Baculites knorrianus* Desmarest, 1817. A–C. NHMW 7459, the original of Favre (1869, pl. 7 (fig. 2)). D–F. Neotype, NHMW 7459, the original of Favre (1869, pl. 7 (figs 3–4, 6)) from the Lower Maastrichtian of Nagoryany, Lvov, Ukraine. Both × 1.

Fig. 133. *Baculites knorrianus* Desmarest, 1817. NHMW 7459c from the Lower Maastrichtian of Nagoryany, Lvov, Ukraine. × 1.

Baculites larsoni Cobban & Kennedy, 1992

Cobban & Kennedy 1992*c*: 682, figs 1.5, 1.6, 1.10–1.20, 2, 3.1.

Type. Holotype is the original of Cobban & Kennedy (1992*c*, figs 1.14–1.16, 3.3) from the Timber Lake Member of the Fox Hills Formation, Bear Creek gravel pit, Dewey County, South Dakota, Maastrichtian.
Occurrence. Maastrichtian, South Dakota.

Baculites larteti Blanckenhorn, 1905

Blanckenhorn 1905: 111. Picard 1929: 443, pl. 10 (fig. 9) (as *B. asper* var. *larteti*.

Type. ?

Occurrence. Maastrichtian, Palestine.

Fig. 134. *Baculites leopoliensis* Nowak, 1908. OUMKZ20219. Upper Campanian, *Nostoceras pozaryskii* zone, Piotrawin, Poland. × 1.

Baculites lechitides Brunnschweiler, 1966
(? = *Trachybaculites)*

Brunnschweiler 1966: 23, pl. 1 (figs 1–3), text-fig. 8. Henderson *et al.* 1992: 162, fig. 23g–j (as *Baculites? lechitides*).

Type. Holotype is the original of Brunnschweiler (1966, pl. 1 (figs 1–3)), from the Maastrichtian of the Marilla Anticline, Miria Marl, Western Australia. CBC 2689.

Occurrence. Maastrichtian, Western Australia.

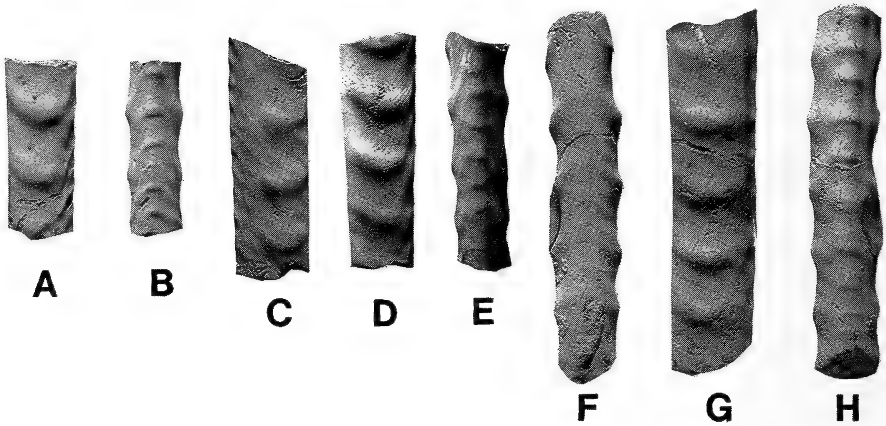

Fig. 135. *Baculites lomaensis* Anderson, 1958. A–B. USNM 463147. C. USNM 463148. D–E. USNM 463149. F–H. USNM 463158. All from the Maastrichtian Prairie Bluff Chalk of Alabama. All × 1.

* ***Baculites leopoliensis*** Nowak, 1908 Fig. 134

Nowak 1908: 328, pl. 14 (figs 1–5), text-figs 1–5 (p. 329), text-figs 5–10 (p. 331) (as *B. anceps* var. *Leopoliensis*). Elias 1933: 310, pl. 34 (fig. 3) (as *B. anceps* var. *leopoliensis*). *non* Mickailov 1951: 46, pl. 3 (fig. 15) (as *B. anceps* var. *leopoliensis*). Glazunova 1955: 180, pl. 1 (figs 1–10). *non* Tzankov 1964: 149, pl. 10 (fig. 2) (as *B. anceps leopoliensis*). *non* Collignon 1970: 10, pl. 610 (figs 2277–2278). *non* Naidin & Shimanskij 1959: 164, pl. 53 (fig. 5) (as *B. anceps leopoliensis*). *non* Atabekian & Khakimov 1976: 96, pl. 11 (figs 11–13) (as *B. anceps leopoliensis*). *non* Tzankov 1982: 17, pl. 3 (figs 2–3) (as *B. anceps leopoliensis*). Kennedy 1986*e*: 1013, pl. 2 (figs 1–2, 11–12), pl. 3 (figs 22–24). Kennedy 1986*b*: 114, pl. 18 (figs 1, 4–12). Hancock & Kennedy 1993: 165, pl. 20 (figs 9–11, 14, 16–19). Klinger & Küchler 1998: fig. 2g.

Type. Lectotype by the subsequent designation of Kennedy (1986*e*: 1013) is the original of Nowak (1908, pl. 14 (fig. 2)) from the Upper Campanian of Lipniki, formerly Galicia, now in Ukraine.

Occurrence. Upper Campanian of Ukraine, Poland and France. (Previous records from the Lower Maastrichtian, e.g. Kennedy 1986*b*: 115, are reputed to be incorrect, *fide* Hancock & Kennedy 1993: 165.)

Fig. 136 *(see facing page)*. A–B. *Baculites mclearni* Landes, 1940. A. GSC 9366a, paratype, from the Pakowki Shale, 30 ft below top, NW¼, sec. 20, tp. 1, range 4th Mer., east side of Bear Gulch, Alberta. B. GSC 9366a, the holotype from the same locality as A. C–E. *Baculites minerensis* Landes, 1940. GSC 9365, the holotype, from the Lower Pakowki Formation, at the mouth of a small coulée entering Milk River Valley from the south near its junction with Deadhorse Coulée, NW¼ sec. 11, tp. 2, range 11, W. 4th mer. All × 1.

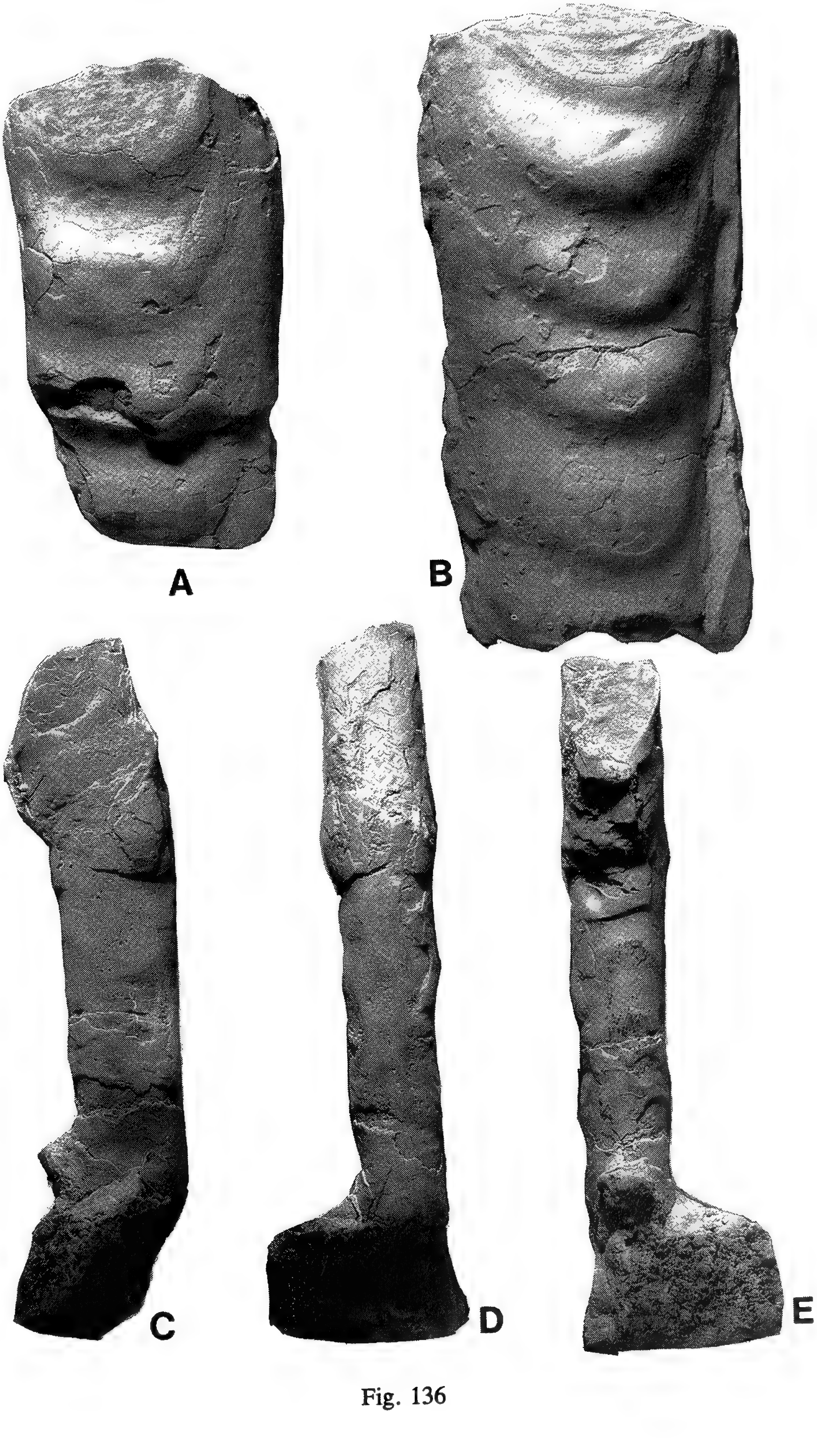

Fig. 136

Baculites libyensis Hassan, 1971

(= ?*B. anceps*)

Hassan 1971: 71, pl. 2 (fig. 12).

Type. Holotype (by monotypy?) is the original of Hassan (1971, pl. 2 (fig. 12)) from the Maastrichtian of Gebel Tarawan, Kharga Oasis, Egypt, ASUE 210.

Occurrence. Maastrichtian, Egypt.

****Baculites lomaensis*** Anderson, 1958 Figs 104L–N, 135

Anderson 1958: 191, pl. 48 (figs 5, 5a, 6). Matsumoto 1959: 126, pl. 34 (figs 1a–c, 2a–c), text-figs 35–38, 39–41. ?Dundo 1971, pl. 1 (fig. 7, 7a) (as *B*. cf. *lomaensis*). Cobban & Kennedy 1995: 18, figs 13.1–13.3, 13.7–13.59, 14.8, 14.10, 15.9.

Type. Holotype is the original of Anderson (1958, pl. 48 (fig. 5)) from the ?Upper Campanian of Joaquin Ridge, north of Coalinga, upper part of Panoche Formation, California, CAS type collection.

Occurrence. ?Upper Campanian, California, Maastrichtian Prairie Bluff Chalk of Alabama and Mississippi; ?Russian Arctic.

Baculites maximus Hagenow, 1842

(= ?*B. knorrianus* fide Schlüter 1876: 148 footnote)

Hagenow 1842: 567.

* ***Baculites mclearni*** Landes, 1940 Fig. 136A–B

Landes 1940: 165, pl. 7 (figs 1–3) . Cobban 1962*b*: 712, pl. 105 (fig. 15), pl. 107 (figs 17–19), text-fig. 1g–h. Scott & Cobban 1965: 1, map I-439. Gill & Cobban 1973: 5. Kauffman 1977: 267, pl. 27 (figs 19–21), pl. 30 (fig. 9). Cobban & Kennedy 1993: 75, figs 5.1–5.2, 6.1–6.14. Larson *et al.* 1997: 22.

Type. Holotype is the original of Landes (1940, pl. 7 (fig. 1)) from the Middle Campanian of the Pakowski Formation, Montana Group, Alberta, Canada, GSC 9366.

Occurrence. Middle Campanian, US Western Interior (Montana, ?Wyoming, Colorado, South Dakota), north-eastern Texas, and Alberta and Saskatchewan, Canada.

Baculites malagasyensis Collignon, 1966

(= *B. capensis*)

Collignon 1966: 7, pl. 457 (fig. 1865).

Type. Holotype (by monotypy?) is the original of Collignon (1966, pl. 457 (fig. 1865)) from the Lower Santonian of Gisement 272, coupe Ampolypoly-Antsirasira-Behamotra (Belo sur Tsiribihina), Madagascar, GD 11865.

Occurrence. Lower Santonian, Madagascar.

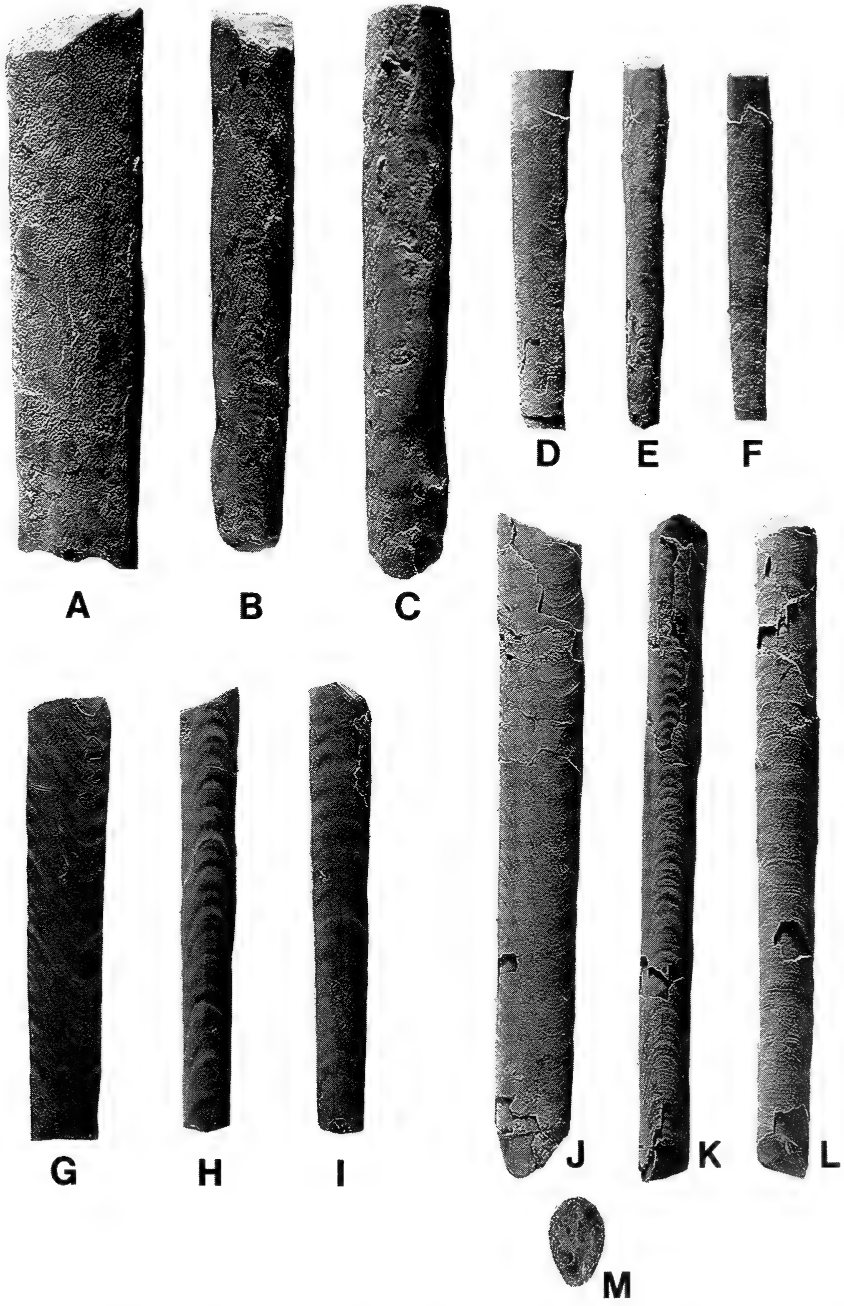

Fig. 137. *Baculites mariasensis* Cobban, 1951. A–C. USNM 433869 from the Mancos Shale, USGS Mesozoic locality D7230, in Sevier County, Utah. D–F. USNM 433877 from the Marais River Shale, USGS Mesozoic locality 21422, in Toole County, Montana. G–I. USNM 433885 from the same locality. J–M. USNM 433876 from the same locality. All from the Middle Coniacian *Inoceramus deformis* zone. All × 1.

Baculites mamillatus Collignon, 1970
(= *B. increscens*)

Collignon, 1970: 7, pl. 609 (figs 2273–2274). Klinger & Kennedy 1997: 132, figs 84a–c, 85a.

Type. Holotype is the original of Collignon (1970, pl. 609 (fig. 2273)) from the Middle Campanian of Gisement 181, Coupe d'Ankilizato (Belo sur Tsiribihina), Madagascar, GD 12273.

Occurrence. Middle Campanian, Madagascar and Zululand.

* ***Baculites mariasensis*** Cobban, 1951 Fig. 137

Cobban 1951: 818, pl. 118 (figs 10–12), text-figs 4–7. Cobban 1955: 204, pl. 2 (fig. 1). Cobban 1976: 124, pl. 2 (figs 5–6). Kauffman 1977: 270, pl. 29 (fig. 10). Kennedy & Cobban 1991*a*: 69, pl. 13 (figs 11–16, 22–23, 29–33, 38–40), pl. 14 (figs 1–23, 26–28, 43–48), text-fig. 25e.

Type. Holotype is the original of Cobban (1951, pl. 118 (fig. 12), text-figs 5–6) from the Middle Coniacian Colorado Shale, south of Shelby, Toole County, Montana, USNM 106985.

Occurrence. Middle Coniacian, US Western Interior (Montana, Wyoming, Utah).

* ***Baculites meeki*** Elias, 1933 Fig. 99A–C

Meek 1876: 404, pl. 39 (fig. 10b–c, *non* 10a, d) (as *B. asper*). Elias 1933: 312, pl. 30 (fig. 4a–b). ?Birkelund 1965: 62, pl. 14 (figs 2–3), pl. 15 (fig. 1), text-figs 53–55 (as *B.* cf. *meeki*).

Type. Holotype is the original of Elias (1933, pl. 30 (fig. 4a–b)) from the Maastrichtian, Beecher Island Shale Member, Pierre Shale, Beecher Island, Yuma County, Colorado. GMUK 59670.

Occurrence. Maastrichtian, US Western Interior (Colorado, South Dakota), possibly West Greenland.

Baculites menabensis Collignon, 1969
(= ?*B. tanakae*)

Collignon 1969: 15, pl. 518 (figs 2036–2037). ?Matsumoto & Miyauchi 1984: 74, pl. 25 (fig. 8) (as *B.* sp. aff. *menabensis*). Klinger & Kennedy 1997: 93, figs 57, 62c.

Type. Holotype is the original of Collignon (1969, pl. 518 (fig. 2036)), from the Lower Campanian of Gisement 307, Coupe Ampolypoly-Antsirasira-Behamotra (Belo sur Tsiribihina), Madagascar, GD 12036.

Occurrence. Lower Campanian Madagascar, possibly Hokkaido.

* ***Baculites minerensis*** Landes, 1940 Fig. 136C–E

Landes 1940: 166, pl. 6 (figs 7–8).

Type. Holotype is the original of Landes (1940, pl. 6 (figs 7–8)), from the lower Pakowski Formation, GSC 9365.

Occurrence. Upper Campanian, Canada.

Baculites natosini Robinson, 1945
(= *Pseudobaculites*)

Robinson 1945: 52, pl. 1 (figs 5–6).

Baculites nibelae Klinger & Kennedy, 1997

Klinger & Kennedy 1997: 162, figs 116, 117a–d, f–i, 118–120.

Type. Holotype is SAM-PCZ9148 from locality 111, Nibela, Zululand, St Lucia Formation, Campanian III.

Occurrence. Campanian, Zululand.

Baculites nitidus Glazunova, 1955

Glazunova 1955: 185, pl. 3 (figs 4–6).

Type. ?

Occurrence. Siberia.

Baculites nugssuaquensis Birkelund, 1965

Birkelund 1965: 48, pl. 4 (fig. 1), pl. 5 (figs 1–4), pl. 6 (figs 1–2), text-figs 35–41.

Type. Holotype is the original of Birkelund (1965, pl. 4 (figs 1a–c), text-fig. 35a–e) from the Lower Santonian of Tuperssuarta, West Greenland, MMH 9755.

Occurrence. Lower Santonian, West Greenland.

Baculites oberholzeri Böhm, 1909
(= ?*B. anceps*)

Böhm 1909: 52, pl. 1 (fig. 9a–b).

Type. Holotype by monotypy is the original of Böhm (1909, pl. 1 (fig. 9a–b)) from the Senonian, Leiboden marls of Leibodenalp, Switzerland, Geological Institute of ETH, Zürich.

Occurrence. Senonian, Switzerland.

Baculites obliquatus Sowerby, 1828
(= *Sciponoceras baculoides*)

****Baculites obtusus*** Meek, 1876 Fig. 100C–H, 138

Meek 1876: 406, text-figs 57–60. Landes 1940: 169. Cobban 1962*b*: 706, pl. 105 (figs 1–14). Birkelund 1965: 58, pl. 8 (fig. 1), pl. 9 (figs 1–3), pl. 10 (fig. 1), pl. 11 (figs 1–2), pl. 12 (figs 1–2), pl. 13 (figs 1–2), pl. 14 (fig. 1), text-figs 47–52 (as *B. obtusus* s.l.). Scott & Cobban 1965: 1, map I–439. Gill & Cobban 1973: 5, fig. 2i. Larson *et al.* 1997: 22.

Type. Meek did not designate a type. Landes (1940: 169) referred to Meek's (1876, figs 58–60) as the 'holotype'. Cobban (1962*b*: 708) referred to the same specimen as the lectotype. It is from the Middle Campanian of Deer Creek on the North Platte River, from the Fox Hills Group of the Upper Missouri Cretaceous Series, USNM 1934*a*.

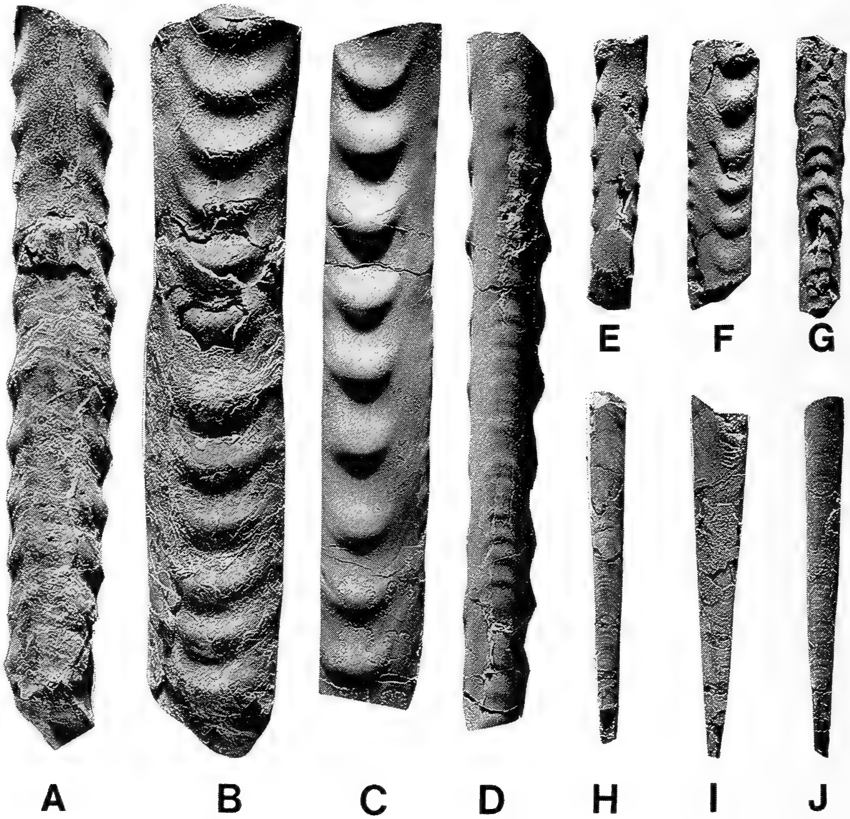

Fig. 138. *Baculites obtusus* Meek, 1876. A–B. USNM 131011e. C–D. USNM 131011c. E–G. USNM 131011b. H–J. USNM 131011a. All from the Pierre Shale, USGS Mesozoic locality D1958, north-east of Canon City in SW¼ sec. 10, T. 18 S., R. 70 W., Fremont County, Colorado. All × 1.

Occurrence. Middle Campanian US Western Interior (New Mexico, Wyoming, South Dakota, Colorado, Montana), Alberta and Saskatchewan, Canada and ?Lower Campanian of West Greenland.

Baculites occidentalis Meek, 1862
(= *Eubaculites* fide Klinger & Kennedy 1993: 190)
Meek 1862: 316.

Fig. 139 *(see facing page)*. *Baculites aquilaensis* Reeside. Collections of the U.S. Geological Survey, Denver, from USGS Mesozoic locality 23639 lower Gammon Shale Member of Pierre Shale along west-facing scarp at head of Owl Creek in SE¼ sec. 12, T. 9 S., R. 61 E., and N½ sec. 13, T. 9 S., R. 16 E., Carter County, Montana. Lower Campanian Zone of *Scaphites hippocrepis* sensu lato.
All × 1.

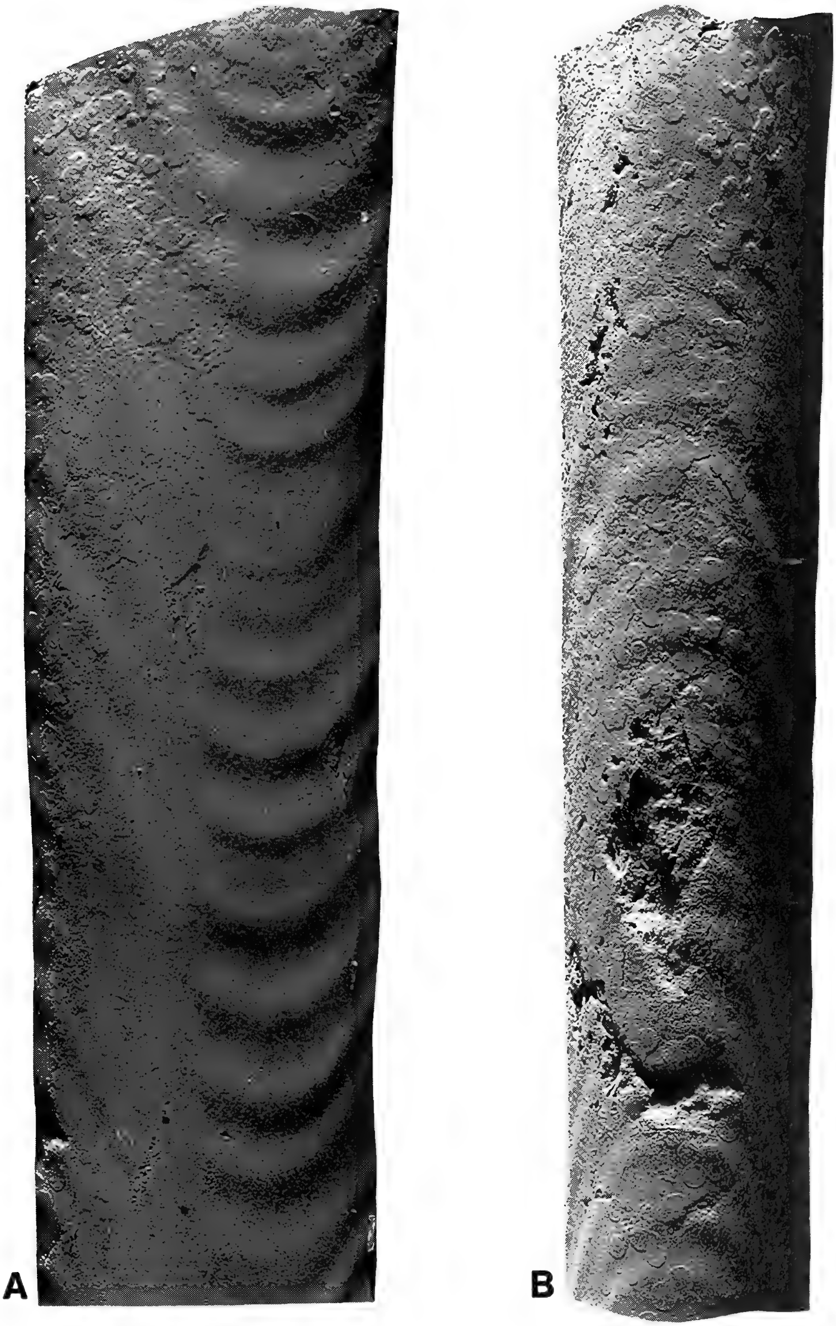

Fig. 139

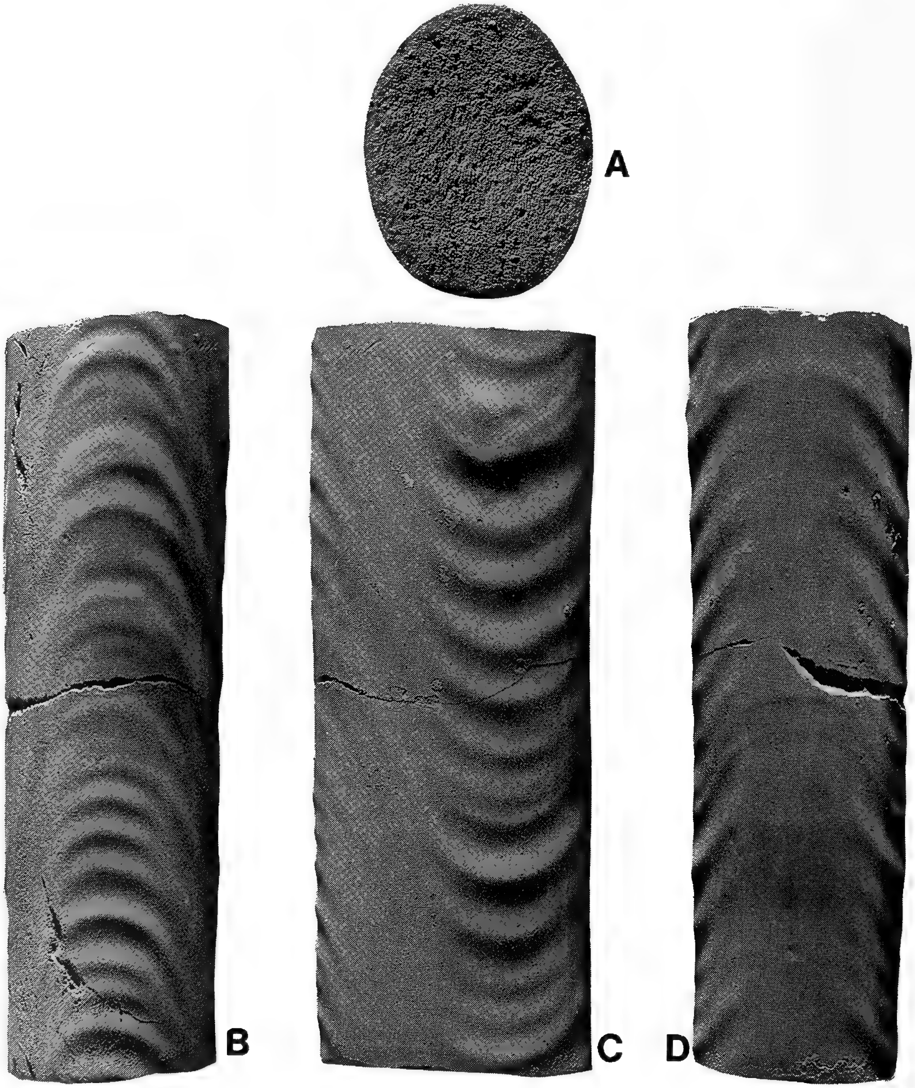

Fig. 140. A–D. *Baculites aquilaensis* Reeside. Collections of the U.S. Geological Survey, Denver, from USGS Mesozoic locality 23639 lower Gammon Shale Member of Pierre Shale along west-facing scarp at head of Owl Creek in SE¼ sec. 12, T. 9 S., R. 61 E., and N½ sec. 13, T. 9 S., R. 16 E., Carter County, Montana. Lower Campanian Zone of *Scaphites hippocrepis* sensu lato. ×1.

Baculites orientalis Matsumoto MS

(= *nom. nud.*) (= *Sciponoceras orientale* Matsumoto & Obata, 1963: 21)

Matsumoto 1942: 195, 197.

Baculites ornatus d'Orbigny, 1847
(= *Eubaculites vagina*)

D'Orbigny 1847, pl. 3 (figs 3–6).

Baculites ovatoides Hanna & Anderson, 1928
(= *nom. nud.* fide Anderson & Hanna 1935: 24).

Baculites ovatus Say, 1821

Say 1821: 41, pl. 5 (figs 5–6). Morton 1834: 42, pl. 1 (figs 6–8). Meek 1876: 394, pl. 20 (figs 1a–b, 2a–b, d). Johnson 1905: 26. *non* Dowling 1917, pl. 30 (fig. 2). ?Taubenhaus 1920: 11, pl. 6 (fig. 1). Wade 1926: 181 (*pars*) *non*. pl. 60 (fig. 9). Reeside 1927*b*: 9 (*pars*). ?Picard 1929: 446, pl. 9 (fig. 11) (as *B. vertebralis* Lamarck (?) var. *ovatus*). *non* Elias 1933: 297, pl. 33 (fig. 3a–c). Landes 1940: 171. *non* Reyment 1958: 7, pl. 1 (figs 1–2), text-figs 1–2 (= *B. yokoyamai*). ?Bodylevski & Shulgina 1958, pl. 44 (fig. 5a–b). Reeside 1962: 113, pl. 68 (figs 1–4). Cobban 1974: 3, pl. 1 (figs 1–32), pl. 2 (figs 1–14), pl. 3 (figs 1–6, 9–11), text-fig. 4. ?Luger & Gröschke 1989: 398, pl. 49 (fig. 2), text-fig. 15i–o. ?Al-Harithi & Ibrahim 1992: 433, pl. 1 (fig. 3), pl. 2 (fig. 5). Kennedy & Cobban 1993*c*: 426, figs 12.3–12.4, 14.5, 14.12, 14.15–14.17, 14.20, 14.22–14.42, 15.1–15.12, 15.14–15.24. Kennedy & Cobban 1994*b*: 1297, figs 5.1–5.2, 14.1–14.30, 14.33–14.35.

Type. Johnson (1905: 26) recorded the type in the collections of the Academy of Natural Sciences, Philadelphia, but this is disputed—see Cobban (1974: 4) for details.

Occurrence. Atlantic Highlands, New Jersey, where it is dated as late Campanian and Arkansas; the US Western Interior, Middle East and North African records are dubious.

Baculites ovatus var. ***baculus*** Meek, 1862
(= *B. baculus*)

Meek 1862: 445. Meek 1876: 397, text-figs 51–52.

Baculites ovatus var. ***haresi*** Reeside, 1927
(= *B. haresi*)

Reeside 1927*b:* 10, pl. 6 (figs 5–10), pl. 7 (figs 9–10).

Baculites palestinensis Picard, 1929
(= ?*B. subanceps* fide Howarth 1965: 370)

Picard 1929: 438, pl. 10 (figs 1–7), text-figs 1–2.

Type. Lectotype here designated, is the original of Picard (1929, pl. 10 (fig. 1a–b)) from the Maastrichtian? of Palestine, collections Department of Geology, Hebrew University of Jerusalem, Israel (cf. Ferber 1985: 66) nr HU 5278.

Occurrence. Maastrichtian?, Palestine.

Baculites paradoxus Pervinquière, 1907
(= probably not *Baculites*; Polyptychoceratinae)

Pervinquière 1907: 94, pl. 4 (figs 10–11), text-fig. 24.

Type. The specimens may be lost, and lectotype designation is deferred.

Occurrence. Maastrichtian, Tunisia.

* ***Baculites perplexus*** Cobban, 1962*b* Figs 141–142

Cobban 1962*b*: 714, pl. 107 (figs 1–16), text-fig. 1a–c. Scott & Cobban 1965: 2, map I-439. Gill & Cobban 1973: 7, fig. 2k. Kennedy & Cobban 1976, pl. 8 (fig. 2), pl. 10 (fig. 8). Larson *et al.* 1997: 24.

Type. Holotype is the original of Cobban (1962*b*, pl. 107 (figs 12–14)) from the Middle Campanian upper part of the Steele Shale near Glenrock, Wyoming, USNM 108914.

Occurrence. Middle Campanian, US Western Interior (Wyoming, Montana, Colorado, South Dakota, Nebraska, New Mexico, Utah).

Baculites princeps Matsumoto & Obata, 1963

Matsumoto & Obata 1963: 55, pl. 13 (figs 1–2), pl. 15 (figs 1–2), text-figs 134–139. Obata & Matsumoto 1963: 80, pl. 22 (fig. 2), pl. 25 (fig. 2), pl. 27 (fig. 10), text-figs 171, 197–199. (as *B.* cf. *princeps*).

Type. Holotype is the original of Matsumoto & Obata (1963, pl. 13 (fig. 1), text-fig. 134, 138), from the Santonian, Kotodo-no-sawa, Haboro Valley, Teshio Province, Hokkaido, GK H4454.

Occurrence. Santonian, Hokkaido, ?Honshu.

Baculites pseudobaculus Matsumoto & Obata, 1963

Matsumoto & Obata 1963: 68, pl. 14 (fig. 3), text-figs 160–162, 166, 167.

Type. Holotype is the original of Matsumoto & Obata (1963, pl. 14 (fig. 3), text-figs 162a–b, 166) from the Lower Santonian, Sankebetsu, a branch of the Chikubetsu, Teshio Province, Hokkaido, GK H4803.

Occurrence. Lower Santonian, Hokkaido.

****Baculites pseudovatus*** Elias, 1933 Figs 99D, 143

Elias 1933: 304, pl. 29 (figs 1a–b, 2) only, *non* pl. 28 (fig.2), pl. 33 (fig. 4a–b, *non* fig. 5a–b)). Landes 1940: 174. Larson *et al.* 1997: 27.

Type. Holotype is the original of Elias (1933, pl. 29 (fig. 1a–b)) from the upper Weskan Shale Member, Pierre Formation, Wallace County, Kansas, GMUK 59668.

Fig. 141 *(see facing page)*. *Baculites perplexus* Cobban, 1962*b*. A. Holotype USNM 108914, from the Lower Campanian Pierre Shale near Glenrock, Wyoming, USGS Mesozoic locality D255. B. Mass occurrence from the Campanian Pierre Shale near Red Bird, Wyoming, USGS Mesozoic locality D1871. After Gill & Cobban (1966). Both × 1.

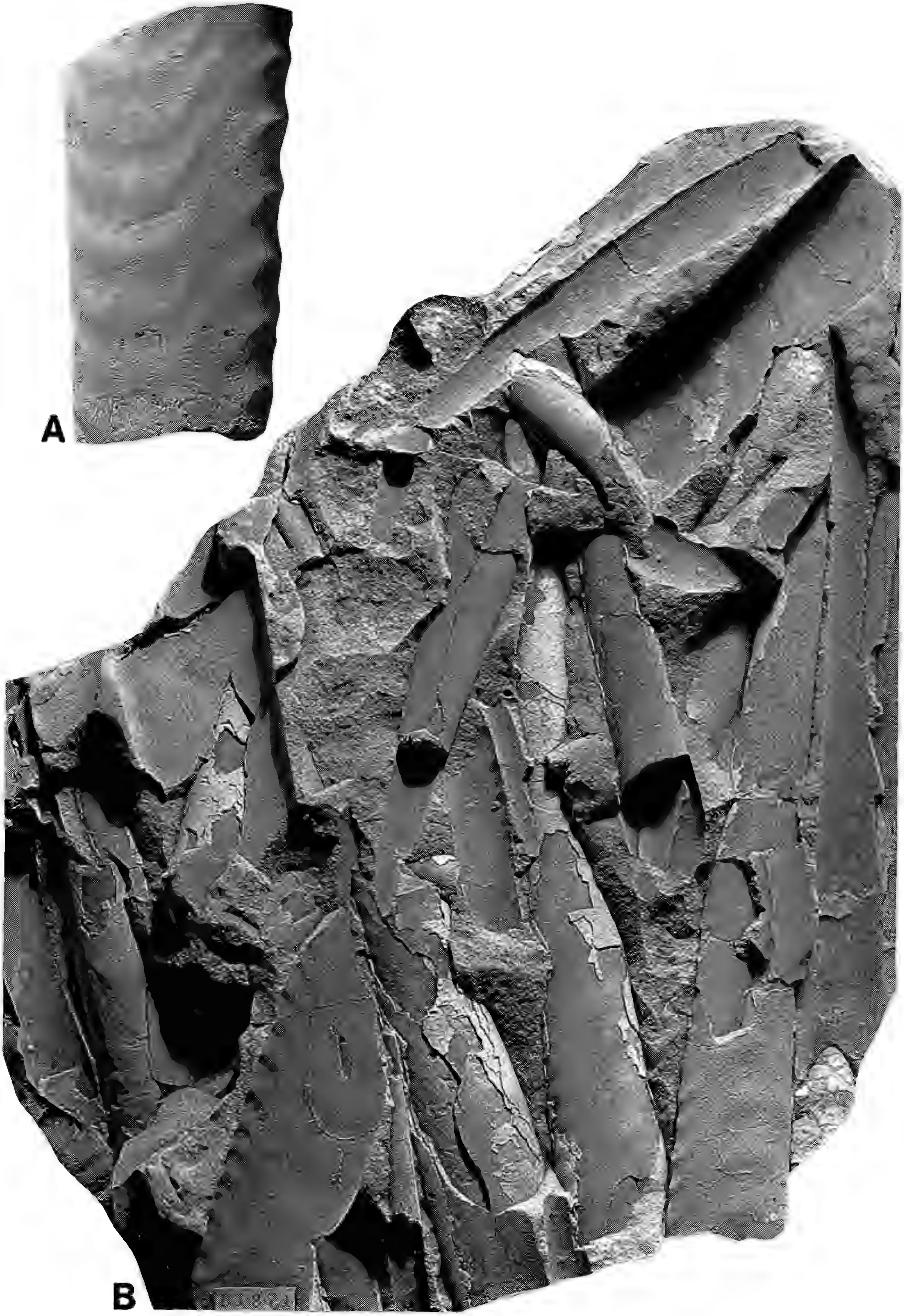

Fig. 141

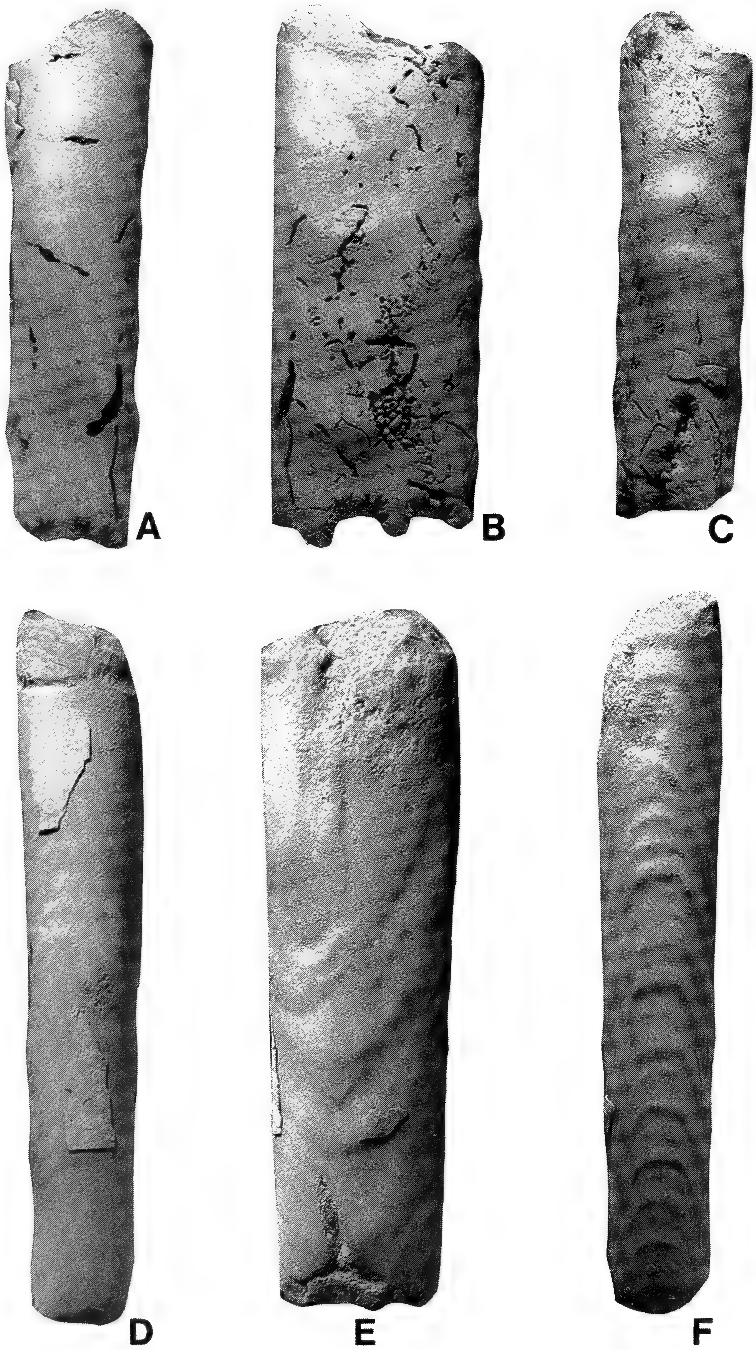

Fig. 142

Occurrence. Upper Campanian, US Western Interior (Kansas, Colorado, South Dakota, Montana, Nebraska, New Mexico).

Baculites rectangulatus Collignon, 1970
(= ?*B. increscens*)

Collignon 1970: 12, pl. 611 (figs 2279–2281). Klinger & Kennedy 1997: 135, fig. 87.

Type. Holotype is the original of Collignon (1970, pl. 611 (fig. 2279)) from the Middle Campanian of Gisement 157 Coupe d'Ankilizato (Belo sur Tsiribihina), Madagascar, GD 12279.

Occurrence. Middle Campanian, Madagascar.

Baculites rectus Marshall, 1926

Marshall 1926: 154, pl. 19 (fig. 1), pl. 32 (figs 9–10). Spath 1953: 19, pl. 7 (fig. 2a–c) (as *B.* aff. *rectus*). Henderson 1970: 23, pl. 3 (figs 2–3), text-fig. 6. ?Collignon 1977: 10 (as *Baculites* sp. indet.). Olivero 1984: 64, pl. 1 (figs 6–9), text-figs 1c, 2. ?Klinger & Kennedy 1997: 47, figs 25–26 (as *Baculites* sp. aff. *B. rectus*).

Type. Lectotype by the subsequent designation of Henderson (1970: 23) is the original of Marshall (1926, pl. 32 (figs 9–10)) from the ?Campanian of Bull Point, New Zealand, GSNZ CE 722.

Occurrence. ?Campanian–Maastrichtian, New Zealand, James Ross Island, Antarctica, and possibly Graham Land, subsurface deposits, Durban, and New Caledonia.

* ***Baculites reduncus*** Cobban, 1977 Figs 144–145

Cobban 1977: 462, figs 2–6. Kennedy & Cobban 1993*d*: 144, pl. 7 (figs 28–32). Larson *et al.* 1997: 25.

Type. Holotype is the original of Cobban (1977, fig. 2f–g) from the Middle Campanian, lower part of the Rock River Formation near Rock River, Wyoming, USNM 108909.

Occurrence. Middle Campanian, US Western Interior (Wyoming, Colorado, South Dakota), and Gulf Coast (Arkansas).

* ***Baculites reesidei*** Elias, 1933 Figs 99E–G, 146

Reeside 1927*b*: 10 (*pars*), pl. 9 (figs 1–5) (as *B. compressus*). Elias 1933: 302, pl. 28 (fig. 1), pl. 31 (fig. 3), pl. 32 (fig. 2a–c), pl. 33 (figs 1–2), (as *B. compressus* var. *reesidei*). Gill & Cobban 1973: 10, fig. 2p, 3c. Riccardi 1983, pl. 26 (figs 3–5). Larson *et al.* 1997: 32.

Type. Holotype is the original of Reeside (1927*b*, pl. 9 (figs 1–5)), said to be from the Campanian Eagle Sandstone in Fergus County, Montana, but from the Bearpaw Shale, probably from central Montana, USNM 73304.

Fig. 142 *(see facing page)*. *Baculites perplexus* Cobban, 1962*b*. A–C. OUM KT7590. D–F. OUM KT7588. Both from the Mitten Member of the Pierre Shale, Middle Campanian *B. perplexus* zone in NE¼ sec. 21, T. 46 N., R. 64 W., Weston County, Wyoming. Both × 1.

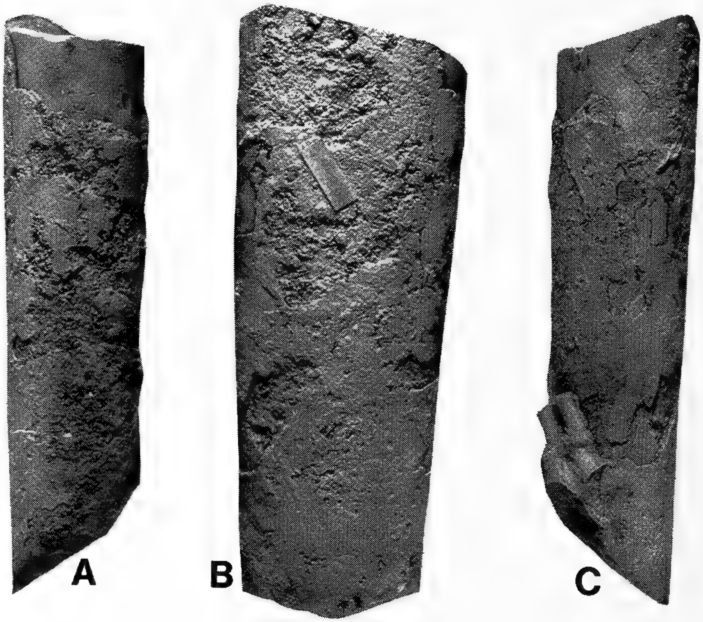

Fig. 143. *Baculites pseudovatus* Elias, 1933. USNM 507280, from USGS Mesozoic locality D13537, Pierre Shale near Newcastle, Wyoming. ×1.

Occurrence. Upper Campanian, US Western Interior (Kansas, South Dakota, Montana, Wyoming, North Dakota, Colorado) and Canada.

Baculites regina Obata & Matsumoto, 1963

Obata & Matsumoto 1963: 85, pl. 22 (figs 3–6), pl. 23 (figs 1–2), pl. 24 (figs 1–5), pl. 25 (figs 3–5), pl. 27 (figs 1, 6–7, 9), text-figs 191–196, 200–214. Matsumoto & Morozumi 1980: 24.

Type. Holotype is the original of Obata & Matsumoto (1963, pl. 24 (fig. 1)) from the Campanian? Azenotani Shale Member at Kuratani, Shinke-mua, Sennan-gun, Osaka Prefecture, Honshu, GT I-575.

Occurrence. Campanian, Honshu.

****Baculites rex*** Anderson, 1958 Figs 108A–C, 147

Anderson 1958: 191, pl. 49 (fig. 2). Matsumoto 1959: 136, pl. 31 (fig. 5a–d), pl. 34 (fig. 5), pl. 39 (fig. 1a–c, 2a–c, 3), pl. 40 (fig. 1a–c), text-figs 45a–b, 46a–c, 47, 48a–c, 49a–b, 50–52. Matsumoto & Obata 1963:

Fig. 144 *(see facing page)*. *Baculites reduncus* Cobban, 1977. A, G–H. USNM 240423, paratype. B. USNM 240245, paratype. C. USNM 240246, paratype. D. USNM 240421, paratype. E–F. USNM 240422, paratype. All from the Upper Campanian Rock River Formation near Rock River, Wyoming. ×1.

Fig. 144

64, pl. 19 (fig. 3), text-fig. 158, 165. ?Dundo 1971, pl. 1 (fig. 5, 5b) (as *Baculites* cf. *rex*). Ward 1978: 1152, pl. 2 (figs 7, 10, text-fig. 2. Haggart 1991, pl. 4 (figs 4–5).

Type. Holotype is the original of Anderson (1958, pl. 49 (fig. 2)) from the Upper Campanian of Crow Creek, West San Joaquin Valley, California, CAS type collection.

Occurrence. Upper Campanian–?Lower Maastrichtian, California, Baha California (Mexico), British Columbia and possibly Arctic Russia.

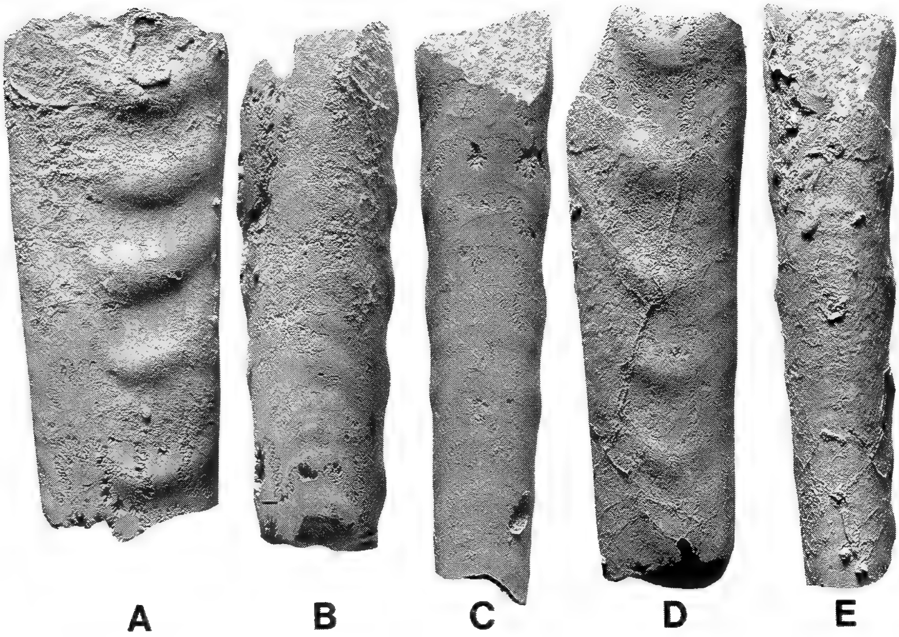

Fig. 145. *Baculites reduncus* Cobban, 1977. A–B. USNM 411300. C–E. USNM 413001. Both from the Upper Campanian, basal phosphate bed of the Annona Chalk at the Okay Quarry, Okay, Howard County, Arkansas. Both × 1.

* ***Baculites rioturbioensis*** **Hünicken, 1965** Fig. 148

(= ?*Eubaculites* fide Klinger & Kennedy 1993: 190)

Hünicken 1965: 58, pl. 2 (figs 1–2), pl. 3 (figs 7–8), pl. 7 (fig. 1), pl. 8 (figs 6–8).

Type. Holotype is the original of Hünicken (1965, pl. 2 (figs 1–2), pl. 3 (fig. 7), pl. 7 (fig. 1), pl. 8 (fig. 7)) from Rio Turbio, in the south-west of Santa Cruz Province, Argentina, CPC N3005.

Occurrence. Uppermost Campanian or basal Maastrichtian, southern Argentina.

Baculites roedereri Collignon, 1931

(= *B. yokoyamai* Tokunaga & Shimizu, 1926 = *B. besairiei*)

Collignon 1931: 38, pl. 5 (fig. 10–10a), pl. 9 (fig. 17).

Type. Holotype by monotypy is the original of Collignon (1931, pl. 5 (fig. 10, 10a), pl. 9 (fig. 17)) from the Upper Coniacian of Mahagaga, Madagascar, GD unregistered.

Occurrence. Upper Coniacian, Madagascar.

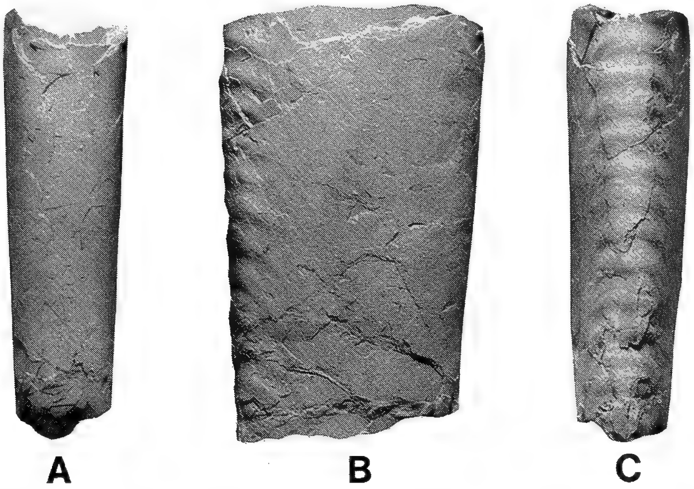

Fig. 146. *Baculites reesidei* Elias, 1933. USNM 507281, from USGS Mesozoic locality 22182, Bearpaw Shale near Roy, Montana. × 1.

Baculites romanovskii Arkhangel'skij, 1912

Arkhangel'skij 1912: 74, pl. 3 (figs 14–15, 26).

Type. ?

Occurrence. ?

Baculites rotundus Reuss, 1845

(= Gen. et sp. indet. *fide* Diener 1925: 62; possibly an anisoceratid *fide* Fritsch & Schlönbach 1872: 49).

* ***Baculites rugosus*** Cobban, 1962*a* Figs 149–151

Cobban 1962*a*: 131, pl. 27 (figs 1–9), pl. 28 (figs 1–11), text-fig. 1c. Kennedy & Cobban 1976, pl. 10 (fig. 7).

Type. Holotype is the original of Cobban (1962*a*, pl. 27 (figs 8–9)) from the Upper Campanian, lower part of the Monument Hill Bentonitic Member of the Pierre Shale, Carter County, Montana, USNM 131120.

Occurrence. Upper Campanian, US Western Interior (Montana, South Dakota, Wyoming, Colorado and New Mexico).

Fig. 147. *Baculites rex* Anderson, 1958. CAS–28325.01, the holotype, from locality 28325 (CAS), on south side of Crow Creek, in NE ¼ sec. 33, T. 6 S., R. 7 W. × 0.75.

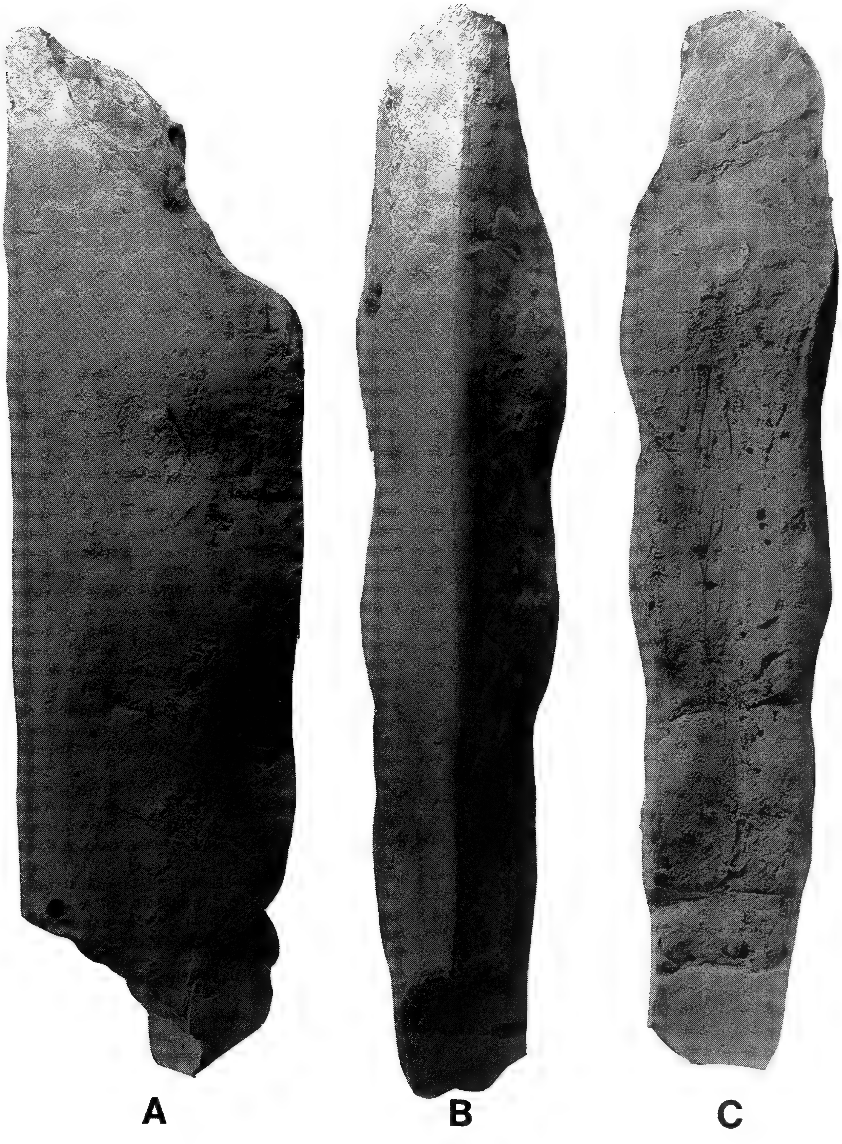

Fig. 148. *Baculites rioturbioensis* Hünicken, 1965. Cast of the holotype, CPC N3005, from the Upper Campanian–Lower Maastrichtian of Rio Turbio in the south-western part of Santa Cruz Province, Argentina. × 1.

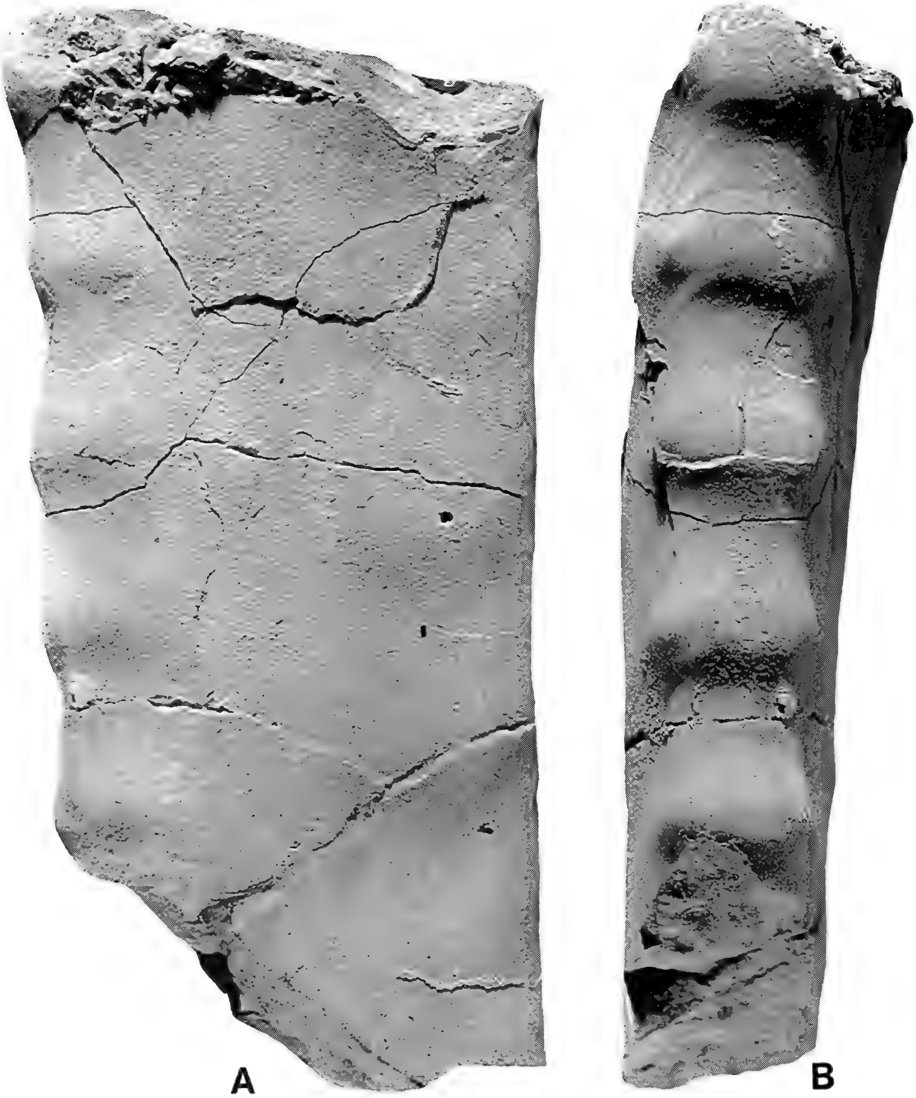

Fig. 149. *Baculites rugosus* Cobban, 1962*a*. A–B. Paratype. USNM 131121i from the lower part of the Monument Hill Bentonitic Member of the Pierre Shale at USGS Mesozoic locality 23054 in Carter County, Montana. ×1.

Baculites sanctae-crucis Pictet & Campiche, 1861

(See *Lechites*.)

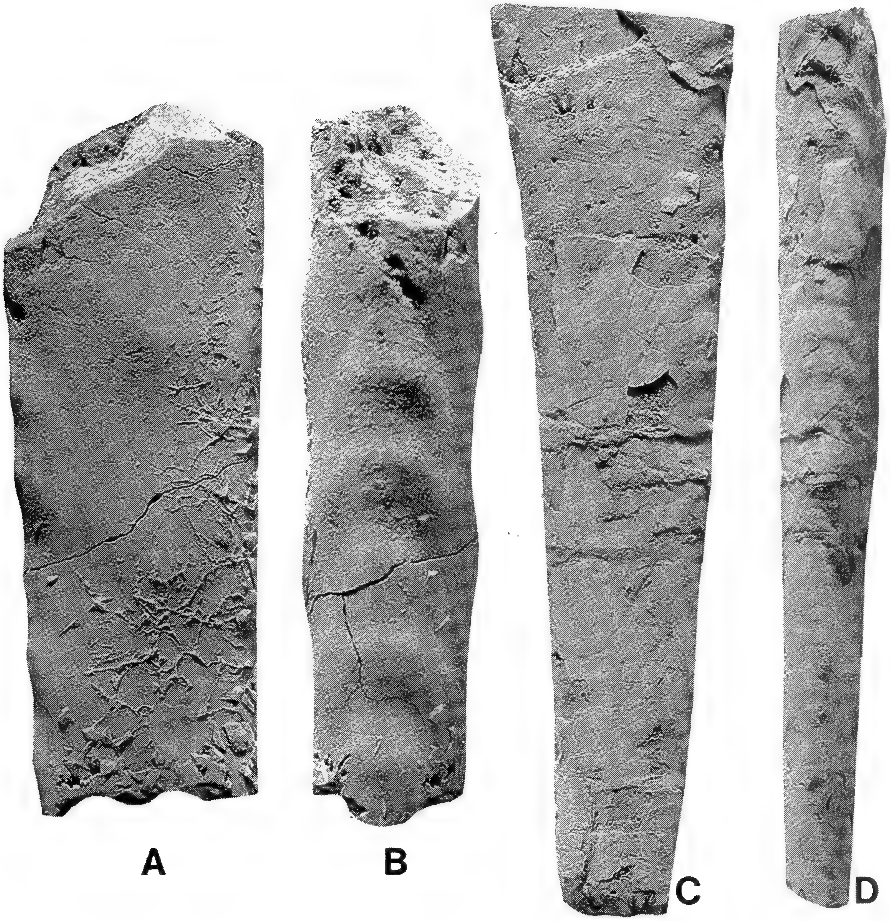

Fig. 150. *Baculites rugosus* Cobban, 1962*a*. A–B. USNM 131121c, paratype. C–D. USNM 131121d, paratype, from the Upper Campanian *Exiteloceras jenneyi* zone, Monument Hill Bentonitic Member of the Pierre Shale, USGS Mesozoic locality 23054 on the north flank of the Black Hills uplift, Carter County, Montana. All × 1.

* ***Baculites schencki*** Matsumoto, 1959 Fig. 104A–C
(= *B. capensis*)

Matsumoto 1959: 113, pl. 32 (figs 1a–c, 2a–c, 3a–b, 4a–b, 5a–c, 6a–c), text-figs 12a–b, 13a–c, 14a–b, 15–21, 22a, 23a–c, 24–25. Matsumoto & Obata 1963: 38, pl. 12 (figs 1–2), pl. 14 (fig. 1), text-figs 90, 131–133.

Type. Holotype is the original of Matsumoto (1959, pl. 32 (fig. 2a–c), text-fig. 12a–b) from the Santonian of locality CIT 1034 in the Redding area, California. UCLA 28830.

Occurrence. Santonian, California and Hokkaido.

* ***Baculites schlueteri*** Moberg, 1885 Fig. 89

(= *nomen dubium* fide Kennedy & Christensen 1997: 111, fig. 27f)

Moberg 1885: 40, pl. 4 (fig. 14). Hägg 1954: 55. Kennedy & Christensen 1997: 111, fig. 27f.

Type. Lectotype by subsequent designation of Kennedy & Christensen (1997: 111) is the original of Moberg (1885, pl. 4 (fig. 14)) from Köpinge, Sweden.

Occurrence. Campanian, Sweden.

* ***Baculites scotti*** Cobban, 1958 Fig. 152

Cobban 1958: 660, pl. 90 (figs 1–9), text-fig. 1a–e, h. Scott & Cobban 1965: 2, map I-439. Gill & Cobban 1973: 7, fig. 2m. ?Hamama & Kassab 1990: 462, pl. 2 (figs 5–9) ?Kennedy & Cobban 1994*a*: 107, fig. 8.1–8.3, 8.12, 8.17–8.19. Larson *et al.* 1997: 26.

Type. Holotype is the original of Cobban (1958, pl. 90 (figs 1–2), text-fig. 1a) from the Middle Campanian Pierre Shale, north-east of Pueblo, Colorado, USNM 108929.

Occurrence. Middle Campanian, US Western Interior (Colorado, Wyoming, Montana, South Dakota, Nebraska, New Mexico, Utah), and very doubtfully Egypt.

Baculites sheringomensis Crick, 1924

(= *Eubaculites carinatus* fide Klinger & Kennedy 1993: 218)

Crick 1924: 139, pl. 9.

Baculites sibiricus Glazunova, 1955

Glazunova 1955: 183, pl. 2 (figs 1, 3).

Type. ?

Occurrence. Siberia.

Baculites singularis Glazunova, 1955

Glazunova 1955: 187, pl. 2 (fig. 2).

Type. ?

Occurrence. Siberia.

Baculites sparsinodosus Collignon, 1969

(= *?B. menabensis*)

Collignon 1969: 23, pl. 521 (figs 2052–2054). Klinger & Kennedy 1997, figs 60, 61a.

Type. Holotype is the original of Collignon (1969, pl. 521 (fig. 2052)) from the Lower Campanian of Gisement 302, Coupe Ampolypoly-Antsirasira-Behamotra (Belo sur Tsiribihina), Madagascar, GD 12052.

Occurrence. Lower Campanian, Madagascar and possibly Zululand.

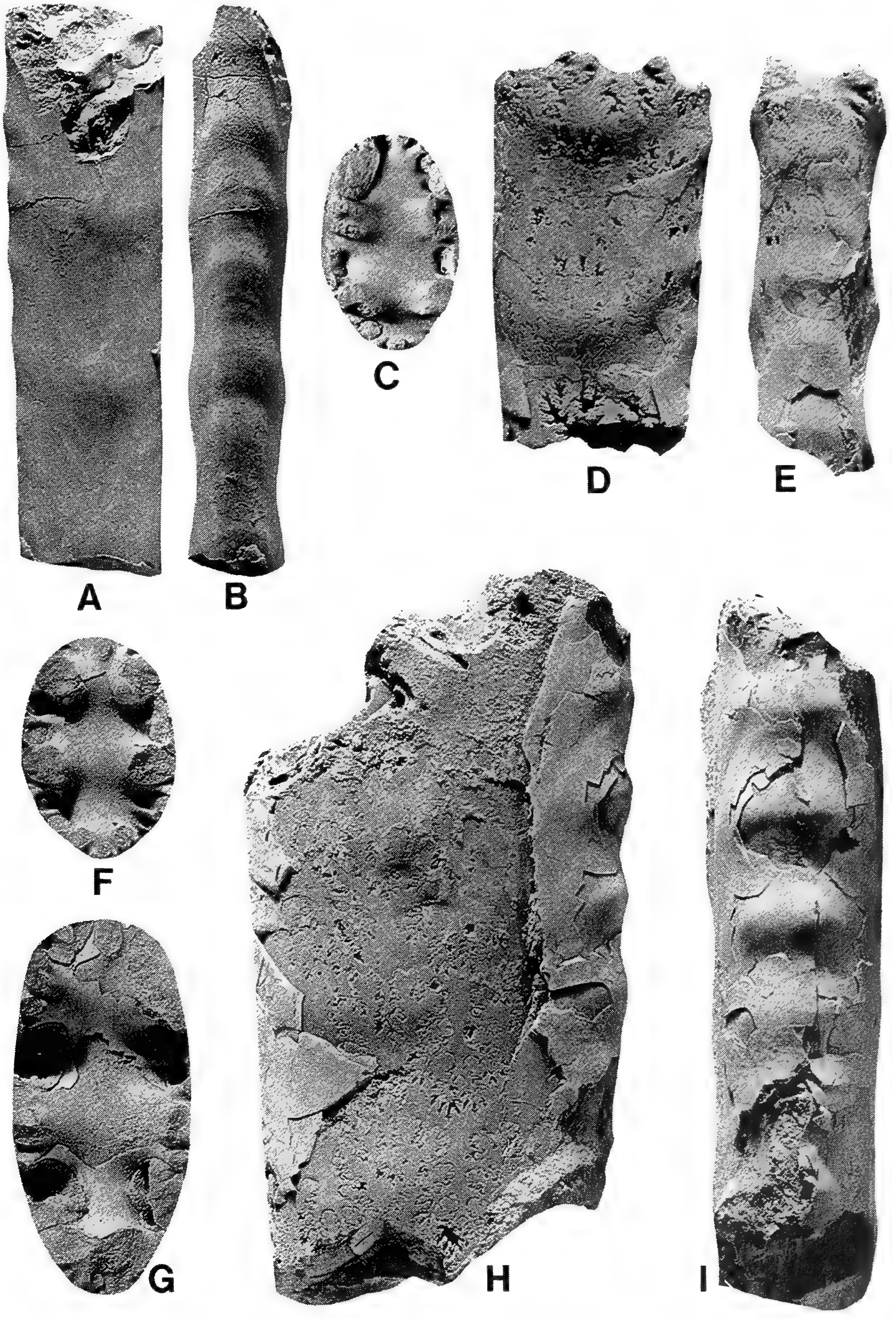

Fig. 151. *Baculites rugosus* Cobban, 1962*a*. A–B. USNM 131121h, paratype. C–E. USNM 131121g, paratype. F. USNM 131121c, paratype. G. USNM 131121b, paratype. H–I. USNM 131120, the holotype. All from the Monument Hill Bentonitic Member of the Pierre Shale at USGS Mesozoic locality 23054 in Carter County, Montana. All × 1.

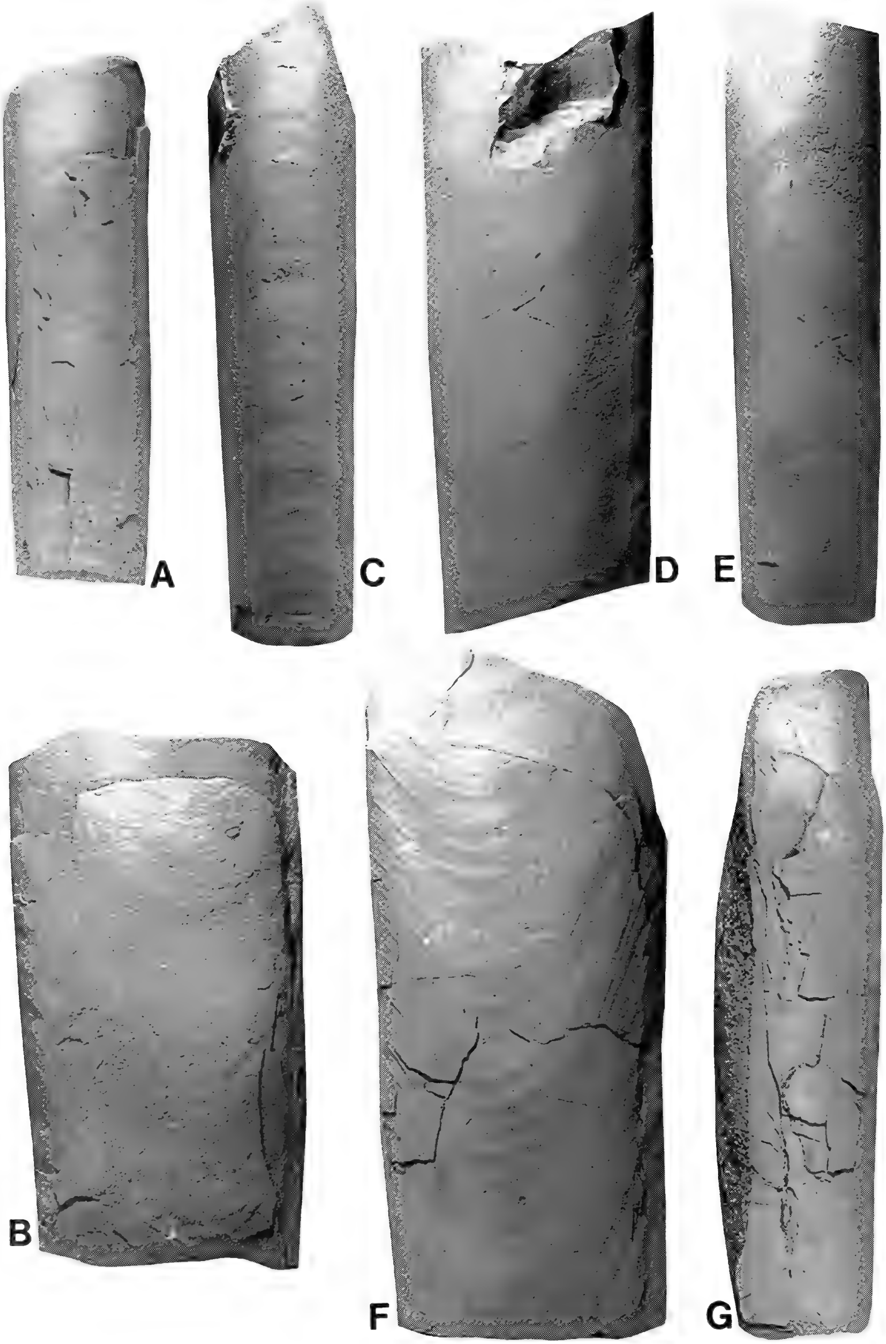

Fig. 152

Baculites spillmani Conrad, 1858
(= *Eubaculites carinatus* fide Klinger & Kennedy 1993: 218)

Conrad 1858: 535, pl. 35 (fig. 24).

Baculites subanceps Haughton, 1925

Haughton 1925: 278, pl. 14 (figs 6–8). Haughton 1926: 24, pl. 3 (figs 6–8). Matsumoto 1959: 130, pl. 34 (fig. 3), pl. 35 (fig. 1) (as *Baculites* aff. *B. anceps*). Matsumoto & Obata 1963: 59, pl. 20 (fig. 3), text-figs 145–146, 156 (as *B. anceps pacificus*). Howarth 1965: 368, pl. 5 (fig. 3), pl. 6 (figs 6–7), pl. 7 (fig. 1), text-figs 4, 13–15. Klinger & Lock 1978: 77, fig. 5a–l. Ward 1978: 1152, pl. 2 (figs 1–4, 8), text-fig. 6 (as *B. anceps pacificus*). ?Matsumoto & Miyauchi 1984: 75, text-fig. 13 (as *Baculites* cf. *B. subanceps pacificus*). Luger & Gröschke 1989: 400, pl. 49 (fig. 1), text-fig. 15a–h. Olivero 1992: 56, pl. 1 (figs 21–22) (as *B.* aff. *subanceps pacificus*). Klinger & Kennedy 1997, fig. 131.

Type. Lectotype by the subsequent designation of Howarth (1965: 368) is the original of Howarth (1965, pl. 6 (fig. 6)), from the Upper Campanian–Lower Maastrichtian of Carimba, Angola, SAM-6829.

Occurrence. Upper Campanian (Lower Maastrichtian?), Angola, Cape Province (Igoda), Egypt, ?Palestine, California, British Columbia, Hokkaido, James Ross Island, Antarctica.

* ***Baculites subcircularis*** Anderson, 1958 Fig. 104H–K
(= *?Fresvillia*)

Anderson 1958: 192, pl. 48 (fig. 7).

Type. Holotype by monotypy is the original of Anderson (1958, pl. 48 (fig. 7)) from the Campanian or Maastrichtian near the mouth of Briones Creek, south of Brentwood, Contra Costa County, California, CAS type collection .

Occurrence. Campanian or Maastrichtian, California.

Baculites sublaevis Griepenkerl, 1889
(= *nom. nud.* fide Kennedy 1986*c*: 191; see also Howarth 1965: 366)

Griepenkerl 1889: 409.

Baculites subtilis Collignon, 1969
(= *B. menabensis*)

Collignon 1969: 18, pl. 519 (figs 2042–2044). Klinger & Kennedy 1997, figs 59d–f, 61c.

Fig. 152 *(see facing page)*. *Baculites scotti* Cobban, 1958. A–B. OUM KT7905. C–E. OUM KT7141. F–G. OUM KT7094. All from the Pierre Shale, *Baculites scotti* zone, west-facing bluff, 1.6 km north-north-east of Oral in NW ¼ NW ¼ sec. 26, T. 7 S., R. 7 E., Fall River County, South Dakota. All ×1.

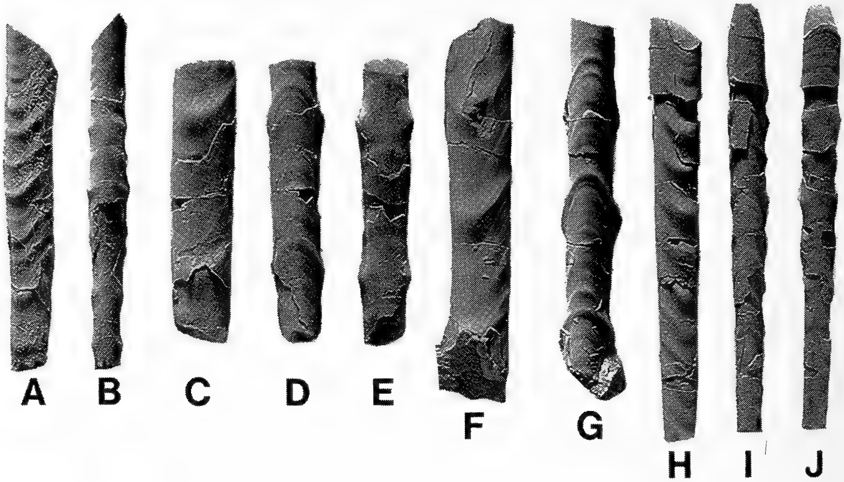

Fig. 153. *Baculites sweetgrassensis* Cobban, 1951. A–B. USNM 43880. C–E. USNM 433882. F–G. USNM 433884. H–J. USNM 433885. All from the Middle Coniacian *Inoceramus deformis* zone at USGS Mesozoic locality 21422 near Shelby, Toole County, Montana. All × 1.

Type. Holotype is the original of Collignon (1969, pl. 519 (fig. 2042)) from the Lower Campanian of Gisement 304, Coupe Ampolypoly-Antsirasira-Behamotra (Belo sur Tsiribihina), Madagascar, GD 12042.

Occurrence. Lower Campanian, Madagascar.

* ***Baculites suecicus*** Moberg, 1885 Fig. 91H

Moberg 1885: 34, pl. 4 (fig. 1). Hägg 1935: 59. Kennedy & Christensen 1997: 108, fig 26a.

Type. Holotype by monotypy is the original of Moberg (1885, pl. 4 (fig. 1)) from the Senonian of Käseberga, Sweden.

Occurrence. Campanian, Sweden.

Baculites sulcatus Baily, 1855

Baily 1855: 457, pl. 11 (fig. 5c only). Woods 1906: 341, pl. 44 (fig. 4). Van Hoepen 1921: 18, pl. 3 (figs 7–8). Spath 1922: 146. *non* Collignon 1931: 36, pl. 5 (figs 3, 3a, 4, 4a, 5, 5a, 13, 13a), pl. 9 (fig. 15). *non* Matsumoto & Obata 1963: 46, pl. 12 (fig. 6), text-figs 94, 130 (as *Baculites* n. sp. (?) aff. *B. sulcatus*). Klinger & Kennedy 1977: 75, fig. 3b–e, j–l. Klinger & Kennedy 1997: 111, figs 63–66, 67a-j, 68–77, 78c.

Type. Lectotype by the subsequent designation of Matsumoto & Obata (1963: 46) is the original of Baily (1855, pl. 11 (fig. 5c)), refigured by Woods (1906, pl. 44 (fig. 4)) from the Lower Campanian of the Mzamba Formation at the Mzamba River Estuary, Pondoland, BMNH C35625.

Occurrence. Lower Campanian, Pondoland, subsurface, Richards Bay, Zululand.

Baculites superstes Pervinquière, 1910
(= *Bochianites* fide Wiedmann, 1973: 311).

Pervinquière 1910: 22, pl. 1 (figs 29–30).

Type. Holotype by monotypy is the original of Pervinquière (1910, pl. 29 (figs 29–3)) allegedly from the Maastrichtian of Constantine. SP unregistered.

Occurrence. The species was erroneously attributed to the Maastrichtian, but is probably Barremian (Durand Delga 1954).

* ***Baculites sweetgrassensis*** Cobban, 1951 Fig. 153

Cobban 1951: 820, pl. 118 (figs 6–9), text-figs 1–3. Kauffman 1977: 270, pl. 29 (fig. 9). Kennedy & Cobban 1991*a*: 70, pl. 14 (figs 24–25, 29–34, 38–42).

Type. Holotype is the original of Cobban (1951, pl. 118 (figs 8–9)) from the Middle Coniacian Marias River Shale on the Sweetgrass Arch, Toole County, Montana, USNM 106983.

Occurrence. Widely distributed in the Middle Coniacian of the US Western Interior.

Baculites tanakae Matsumoto & Obata, 1963

Matsumoto & Obata 1963: 51, pl. 13 (fig. 4), pl. 16 (figs 1–5), pl. 17 (figs 1–5), pl. 18 (figs 1, 3–4), pl. 19 (figs 1, 4), text-figs 97–113, 115). ?Collignon 1969: 23, pl. 521 (fig. 2055), (as *Baculites* cf. *tanakae*). ?Summesberger 1979: 116, pl. 2 (figs 10–13), text-fig. 6 (as *Baculites* cf. *tanakai*).

Type. Holotype is the original of Matsumoto & Obata (1963, pl. 17 (fig. 2), text-fig. 106), from the Campanian along the main stream of the Haboro, uppermost part of the Upper Yezo Group, Teshio Province (Hokkaido), Campanian, GK H4288.

Occurrence. Campanian, Hokkaido, and possibly Austria and Madagascar.

Baculites tanakaeformis Collignon, 1970
(= *B. increscens*)

Collignon 1970: 2, pl. 607 (figs 2263–2265). Klinger & Kennedy 1997: 132, fig. 84d–f.

Type. Holotype is the original of Collignon (1970, pl. 607 (fig. 2263)) from Gisement 326, Middle Campanian of Coupe Ampolypoly-Antsirasira-Behamotra (Belo sur Tsiribihina), Madagascar, GD 12263.

Occurrence. Middle Campanian, Madagascar.

* ***Baculites taylorensis*** Adkins, 1929 Figs 154–155

Adkins 1929: 204, pl. 5 (figs 9–11). Kennedy & Cobban 1993*a*: 93, figs 10.1–10.9, 10.11–10.12, 10.16, 10.18–10.19, 11.1–11.2. Kennedy & Cobban 1993*d*: 143, pl. 6 (figs 1–9), pl. 7 (figs 1–6, 10–13), text-fig. 8b, d.

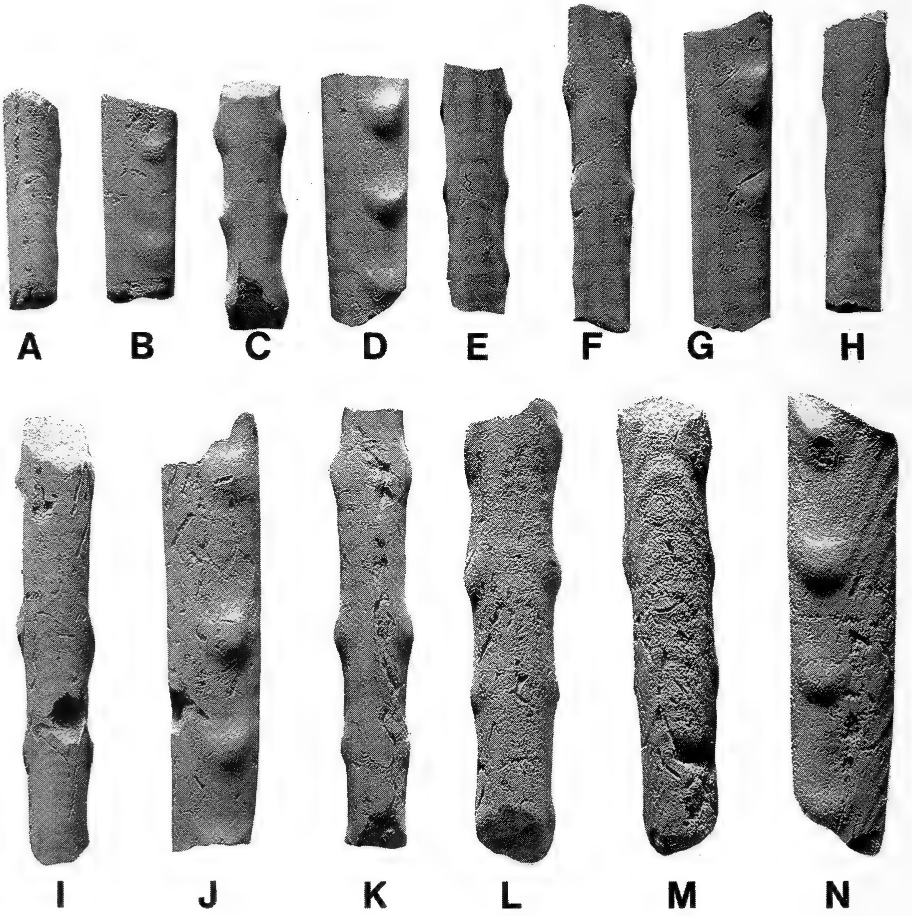

Fig. 154. *Baculites taylorensis* Adkins, 1929. A–B. USNM 411296. C–E. USNM 411295. F–H. USNM 411299. I–K. USNM 411294. L–N. USNM 411298. All from the basal phosphate bed of the Annona Chalk at the Okay Quarry, Okay, Howard County, Arkansas. All × 1.

Type. Holotype is the original of Adkins (1929, pl. 5 (figs 10–11)) from the Middle Campanian of Travis County, 7.5 miles north-east of Austin, Texas. BEGAT collections.

Occurrence. Middle Campanian, Texas; Campanian, Arkansas.

Baculites teicheri Reyment, 1956

Reyment 1955: 15, pl. 1 (fig. 5a–b), text-fig. 2a. Reyment 1956: 50.

Type. Holotype is the original of Reyment (1955, pl. 1 (fig. 5a–b)) from the Maastrichtian Nkoporo Shales, Amamgbala, Afikpo Division, Ogoja Province, Nigeria, BMNH C47413.

Occurrence. Maastrichtian, Nigeria.

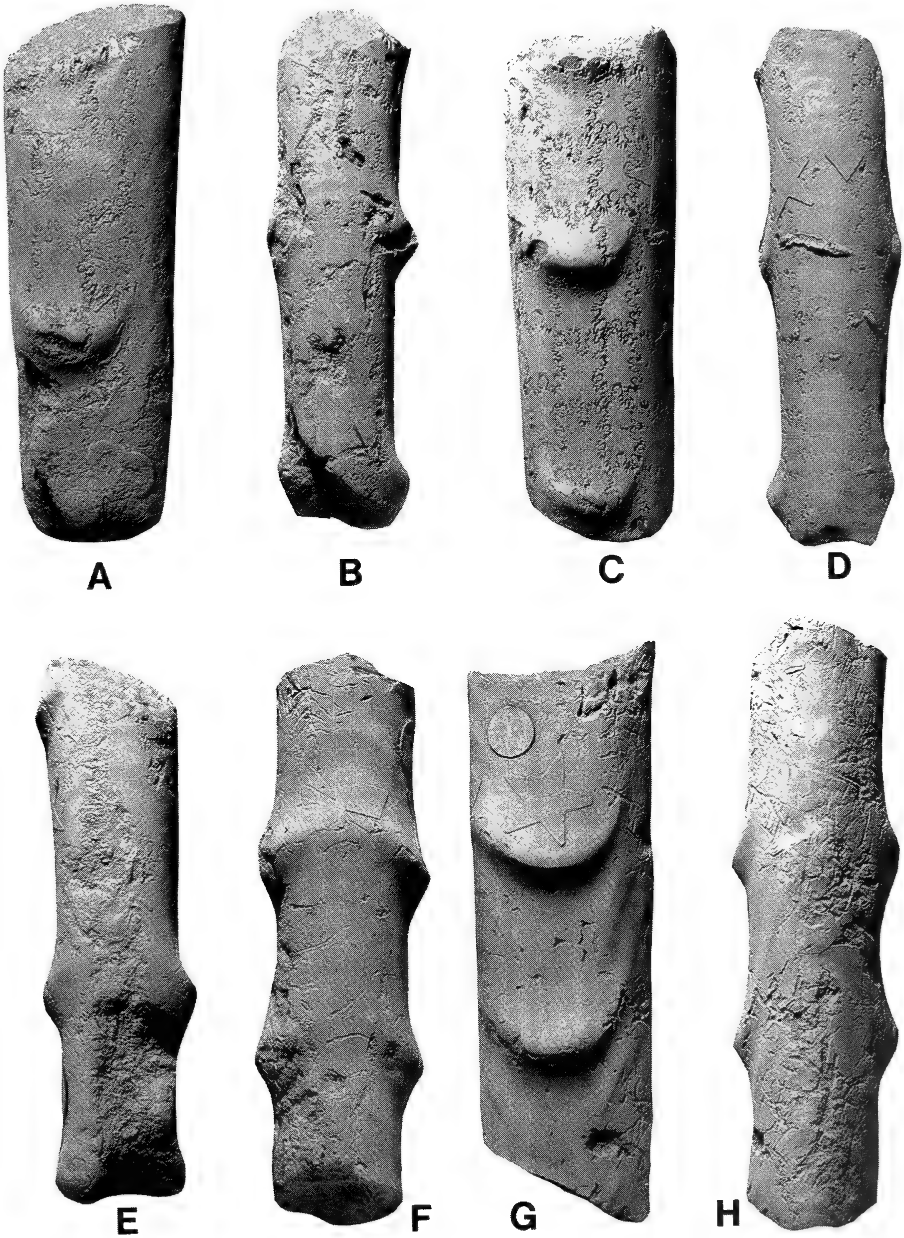

Fig. 155. *Baculites taylorensis* Adkins, 1929. A–B. TMM–21016, paratype. C–E. TMM–21015, paratype. F–H. TMM–21014, the holotype. All from the Pecan Gap Chalk, Campanian, along the old Austin-Manor highway on the eastern side of the Big Walnut Creek Valley, 9 km approximately north-east of Austin, Travis County, Texas. All × 1.

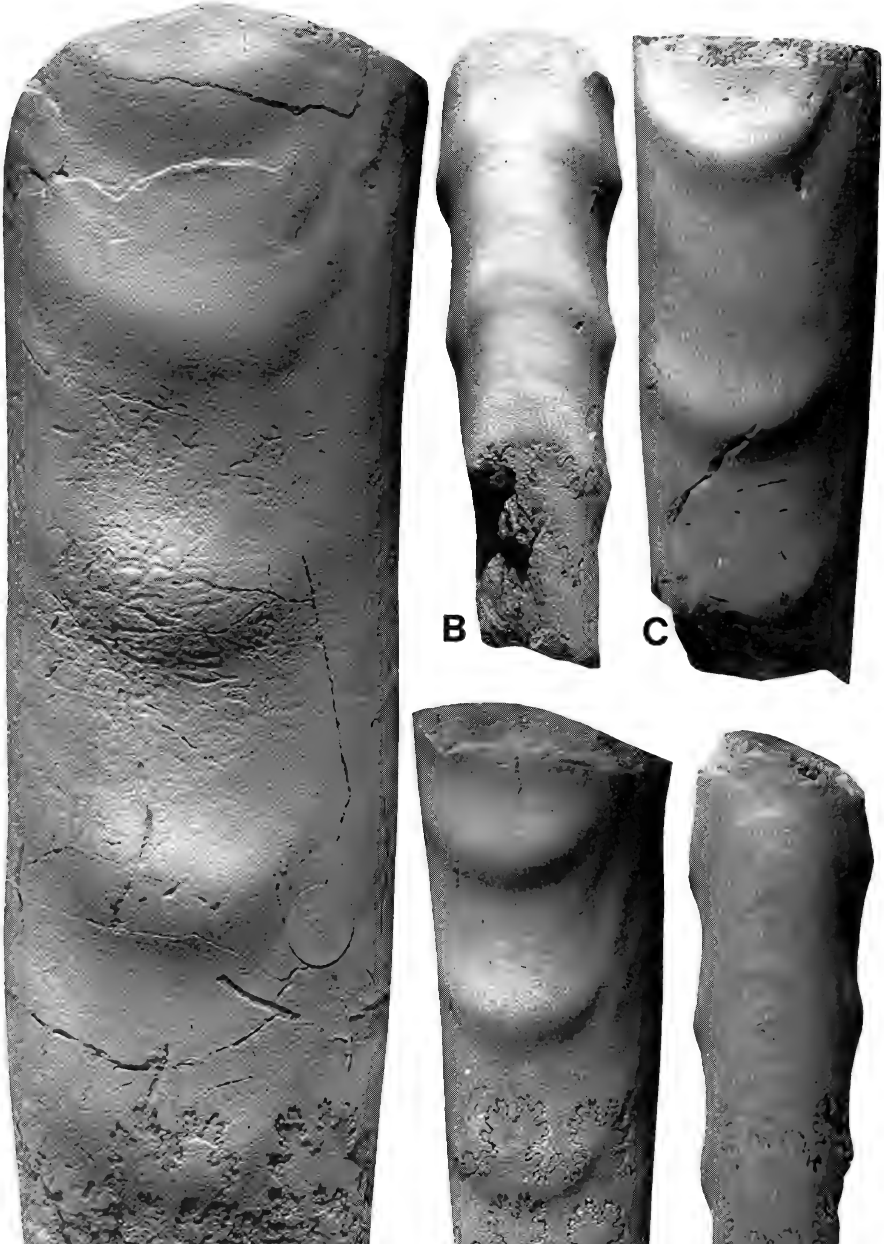

Fig. 156

Baculites teres Forbes, 1846
(see *Fresvillia*)

Forbes 1846: 115, pl. 10 (fig. 5).

'Euhomaloceras' teshioense Shimizu, 1935
(*nom. nud.* fide Matsumoto & Obata 1963: 8).

****Baculites texanus*** Kennedy & Cobban, 1999 Fig. 156

Kennedy & Cobban 1999: 75, pls 6–7, text-fig. 7.

Type. Holotype is the original of Kennedy & Cobban (1999, pl. 6 (figs 4–6), text-fig. 7a) from the Campanian Bergstrom Formation at USGS Mesozoic locality 15535, USNM 475059.

Occurrence. Campanian, Texas, U.S. Gulf Coast Region, US Western Interior (South Dakota and Colorado).

* ***Baculites thomi*** Reeside, 1927 Fig. 157

Reeside 1927*b*: 13, pl. 12 (figs 9–14). Reeside 1927*b*: 13 (*pars*), pl. 10 (figs 9–12) (as *B. asper*). Cobban & Kennedy 1991*a*: C5, pls 1–2, text-fig. 2. Kennedy & Cobban 1991*a*: 74, text-fig. 26.

Type. Holotype is the original of Reeside (1927*b*, pl. 12 (figs 9–14)) from the Santonian Elk Basin Sandstone Member of the Telegraph Creek Formation, Big Horn County, Montana, USNM 73315.

Occurrence. Upper Santonian, but ranges into the Lower Campanian, US Western Interior (Montana, Wyoming, New Mexico).

Baculites tippaensis Conrad, 1858
(= *Eubaculites carinatus* fide Klinger & Kennedy 1993: 218)

Conrad 1858: 334, pl. 35 (fig. 27).

* ***Baculites trifidilobatus*** Warren, 1930 Fig. 117I–K

(= *B. codyensis* fide Kennedy & Cobban 1991: 72). Warren 1930: 65, pl. 5 (figs 1–2, 11–12).

Type. Lectotype here designated is the original of Warren (1930, pl. 5 (figs 1–2)) from the Coniacian, Smoky River Shales, Little Smoky River, Alberta, Canada, GMUA Ct 462.

Occurrence. Coniacian, Alberta.

Fig. 156 *(see facing page)*. *Baculites texanus* Kennedy & Cobban, 1999. A. USNM 475064, paratype. B, D–E. USNM 475061, paratype. C. USNM 475062, paratype. All from the Bergstrom Formation, Upper Campanian, south-south-west of Manda, Travis County, Texas.
All × 1.

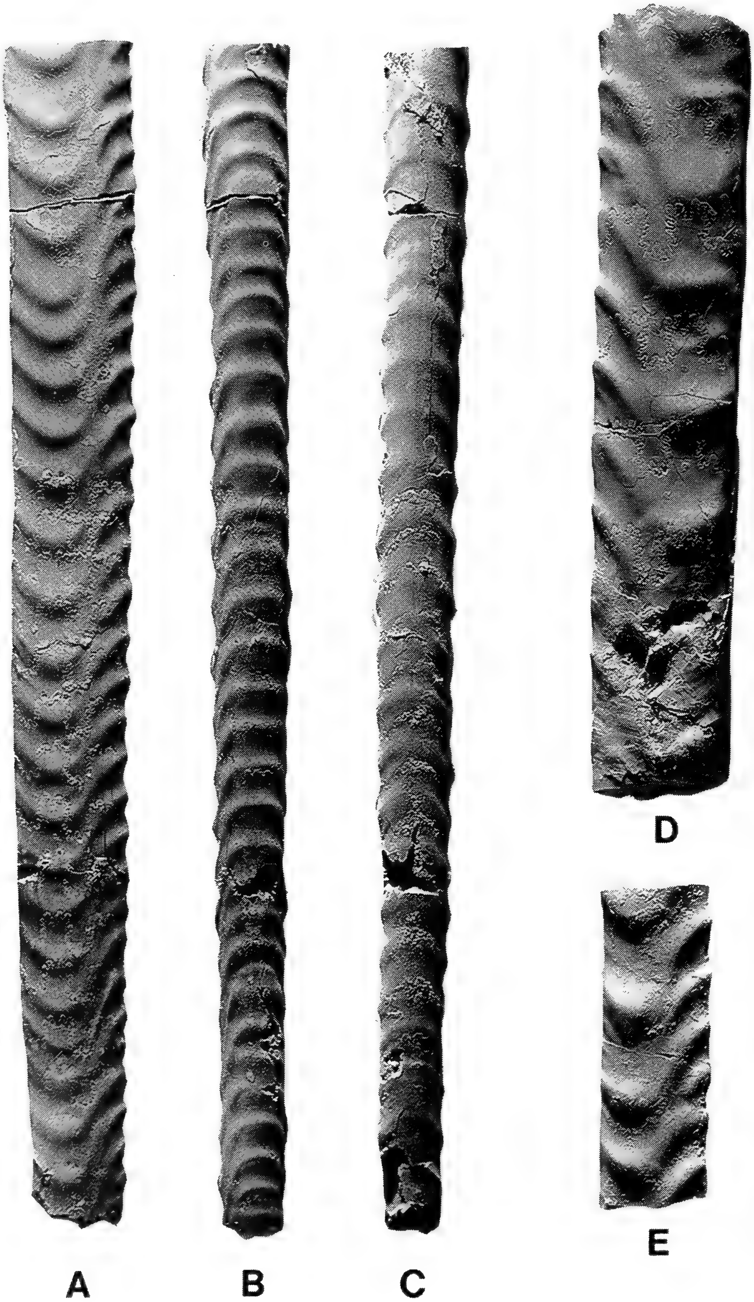

Fig. 157. *Baculites thomi* Reeside, 1927*b*. A–C. USNM 433907. D. USNM 433905. E. USNM 433906. All from the Santonian *Desmoscaphites erdmanni* zone near the top of the Marias River Shale at USGS Mesozoic locality 21419, 12.8 km west of Shelby in the NE¼ sec. 31, T. 32 N., R. 3 W., Toole County, Montana. All × 1.

Baculites tuberculata d'Orbigny, 1842

(= *B. incurvatus* Dujardin, 1837, *fide* Schlüter 1876: 142; Kennedy 1984: 143–4).

D'Orbigny 1842: 565.

Fig. 158. *Baculites undatus* Stephenson, 1941. A–C. USNM 449487, from the Upper Campanian *Nostoceras hyatti* zone fauna of the Coon Creek Tongue of the Ripley Formation at Coon Creek, McNairy County, Tennessee. × 1.

Baculites uedae Matsumoto & Obata, 1963

Matsumoto & Obata 1963: 40, pl. 20 (figs 5–7), pl. 21 (figs 1, 3, 6), text-figs 91–92, 121–129.

Type. Holotype is the original of Matsumoto & Obata (1963, pl. 20 (fig. 6)) from the Santonian, main stream of the Detofutamata River, Chikubetsu area, Teshio Province, Hokkaido, GK H4794.

Occurrence. Santonian, Hokkaido.

*__Baculites undatus__ Stephenson, 1941 Figs 158–159

Stephenson 1941: 405, pl. 79 (figs 5–10). Cobban 1973: 459, figs 2–5. Cobban 1974: 6, text-fig. 3. Cobban *et al.* 1992: A7. Kennedy & Cobban 1993*c*: 424, figs 12.2, 14.18, 14.19, 14.21, 15.13, 15.25–15.27. Kennedy & Cobban 1994*b*: 1297, figs 14.31–14.32, 15.5–15.7. Cobban & Kennedy 1994*c*: B8, pl. 8 (figs 9–11), pl. 9 (figs 1–6). Larson *et al.* 1997: 31.

Type. Holotype is the original of Stephenson (1941, pl. 79 (figs 5–7)) from the Campanian Nacatoch Sand near Chatfield, Texas, USNM 77245.

Occurrence. Upper Campanian to Lower Maastrichtian, Texas, Colorado and New Mexico; also recorded from Tennessee, Mississippi, Delaware and New Jersey (Owens *et al.* 1970: 32) and Arkansas, and recently by Cobban *et al.* (1992) from the US Western Interior.

*__Baculites undulatus__ d'Orbigny, 1850 Fig. 182H

D'Orbigny 1850: 19, 20, no. 21. Fritsch & Schlönbach 1872: 49. Roman & Mazeran 1913: 11, pl. 4 (figs 6–8). Matsumoto & Obata 1963: 28, pl. 8 (fig. 4), pl. 9 (figs 1–5), pl. 11 (figs 2–3), text-figs 62–71. Wright 1979: 287, pl. 1 (figs 6–8), pl. 7 (fig. 11). Szász 1986: 121, pl. 1 (figs 1–2) (as *B.* aff. *undulatus*). Breton & Bavent 1985: 102, figs 1–3. Nishida *et al.* 1992, pl. 6 (figs 4–5). Kennedy *et al.* 1989: 101, fig. 31i. Vašiček 1993: 184, pl. 3 (figs 2–3) (as *Baculites* cf. *undulatus*). Summesberger & Kennedy 1996: 135, pl. 18 (figs 8–13, 17–20, 22–25) (as *Baculites* cf. *undulatus*).

Type. Holotype by monotypy is the original of d'Orbigny (1850: 190), figured by Roman & Mazeran (1913, pl. 4 (fig. 6)) and Sornay (1955), from the Upper Turonian of Uchaux, Vaucluse, France; MNHP, d'Orbigny Collection no. 6796.

Occurrence. Upper Turonian, England, France, Bohemia, Hokkaido, Trans-Pecos, Texas and New Mexico, and possibly Lower Turonian, Romania.

Baculites vaalsensis Kennedy & Jagt, 1995

Kennedy & Jagt 1995: 282, figs 4.1–4.18, 5.1–5.17, 6.1–6.9. Kennedy *et al.* 1997*b*: 11, figs 9–10.

Type. Holotype is the original figured specimen of Van der Weijden (1943, pl. 13 (fig. 5)) from the Hervian of Emma Colliery, shaft 1, near Treebeek, The Netherlands.

Fig. 159 *(see facing page)*. *Baculites undatus* Stephenson, 1941. A–C. USNM 182430 from the Nacatoch Sand, 1.1 mile north-west of Chatfield, Navarro County, Texas. D–F. USNM 18243, from the same locality as A–C. G–I. USNM 182427 from the Nacatoch Sand at USGS Mesozoic locality 762 near Chatfield, Texas. J. USNM 182437 from the Pierre Shale at USGS Mesozoic locality D1353, Grand County, Colorado. × 1.

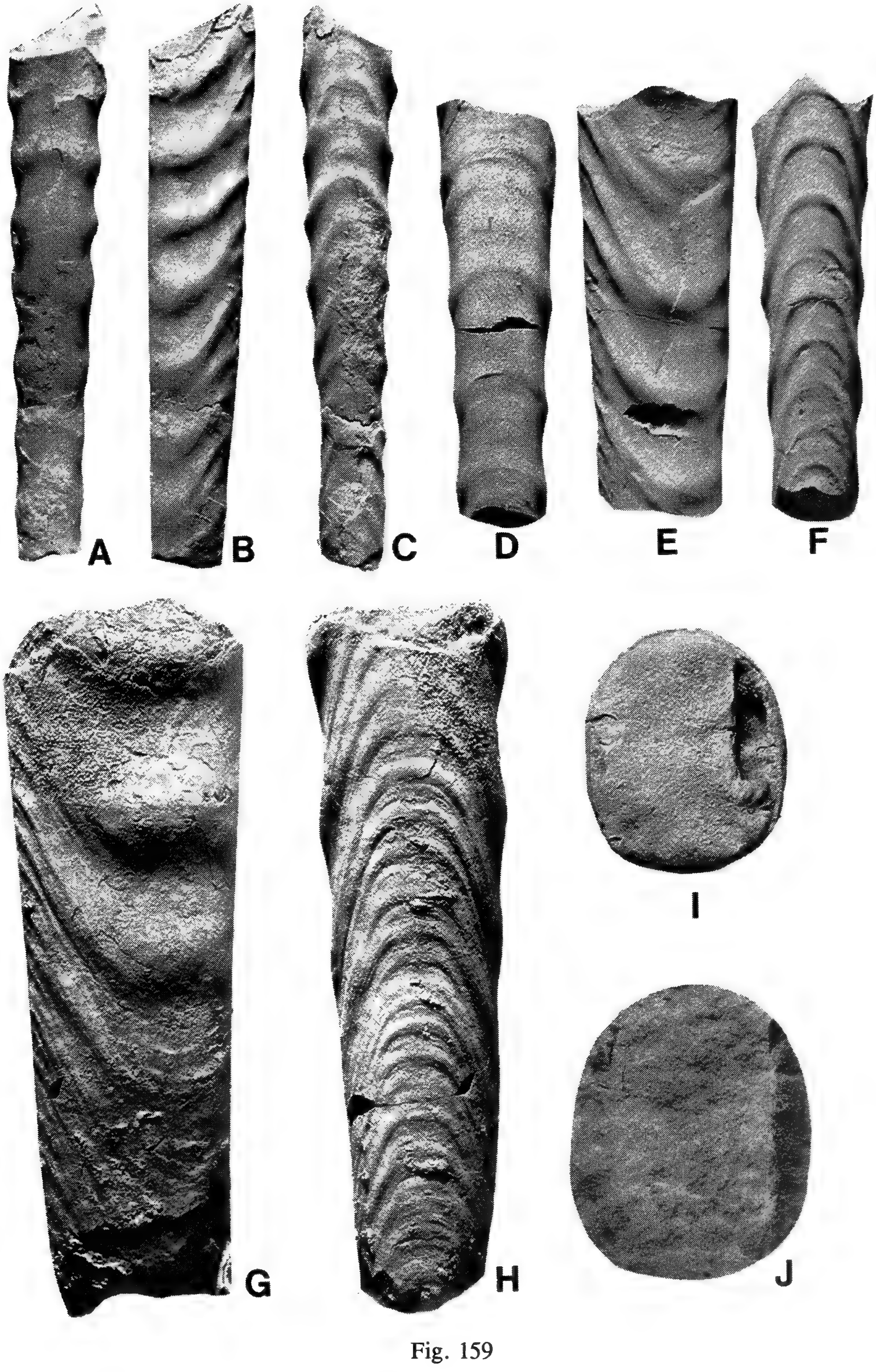

Fig. 159

Fig. 160. *Baculites vertebralis* Lamarck, 1801. A–B. BMNH C70591, from Valognes, France. C–D. NHMW 7460 from Fresville. Both from the Upper Maastrichtian Calcaire à *Baculites* of the Cotentin Peninsula, Manche, France. Both × 1.

Occurrence. Lower Campanian, north-eastern Belgium, and adjacent parts of The Netherlands, Germany, northern Aquitaine (France) and New Jersey.

Baculites valognensis Böhm, 1891
(*nom. dub.* fide Howarth 1965: 366; Kennedy 1986*a*: 61; 1986*c*: 191)

Böhm 1891: 50, pl. 1 (fig. 13a–b). Nowak 1908: 335, pl. 14 (figs 6–7), text-figs 1–4 (p. 331), text-figs 6a, 7a–b, 9, 12 (p. 337). Birkelund 1979: 53.

Type. ?

Occurrence. Senonian, northern Alps; in Denmark Birkelund (1979: 53) recorded it from the Upper Maastrichtian (as *B. vertebralis*).

Baculites vanhoepeni Venzo, 1936

Venzo 1936: 116 (58), pl. 10 (6) (figs 11–12) (as *B. vagina* var. *van hoepeni*). Klinger & Kennedy 1977: 73, figs 2g–k, 3a–i, 4a–c, 5c. Klinger & Kennedy 1997: 138, figs 79m, 91–115.

Type. Lectotype, by the subsequent designation of Klinger & Kennedy (1977: 73), is the original of Venzo (1936, pl. 10 (6) (fig. 11a–b)) from 'False Bay', Zululand. DSGUB 1 GO 242.

Occurrence. Middle–?Upper Campanian, Zululand and Natal (Durban subsurface).

Baculites ventroplanus Collignon, 1969
(= *B. menabensis*)

Collignon 1969: 20, pl. 520 (figs 2048–2050), p. 24, pl. 521 (figs 2056–2058). Klinger & Kennedy 1997, fig. 58d–f.

Type. Holotype is the original of Collignon (1969, pl. 520 (fig. 2048)) from the Lower Campanian of Gisement 303, Coupe Ampolypoly-Antsirasira-Behamotra (Belo sur Tsiribihina), Madagascar, GD 12048.

Occurrence. Lower Campanian, Madagascar.

* ***Baculites vertebralis*** Lamarck, 1801 Figs 160–161

Lamarck 1801: 159. Schlüter, 1876: 143 (*pars*), pl. 39 (figs 12–13), pl. 40 (figs 4, 5, *non* 6). *non* Moberg 1885: 38, pl. 4 (figs 8–9). ?Pervinquière 1907: 93 (*pars*), *non* pl. 4 (fig. 9). Pervinquière 1910: 21. *non* Taubenhaus 1920: 11. *non* ?Picard 1929: 444, pl. 9 (figs 5–8), text-figs 3–6. Hägg 1947: 93 (*pars*). Mikhailov 1951: 48, pl. 1 (figs 4–6), text-figs 15a–b, 16a–b. Hägg 1954: 55 (*pars*). Glazunova 1955: 182, pl. 3 (figs 1–3, 6). Naidin & Shimanskij 1959: 183, pl. 3 (figs 1a–b, 3), text-fig. 17-1. *non* Giers 1964: 256, text-figs 1–2. Tzankov 1982: 17, pl. 3 (fig. 4, 4a). Balan 1982: 209, pl. 19 (figs 8–9). Kennedy 1986*a*: 57, pl. 11 (figs 6–11), pl. 12 (figs 1–6), text-figs 3a–d, 7d–f, 8. Kennedy 1986*c*: 187, pl. 19 (figs 1–4, 7–10), pl. 20 (figs 3–5), pl. 28 (figs 2, 7–10, 14–16), pl. 29 (figs 1–15), pl. 30 (figs 1–9), text-figs 11a–b, 12. Kennedy 1986*e*: 1012, pl. 1 (figs 8–9). Kennedy 1986*d*, fig. 10e. Ward *et al.* 1991: 1183, fig. 2. Birkelund 1993: 53, pl. 13 (figs 1–11), pl. 16 (figs 1–5), text-fig. 6a, 8d–i. Ward & Kennedy 1993: 51,

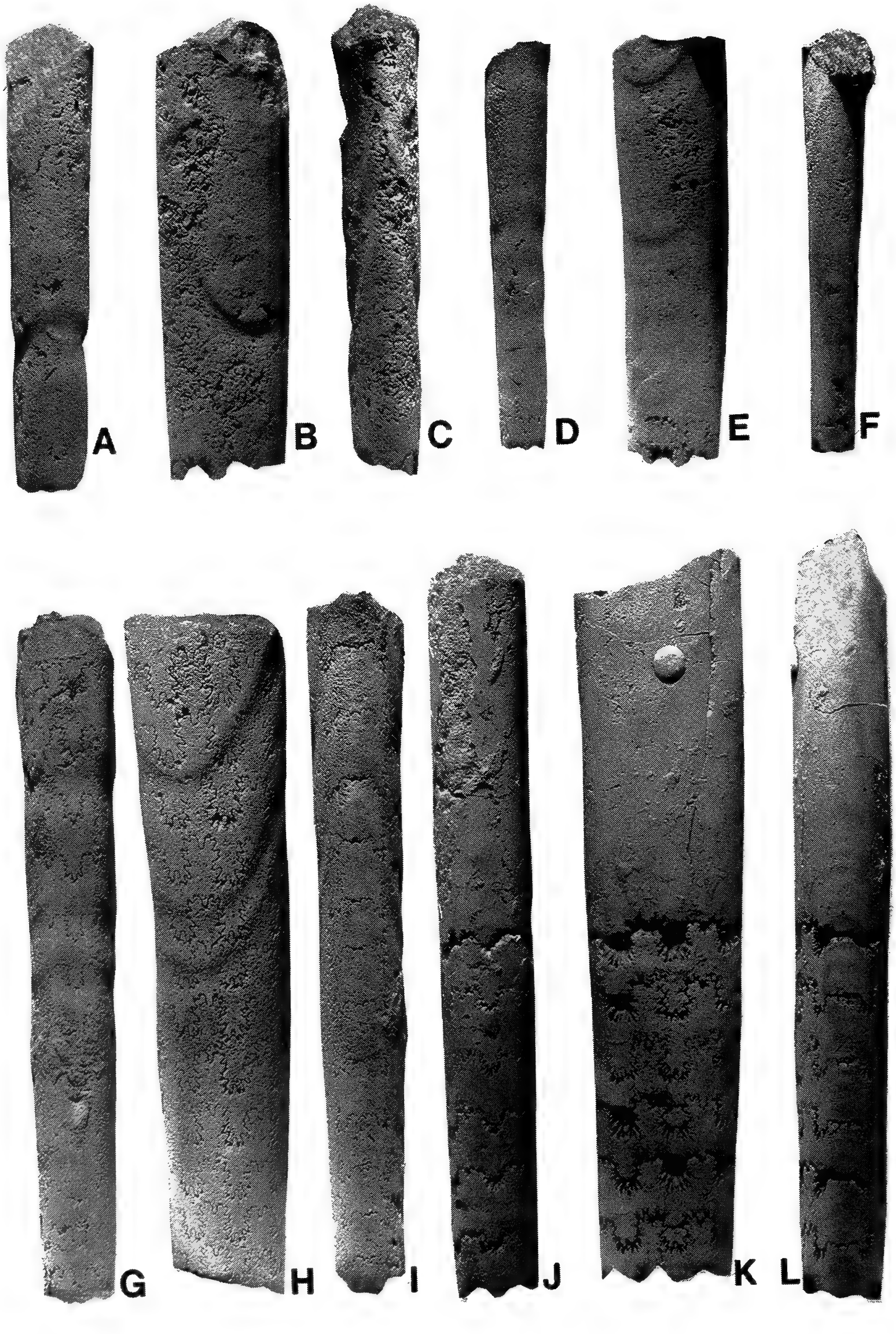

Fig. 161

figs 43.5–43.7, 43.14, 43.15. (as *Baculites* cf. *B. vertebralis*). Kennedy & Christensen 1997: 110, fig. 26i, l–m. Kennedy *et al.* 1997*a*: 18, figs 15e–j, m–o, 16a–f, i–k, 17–18.

Type. Lectotype by subsequent designation of Kennedy (1986*a*: 57) is the original of Faujas-Saint-Fond (1799, pl. 21 (figs 2–3)). It is the holotype by monotypy of *B. faujasii* Lamarck, 1822, which is thus a subjective synonym.

Occurrence. Upper Maastrichtian, France, Belgium, Denmark, southern Sweden, northern Germany, Poland, southern Russia, Maryland, U.S.A., and possibly North Africa and Palestine. According to Ward *et al.* (1991: 1183, fig. 2), *B. vertebralis* possibly already occurs in the Lower Maastrichtian of Zumaya.

Baculites vertebralis var. ***syriacus*** Conrad, 1852

Conrad 1852: 227, pl. 20 (fig. 121) (as *B. syriacus*). Picard 1929: 445, pl. 9 (figs 9–10) (as *B. vertebralis* var. *syriacus*).

Type. According to Dr S. Rothmann, Jerusalem, most of Conrad's types are in the Peabody Museum, Yale University.

Occurrence. Maastrichtian, Palestine.

Baculites vicentei Stinnesbeck, 1986
(= *Trachybaculites*)

Stinnesbeck 1986: 203, pl. 9 (fig. 4), pl. 10 (figs 3–6), text-fig. 23a–c.

* ***Baculites yokoyamai*** Tokunaga & Shimizu, 1926 Fig. 105B–R

Tokunaga & Shimizu 1926: 195, pl. 22 (fig. 5a–b), pl. 26 (fig. 11). Reyment 1958: 7, pl. 1 (figs 1–2), text-figs 1–2) (as *B. ovatus* Say?). Matsumoto & Obata 1963: 30, pl. 8 (fig. 5), pl. 10 (figs 1–6), pl. 11 (figs 1, 4–5), pl. 12 (fig. 3), pl. 14 (fig. 4), text-figs 72–87. Cobban & Scott 1972: 48, pl. 20 (figs 15–21) (as *Baculites* cf. *yokoyamai*). Hattin & Siemers, 1978, text-fig. 7.2 (as *Baculites* cf. *yokoyamai*). Cobban & Hook 1979: 13, pl. 4 (figs 9–10). Renz 1982: 105, pl. 34 (figs 3–6), text-fig. 80 (as *B. inornatus*). Cobban & Hook 1983: 7, pl. 1 (figs 1–7). Cobban 1983: 16, pl. 14 (figs 6–8). Cobban 1984: 14, pl. 1 (figs 5–6). Cobban 1986, fig. 3h–i. Kennedy 1988: 110, pl. 23 (figs 8–10), text-fig. 29c. Kennedy & Cobban 1988: 608, figs 3: 1, 2, 7, 13–14, 18–19. Cobban 1990, pl. 9 (figs 16–22). Kennedy & Cobban 1991*a*: 69, pl. 13 (figs 4–10, 17–21, 24–28, 34–37, 41–42), text-fig. 22a. Kennedy *et al.* 1989: 101, fig. 31e–h. Summesberger 1992: 124, pl. 8 (figs 10–11). Summesberger & Kennedy 1996: 135, pl. 18 (figs 5–7, 16). Klinger & Kennedy 1997: 21, figs 7–11, 12a–i.

Fig. 161 *(see facing page)*. *Baculites vertebralis* Lamarck, 1801. A–C. IRSNB 10283 (IG 4285 ex Bosquet Collection) from the Upper Maastrichtian Calcaire de Kunraed of Kunrade, Limburg, The Netherlands. D–F. IRSNB 10284 (IG 8261 ex De Jaer Collection). Horizon and locality as in A–C. G–I. IRSNB 10278 (IG 6521). Horizon and locality as above. J–L. IRSNB 10282 (IG 6521 ex Ubaghs Collection). Horizon and locality as above. All × 1.

Type. Holotype by monotypy is the original of Tokunaga & Shimizu (1926, pl. 22 (fig. 5a–b), pl. 26 (fig. 11)) from the lower Futaba Beds in the upper reaches of the Sakurazawa in Oriki, Hirono-mura, Fukushima prefecture, north-east Honshu. The type was destroyed during WW II (see Matsumoto & Obata 1963: 31). A neotype has been designated by Matsumoto & Obata (1963, pl. 10 (fig. 5)) and is from the Coniacian along the Bannosawa, Hokkaido, GK H4580.

Occurrence. Lower Turonian to Lower Coniacian, US Western Interior (Wyoming, Montana, South Dakota, Colorado, Kansas, New Mexico and Texas); Trans-Pecos, Texas, mid-Turonian of Austria; and Coniacian of Hokkaido, Venezuela, Zululand and India (Klinger in prep.).

Baculites zhuravlevi Grabovskaya, 1984

Grabovskaya 1984: 84, pl. 12 (figs 4–6), text-fig. 8b–g.

Type. Holotype is the original of Grabovskaya (1984, pl. 12 (fig. 4)) from the Campanian of Saghalin, BPI 951/20.

Occurrence. Campanian, Saghalin.

Genus *Boehmoceras* Riedel, 1931

* ***Boehmoceras arculus*** (Morton, 1834) Fig. 162A–F

Morton 1834: 44, pl. 15 (figs 1–2). Morton 1834: 45 (as *Hamites arculus* var. A). Riedel 1931: 692, pl. 78 (figs 3–6) (as *B. löscheri*). Ulbrich 1971, pl. 5 (fig. 4) (as *B. loescheri*). Summesberger 1979: 119, pl. 2 (figs 15–16, 18), text-figs 9–12) (as *B. löscheri*). Kennedy & Wright 1983: 866 (as *Boehmoceras*). Kennedy 1983, pl. 2 (fig. 1) (as *Boehmoceras* sp.). Schönfeld 1985, pl. 2 (fig. 6). Kennedy 1987: 777, pl. 82 (figs 4–16), text-fig. 2 (as *B. loescheri*). Immel 1987: 131 (as *B. loescheri*). Kennedy & Cobban 1991*b*: 182, figs 6: 2, 8, 8: 9–15, 18–22, 9: 1–2, 11–52, 10: 20–21, 24–26, 12: 3. Kennedy & Christensen 1993: 154, figs 3, 41.

Type. Morton (1834) illustrated two specimens; Richards (1968) referred to two to five co-types; a lectotype was designated by Kennedy & Christensen (1993: 155) and is the specimen figured as their fig. 3, ANSP collections, from the 'Older Cretaceous strata, Greene County, Alabama'.

Occurrence. Upper Santonian, Germany, Austria, France, Sweden, Gulf Coast Region, USA.

* ***Boehmoceras krekeleri*** (Wegner, 1905) Fig. 163

Wegner 1905: 210, pl. 8 (fig. 2) (as *Ancyloceras krekeleri*). Riedel 1931: 691. pl. 77 (figs 3–5), pl. 78 (figs 1–2). Summesberger 1979: 118, pl. 2 (fig. 14), text-figs 7–8. Kennedy & Wright 1983: 866. Schönfeld 1985, pl. 2 (fig. 4). Immel 1987: 131. Kennedy 1987: 778, text-fig. 3a–b. Kennedy & Christensen 1993: 154, figs 2d–h, 4c, d, h, j.

Type. Holotype by monotypy is the original of Wegner (1905, pl. 8 (fig. 2)) from the Santonian of the Recklinghäuser Mergel in the mine Waldersee near Horneburg, Münster Basin, Germany. Originally deposited in the

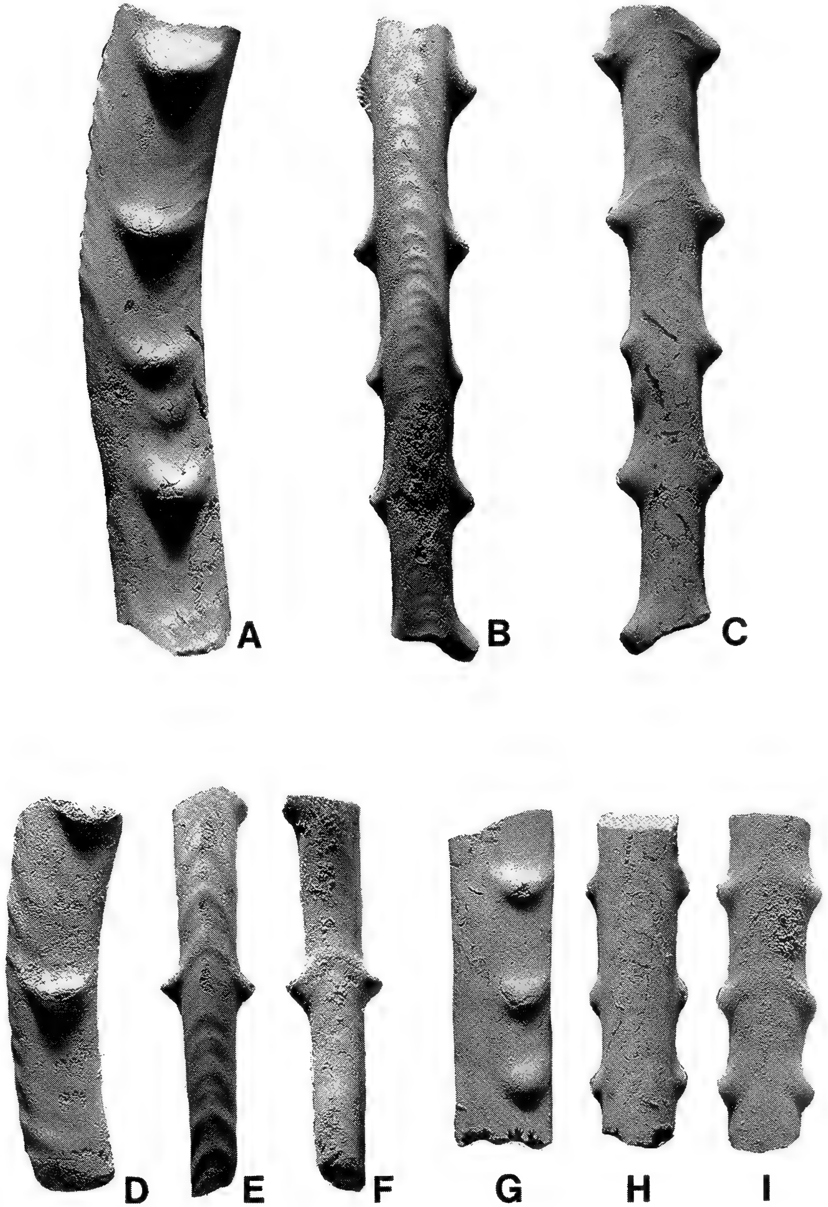

Fig. 162. A–F. *Boehmoceras arculus* (Morton, 1834). A–C. USNM 434130. D–F. USNM 434120. Both from the Upper Santonian of USGS Mesozoic locality 31555, Tombigbee Sand Member of the Eutaw Formation, collections from spoil heaps for lock and dam at Columbus, about 16 m below top of Member, Columbus, Lowndes County, Mississippi. G–I. *Baculites capensis* Woods, 1906, USNM 434089, from the Upper Santonian of USGS Mesozoic locality 31555. All × 1.

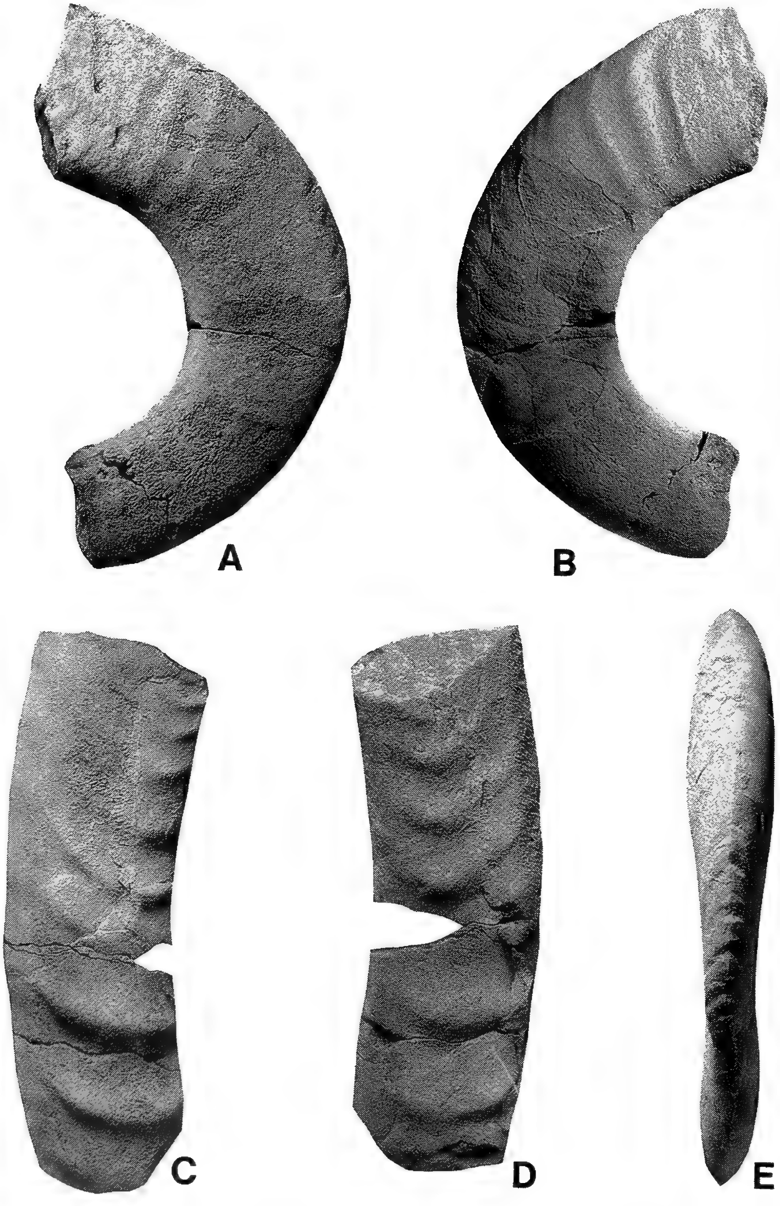

Fig. 163. *Boehmoceras krekeleri* (Riedel, 1931). A–B, E. UPST L1 (Université Paul Sabatier, Toulouse), from the Santonian of Sougraine, Corbières, Aude, France. C–D. UPST PMA7-1, Santonian of Chemin de Croutets, Corbières, Aude. Both × 1.

Museum für Naturkunde, Berlin; apparently the types are lost (see Kennedy & Christensen 1993: 154).

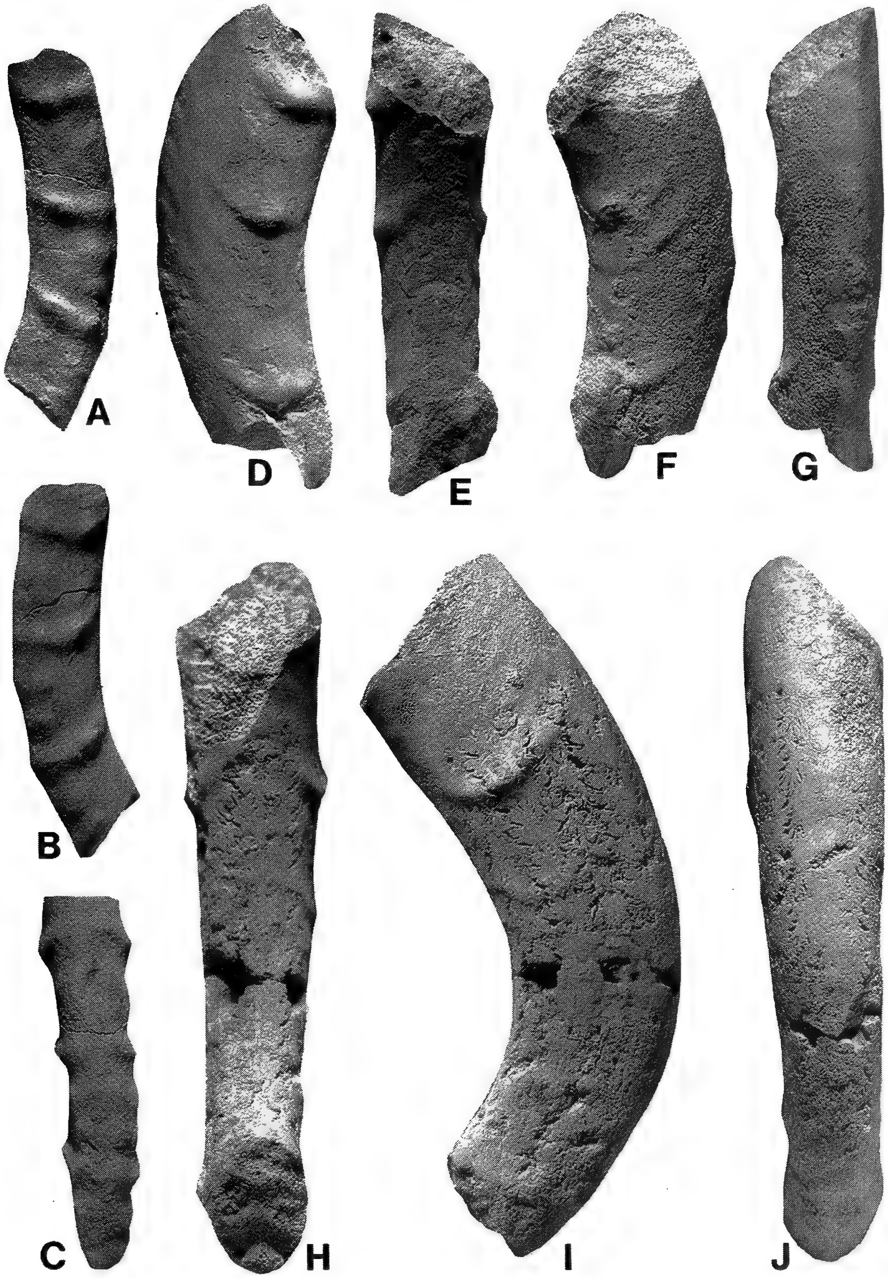

Fig. 164. *Boehmoceras loescheri* Riedel, 1931. All SP unregistered, ex Arnaud Collection. A–C from Assize N1, Charmant (Charente); D–G, H–J from Assize M2, Nieul-le Virouil (Charente-Maritime).
All × 1.

Occurrence. Upper Santonian, northern Germany, France and Gosau, Austria; subsurface deposits in Sweden.

* ***Boehmoceras loescheri*** Riedel, 1931 Fig. 164
(= *B. arculus* (Morton, 1834)

Riedel 1931: 692, pl. 78 (figs 3–6).

Type. Riedel's (1931) types were lodged in the former Preussische Geologische Landesanstalt, later the Zentrale Geologische Anstalt. They are from various localities in the Upper Santonian of the Münster Basin. As yet, no lectotype has been designated.

Occurrence. Upper Santonian, northern Germany, Gosau, Austria and northern Aquitaine, France.

Genus ***Criobaculites*** Klinger & Kennedy, 1997

* ***Criobaculites trabeatus*** (Morton, 1834) Fig. 165A–D, G–J

Morton 1834: 45, pl. 15 (fig. 3). Cobban & Kennedy 1995: 23, fig. 17.32–17.35.

Type. Holotype by monotypy is the original of Morton (1834, pl. 15 (fig. 3)) from the Maastrichtian Prairie Bluff Chalk of Alabama, according to Johnson (1905: 27), in the collections of the Academy of Natural Sciences, Philadelphia, ANSP 72865.

Occurrence. Maastrichtian, Prairie Bluff Chalk, Alabama.

Criobaculites? sp.

Cobban & Kennedy (1992*c*: 684, fig. 1.1–1.4, 3.1 (as *Baculites* sp.)).

Occurrence. Maastrichtian, Fox Hills Formation, South Dakota.

Genus ***Eubaculites*** Spath, 1926

Eubaculites ambindensis Collignon, 1971
(= *E. latecarinatus*)

Collignon 1971: 13, pl. 646 (fig. 2393). Klinger & Kennedy 1993, fig. 48.

Type. Holotype is the original of Collignon (1971, pl. 646 (fig. 2393)) from the 'Lower' Maastrichtian, zone of *Pachydiscus gollevillensis* and *Pachydiscus neubergicus* of Gisement 504, Mont Ambinda-Mikoboka (Manera), Madagascar, GD 12393.

Occurrence. Lower Maastrichtian, Madagascar.

Fig. 165 *(see facing page)*. A–D, G–J. *Criobaculites trabeatus* (Morton, 1834). ANSP 72865, from the Maastrichtian Prairie Bluff Chalk at Prairie Bluff, Alabama. E–F. *Criobaculites* sp. USNM 449803, from the Trail City Member of the Fox Hills Formation on the Pat Peterson Ranch in the NE¼ sec. 7, T. 20 N., R. 25 E., Corson County, South Dakota. K–L. *Boehmoceras arculus* (Morton, 1834). Lectotype, ANSP collection, from the 'older' Cretaceous strata of Greene County, Alabama, that is, the Tombigbee Sand Member of the Eutaw Formation. A–F, K–L × 1; G–J × 2.

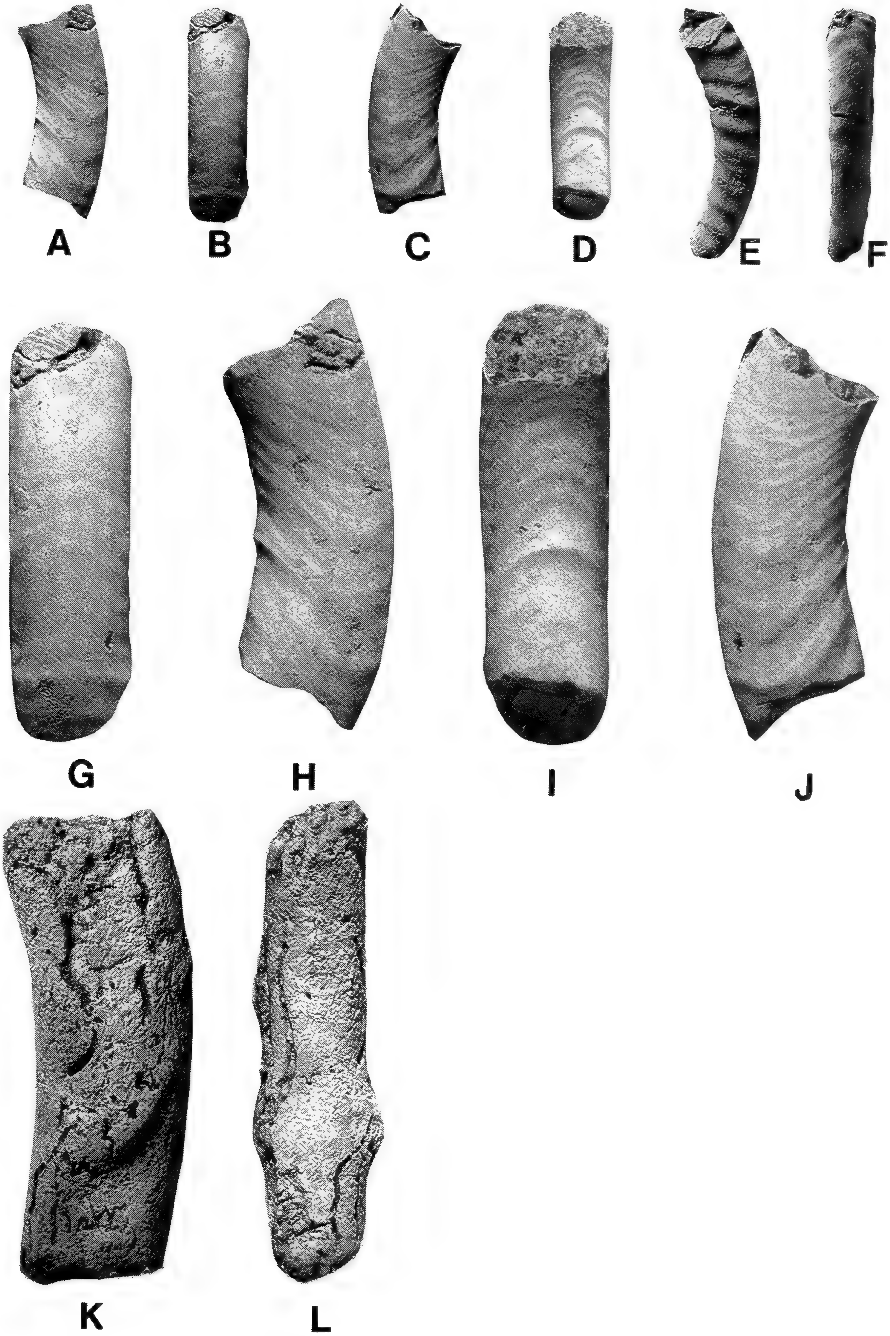

Fig. 165

Fig. 166. *Eubaculites occidentalis* (Meek, 1862). USNM 1363, one of Meek's syntypes and refigured by Matsumoto (1959, pl. 42 (fig. 2)) from 'Komooks', Vancouver Island. × 1.

Baculites binodosus Noetling, 1897
(= ?*Eubaculites* fide Klinger & Kennedy 1993)

Noetling 1897: 77, pl. 23 (fig. 3). Klinger & Kennedy 1993, fig. 56. Fatmi & Kennedy 1999: 659, figs 6.3–6.7, 13.19–13.22, 16.3

Type. Holotype by monotypy is the original of Noetling (1897, pl. 23 (fig. 3)) from the Maastrichtian of Des Valley near Khattan, Baluchistan, India, GSI 3097.

Occurrence. Maastrichtian, Baluchistan, India.

Fig. 167. *Eubaculites occidentalis* Meek, 1862. CAS-66773.01 from Fresno County, Coalinga Quadrangle, from *c.* 50 ft above contact with massive sandstone, west of Los Gatos Creek, California. × 1.

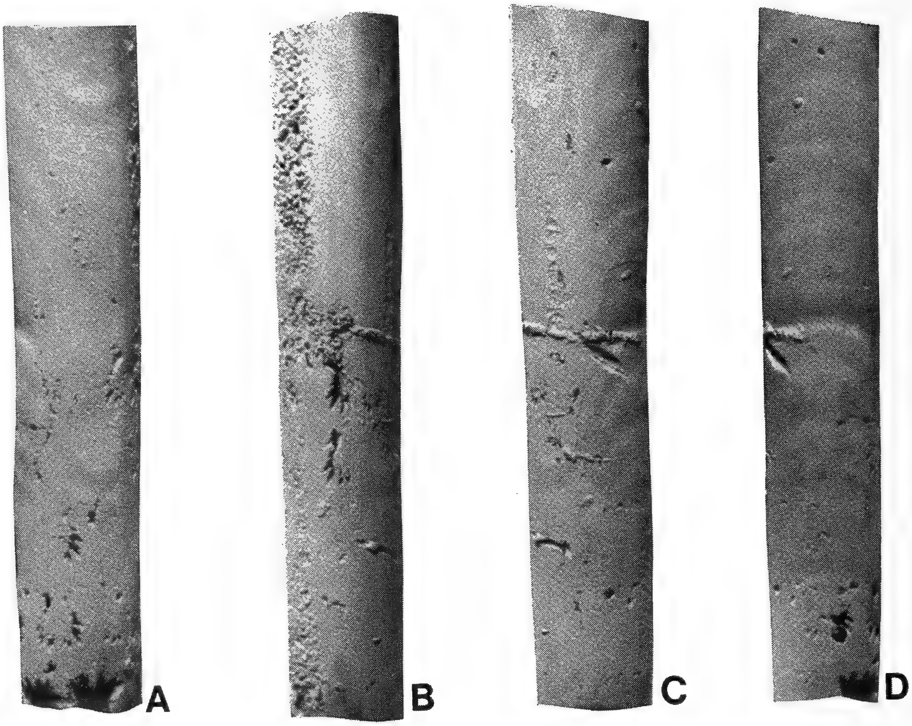

Fig. 168. *Fresvillia constricta* Kennedy, 1986*a*. IRSNB 10254 (ex Leriche Collection, IG 19859) from the Upper Maastrichtian Calcaire à *Baculites* of Fresville, Manche, France. ×1.

Eubaculites carinatus (Morton, 1834)

Morton 1834: 44, pl. 13 (fig. 1). D'Orbigny 1847, pl. 1 (figs 3–7) (as *Baculites lyelli*). Conrad 1858: 334, pl. 35 (fig. 27) (as *B. tippaensis*). Conrad 1858: 335, pl. 35 (fig. 24) (as *B. spillmani*). Binckhorst 1861: 42, pl. 5d (fig. 3a–d) (as *B. anceps*). Gabb 1864: 80 (*pars*), pl. 14 (fig. 29–29a); *non* pl. 17 (fig. 27, 27a), *non* pl. 14 (fig. 27b) (as *B. chicoensis*). Kossmat 1895: 156 (60) (*pars*), pl. 19 (5) (fig. 14a–b) only (as *B. vagina* n. var. *simplex*). Kossmat 1895: 157 (61) (*pars*), pl. 19 (5) (fig. 16, ?*non* fig. 15 (as *B. vagina* var. *otacodensis*). Steinmann 1895: 89, pl. 6 (fig. 4), text-figs 8–10) (as *B. vagina*). Kossmat 1897, pl. 6 (fig. 4) (as *B. vagina*). Wetzel 1930: 90, pl. 10 (figs 3–4) (as *B. vagina*). Crick 1924: 139, pl. 9 (figs 1–3) (as *B. sheringomensis*). Crick 1924: 140, pl. 9 (figs 4–5) (as *Baculites* cf. *vagina* var. *otacodensis*). Crick 1924: 140, pl. 9 (figs 6–7) (as *Baculites* cf. *vagina* var. *simplex*). Basse 1931: 20, pl. 2 (figs 6–10) (as *Baculites vagina*.) Spath 1940: 49 (*pars*) (as *E. otacodensis*). ?Olsson 1944: 104, pl. 16 (figs 3–5), text-fig. 1 (as *B. lyelli*). Wright 1957: L218, text-fig. 245, 6a–b (as *Eubaculites otacodensis*). Matsumoto 1959: 166, pl. 43 (fig. 6), pl. 44 (figs 1–3), text-figs 84a–b, 85a–b) (as *E. ootacodensis*).

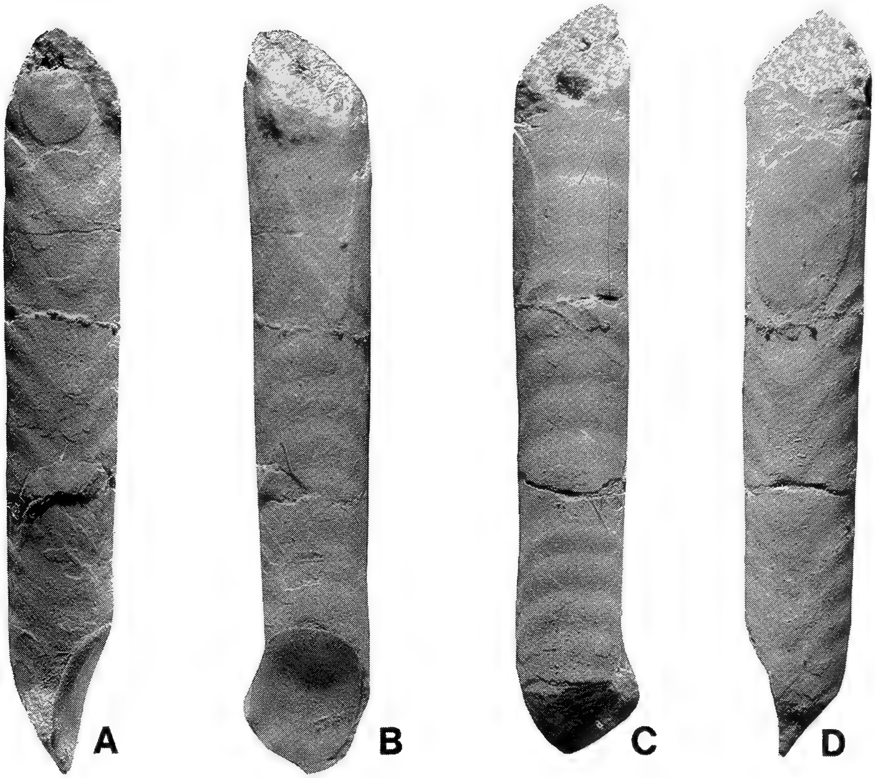

Fig. 169. *Fresvillia teres* (Forbes, 1846). BMNH C51152, holotype, the original of Forbes (1846, pl. 10 (fig. 5)) from the Upper Maastrichtian Valudavur Formation, Pondicherry, South India. × 1.

Leanza 1964: 95, pl. 1 (figs 1–5), text-fig. 1 (as *Eubaculites argentinicus*). Rossi de Garcia & Comacho 1965: 72, pl. 1 (fig. 1) (as *Eubaculites* sp.). Brunnschweiler 1966: 27, pl. 1 (figs 9–14), text-figs 9–11 (as *E. ootacodensis*). Brunnschweiler 1966: 29, pl. 1 (fig. 7), pl. 2 (figs 1–14), text-figs 12–14 (as *E. vagina*). Brunnschweiler 1966: 31, pl. 2 (figs 15–17), pl. 3 (figs 1–7), text-fig. 15 (as *E. kossmati*). Brunnschweiler 1966: 32, pl. 3 (figs 8–12), text-fig. 16 (as *E. multicostatus*). Collignon 1971: 15, pl. 645 (figs 2388–2389) (as *B. simplex*). Riccardi 1974: 388, pl. 1 (figs 1–7), pl. 2 (figs 1–4), pl. 3 (figs 1–6), pl. 4 (figs 1–7), text-fig. 2 (as *E. ootacodensis*). Hünicken & Covacevich 1975: 149, pl. 1 (figs 5–12), pl. 2 (figs 4–9), pl. 3 (figs 1–8), pl. 4 (figs 1–8), pl. 5 (figs 1–4), text-figs 6–28 (as *E. lyelli*). Klinger 1976: 90 (*pars*), pl. 39 (fig. 1), *non* 3; pl. 41 (figs 1–2), pl. 42 (figs 3, 8), ?*non* pl. 43 (fig. 1), text-fig. 11c (as *E. ootacodensis*). Kennedy & Summesberger 1986: 197, pl. 14 (figs 1–5) (as *E. lyelli*). Kennedy 1986*e*: 1016, pl. 1 (figs 1–3), pl. 2 (figs 3–8), pl. 3 (figs 2–8, 13–21) (as *E. lyelli*). Kennedy 1986*c*: 194 (as *E. ootacodensis*). Henderson *et al.* 1992: 150, figs 6f, g, 14–16, 17a–c, g–j, 18–20). Kennedy & Henderson 1992, text-fig. 5a–c, l–p. Klinger & Kennedy 1993: 218, figs 7a–e, 21–30, 31a–g, 32–35, 36e–f, 37–38, 42a, 52g–h. Kennedy & Cobban 1993*b*: 62, fig. 3b–i, l–s, 5. Ward & Kennedy 1993: 53, figs 43.8–43.9, 43.13. Cobban & Kennedy 1995: 26, figs 14.1, 14.5–14.7, 15.4, 15.6–15.8, 16.13–16.15, 16.23–16.24, 16.28–16.30, 17.52–17.59, 18.1–18.44.

Type. Holotype by monotypy is the original of Morton (1834, pl. 13 (fig. 1)) from the Maastrichtian Prairie Bluff Chalk of Alabama, ANSP 72866.

Occurrence. Lower and Upper Maastrichtian with records from the Biscay Region and northern Spain, the Netherlands, southern France, Austria, Zululand, South India, Western Australia, Chile, California, Texas, Missouri, Mississippi, Alabama and New Jersey.

'*Eubaculiceras*' *compressum* Brunnschweiler, 1966
(= *Eubaculites simplex*)

Brunnschweiler 1966: 36, pl. 4 (figs 15–17), pl. 5 (figs 1–3), text-fig. 21.

Type. Holotype is the original of Brunnschweiler (1966, pl. 4 (figs 15–17), text-fig. 21) from the Upper Maastrichtian, Miria Formation, Western Australia, CBC 2724.

Occurrence. Upper Maastrichtian, Western Australia.

'*Eubaculiceras*' *fastigiatum* Brunnschweiler, 1966
(= *Eubaculites simplex*)

Brunnschweiler 1966: 37, pl. 5 (figs 7–9), text-fig. 22.

Type. Holotype by monotypy is the original of Brunnschweiler (1966, pl. 5 (figs 7–9)), text-fig. 22) from the Upper Maastrichtian, Miria Formation, Western Australia, CBC 2726.

Occurrence. Upper Maastrichtian, Western Australia.

Fig. 170 *(see facing page)*. A–B. *Sciponoceras roto* Cieslinski, the original of Collignon's (1964: 8, pl. 319 (fig. 1361)) *S. baculoides* from the Lower Cenomanian, zone of *Mantelliceras martimpreyi*, from Gisement 478 (5 km west of Beraketa, Manera), and Gisement 485, hills of Vohipaly, lower level, Sakaraha. C–D. *Hemiptychoceras ambiguus* (Collignon, 1964), the holotype and original of Collignon's (1964, pl. 319 (fig. 1475)) *Baculites (?) (Protobaculites* nov. subgen.) *ambiguus* from the Lower Cenomanian, Zone of *Mantelliceras martimpreyi*, Gisement 478, 5 km west of Beraketa (Manera) (see Kennedy & Wright 1994). E–F. *S. roto*, the original of Collignon's (1964: 8, pl. 319 (fig. 1362)) *S. baculoides*, horizon and locality as in A and B. G–J. *S. roto*, the original of Collignon's (1964: 8, pl. 319 (fig. 1359)) *S. baculoides*, horizon and locality as in A and B. H–I. *S. roto*, the original of Collignon's (1964: 8, pl. 319 (fig. 1360)) *S. baculoides*; horizon and locality as in A and B. K–L. *S. roto*, the original of Collignon's (1964: 35, pl. 325 (fig. 1452)) *Sciponoceras baculoides*, horizon and locality as in A and B. M–N. *Sciponoceras antanimangaensis* (Collignon, 1964), the original and holotype of Collignon's (1964: 34, pl. 325 (fig. 1451)) *Lechites antanimangaensis* from the Lower Cenomanian, zone of *Mantelliceras mantelli* and *M. newboldi* from Gisement 362, Signal Antanimanga I (Mandabe), Madagascar. All in the collections of the Départment des Sciences de la Terre, Université de Bourgogne, Dijon, France. A–I × 2; K–N × 1.

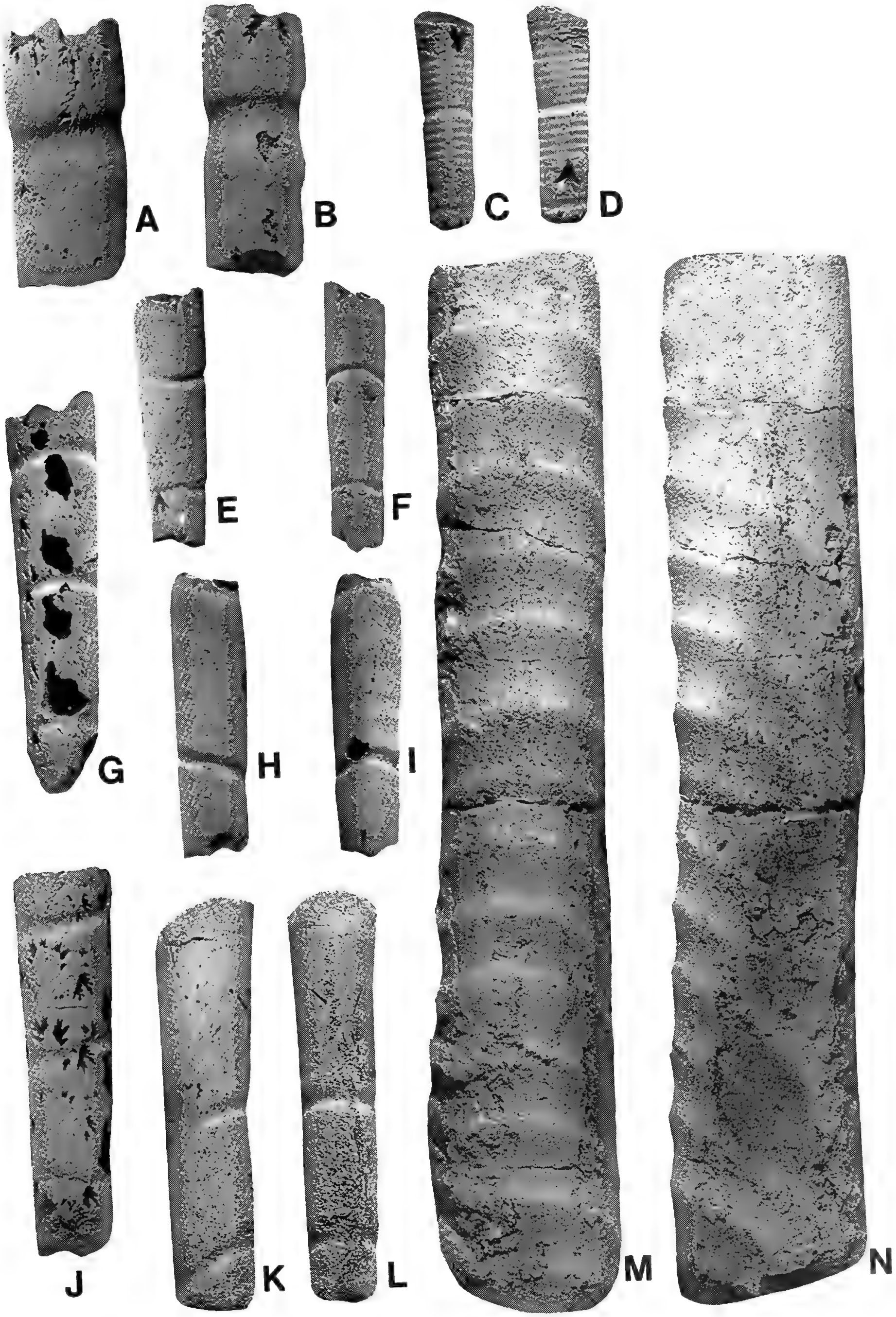

Fig. 170

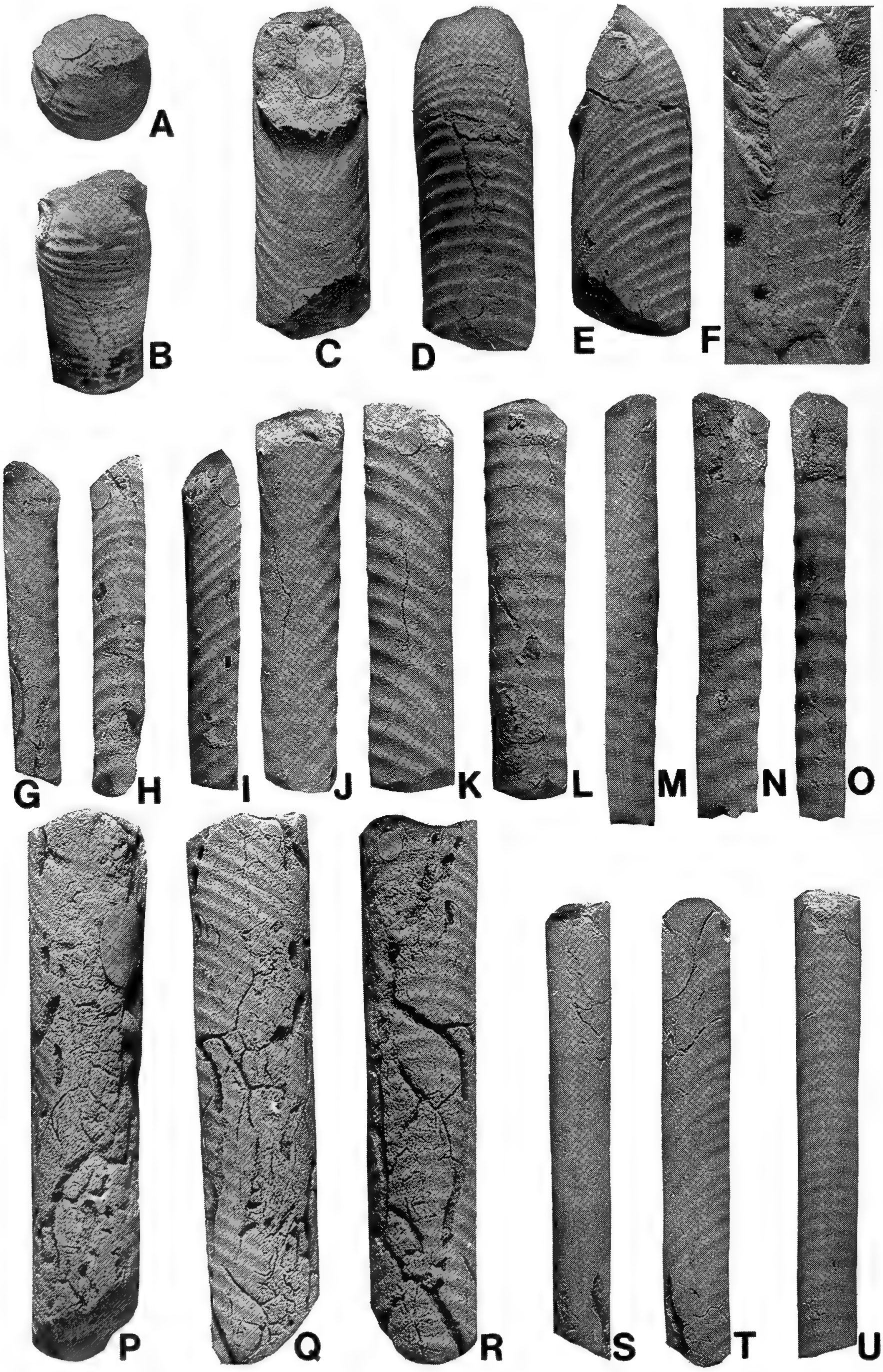

Fig. 171

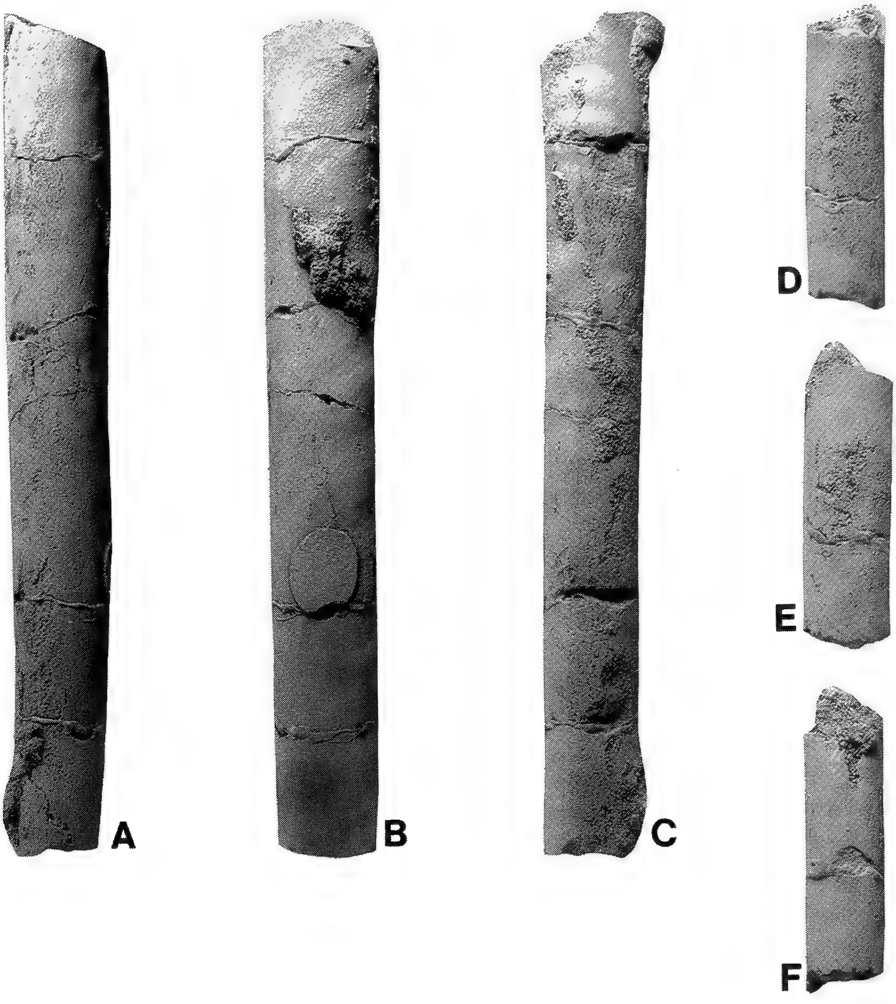

Fig. 172. *Lechites* sp. Extreme smooth form of *L. gaudini*. A–C. BMNH C93267i. D–F. BMNH C93268. Upper Albian, *S. dispar* zone, Upper Greensand phosphate bed, Dorsetshire Gap, 800 m west-south-west of Melcombe Park Dairy Farm, Melcombe, Hersey, Dorset. All × 1.

Fig. 171 *(see facing page)*. *Lechites gaudini*. A–E. Macroconch, BMNH C4755 from the Cambridge Greensand, Upper Albian, *Stoliczkaia dispar* zone, Cambridge. F. Microconch from the Gault Clay, Upper Albian *S. dispar* zone, Folkestone, Kent. G–I. BMNH C34738a, the original of Spath (1941, pl. 72 (fig. 4)). J–L. BMNH C4754a, the original of Spath (1941, pl. 72 (fig. 7)). M–O. BMNH C4756, the original of Spath's (1941, text-fig. 243e–g) *L. moreti*. P–R. BMNH C4754a, the holotype of *L. communis* Spath (1941: 666, text-fig. 244a–c). S–U. BMNH C34738b. All × 1.

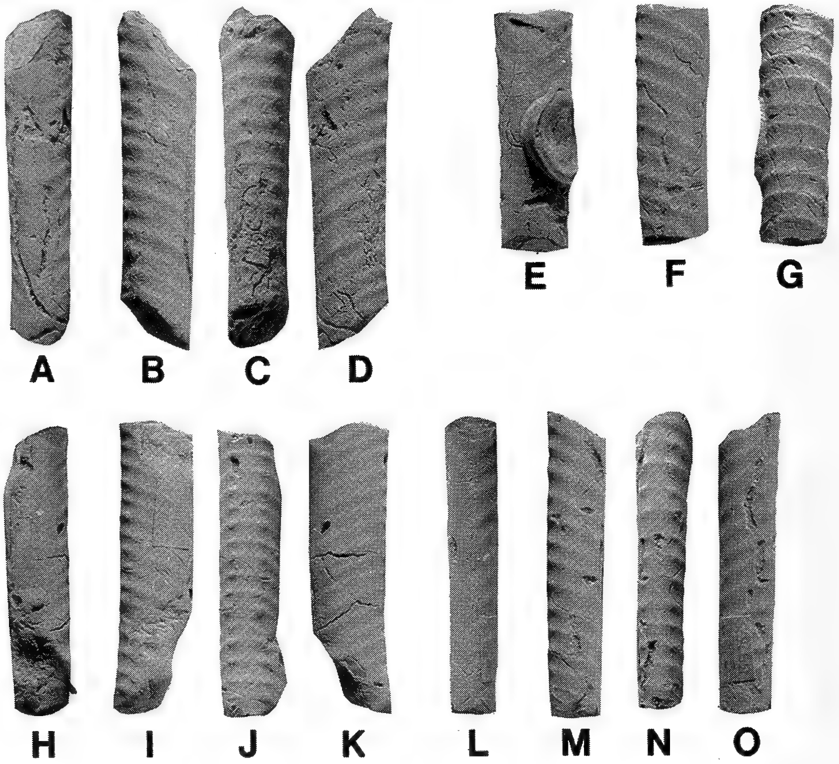

Fig. 173. *Tuberolechites regifex* Cooper & Kennedy, 1977. A–D. SMC B38412, paratype. E–G. SMC B97583, paratype. H–K. SMC B97668, paratype. L–O. SMC 97675, the holotype. All from the Upper Albian, *Stoliczkaia dispar* zone, Cambridge Greensand, Cambridge.
All × 1.

Eubaculites kossmati Brunnschweiler, 1966
(= *E. carinatus*)

Brunnschweiler 1966: 31, pl. 2 (figs 15–17), pl. 3 (figs 1–7), text-fig. 15.

Type. Holotype is the original of Brunnschweiler (1966, pl. 2 (fig. 15–17), text-fig. 15) from the Upper Maastrichtian, Miria Formation, Western Australia, CBC 2704.

Occurrence. Upper Maastrichtian, Western Australia.

Eubaculites labyrinthicus (Morton, 1834)

Morton 1834: 44, pl. 13 (fig. 10) (as *Baculites labyrinthicus*). Stoliczka 1866: 199, pl. 90 (fig. 14, *non* fig. 15) (as *B. vagina* var. *otacodensis*. Kossmat 1895: 157, pl. 19 (5) (?fig. 15, *non* fig. 16) (as *B. vagina* var. *otacodensis*). Cottreau 1922: 180 (72), pl. 9 (17) (fig. 11–11b) (as *B. vagina* var. *otacodensis*). Spengler 1923: 54, pl. 4 (fig. 9) (as *B. vagina*). Besairie

1930: 222, pl. 26 (figs 12–13) (as *B. vagina*). Klinger 1976: 87 (*pars*), pl. 42 (fig. 4) (as *E. vagina*). Kennedy & Henderson 1992: 716, text-fig. 5d–k. Klinger & Kennedy 1993: 194, figs 1–6, 7f–h, 36a–d, 52a–c. Cobban & Kennedy 1995: 23, figs 14.2, 15.2–15.3, 17.36–17.51.

Type. There are two syntypes, the figured specimen in Morton (1834, pl. 13 (fig. 10)), ANSP 72868, and an unfigured specimen, ANSP 72869, both from the Prairie Bluff Chalk of Alabama. Cobban & Kennedy (1995: 23) designated Morton's figured specimen as the lectotype.

Occurrence. Lower Maastrichtian, Alabama, New Jersey, South India, Zululand, and Madagascar.

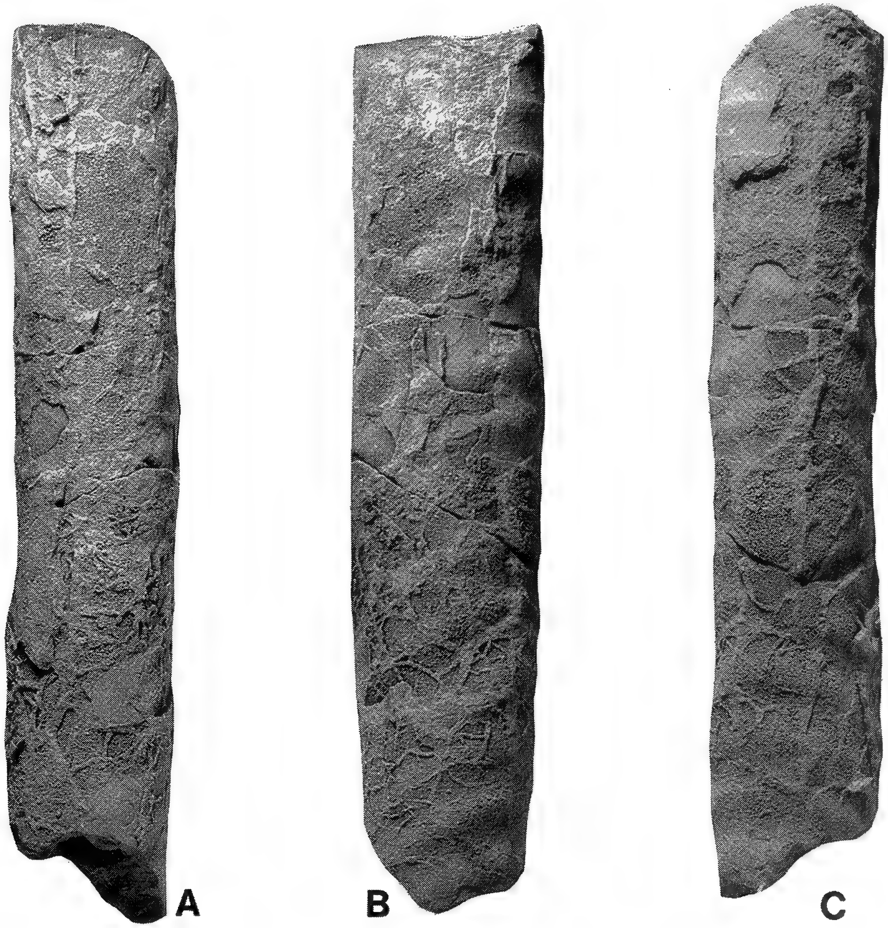

Fig. 174. *Lechites?* sp. OUM KY303, Utatur Group. Odium, South India. Ex Geological Survey of India Collections, GSI 42 L3/184. This appears to be the *'Baculites gaudini'* of Stoliczka (1865: 199). × 1.

Eubaculites latecarinatus (Brunnschweiler, 1966)

Brunnschweiler 1966: 33, pl. 3 (figs 13–14), pl. 4 (figs 1–5), text-figs 17–18. Brunnschweiler 1966: 35, pl. 4 (figs 11–14), text-fig. 20 (as *Giralites quadrisulcatus*). Collignon 1971: 18, pl. 646 (fig. 2393) (as *Eubaculites ambindensis*). Collignon 1971: 15, pl. 645 (fig. 2390) (as *Baculites occidentalis*). Klinger 1976: 91, pl. 40 (figs 1–2), pl. 41 (fig. 3), pl. 42 (figs 2, 6), pl. 43 (figs 3–4), text-fig. 11d–e. Klinger & Kennedy 1980: 296, figs 2–4, 5d. Henderson *et al.* 1992: 159, figs 22l–n, 23n–p. Klinger & Kennedy 1993: 238, figs 26a, 39–41, 42b–c, 43–49, 50a, 53a. Kennedy *et al.* 1997*a*: 20, figs 15a–d, k–l, 16g–h, 16.

Type. Holotype is the original of Brunnschweiler (1966, pl. 4 (figs 2–4)) from the Lower Maastrichtian, nodule bed at the top of the Korojong Calcarenite, Western Australia, CBC 2718.

Occurrence. Lower Maastrichtian, Western Australia, Madagascar, Zululand, and offshore Alphard Group, southern Cape Province; and Upper Maastrichtian, Severn Formation, Maryland.

Eubaculites multicostatus Brunnschweiler, 1966
(= *Eubaculites carinatus*)

Brunnschweiler 1966: 32, pl. 3 (figs 8–12), text-fig. 16.

Type. Holotype is the original of Brunnschweiler (1966, pl. 3 (figs 10–12), text-fig. 16) from the Upper Maastrichtian, Miria Formation, Western Australia, CBC 2710.

Occurrence. Upper Maastrichtian, Western Australia.

* ***Eubaculites occidentalis*** (Meek, 1862) Figs 107A–D, 166–167

Meek 1862: 316. Anderson & Hanna 1935: 24, pl. 8 (figs 3–4). Usher 1952: 98, pl. 28 (fig. 1), pl. 31 (fig. 19), text-fig. 4. Matsumoto 1959: 150, pl. 35 (figs 2a–d, 3a–d), pl. 36 (fig. 1a–d), pl. 41 (fig. 1a–d), pl. 42 (figs 1a–c, 2a–c), text-figs 64, 65a–b, 66, 67–71. Obata & Matsumoto 1963: 82, pl. 23 (fig. 3), pl. 25 (fig. 1), pl. 26 (figs 1–3), pl. 27 (figs 2–5, 8), text-figs 172–186. Jones 1963: 28, pl. 11 (fig. 13). *non* Collignon 1971: 15, pl. 645 (fig. 2390) (= *E. simplex*). ?Dundo 1971, pl. 1 (fig. 10) (as *B.* cf. *occidentalis*). Ward 1978: 1153, pl. 2 (figs 5–6, 9), text-fig. 2. Haggart 1991, pl. 5 (fig. 5). (All as *Baculites occidentalis*.)

Type. Meek (1862) based this species on several specimens; as yet, no lectotype has been designated (see Matsumoto 1959: 150).

Occurrence. Upper Campanian, California, Baha California (Mexico), British Columbia, southern Alaska, Honshu, and possibly Arctic Russia.

Fig. 175 *(see facing page)*. *Pseudobaculites natosini* (Robinson, 1945). USNM 458244 from the Bearpaw Shale at USGS Mesozoic locality D1442 in the NW¼ SW¼ sec. 9, T. 27 N., R. 20 E., Blaine County, Montana. × 0.74

Fig. 175

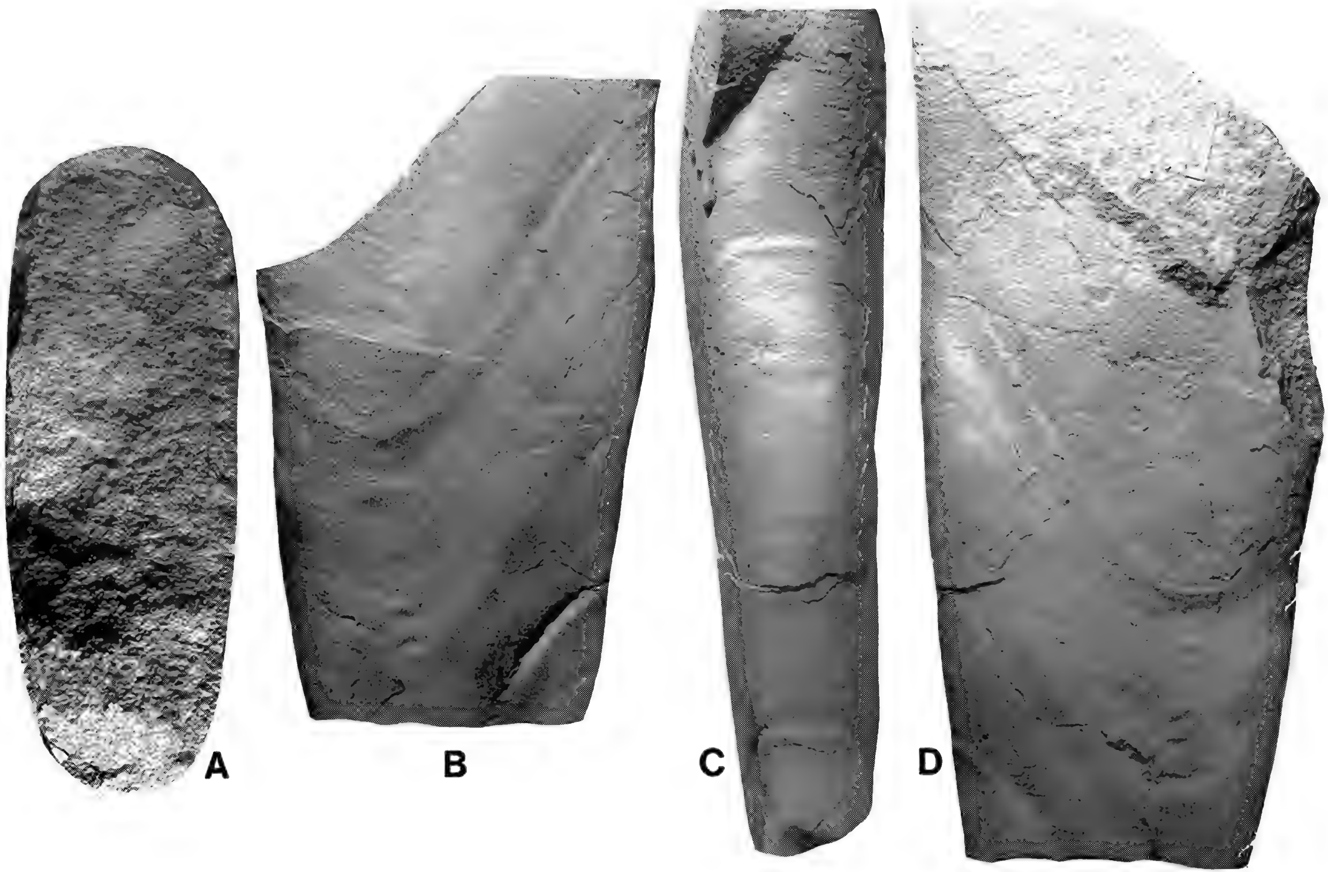

Fig. 176. *Pseudobaculites natosini* (Robinson, 1945). A. USNM 458243 from the Lewis Shale at USGS Mesozoic locality D4508 in the SE¼ SW¼ sec. 24, T. 35 N., R. 85 W., Natrona County, Wyoming. B–D. USNM 458242 from the same locality. Both × 1.

'*Giralites*' *quadrisulcatus* Brunnschweiler, 1966
(= *Eubaculites latecarinatus*)

Brunnschweiler 1966: 35, pl. 4 (figs 11–14), text-fig. 20.

Type. Holotype is the original of Brunnschweiler (1966, pl. 4 (figs 12–14), text-fig. 20) from the Lower Maastrichtian, Korojong Calcarenite, Western Australia, CBC 2722.

Occurrence. Maastrichtian, Western Australia.

'*Cardabites*' *scimitar* Brunnschweiler, 1966
(= *Eubaculites simplex*)

Brunnschweiler 1966: 38, pl. 5 (figs 16–21), text-fig. 24.

Type. Holotype is the original of Brunnschweiler (1966, pl. 5 (figs 16–18), text-fig. 24) from the Upper Maastrichtian, Miria Formation, Western Australia, CBC 2729.

Occurrence. Upper Maastrichtian, Western Australia.

Eubaculites simplex (Kossmat, 1895)

Kossmat 1895: 156 (*pars*), pl. 19 (fig. 13a–b), *non* pl. 19 (fig. 14a–b) (as *B. vagina* var. *simplex*). *non* Collignon 1938: 105. Hünicken 1965: 64, pl. 2 (figs 3–4), pl. 3 (figs 5–6), pl. 5 (fig. 5), pl. 6 (figs 6–7), pl. 8 (figs 2, 5) (as *Baculites* sp.). Brunnschweiler 1966: 34, pl. 4 (figs 6–10), text-fig. 19 (as *Giralites simplex*). Brunnschweiler 1966: 36, pl. 4 (figs 15–17),pl. 5 (figs 1–3), text-fig. 21 (as *Eubaculiceras compressum*). Brunnschweiler 1966: 37, pl. 5 (figs 7–9), text-fig. 22 (as *Eubaculiceras fastigiatum*). Brunnschweiler 1966: 38, pl. 5 (figs 12–15), text-fig. 23 (as *Cardabites tabulatus*). Brunnschweiler 1966: 38, pl. 5 (figs 16–21), text-fig. 24 (as *Cardabites scimitar*). Collignon 1971: 15, pl. 545 (fig. 2390) (as *B. occidentalis*). Klinger 1976: 92 (*pars*) pl. 42 (fig. 10), pl. 43 (fig. 2, 14) (as *Eubaculites compressum*). Henderson *et al.* 1992: 153, figs 21, 22a–k, o–p, 23a–f, k–m, 24–25. Kennedy & Henderson 1992, text-fig. 6d–f. Klinger & Kennedy 1993: 252, figs 7i–k, 50b, 51, 52d–f, i–n, 53b, 54–55.

Type. Lectotype by the subsequent designation of Kennedy (1986*c*: 195) is the original of Kossmat (1895, pl. 19 (figs 13a–b)) from the Maastrichtian Arrialoor Group of Otacod, South India, GSI 14819.

Occurrence. Maastrichtian, South India, Western Australia, Patagonia and Zululand.

'*Cardabites*' *tabulatus* Brunnschweiler, 1966
(= *Eubaculites simplex*)

Brunnschweiler 1966: 38, pl. 5 (figs 12–15), text-fig. 23.

Type. Holotype is the original of Brunnschweiler (1966, pl. 5 (figs 10–12), text-fig. 23) from the Upper Maastrichtian, Miria Formation, Western Australia, CBC 2727.

Occurrence. Upper Maastrichtian, Western Australia.

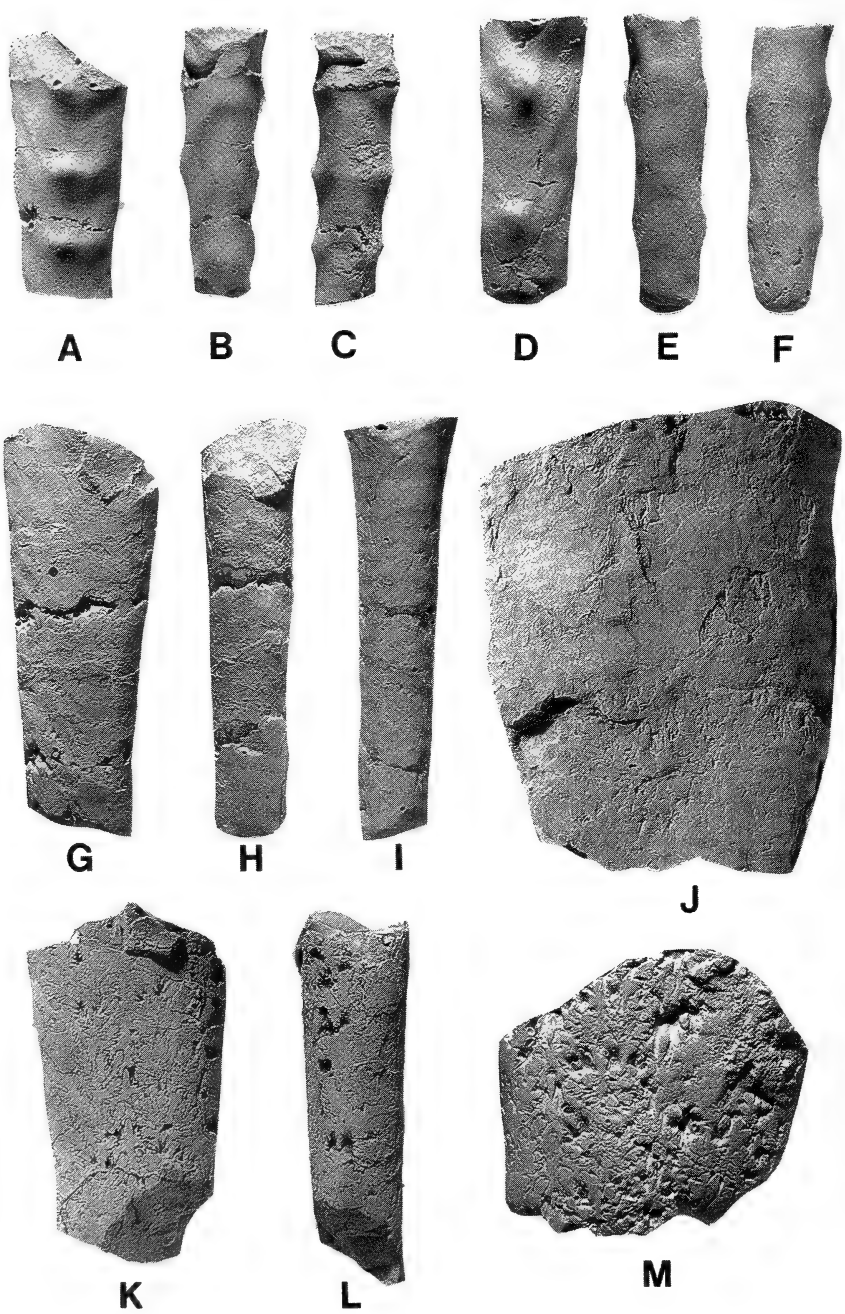

Fig. 177

* ***Eubaculites vagina*** (Forbes, 1846) Figs 39–41

Forbes 1846: 114, pl. 10 (fig. 4) (as *Baculites vagina*). D'Orbigny 1847, pl. 3 (figs 3–6) (as *Baculites ornatus*). Stoliczka 1866: 198 (*pars*), pl. 91 (figs 1–6). Kossmat 1895: 155 (59), pl. 19 (5) (fig. 17) (as *Baculites vagina* (a) Typische Form). Crick 1898: 78, pl. 17 (fig. 5). *non* Basse 1931: 20, pl. 2 (figs 6–10). Collignon 1971: 15, pl. 645 (fig. 2391), p. 18, pl. 646 (fig. 2394). Klinger 1976: 87, pl. 35 (figs 1–4), pl. 36 (figs 1–4), pl. 37 (figs 1–5), pl. 38 (figs 1–3), pl. 39 (fig. 2), pl. 42 (fig. 1, *non* figs 4, 7 , 9, 11), pl. 43 (figs 5–12). Kennedy 1977, text-fig. 31.1–31.2. Klinger & Kennedy 1980: 299, text-fig. 5a–c. Kennedy 1989, text-fig. 17i–j. Kennedy & Henderson 1992: 712, pl. 5 (figs 10–13), pl. 7 (figs 1–18), pl. 8 (figs 1–12), pl. 9 (figs 1–13), pl. 10 (figs 1–3), text-fig. 1c, f. Klinger & Kennedy 1993: 203, figs 8-20.

Type. Lectotype by the subsequent designation of Kennedy & Henderson (1992: 713) is the original of Forbes (1846, pl. 10 (fig. 4)) from the Upper Maastrichtian Valudavur Formation of Pondicherry, South India, BMNH C49726.

Occurrence. Maastrichtian of South India and Madagascar.

Genus *Fresvillia* Kennedy, 1986

* ***Fresvillia constricta*** Kennedy, 1986 Fig. 168

Kennedy 1986*a*: 62, pl. 14 (figs 39–42), text-fig. 10a.

Type. Holotype by monotypy, is the original of Kennedy (1986*a*, pl. 14 (figs 39–42), text-fig. 10a) from the Upper Maastrichtian Calcaire à *Baculites*, Fresville, Manche, France, IRSNB 10254 (ex Leriche collection IG 19859).

Occurrence. Upper Maastrichtian, France.

* ***Fresvillia teres*** (Forbes, 1846) Fig. 169

Forbes 1846: 115, pl. 10 (fig. 5). D'Orbigny 1850: 215. Stoliczka 1866: 197 (*pars*), pl. 90 (fig. 12 only, *non* 13). Kossmat 1895: 155 (59). Kossmat 1897: 64. Spath 1953: 16 (all as *Baculites teres*). Matsumoto 1959: 163, pl. 45 (figs 5–6), text-figs 82a–c, 83 (as ?*Baculites* aff. *B. teres*). Jones 1963: 29, pl. 16 (figs 10–12, 14), text-fig. 14 (as *Baculites* aff. *B. teres*). Kennedy 1986*a*: 62. Stinnesbeck 1986: 204 (as ?*B. teres*). Kennedy & Henderson 1992: 718, pl. 5 (figs 14–17), text-fig. 2c.

Fig. 177 *(see facing page)*. A–F. *Pseudobaculites nodosus* Cobban, 1952. A–C. USNM 108209, the holotype from USGS Mesozoic locality 21096. D–F. USNM 108214, paratype, from USGS Mesozoic locality 23100. G–M. *Pseudobaculites wyomingensis* Cobban, 1952. G–I. USNM 108217, the holotype from USGS Mesozoic locality 21748. J. USNM 433904 from USGS Mesozoic locality 4991. K–L. USNM 433903 from USGS Mesozoic locality D3797. M. USNM 108219. All from the Upper Coniacian *Scaphites depressus* zone in the Cody Shale of Fremont County, Wyoming. All × 1.

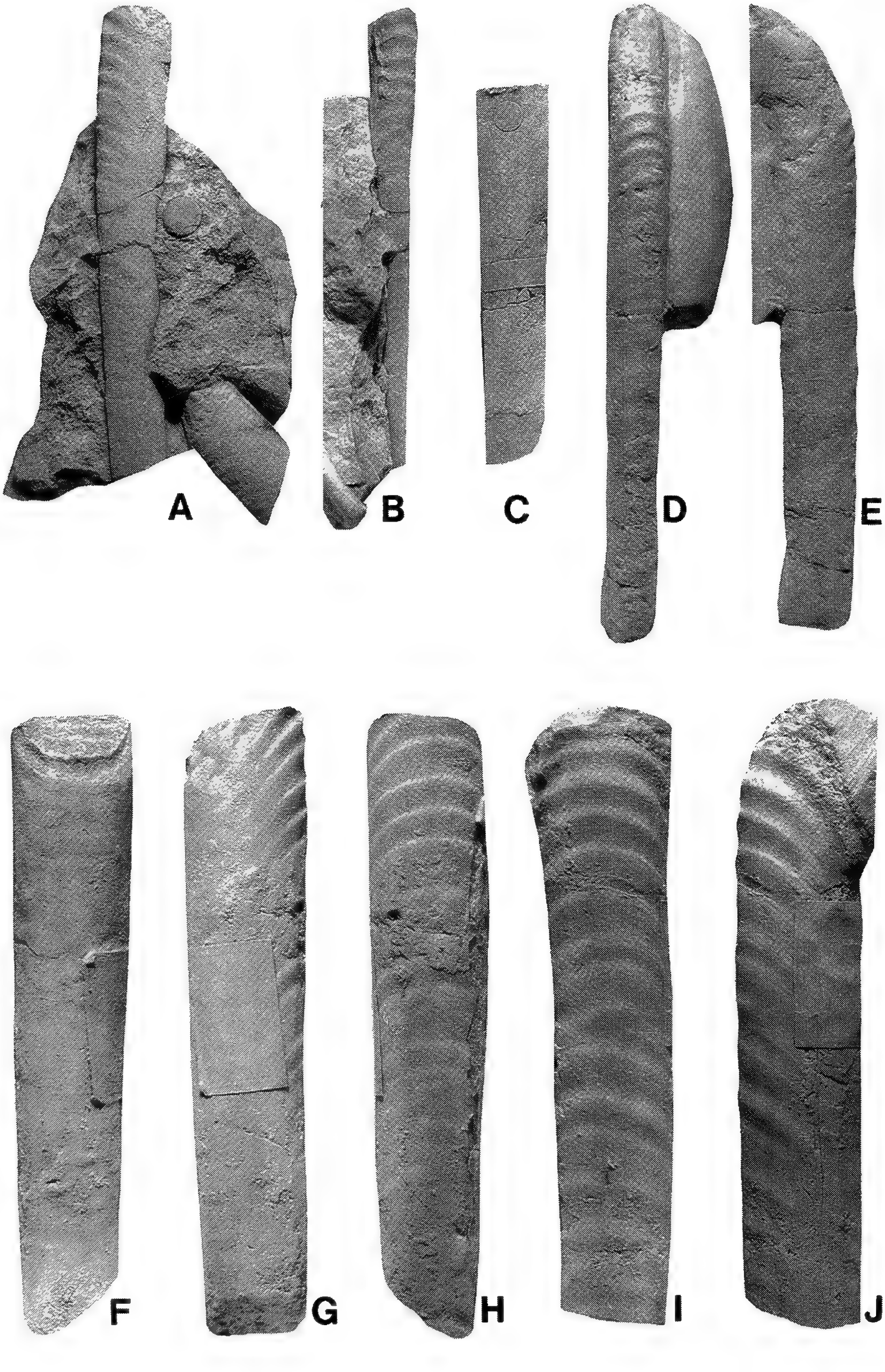

Fig. 178

Type. Holotype by monotypy is the original of Forbes (1846, pl. 10 (fig. 5)) from the Maastrichtian of the Valudavur Formation, south India, BMNH C51152 (ex Geological Society Collection R10890).

Occurrence. Maastrichtian of South India, California and Alaska, and possibly Chile.

Genus *Lechites* Nowak, 1908

* ***Lechites antanimangaensis*** Collignon, 1964 Fig. 170M–N
(? =*Sciponoceras* fide Cooper & Kennedy 1977: 652–3)

Collignon 1964: 34, pl. 325 (fig. 1451).

Type. Holotype by monotypy is the original of Collignon (1964, pl. 325 (fig. 1451)) from the Lower Cenomanian of Signal Antanimanga I (Mandabe), Madagascar. GD 11451.

Occurrence. Lower Cenomanian, Madagascar.

Lechites campichei Renz, 1968
(= *L. gaudini* fide Cooper & Kennedy 1977: 651–652)

Pictet & Campiche 1861: 112, pl. 55 (fig. 9) (as *B. gaudini*). Boule *et al.* 1907: 64, pl. 15 (fig. 1) (as *B. gaudini*). Spath 1941: 665, pl. 72 (fig. 5) (as *L. gaudini*). Renz 1968: 82, pl. 17 (figs 8a–c, 9a–c, 10a–b), text-fig. 29m.

Type. Holotype is the original of Pictet & Campiche (1861, pl. 55 (fig. 9)), refigured by Renz (1968, pl. 17 (fig. 9)), from the Upper Albian of Ste Croix, Switzerland, MGL L40020.

Occurrence. Upper Albian, Switzerland, Cambridge Greensand of England and Madagascar.

Lechites comanchensis (Adkins, 1920)

Adkins 1920: 51, pl. 2 (figs 20–22). Adkins 1928: 207, pl. 20 (fig. 9) (as *Cyrtochilus ?comanchensis*). Clark 1965: 23, pl. 3 (figs 1–2, 5–11), pl. 4 (fig. 16), text-fig. 6a.

Type. Holotype is the original of Clark 1965, pl. 3 (figs 8–11), BEG 20997.

Occurrence. Upper Albian of Texas.

Fig. 178 *(see facing page)*. *Sciponoceras baculoides* (Mantell, 1822). A–B. The lectotype (larger specimen), a microconch, and a paralectotype (smaller specimen), the original of Mantell (1822 pl. 23 (fig. 6)), BMNH C8612 from the Lower Chalk of Sussex. C. Paralectotype BMNH C36576a, the original of Mantell (1822, pl. 23 (fig. 7)) from the same locality and horizon as A and B. D–E. SMC B21312, a microconch from the Lower Chalk of Ventnor, Isle of Wight. F–H. SMC B21321, a macroconch from the same locality and horizon as D and E. I–J. SMC B21320, a macroconch. Details as for D and E.
All × 1.

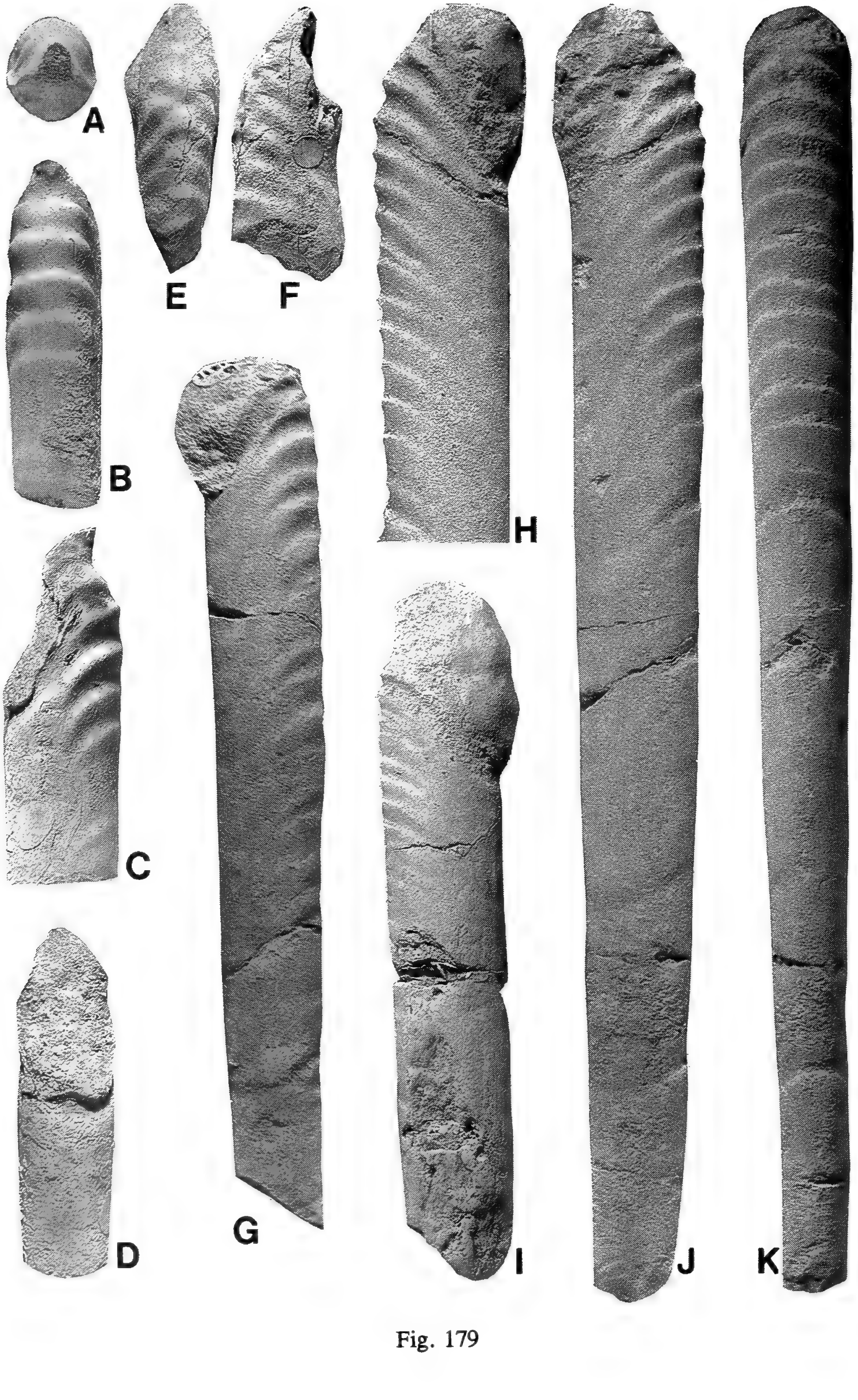

Fig. 179

* **Lechites communis** Spath, 1941 Fig. 171P–R

(= *L. gaudini* fide Cooper & Kennedy 1977: 648)

Spath 1941: 666, text-fig. 244a–e. Renz 1968: 81, pl. 17 (figs 6a–c, 13a–b), text-fig. 29c–d. Nagy 1971: 17, pl. 1 (figs 7–8). Horvath 1983, pl. 1 (fig. 5). Mitiu 1984: 85, pl. 2 (figs 12–13).

Type. Holotype is the original of Spath (1941, text-fig. 244a–c) from the Upper Albian Cambridge Greensand, BMNH C4754b.

Occurrence. Upper Albian, Cambridge Greensand, England, Switzerland, Hungary.

Lechites fasciatus Scholz, 1971

Scholz 1971: 431, figs 1–2.

Type. ?

Occurrence. Upper Albian, Hungary.

* **Lechites gaudini** (Pictet & Campiche, 1861) Figs 171–172

Pictet & Campiche 1861: 112, pl. 55 (figs 5–9) (as *B. gaudini*). Böse 1923: 157 (as *Baculites* cfr. *gaudini*). ?Collignon 1933: 73, pl. 5 (fig. 8, 8a). Spath 1941: 662, pl. 72 (figs 4–7, 9–10), text-fig. 242 (*cum. synon.*). Spath 1941: 66, text-fig. 244 (as *L. communis*). Breistroffer 1947: 94 (as *L. gaudini* var. *raricosta*). ?Wiedmann & Dieni 1968: 64, pl. 6 (fig. 10), text-fig. 37 (as *L. italicus*). Renz 1968: 82, pl. 17 (figs 11–12, 14–15), text-figs 29b, g–h, k. (as *L. vraconensis*). ?Scholz 1971: 431, figs 1–2 (as *L. fasciata*). Nagy 1971: 17, pl. 1 (figs 5–6). Cooper & Kennedy 1977: 644, figs 1 (1–38), 2 (1–30), 3, 4 (1–18), 5 (1–15), 6–7, 8 (16–26) (*cum. synon.*). Scholz 1978, pl. 3 (figs 1, 8). Scholz 1979: 12, pl. 1 (figs 1–9), text-fig. 5a–b. Chiriac 1981: 63, pl. 3 (fig. 6a–c), text-fig. 20. Horvath 1983, pl. 1 (fig. 2). Mitiu 1984, pl. 3 (figs 6–9). Immel & Seyed-Emami 1985: 112, pl. 7 (fig. 11). Delamette 1988, pl. 11 (fig. 6). Immel 1987: 128. Föllmi 1989: 120, pl. 4 (fig. 1) (as *Lechites* aff. *gaudini*). Henderson 1990: 129, fig. 12a–m. Ivanov 1991, pl. 4 (fig. 11). Moncrieff & Kelly 1993: 5. Gale *et al.* 1996: 577, figs 22a–c, 27e–i, l–o. Klinger & Kennedy 1997: 7, figs 2a–c, 3.

Fig. 179 *(see facing page)*. *Sciponoceras baculoides* (Mantell, 1822). A–D. BMNH C422, a macroconch, the original of Crick (1896: 80) (see also Wright & Kennedy 1995, pl. 95 (fig. 5)) from the phosphatic Middle Cenomanian, *A. rhotomagense* zone, *Turrilites acutus* subzone fauna of the Chalk Basement Bed at Chardstock, Devon. E–F. BMNH C44005a, a macroconch and a syntype of *Baculites obliquatus* J. de C. Sowerby (1828, pl. 592 (fig. 2 left)) (see also Wright & Kennedy 1995, pl. 95 (fig. 3)) from the Lower Chalk, Middle Cenomanian, *A. rhotomagense* zone, *T. costatus* subzone, Hamsey near Lewes, Sussex. G–H. SMC B21311, macroconch, horizon as for E and F, Ventnor, Isle of Wight. I. BGS–GSM37740, horizon and locality as for G and H (see also Wright & Kennedy 1995, pl. 97 (fig. 1)). J–K. BGS–GSM92186, horizon and locality as for G and H (see also Wright & Kennedy 1995, pl. 96 (fig. 7)). All × 1.

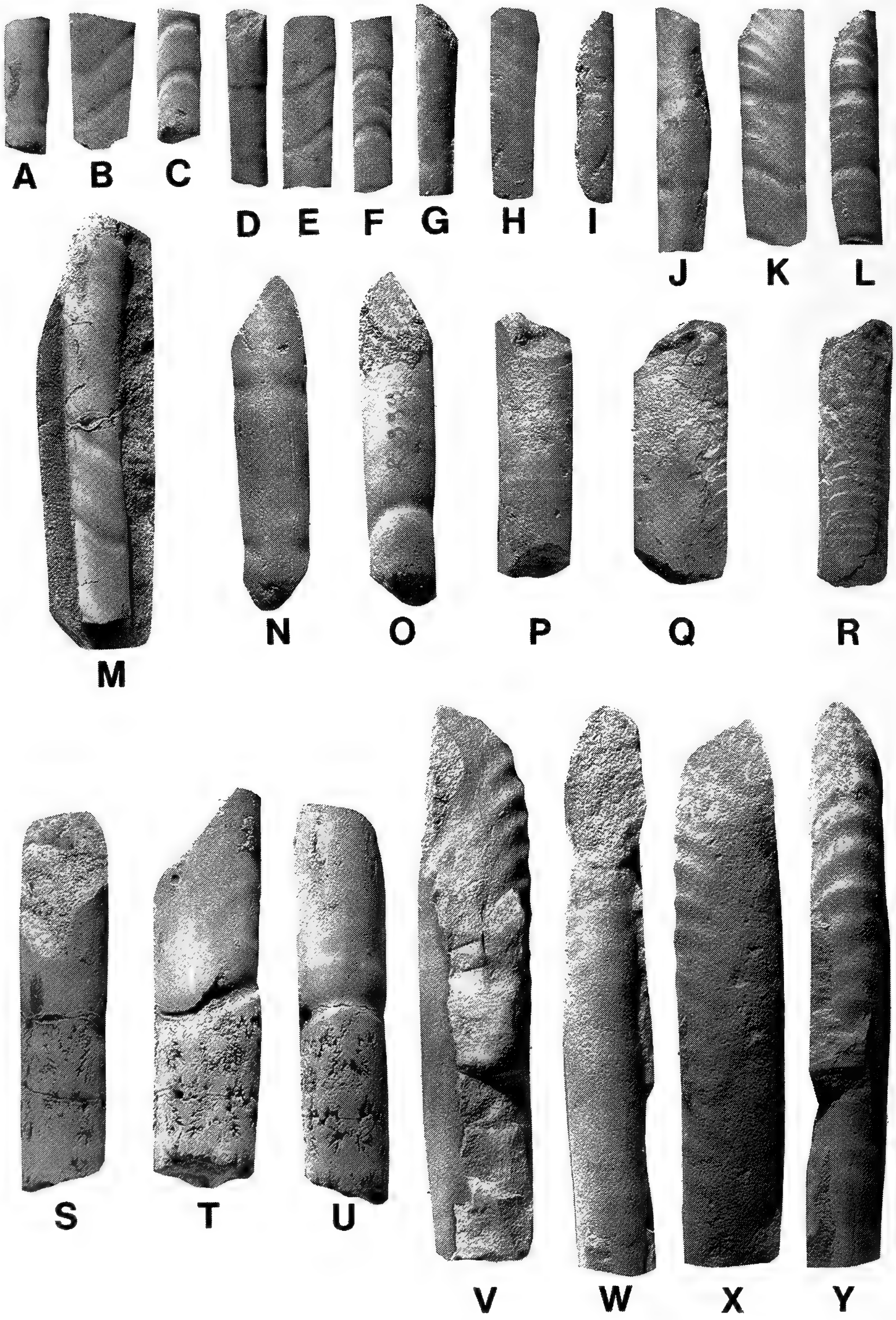

Fig. 180

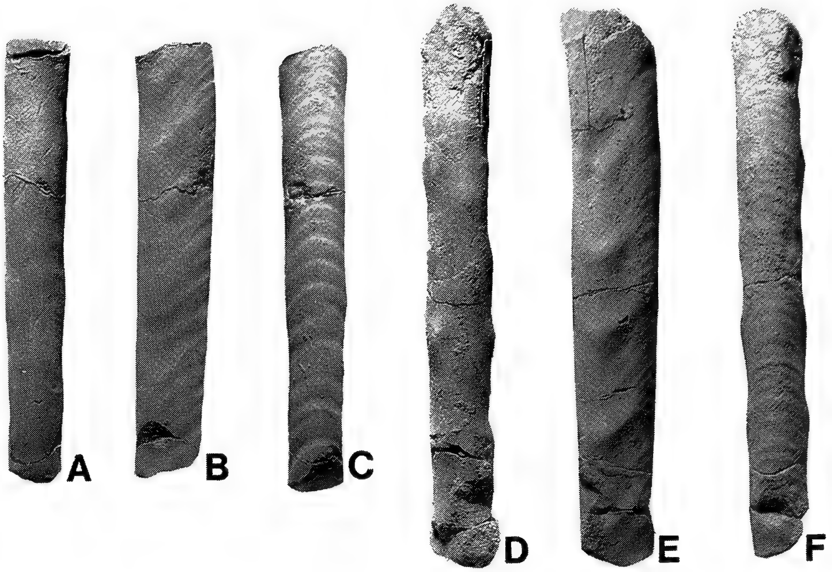

Fig. 181. *Sciponoceras bohemicum* (Fritsch, 1872). A–C. BGS–GSM108888 from the Chalk Rock, Upper Turonian, Hitch Wood near Hitchin, Hertfordshire. D–F. BGS–Zr7803 from the Chalk Rock, Upper Turonian, Kensworth near Dunstable, Bedfordshire. Both × 1.

Fig. 180 *(see facing page)*. *Sciponoceras baculoides* (Mantell, 1822). Muséum d'histoire Naturelle Paris Collections, ex D'Orbigny Collection no. 6136. These specimens are the basis of the illustrations of D'Orbigny (1842, pl. 138 (figs 6–11)). A–U are from the Middle Cenomanian of Rouen, Seine Maritime, France; V–Y, is, by its preservation from the same horizon at Cap Blanc Nez, Boulonnais, France. All × 1.

Fig. 182 *(see overleaf)*. A–G, I–M. *Sciponoceras bohemicum* (Fritsch, 1872). A–C. BGS–GSM115260 from the Chalk Rock, Upper Turonian, Kensworth near Dunstable, Bedfordshire. D–F. BGS–Yc7286, horizon and locality as A–C. G. SMC B4142, horizon as A–C, from Cuckhamsley, Farnborough, Berkshire; the original of Woods (1896, pl. 2 (fig. 9))). I–K. BGS–Yc7523c from the Chalk Rock, Upper Turonian, Hitch Wood near Hitchin, Hertfordshire. L–M. BGS–Yc7303. Horizon and locality as A–C. H. *Baculites undulatus* d'Orbigny, 1850. The holotype, Muséum d'Histoire Naturelle, Paris Collection, ex d'Orbigny Collection, from the Upper Turonian of Uchaux, Vaucluse, France. A–G, I–M × 1, H × 2.

Fig. 183 *(see overleaf)*. *Sciponoceras bohemicum* (Fritsch, 1872). A–C. BMNH C33427, Upper Turonian, Chalk Rock, Hill End, near Hitchin, Hertfordshire. D. GPIB 80. The original of Schlüter's (1876, pl. 39 (fig. 1)) *Baculites* cf. *bohemicum* from the Upper Turonian Scaphiten–Pläner of Oerlinghausen, Teutoburgerwald, Germany. E–G. BMNH C79507, Upper Turonian, Chalk Rock, Hitch Wood, near Hitchin, Hertfordshire. H–J. Horizon and locality as for A–C. K–M. BGS–Zr7804, Upper Turonian, Chalk Rock, Kentworth, near Dunstable, Bedfordshire. N–P. BMNH C73688. Locality as for K–M. All × 1.

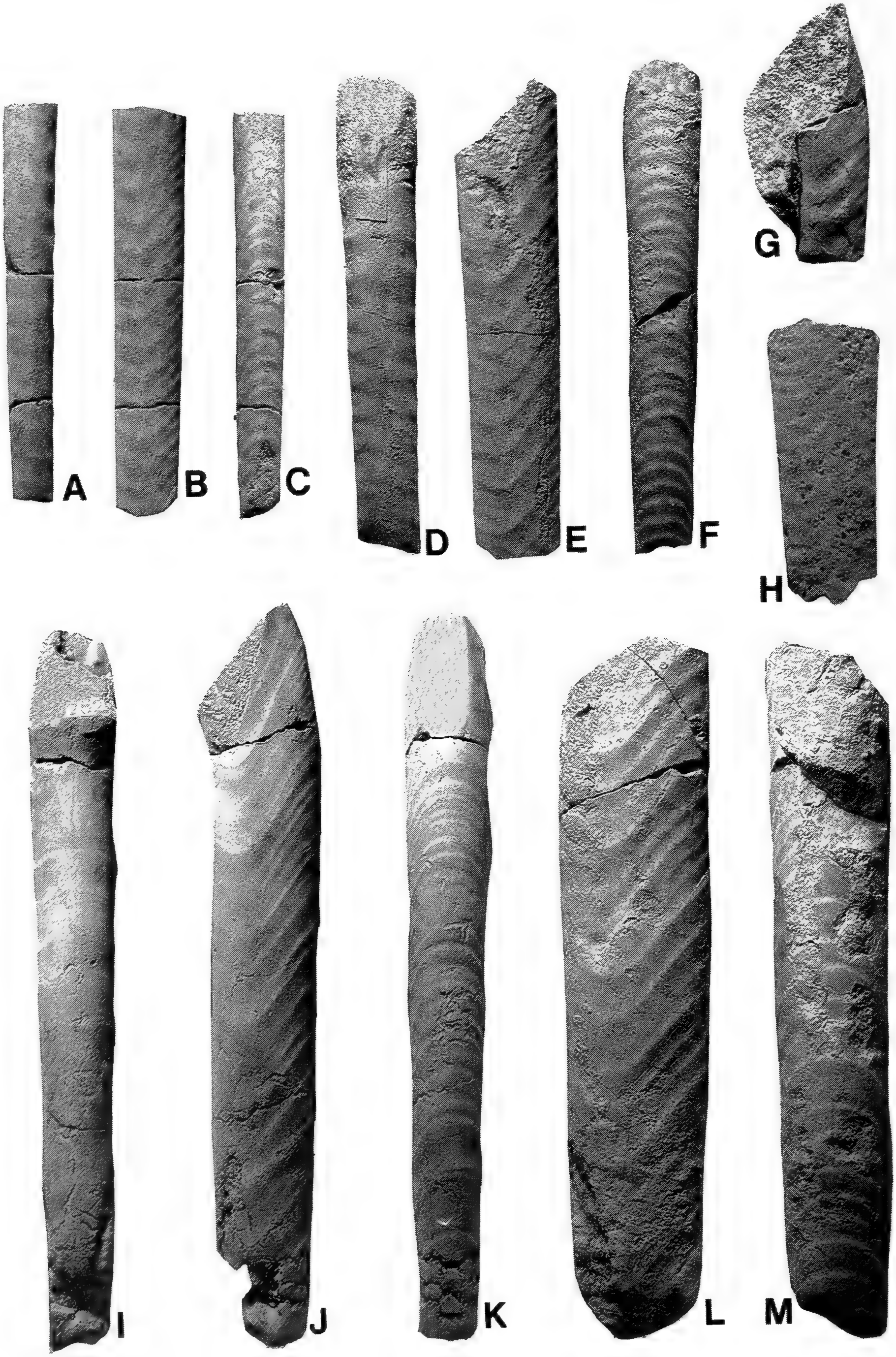

Fig. 182

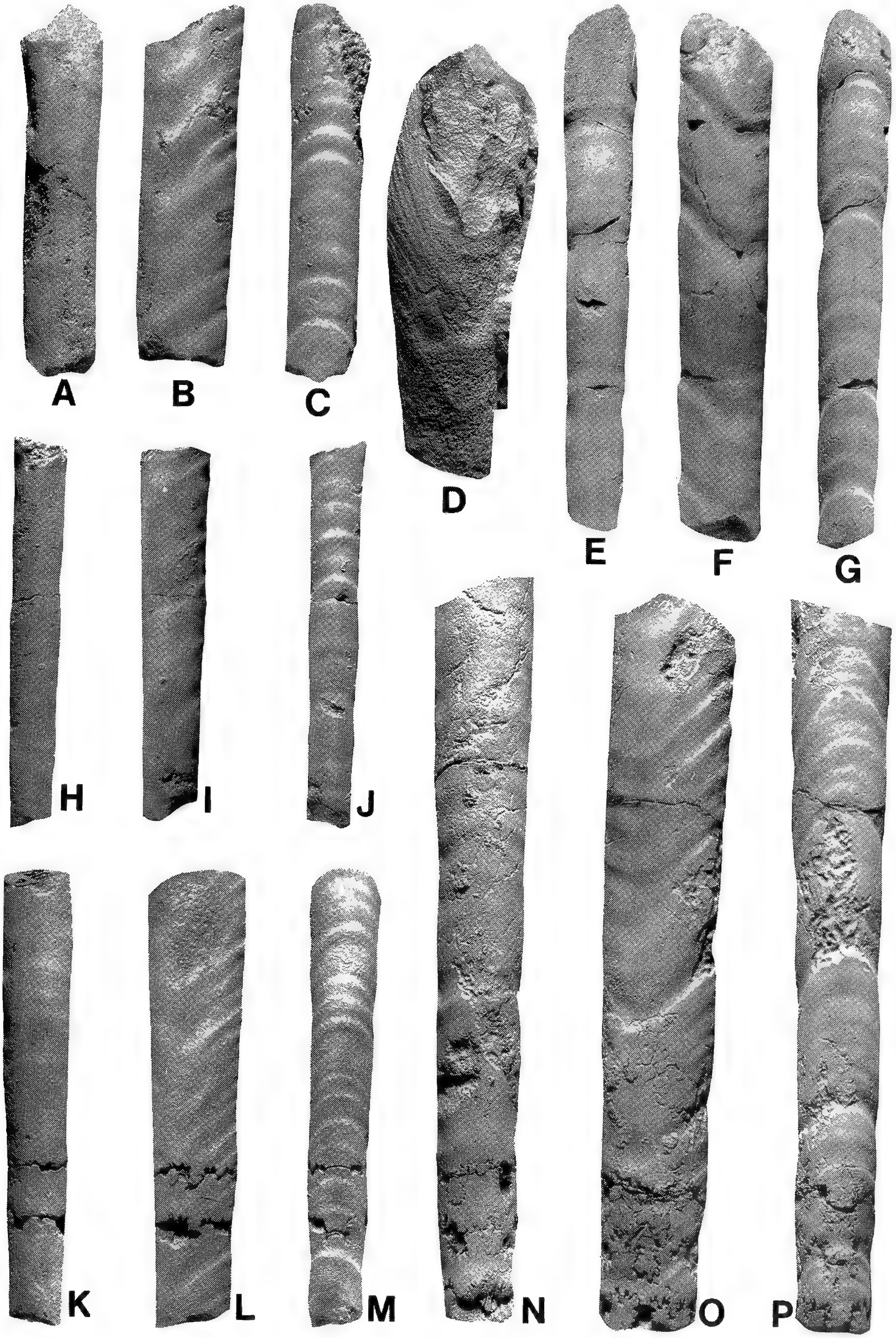

Fig. 183

Type. Lectotype by the subsequent designation of Spath (1941: 663) is the original of Pictet & Campiche (1861, pl. 55 (fig. 5a–c)) from the upper Albian of St Croix, Switzerland, MGL L21271.

Occurrence. Upper Albian, England, France, Switzerland, Hungary, Romania, Sardinia, North Africa, Madagascar, Zululand, South India, Hokkaido, Mexico and Antarctica.

Lechites imlayi Leanza, 1970

(= *Rossalites* fide Aguirre Urreta & Riccardi 1988: 600)

Leanza 1970: 211, fig. 10.1–10.3.

Lechites italicus Wiedmann & Dieni, 1968

(= ?*L. gaudini* fide Cooper & Kennedy 1977)

Wiedmann & Dieni 1968: 64, pl. 6 (fig. 10), text-fig. 37.

Type. Holotype by monotypy is the original of Wiedmann & Dieni (1968, pl. 6 (fig. 10), text-fig. 37) from the condensed Upper Albian of Orosei, Sardinia (coll. Sardegna), IGP 59.

Occurrence. Upper Albian, Sardinia.

* ***Lechites moreti*** Breistroffer, 1936 Fig. 171M–O

Pictet & Campiche 1861: 112, pl. 55 (fig. 10–11) (as *B. gaudini*). Breistroffer 1936: 66. Spath 1941: 665, pl. 72 (fig. 8), text-fig. 243. Breistroffer 1947: 62. Wiedmann 1962*a*: 184, pl. 10 (fig. 1), text-fig. 45. Renz 1968: 81, pl. 16 (figs 10a–c, 12–13), text-fig. 29a, i. Scholz 1979: 14, pl. 1 (fig. 10), text-fig. 5c. (as *L. gaudini moreti*). Chiriac 1981: 63, pl. 3 (figs 7–9). Horvath 1983, pl. 2 (fig. 11). Delanoy & Latil 1988, pl. 1 (fig. 4).

Type. Lectotype by subsequent designation Spath (1941: 665) is the original of Pictet & Campiche (1861, pl. 55 (fig. 10a–d)), refigured by Renz (1968, pl. 16 (fig. 10), text-fig. 29a, i) from the Upper Albian of Ste Croix, Switzerland, MGL L40016.

Occurrence. Upper Albian, Cambridge Greensand, England, France, Switzerland, Spain, Sardinia, Hungary, North Africa.

Lechites raricostatus Breistroffer, 1947

(= *L. gaudini* fide Cooper & Kennedy 1977: 645)

Pictet & Campiche 1861: 112, pl. 55 (fig. 8) (as *B. gaudini*). Collignon 1929: 70, pl. 7 (fig. 12) (as *B. gaudini*). Breistroffer 1947: 94 (as *Lechites gaudini* var. *raricostata*). Renz 1968: 82, pl. 16 (fig. 11a–b), pl. 17 (fig. 7a–c), text-fig. 29l. Nagy 1971: 18 (as *Lechites* aff. *raricostatus*).

Type. Lectotype is the original of Pictet & Campiche (1861, pl. 55 (fig. 8)), by subsequent designation of Renz and refigured by him (Renz 1968, pl. 17 (fig. 7), text-fig. 29l) from the Upper Albian of St Croix, Switzerland, MGL L40021.

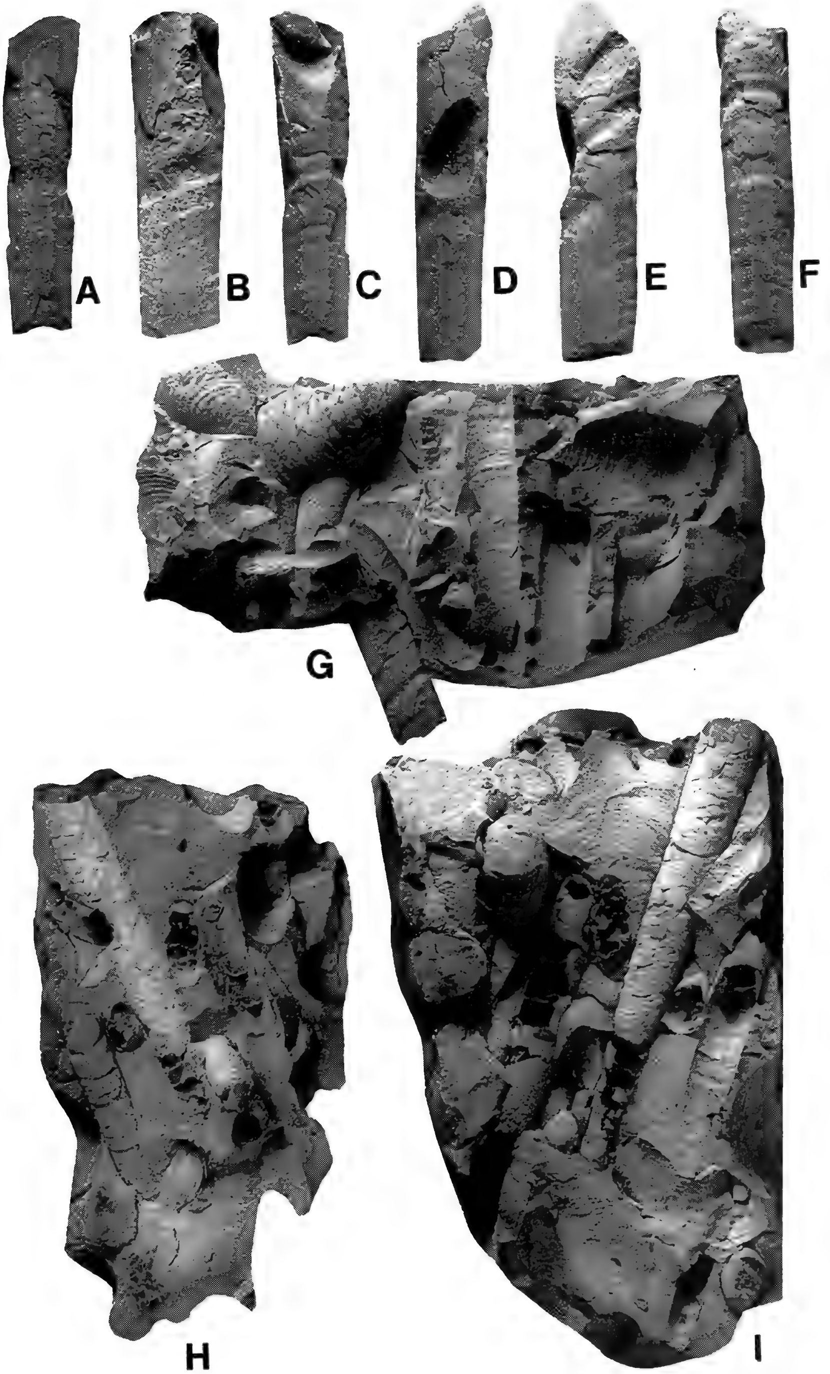

Fig. 184. A–I. *Sciponoceras glaessneri* Wright, 1963. R. Henderson Collection L.842 from the Middle Cenomanian of Bathurst Island, Northern Australia. All × 1.

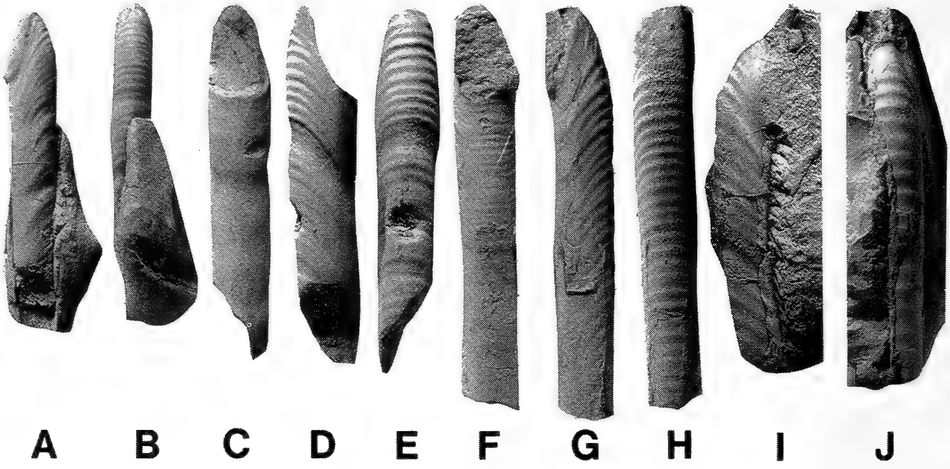

Fig. 185. *Sciponoceras gracile* (Shumard, 1860). Microconchs. A–B. USNM 411539 from Texcrete Quarries, Dallas County. C–E. USNM 411542 from the same locality. F–H. USNM 411541 from Newton Branch, 3.75 miles south of Britton on old Britton–Midlothian Road, Ellis County. I–J. USNM 411540, from 1.5 to 1.8 miles south-east of Britton on Rogers Farm, Ellis County. All specimens from the Upper Cenomanian *Sciponoceras gracile* zone fauna of the Britton Formation in north-east Texas. All × 1.

Occurrence. Upper Albian, Cambridge Greensand, England, Switzerland, Hungary and Madagascar.

Lechites (?) sanctaecrucis (Pictet & Campiche, 1861)
(= ?Anisoceratid; see also Spath 1939: 573; 1941: 661 footnote)

Pictet & Campiche 1861: 109, pl. 55 (fig. 1a–h, 2–4) (as *Baculites sanctae-crucis*). Tavani 1942: 30 (116) (as *Lechites* cfr. *sanctae-crucis*).

Type. Lectotype, by the subsequent designation of Spath (1939: 573) is the original of Pictet & Campiche (1861, pl. 55 (fig. 1a–c)) from the Middle? Albian of Switzerland.

Occurrence. ?Middle Albian of Switzerland and, doubtfully, Somalia.

Lechites varicostatus Chiriac, 1981

Chiriac 1981: 64, pl. 3 (figs 10, 11a–c).

Type. Holotype is the original of Chiriac (1981, pl. 3 (figs 10, 11a–c)), from the Upper Albian, probably *dispar* zone of Southern Dobrogea, IGG 16 925.

Occurrence. Upper Albian, Romania.

Lechites vraconensis Renz, 1968
(= *L. gaudini* fide Cooper & Kennedy 1977)

Renz 1968: 82, pl. 17 (fig. 11a–c, 12a–b, 14a–b, 15a–c), text-fig. 29b, g–h, k.

Type. Holotype is the original of Renz (1968, pl. 17 (fig. 11a–c), text-fig. 29g–h) from the Upper Albian of La Vraconne, Switzerland, MGL L40024.

Occurrence. Upper Albian, Switzerland.

Subgenus *Lechites (Tuberolechites)* Cooper & Kennedy, 1977

* ***Lechites (Tuberolechites) regifex*** Cooper & Kennedy, 1977 Fig. 173

Cooper & Kennedy 1977: 654, fig. 8, 1–15. Scholz 1979: 15, pl. 1 (figs 11–16) (as *L. gaudini nodosus*).

Type. Holotype is the original of Cooper & Kennedy (1977, fig. 8 (1–4)) from the Upper Albian of the Cambridge Greensand, England, SM B97675.

Occurrence. Upper Albian, Cambridge Greensand, England, Salazac (Gard), France, and Hungary.

Genus *Pseudobaculites* Cobban, 1952

* ***Pseudobaculites natosini*** (Robinson, 1945) Figs 175–176

Robinson 1945: 52, pl. 1 (figs 5–6). Cobban & Kennedy 1994*a*: C2, pls 1–2. Larson *et al.* 1997: 37.

Type. Holotype by monotypy is the original of Robinson (1945, pl. 1 (figs 5–6)) from the Bearpaw Shale, south-western Saskatchewan, GSC 9119.

Occurrence. Upper Campanian and Lower Maastrichtian, southern Saskatchewan, Montana, Wyoming, Colorado.

* ***Pseudobaculites nodosus*** Cobban, 1952 Fig. 177A–F

Cobban 1952: 759, pl. 110 (figs 1–10, 17–18). Kennedy & Cobban 1991*a*: 78, pl. 17 (figs 9–14), text-fig. 27.

Type. Holotype is the original of Cobban (1952, pl. 110 (figs 1–4)) from the Upper Coniacian, 152 m above base of the Cody Shale near Lander, Fremont County, Wyoming, USNM 108209.

Occurrence. Upper Coniacian of western Wyoming only.

* ***Pseudobaculites wyomingensis*** Cobban, 1952 Fig. 177G–M

Cobban 1952: 760, pl. 110 (figs 11–16, 19–21). Kennedy & Cobban 1991*a*: 79, pl. 14 (figs 35–37), pl. 17 (figs 15–23).

Type. Holotype is the original of Cobban (1952, pl. 110 (figs 11–13)) from the Upper Coniacian, about 457 m above the base of the Cody shale near Dubois, Fremont County, Wyoming, USNM 108217.

Occurrence. Upper Coniacian, US Western Interior (Wyoming, Utah and possibly south-eastern Colorado).

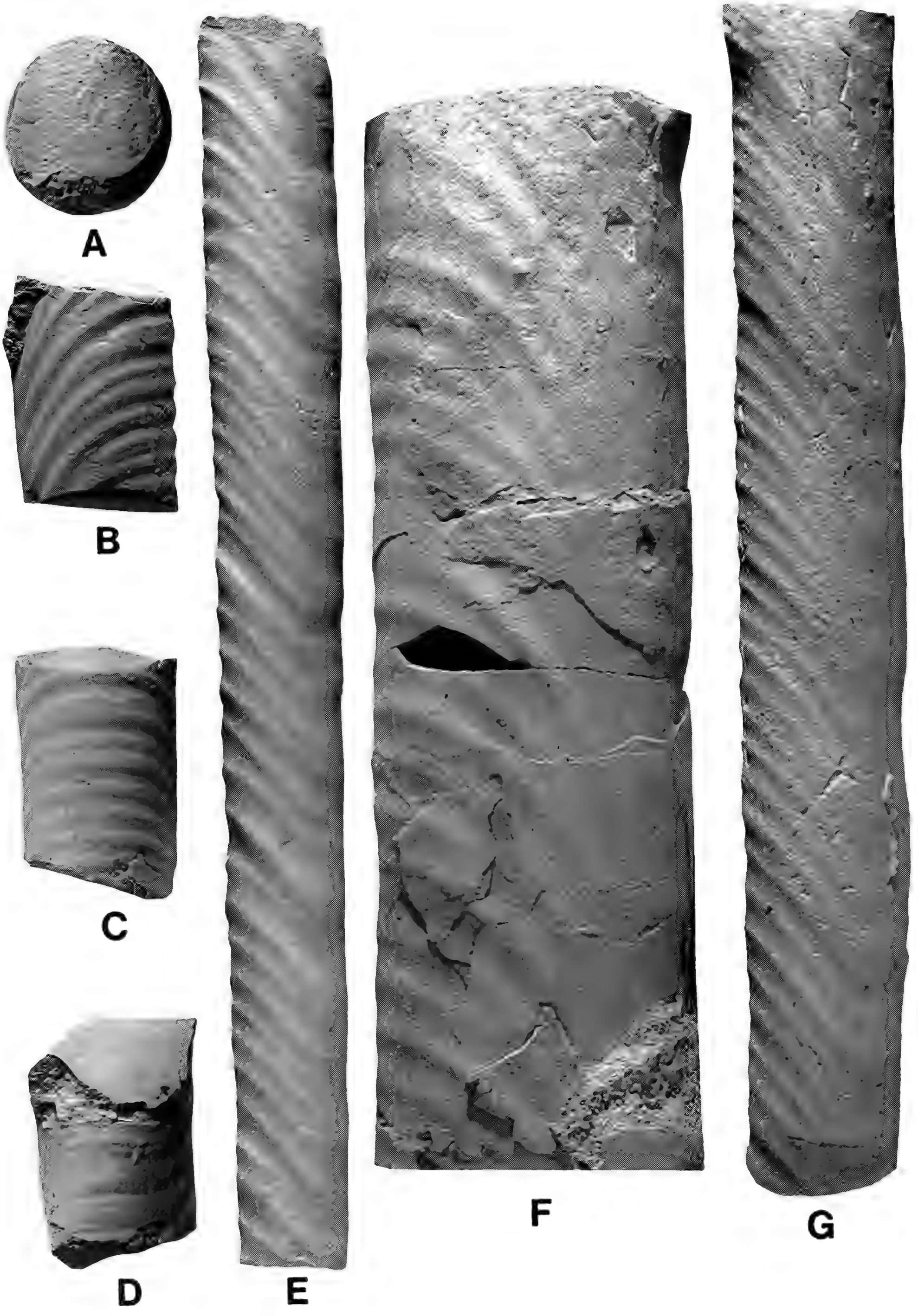

Fig. 186

Fig. 187. *Sciponoceras kossmati* (Nowak, 1908), the original of Matsumoto & Obata (1963, pl. 4 (fig. 1)), Kyushu University Collections, GK H4335, from the Upper Cenomanian Mikasa Formation, Ikushumbets Valley, Ishikari Province, Hokkaido, Japan. × 1.

Fig. 186 *(see facing page)*. *Sciponoceras gracile* (Shumard, 1860). Macroconchs. A–D. USNM 411544 from Texcrete Quarries, Dallas County. E. USNM 41537 from 1.5 to 1.8 miles south-east of Britton on Rogers Farm, Ellis County. F. USNM 411543 from Texcrete Quarries, Dallas County. G. USNM 411538 from the same locality as E. All the specimens are from the Upper Cenomanian *Sciponoceras gracile* zone fauna of the Britton Formation in north-east Texas. All × 1.

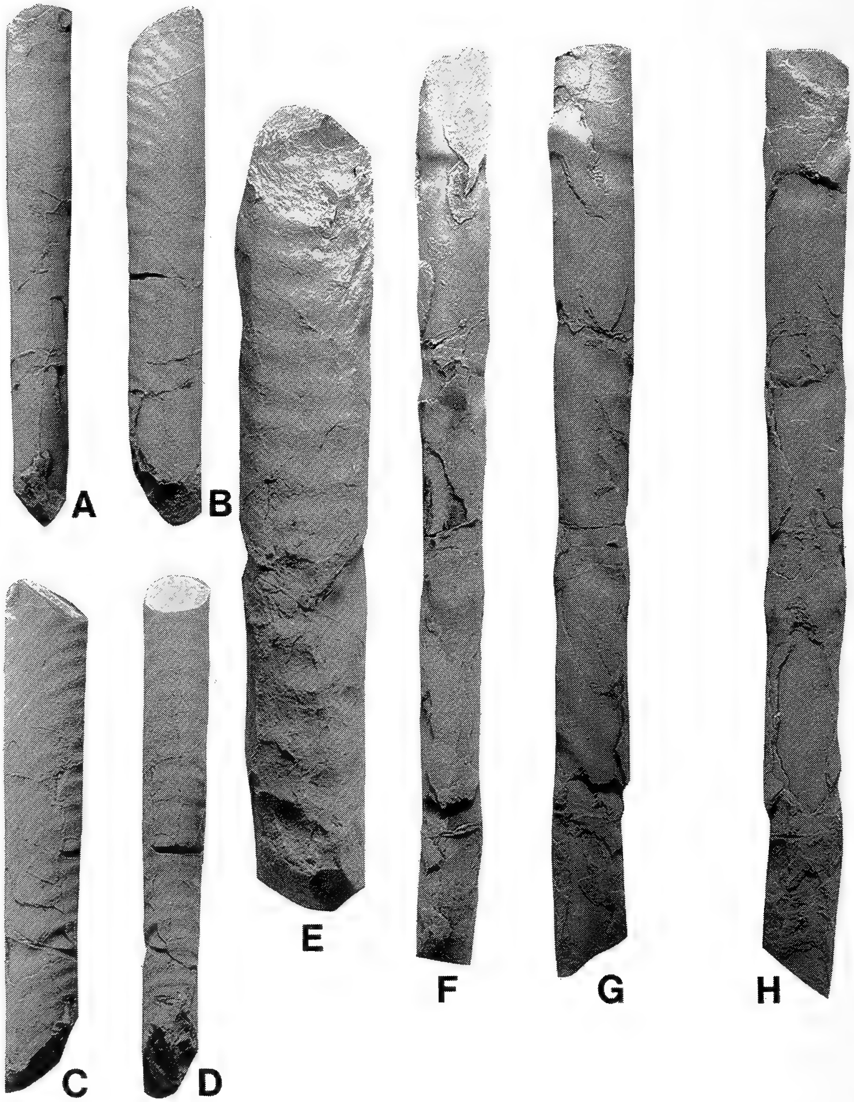

Fig. 188. A–E. *Sciponoceras kossmati* (Nowak, 1908). A–D. The original of Matsumoto & Obata (1963, pl. 6 (fig. 4)), Kyushu University Collections, GK H4337, 'approximately basal Turonian' Mikasa Formation, Ikushumbets Valley, Ishikari Province, Hokkaido, Japan. E. Dorsal view of the original of Matsumoto & Obata (1963, pl. 5 (fig. 3)), Kyushu University Collections, GK H4342, from the same horizon and locality as A–D. F–H. *Sciponoceras baculoides* (Mantell, 1822), the original of Matsumoto & Obata (1963, pl. 1 (fig. 3)), Kyushu University Collections H5453 from the Cenomanian of the D-sawa, a tributary of the Ikushumbets Valley, Ishikari Province, Hokkaido, Japan.
All × 1.

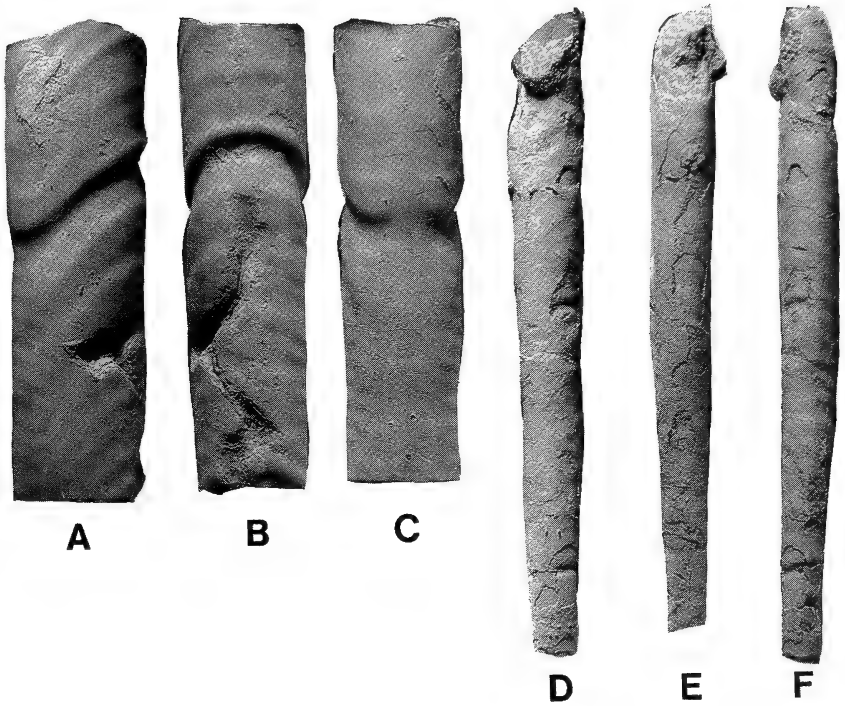

Fig. 189. A–C. *Sciponoceras ?baculoides* (Mantell, 1822). CAS-61818.01, the holotype of *Cyrtochilus major* Anderson, 1958, from Shasta County, Cottonwood District, Hayes Gulch, 2 miles north-west of Gas Point, near-basal beds of Upper Cretaceous Series. D–F. *Sciponoceras ?kossmati* (Nowak, 1908). CAS-31097.01, the holotype of *Cyrtochilus stylus* Anderson, 1958, from Tehama County, on Dry Creek (Redbluff–Beegum road), 4.6 miles W of Rosewood, a few hundred feet above the local base of Upper Cretaceous, 0.1 miles east of basal Chico conglomerate.
Both × 1.

Genus *Sciponoceras* Hyatt, 1894

* ***Sciponoceras baculoides*** (Mantell, 1822) Figs 178–180

Mantell 1822: 123, pl. 23 (figs 6–7) (as *Hamites baculoides*). ?Collignon 1933: 72, pl. 5 (fig. 7) (as *Baculites baculoides*). Matsumoto 1959: 104, pl. 31 (fig. 1a–d), text-fig. 2a–b (*cum. synon.*). Matsumoto & Obata 1963: 9, pl. 1 (figs 1–4), pl. 2 (figs 1–3), text-figs 3, 26–32. *non* Henderson 1973: 81, figs 4a–d, 6, nos 4a–c, 5a–c, 7a–c. Förster 1975: 166, pl. 4 (fig. 6), text-fig. 36. *non* Wiedmann & Schneider 1979: 656, pl. 4 (figs 2–4), text-fig. 5. Marcinowski 1980: 252, pl. 3 (figs 17–20). Chiriac 1981: 64, pl. 4 (figs 1–5), text-fig. 21. Szász 1982, 35, pl. 2 (figs 2a–b, 3a–b, 4a–b), pl. 3 (fig. 2a–b). Kennedy & Juignet 1983: 19 (figs 11(a)–(y), 12(a)–(bb), 13(a)–(w), 14(a)–(n) (*cum. synon.*). Marcinowski & Walaszczyk 1985, pl. 1 (fig. 3). Kaplan *et al.* 1983, pl. 5 (fig. 2). Wright & Kennedy 1987: 177, pl. 37 (fig. 13). Blaszkiewicz & Szymakowska 1989: 266, pl. 519 (fig. 2). Delamette & Kennedy 1991: 462, figs 17.6, 17.7, 17.14, 17.15. Young (undated) 1979: 23, pl. 1 (figs 41–45), text-fig. 9j (as *Sciponoceras* sp. cf. *baculoides*). Summesberger 1992: 123, pl. 8 (figs 7–9). Thomel 1992, pl. 6 (fig. 7), pl. 10 (fig. 2), pl. 11 (figs 1–3), pl. 19 (fig. 4). Kennedy 1994: 234, pl. 10 (figs 7–9), pl. 12 (figs 1–6). Wright & Kennedy 1995: 317, pl. 95 (figs 1–3, 5–10), pl. 96 (figs 1–7), pl. 97 (figs 1–5), pl. 98 (figs 29–32), text-figs 129h, 132r–s, 133a–c, m–ff. Klinger & Kennedy 1997: 11, fig. 2d–f.

Type. Lectotype by the subsequent designation of Kennedy (1971: 9) is the larger specimen on the block figured by Mantell (1822, pl. 23 (fig. 6)) from the lower Middle Cenomanian of Hamsey, Sussex (refigured by Kennedy 1971, pl. 2 (fig. 5a–b)), BMNH 8612.

Occurrence. This species has been recorded from the Lower to the Upper Cenomanian, but many of these records cannot be substantiated. According to Wright & Kennedy (1995: 319), *S. baculoides* occurs 'in flood abundance at the top of the Middle Cenomanian *T. costatus* Subzone of the

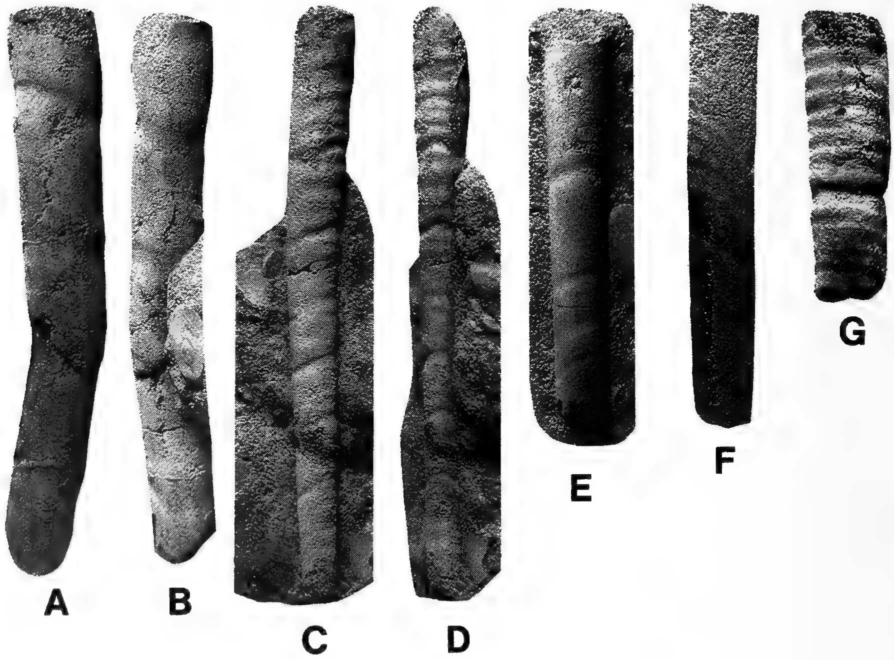

Fig. 190. *Sciponoceras roto* Cieśliński, 1959. A–B. BGS-GSM70774 from the phosphatic Lower Cenomanian *Mantelliceras mantelli* zone fauna near Warminster, Wiltshire. C–D. BMNH C88900 from the same horizon and locality. E. BGS-GSM70778 from the same horizon and locality. F. BMNH C24423 from the same horizon and locality. G. Muséum d'Histoire naturelle de Genève Collections no. 1316, from the Cenomanian of the Rochers de Fiz, Haute Savoie, France. All × 1.

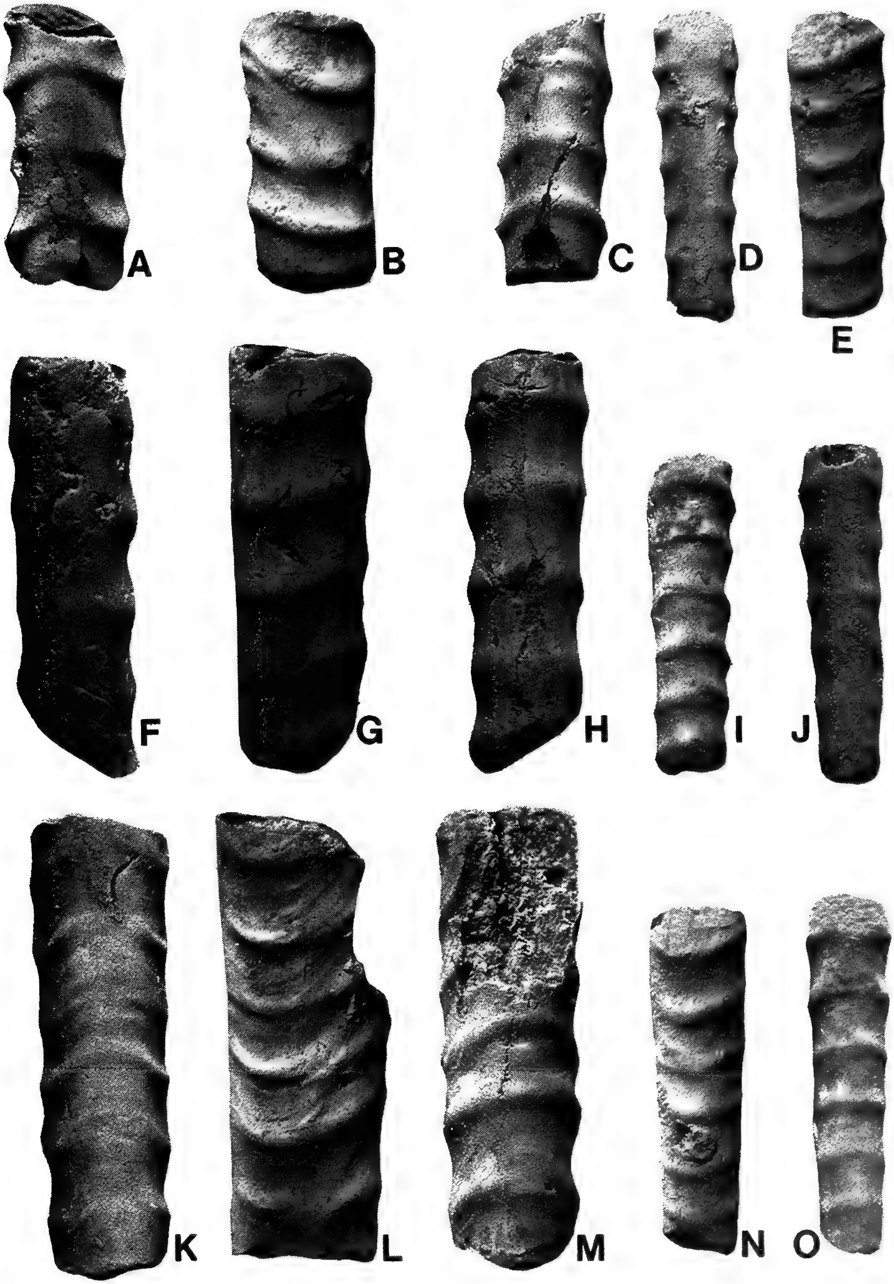

Fig. 191. *Trachybaculites columna* (Morton, 1834). A–C. ANSP 72867a. D–E. ANSP 72867b. F–H. ANSP 72867e. J, N–O. ANSP 72867c. K–M. ANSP 72867d. All syntypes and from the Maastrichtian Prairie Bluff Chalk at Prairie Bluff, Alabama. All × 2.

A. rhotomagense Zone in the Lower Chalk from Kent to the Isle of Wight, and in the phosphatized faunas of the Chalk Basement bed of comparable age at Punfield Cove and Buckland Newton, Dorset. It ranges to the lower Upper Cenomanian *C. guerangeri* Zone, occurring in the phosphatized faunas of the Chalk Basement Bed of Dorset and Somerset, and C Bed of the Cenomanian Limestone in Devon.' It is also known from West and Central Europe, North Africa, southern India, California, ?Texas, Hokkaido, Mozambique, Zululand and Madagascar.

* ***Sciponoceras bohemicum*** (Fritsch, 1872) Figs 181–183

Fritsch 1872: 49, pl. 13 (figs 23–25, 29, 30); Fritsch 1875: 78, fig. 63 (as *Baculites faujasii* var. *bohemica*). Wright 1979: 285, pl. 1 (figs 3–5), pl. 7 (figs 10, 12) (*cum. synon.*). Wright & Kennedy 1981: 115. Wright & Kennedy 1981: 115, pl. 31 (figs 4–6, 8, 10–11, ?7), pl. 32 (figs 9–10, 12–15) (as *S. bohemicum anterius*). Wright & Kennedy 1981: 116, pl. 31 (fig. 9) (as *S. bohemicum bohemicum*). Szász 1982: 35, pl. 2 (figs 2a–b, 3a–b, 4a–b), pl. 3 (fig. 2a–b). Wright & Kennedy 1987: 177, pl. 37 (figs 7–8). Summesberger 1992: 123, pl. 8 (figs 7–9). Metzdorf 1992: 293, pl. 3 (figs 5, 7). Santamaria Zabala 1992: 235 (as *S. bohemicum anterius*); 1992: 236, pl. 2 (fig. 7). Summesberger & Kennedy 1996: 134, pl. 18 (figs 4, 26) (as *S. bohemicum*).

Type. Lectotype by the subsequent designation of Wright (1979: 285) is the original of Fritsch (1872, pl. 13 (fig. 25a–c)) from the Turonian Priesen Beds of Lenesic, near Laun, Bohemia.

Occurrence. Turonian, northern and central Europe, Spain.

Sciponoceras cucullatum Collignon, 1964

Collignon 1964: 38, pl. 326 (fig. 1458). Klinger & Kennedy 1997: 12, figs 2g–l, n–o, 4–5, 6a–d.

Type. Holotype by monotypy is the original of Collignon (1964, pl. 326 (fig. 1458)) from the Lower Cenomanian, west of the falls of Mahaboka, Manera, Madagascar, GD 11458.

Occurrence. Lower Cenomanian of Madagascar; Cenomanian, Zululand.

* ***Sciponoceras glaessneri*** Wright, 1963 Fig. 184

Wright 1963: 599, pl. 81 (figs 2–3).

Type. Holotype is the original of Wright (1963, pl. 81 (fig. 2)) from the Middle Cenomanian of Meadinga, Bathhurst Island, GDUA F.15852.

Occurrence. Middle Cenomanian, Bathhurst Island, Australia.

Fig. 192 *(see facing page)*. Nodose *Baculites* sp. from the Upper Campanian of Oron, Israel. A–C. SAM-PCI8582. D–F. SAM-PCI8583. G–I. SAM-PCI8585. J–L. SAM-PCI8586. M–O. SAM-PCI8581. All × 1.

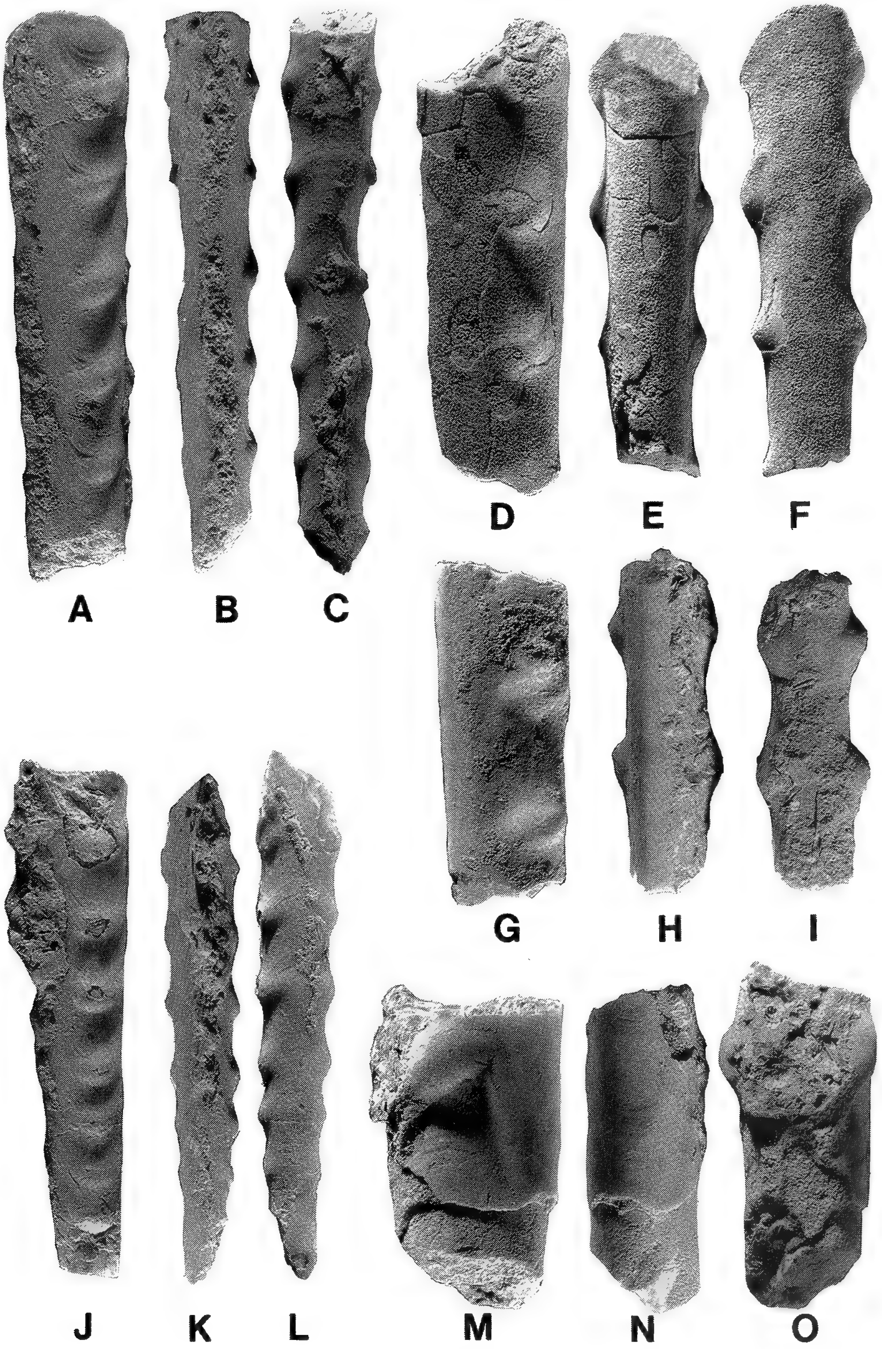

Fig. 192

Sciponoceras gracile (Shumard, 1860) Figs 185–186

Shumard 1860: 596 (as *B. gracilis*). *non* Boule *et al.* 1907: 44. ?*non* Collignon 1931: 94 (54), pl. 9 (5) (fig. 28). Cobban & Scott 1972: 47, pl. 17 (figs 9–29), text-fig. 18 (*cum. synon.*). Kauffman & Powell 1977: 100, pl. 10 (fig. 4). ?Cooper 1978: 70, fig. 12b–d. Wright & Kennedy 1981: 112, pl. 31 (figs 1–3), pl. 32 (figs 8, 11), text-figs 38a–q (*cum. synon.*). Kennedy *et al.* 1981: 30, pl. 8 (figs 9–10), pl. 10 (figs 1–4). Kennedy & Juignet 1983: 22, figs 18(a)–(d), 32(i)–(p) (*cum. synon.*). Wright & Kennedy 1987: 177, pl. 37 (figs 3–4). Kennedy 1988: 108, pl. 20 (figs 1–14, 17–20), text-fig. 38. ?Konecny & Vašiček 1987: 91, pl. 1 (fig. 3), pl. 5 (fig. 2) (as *Baculites* cf. *gracile*). Cobban *et al.* 1989: 61, figs 94a–b, 95g–n, 96a–b.

Type. Shumard's types are lost (*fide* Cobban & Scott 1972: 47) and, as yet, no neotype has been designated.

Occurrence. Upper Cenomanian of southern England, France, southern Germany, Czechoslovakia, the United States, Mexico, and perhaps Angola. Records from Madagascar (Boule *et al.* 1907; Collignon 1931) are dubious, as is that from Cameroon (Solger 1904; see Reyment 1955: 15).

Sciponoceras intermedium Matsumoto & Obata, 1963

Matsumoto 1959: 109, pl. 30 (figs 2a–c, 3a–b), pl. 31 (?fig. 4), text-figs 7a–b, 8–11 (as *S.* aff. *bohemicum*). Matsumoto & Obata 1963: 24, pl. 8 (figs 1–3, 6), pl. 11 (fig. 6), pl. 12 (figs 4–5), text-figs 50–59, 61.

Type. Holotype is the original of Matsumoto & Obata (1963, pl. 8 (fig. 1a–d)), Upper Turonian, from the basal part of the Upper Yezo Group, along the Pombets, a tributary of the Ikushumbets River, Hokkaido, GK H5386.

Occurrence. Upper Turonian, Hokkaido.

* ***Sciponoceras kossmati*** (Nowak, 1908) Figs 187, 188A–E
(= ?*S. gracile* (*pars*) fide Wright & Kennedy 1981: 114)

Kossmat 1895: 154, pl. 19 (5) (fig. 18a–d) (as *Baculites* n. sp. aff. *bohemicum*). Nowak 1908: 348 (as *Baculites kossmati*). Anderson 1958: 188, pl. 11 (fig. 5, 5a) (as *Cyrtochilus stylus*). Matsumoto 1959: 106, pl. 31 (figs 2a–b, 3), text-figs 4a–b, 5a–b, 6a–b. Matsumoto & Obata 1963: 13, pl. 3 (fig. 2), pl. 4 (fig. 1), pl. 5 (figs 1–3), pl. 6 (figs 3–5), text-figs 5–25. Immel 1979: 631, pl. 3 (fig. 4) (as *S.* cf. *kossmati*). Immel 1987: 128 (as *S.* cf. *kossmati*).

Type. Holotype is the original of Kossmat (1895, pl. 19 (5) (fig. 18a–d)) from the Lower Trichonopoly Group of India, GSI.

Fig. 193 *(see facing page).* Nodose *Baculites* sp. from the Upper Campanian and Lower Maastrichtian of Israel. A–C. SAM-PCI8576. N–P. SAM-PCI8577. Q–S. SAM-PCI8578. All from the Lower Maastrichtian of the upper part of the Mishash Formation, Phosphate Member, Oron. D–F. SAM-PCI8587. K–M. SAM-PCI8584. D–M. All from the Upper Campanian, Oron. All × 1.

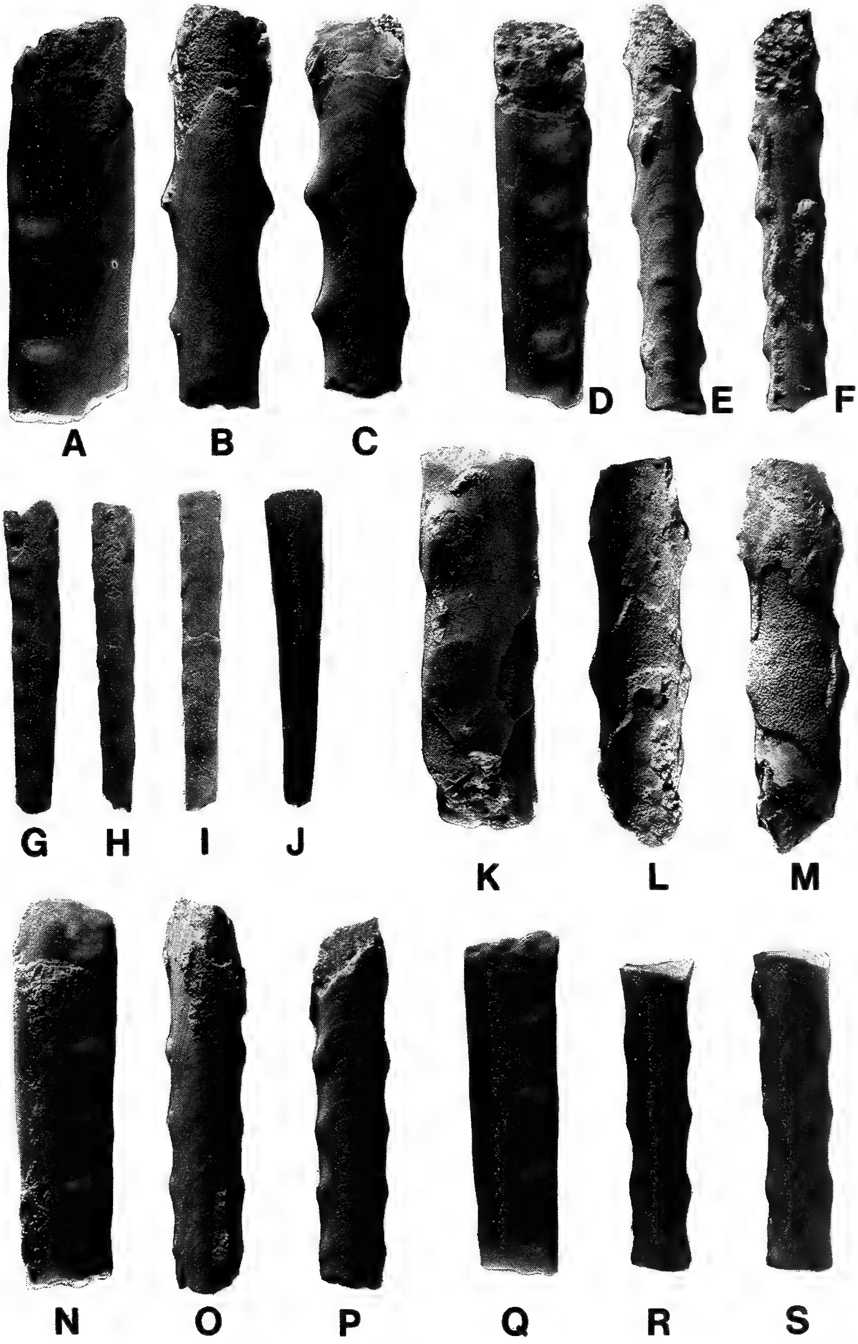

Fig. 193

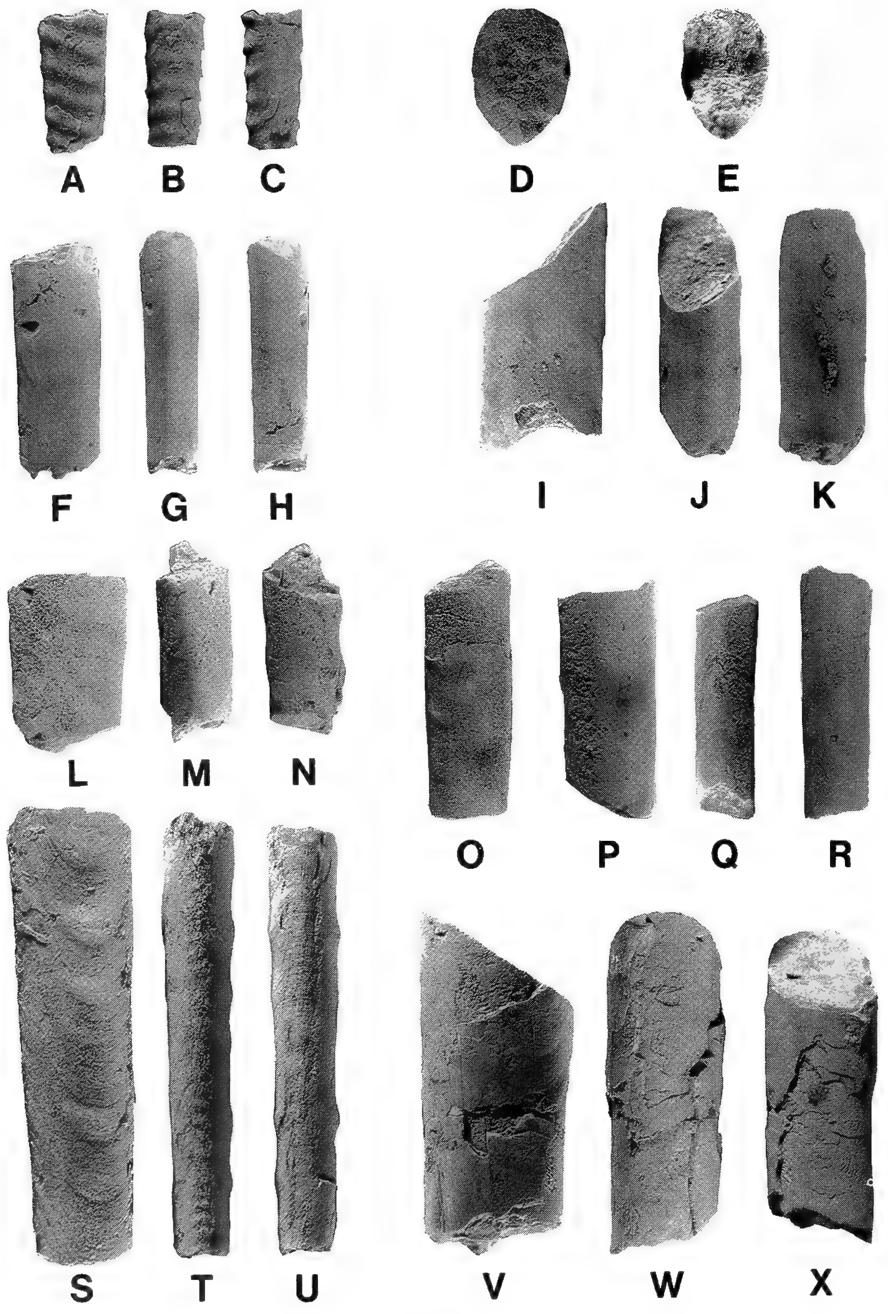

Fig. 194

Occurrence. Lower Turonian, California, rarely in the Middle Cenomanian; common in uppermost Cenomanian and basal Turonian of Hokkaido; the Indian holotype was recorded from the Lower Trichonopoly Group of Garudamungalum (Lumachelles), which dates it as late Turonian; Germany.

* ***Sciponoceras major*** (Anderson, 1958) Fig. 189A–C
(= *S. baculoide* fide Matsumoto 1959: 104)

Anderson 1958: 189, pl. 38 (fig. 6) (as *Cyrtochilus major*).

Type. Holotype by monotypy is the original of Anderson (1958, pl. 38 (fig. 6)) from Hayes Gulch, Cottonwood District, Shasta County, California. CAS type collection.

Occurrence. Cenomanian, California.

Sciponoceras matsumotoi Inoma, 1980

Inoma 1980: 171, pl. 2 (figs 4–6), text-fig. 4.

Type.

Occurrence. Cenomanian, Hokkaido.

Sciponoceras orientale Matsumoto & Obata, 1963

Matsumoto & Obata 1963: 18, pl. 3 (fig. 1), pl. 6 (figs 1–2), pl. 7 (figs 1–6), pl. 9 (fig. 6), text-figs 33–49.

Type. Holotype is the original of Matsumoto & Obata (1963, pl. 6 (figs 1–2)) from the Turonian, upper part of the Middle Yezo Group, Abeshinai-Saku area, Teshio Province, Hokkaido, Geological Institute, University Tokyo, GT I–3160a.

Occurrence. Approximately Lower and Middle Turonian of Hokkaido.

Sciponoceras pervinquierei Breistroffer, 1940

Pervinquière 1907: 92, pl. 4 (fig. 8) only (as *B. baculoides*). Breistroffer 1940: 29 (as *Cyrtochilus Pervinquierei* = invalid under article 13(a) of ICZN; = *S. roto*).

Type. Holotype by the original designation of Breistroffer (1940: 29, p. 36 footnote) is the original of Pervinquière (1907, pl. 4 (fig. 8)) from the Vraconian of Mechtat Mergueb, Tunisia.

Occurrence. Lower Cenomanian, Tunisia.

Fig. 194 *(see facing page)*. A–C. *Trachybaculites? furcillatus* (Blanckenhorn, 1905). SAM-PCI8573 from the Lower Maastrichtian of Israel. D–R. *Baculites ?anceps*. D. SAM-PCI8560. E, I–K. SAM-PCI8561. F–H. SAM- PCI8551. O. SAM-PCI8550. P–R. SAM-PCI8549, all from the Lower Maastrichtian, upper part of Mishash Formation, Phosphatic Member, Nahal Ashosh. S–X. Smooth *Baculites* from the upper Lower Campanian of Nahal Qidron, Judean Desert, Israel. All × 1.

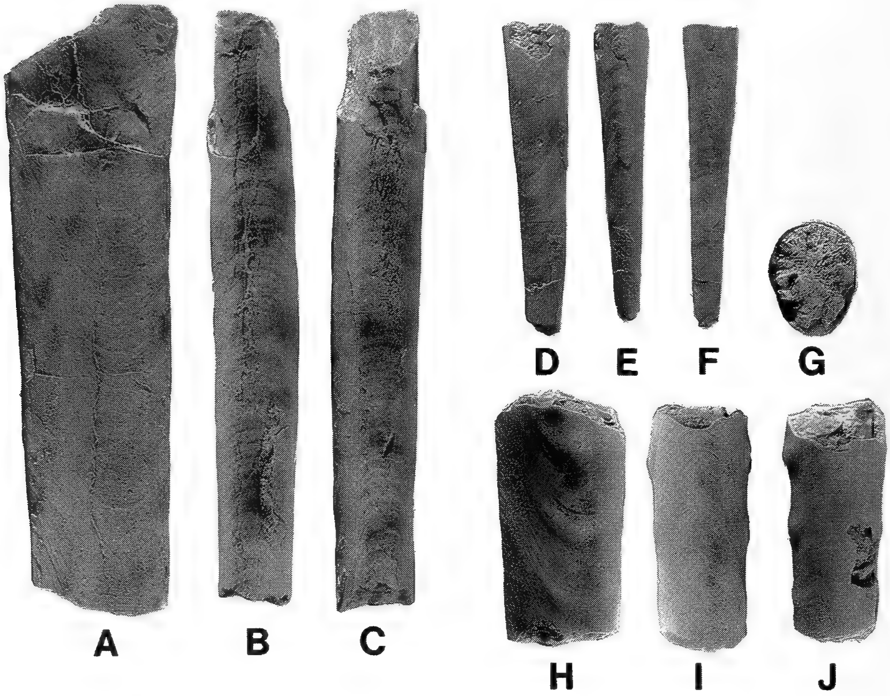

Fig. 195. Smooth *Baculites*. A–C. SAM-PCI8571 from the upper Lower Campanian of Nahal Qidron, Judean Desert. D–F. SAM-PCI8569. G–J. SAM-PCI8567, both from the lower Upper Campanian of the Arad Region, east-central Israel. All × 1.

* ***Sciponoceras roto*** Cieśliński 1959 Figs 170A–B, E–L, 190

Cieśliński 1959: 89, pl. 4 (fig. 10a–c), text-fig. 14. Kennedy 1971: 10, pl. 3 (fig. 7). Hancock *et al.* 1972, pl. 81 (fig. 8a–c). Wiedmann & Schneider 1979: 657. Immel 1979: 632, pl. 4 (fig. 5) (as *S.* cf. *roto*). Kennedy *et al.* 1979: 10 (as *S.* cf. *roto*). Marcinowski 1980: 254, pl. 3 (figs 14–15). Wiedmann & Boess 1984: 501, fig. 6ls–t. Immel & Seyed-Emami 1985: 112 (as *Baculites* cf. *roto*). Immel 1987: 128 (as *S.* cf. *roto*). Blaszkiewicz & Szymakowska 1989: 266, pl. 566 (fig. 2). Delamette & Kennedy 1991: 460, figs 17.8–17.13, 17.16–17.23. Wright & Kennedy 1995: 315, pl. 94 (figs 13–19), pl. 95 (fig. 4), pl. 98 (fig. 28), text-figs 131j–l, n. Klinger & Kennedy 1997: 17, fig. 2p.

Fig. 196 *(see facing page)*. ***Baculites vaalsensis*** Kennedy & Jagt, 1995. A–C. Paratype, IRSNB 10462b, from the Hervian of Aachen. D. IRSNB IG 5425, from the Hervian of Battice-Croix Polinard. E–F. IRSNB 10460, from the Vaals Formation of Aachen. G. IRSNB IG 5425, locality as for 4. H–J. Collections of the Rheinisch-Westfälische Technische Hochschule, Aachen, from the Vaals Formation of Aachen. K–M. IRSNB IG, locality as for 4. N. Paratype IRSNB 10462c, locality as for 1–3. O–Q. IRSNB IG 5425, locality as for 4. All × 1.

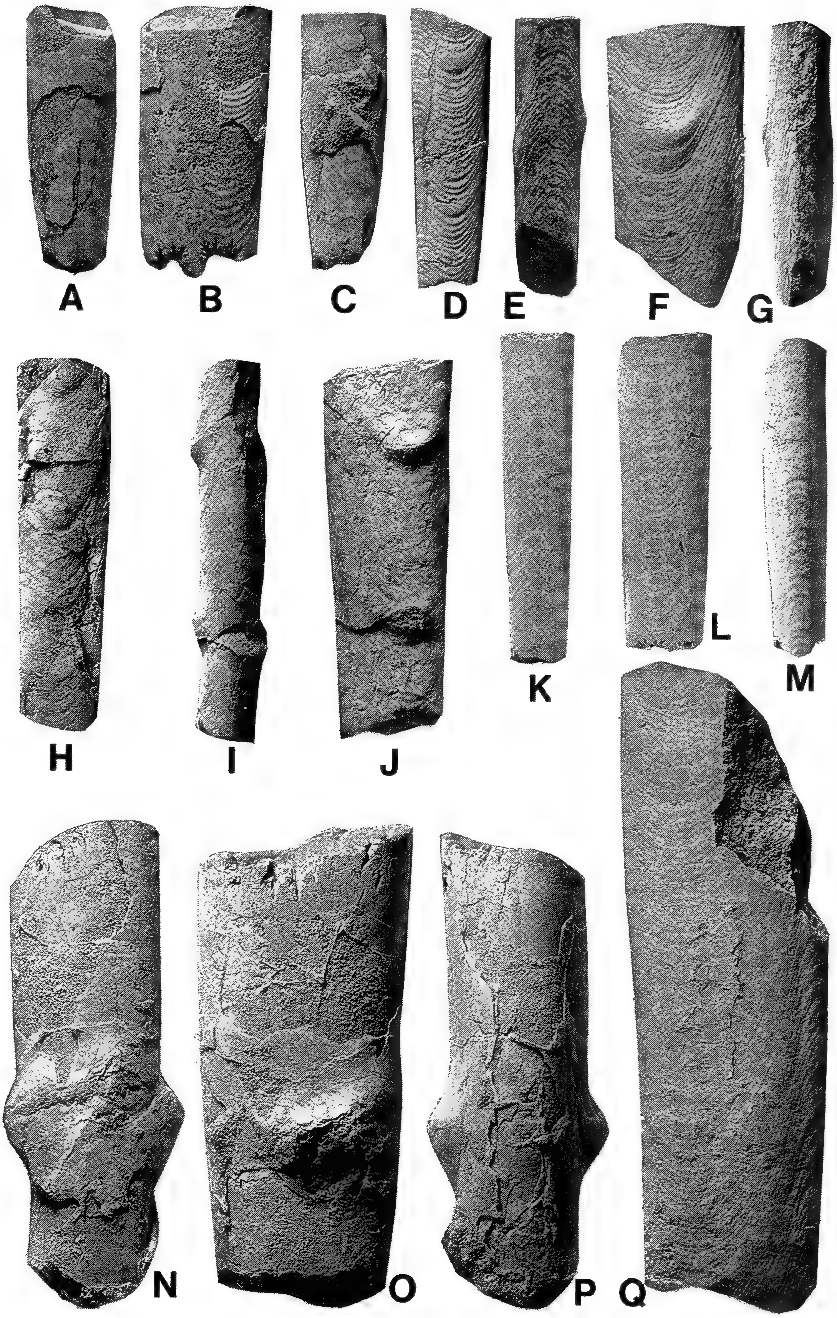

Fig. 196

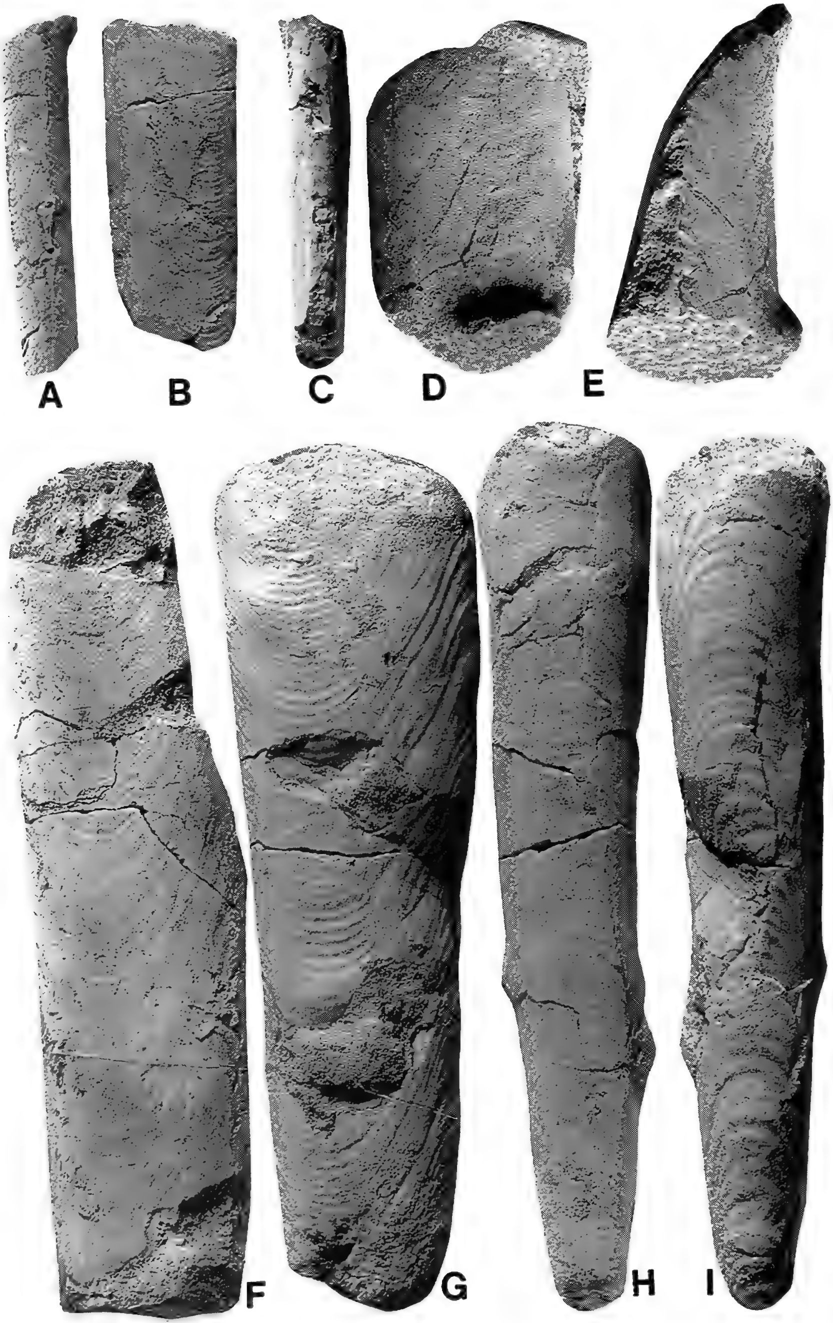

Fig. 197

Type. Cieśliński (1959) based this species on nine syntypes; no lectotype has as yet been designated. The figured specimens are housed in the collections of the Geological and Palaeontological Institute, University of Warsaw.

Occurrence. Lower Cenomanian of southern England, Germany, Spain, Zululand and Mangyschlak; according to Marcinowski (1980: 254) it ranges through the whole Cenomanian of Poland.

Sciponoceras santacrucense Leanza, 1970

Leanza 1970: 212, fig. 11 (1–7). Riccardi & Aguirre Urreta 1988, pl. 2 (figs 3–4). Klinger & Kennedy 1997, fig. 6e.

Type. Holotype is the original of Leanza (1970, fig. 11 (1–3)) from the upper reaches of the section at Puesta Los Alamos, Santa Cruz Province, Argentina, CPC 4326.

Occurrence. Turonian, Argentina.

Sciponoceras subbaculoides (Geinitz, 1875)

Geinitz 1875: 281, pl. 63 (fig. 1). Horvath 1983, pl. 3 (figs 15–16).

Type. Lectotype by the subsequent designation of Wright & Kennedy (1981: 114) is the original of Geinitz (1875, pl. 63 (fig. 1)) from the lower Pläner at Oberau, Bohemia.

Occurrence. ?Upper Cenomanian, Czech Republic (Bohemia) and Hungary.

* ***Sciponoceras stylus*** (Anderson, 1958) Fig. 189D–F

(= *S. kossmati* fide Matsumoto 1959: 106; *S. gracile* fide Cooper 1978: 70)

Anderson 1958: 188, pl. 11 (fig. 5, 5a) (as *Cyrtochilus stylus*).

Type. Holotype is the original of Anderson (1958, pl. 11 (fig. 5, 5a)) from the Lower Cenomanian of Dry Creek, west of Rosewood, northern Tehama County, California, CAS type collection.

Occurrence. Lower Cenomanian, California.

Genus *Trachybaculites* Cobban & Kennedy, 1995

* ***Trachybaculites columna*** (Morton, 1834) Fig. 191

Morton 1834: 44, pl. 19 (fig. 8). Johnson 1905: 27. Stephenson 1941: 405, pl. 76 (figs 1–4). Matsumoto 1959: 161, pl. 30 (fig. 1), pl. 34 (fig. 4), pl. 43 (fig. 4), text-figs 80a–b, 81. Cobban & Kennedy 1992*c*: 682, figs 1.7–1.9, 3.2. Cobban & Kennedy 1995: 29, figs 10.1, 10.3, 13.4-13.6, 14.3, 14.9, 17.1–17.4, 17.17–17.31. Kennedy & Jagt, 1998: 161, pl. 2 (figs 1–6).

Fig. 197 *(see facing page)*. *Baculites vaalsensis* Kennedy & Jagt, 1995. A–C. Collections of the Rheinisch-Westfälische Technische Hochschule, Aachen, from the Vaals Formation of Aachen. D, E–G. IRSNB IG 5425, from the Hervian of Battice-Croix Polinard. H. IRSNB 10459a from the Vaals Formation of Vaals, the Netherlands. I. IRSNB IG 5425, locality as for D. All × 1.

Type. Lectotype, by subsequent designation of Cobban & Kennedy (1995: 29) is ANSP 72867a from the Prairie Bluff Chalk, Prairie Bluff, Alabama.

Occurrence. Maastrichtian, Prairie Bluff Chalk of Alabama and Mississippi, Fox Hills Formation, California, and the Netherlands.

Trachybaculites vicentei Stinnesbeck, 1986

Stinnesbeck 1986: 203, pl. 9 (fig. 4), pl. 10 (figs 3–6), text-fig. 23a–c.

Type. Holotype is the original of Stinnesbeck (1986, pl. 10 (fig. 3)) from the Maastrichtian of west of La Gloria, San Vicente near Talcahuano, Central Chile, GPIB V3/240.

Occurrence. Maastrichtian, Central Chile.

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6. SYSTEMATIC papers must conform to the *International code of zoological nomenclature* (particularly Articles 22 and 51).

Names of new taxa, combinations, synonyms, etc., when used for the first time, must be followed by the appropriate Latin (not English) abbreviation, e.g. gen. nov., sp. nov., comb. nov., syn. nov., etc. The name of the taxon should be followed, without intervening punctuation, by the author's name (not abbreviated) and the year of publication; a comma must separate author's name and year. The author's name and date must be placed in parentheses if a species or subspecies is transferred from its original genus. The name of a subsequent user of a scientific name must be separated from the scientific name by a colon.

Synonymy arrangement should be either according to chronology of names, i.e. all published scientific names by which the species previously has been designated are listed in chronological order, with all references to that name following in chronological order (see example 1), or according to chronology of bibliographic references, whereby the year is placed in front of each entry, and the synonym repeated in full for each entry (see example 2). The author should adopt one style or the other throughout a paper.

Family Nuculanidae
Nuculana (Lembulus) bicuspidata (Gould, 1845)
Figs 14–15A

Example 1

Nucula (Leda) bicuspidata Gould, 1845: 37.
Leda plicifera A. Adams, 1856: 50.
Laeda bicuspidata (Gould) Hanley, 1859: 118, pl. 228 (fig. 73). Sowerby, 1871, pl. 2 (fig. 8a–b).
Nucula largillierti Philippi, 1861: 87.
Leda bicuspidata (Gould): Nicklès, 1950: 163, fig. 301; 1955: 110. Barnard, 1964: 234, figs 8–9.

Note punctuation in the above example: comma separates author's name and year; semicolon separates more than one reference by the same author; full stop separates references by different authors; figures of plates are enclosed in parentheses to distinguish them from text-figures; dash, not comma, separates consecutive numbers.

Example 2

1845 *Nucula (Leda) bicuspidata* Gould, p. 37.
1856 *Leda plicifera* A. Adams, p. 50.
1859 *Laeda bicuspidata* (Gould) Hanley, p. 118, pl. 228 (fig. 73).
1861 *Nucula largillierti* Philippi, p. 87.
1871 *Laeda bicuspidata* (Gould): Sowerby, pl. 2 (fig. 8a–b).
1950 *Leda bicuspidata* (Gould): Nicklès, p. 163, fig. 301.
1955 *Leda bicuspidata* (Gould): Nicklès, p. 110.
1964 *Leda bicuspidata* (Gould): Barnard, p. 234, figs 8–9.

In describing new species, one specimen must be designated as the holotype; other specimens mentioned in the original description are to be designated allotype (if applicable) and/or paratypes; additional material not regarded as paratypes should be listed separately. The complete data (registration number, depository, description of specimen, locality, collector, date) of the holotype and paratypes must be recorded, e.g.:

Holotype. SAM–A13535 in the South African Museum, Cape Town. Adult female from mid-tide region, King's Beach, Port Elizabeth (33°51'S 25°39'E), collected by A. Smith, 15 January 1973.

Note standard form of writing South African Museum registration numbers and date.

7. SPECIAL HOUSE RULES

Capital initial letters

(a) The Figures, Maps and Tables of the paper when referred to in the text, e.g. '. . . the Figure depicting *C. namacolus* . . .', or '. . . in *C. namacolus* (Fig. 10) . . .'
(b) The prefixes of prefixed surnames in all languages, when used in the text, if not preceded by initials or full names: e.g. Du Toit, but A. L. du Toit; Von Huene, but F. von Huene
(c) Scientific names, but not their vernacular derivatives e.g. Therocephalia, but therocephalian

Punctuation should be loose, omitting all not strictly necessary. Reference to the author should preferably be expressed in the third person. **Roman numerals** should be converted to arabic, except when forming part of the title of a book or article, e.g. 'Revision of the Crustacea. Part VIII. Amphipoda.'. A **specific name** must not stand alone, but be preceded by the generic name or its abbreviation to initial capital letter (except at the beginning of a sentence or paragraph), provided the same generic name is used consecutively. The name of **new genus or species** should not be included in the title; it should be included in the abstract, counter to Recommendation 23 of the Code, to meet the requirements of *Biological Abstracts*.

8. GENERAL. Once referees' reports have been received by the editor, these will be discussed by the editorial committee. If the paper is considered acceptable after minor or major revision, the reports will be forwarded to the author who must then thoroughly revise in accordance with the referees' suggestions. Final acceptance of the revised manuscript will be considered by the editorial committee. In the case of major revision being necessary, the committee reserves the right to consult one or more referees regarding the revised manuscript.

HERBERT CHRISTIAN KLINGER
&
WILLIAM JAMES KENNEDY

STRATIGRAPHIC AND GEOGRAPHIC DISTRIBUTION, PHYLOGENETIC TRENDS AND GENERAL COMMENTS ON THE AMMONITE FAMILY BACULITIDAE GILL, 1871 (WITH AN ANNOTATED LIST OF SPECIES REFERRED TO THE FAMILY)