

# Belemnites from the Lower Jurassic of East Greenland and their biostratigraphical and biogeographical significance

PETER DOYLE



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Belemnites collected in the 1920s from the Lower Jurassic Neill Klintner Formation of East Greenland are described for the first time. Two belemnite faunas are recognised. The Rævekløft Member yielded *Nannobelus*, *Pseudohastites*, *Passaloteuthis?*, *Gastrobelus?* and a hastitid, giving an age of the Lower Pliensbachian *Uptonia jamesoni* to *Prodactyloceras davoei* zones for the molluscan-rich lower faunal division. The Ostreaelv Member yielded *Parapassaloteuthis*, *Acrocoelites* (*Toarcibelus*), *A.* (*Odontobelus*), *Simpsonibelus* and "*Parabrachybeus*" representative of a Toarcian *Hildoceras bifrons* to *Haugia variabilis* Zone age as previously determined. However, the presence of *Parapassaloteuthis* gives a oldest age of at least *Dactyloceras commune* Subzone, with a loose specimen of a possible juvenile *Acrocoelites trisulculosus* suggesting that the Ostreaelv Member may range into the *Harpoceras falciferum* Zone. The Pliensbachian species are identical to those from western Europe and are the most northerly representatives of their taxa. The Toarcian species have closest affinity to those of northwest Europe rather than the distinct and endemic Siberian Toarcian belemnite fauna which arose at this time.

Peter Doyle, School of Earth Sciences, Thames Polytechnic, Walburgh House, Bigland Street, London E1 2NG England. March 20th, 1991.

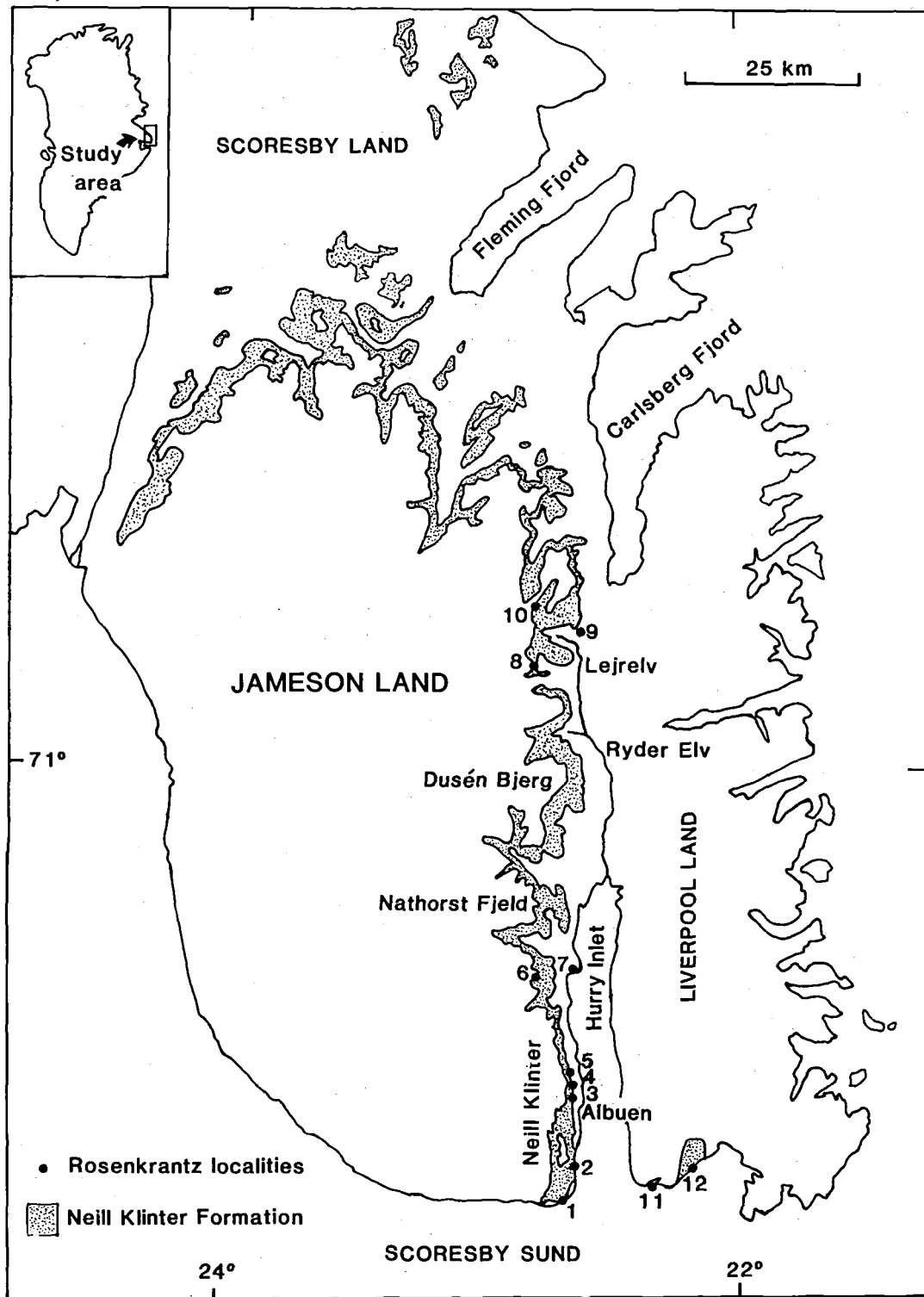
During the 1926–27 Danish expedition to East Greenland, Alfred Rosenkrantz studied in detail for the first time the Lower Jurassic deposits of Jameson Land. Extensive collections of the rich fossil invertebrate fauna were made by Rosenkrantz, and were listed in his subsequent stratigraphical publications (Rosenkrantz, 1934, 1942). However, of these specimens, only two crustacean species (*Glyphaea rosenkrantzi* van Straelen, 1929, *Glyphaea* sp.) and one bivalve (*Velata hartzi* Rosenkrantz, 1956) have been formally described (van Straelen, 1929; Rosenkrantz, 1956). The purpose of this paper therefore is to describe for the first time Lower Jurassic belemnites from Jameson Land and Liverpool Land, and to discuss their wider stratigraphical and biogeographical significance.

## Stratigraphy

William Scoresby (1823) was first to record a stratigraphical succession in Neill Klintner (Neill's Cliffs) at Kap Stewart, which was dominated by

sandstone with a marine fauna and underlain by coal-bearing strata. Subsequent macrofloral work determined a "Rhaeto-Liassic" age for the lower strata (Kap Stewart Formation), with the overlying marine strata (Neill Klintner Formation) yielding Early Pliensbachian and Toarcian fossils (see Rosenkrantz, 1934, p. 8). An early systematic study of the Lower Jurassic beds of south-eastern Jameson Land and Liverpool Land is given in the papers of Rosenkrantz (1929, 1934, 1942). Since this seminal work, detailed aspects of the lithostratigraphy, sedimentology, ichnology and palaeogeographical significance of the Kap Stewart and Neill Klintner formations have been discussed by Surlyk *et al.* (1973, 1981), Sykes (1974a, b), Dam (1989, 1990) and Surlyk (1990).

Surlyk *et al.* (1973, 1981) and Surlyk (1977, 1978, 1990) traced the development of the sediments within the East Greenland Jurassic basin. Taking a section from Jameson Land in the south to Store Koldewey Ø in the north, a series of blocks active in the Jurassic can be recognised. In the Jameson Land-Scoresby Land area, the basin was downfaulted during Late Triassic to Early



Text-fig. 1. Map of Jameson Land and Liverpool Land, showing the outcrop of the Neill Klintner Formation (from Dam, 1989, fig. 1), and the approximate positions of the collecting localities of Rosenkrantz (1934). Key to localities: 1, Kap Stewart; 2, Trancediakløft; 3, Goniomyakløft; 4, Vardekløft; 5, Astartekløft; 6, Harris Fjeld; 7, Constable Pynt; 8, Umingmakbjerg (Uminmak Fjeld); 9, "mountain near Lejrelv" (unnamed); 10, Hjørnefjeldet; 11, Igtåjigmít (Igtarajivit); 12, Kumait.

Jurassic times allowing the accumulation of, first, non-marine alluvial sediments (Kap Stewart Formation, Rhaetian – Hettangian), followed by shallow marine deposits (Neill Klintner Formation, Pliensbachian – Toarcian) deposited in a Pliensbachian marine transgression. Lower Jurassic rocks are absent elsewhere in East Greenland. Subsequent deepening of this basin in later Jurassic times led to the accumulation of the shelf sediments of the Vardekløft Formation (Heinberg & Birkelund, 1984) which caps the Lower Jurassic sediments in Neill Klintner.

Three members are presently recognised within the Neill Klintner Formation: Rævekløft Member (Lower Pliensbachian, *Uptonia jamesoni* and *Prodactyloceras davoei* zones have been recognised) (= Pecten limestone series of Rosenkrantz, 1934, p. 21); Gule Horn Member (largely lacking body fossils, possible Upper Pliensbachian); Ostreaelv Member (Toarcian, *Hildoceras bifrons* and "*Lytoceras jurensis*" zones) (= Oyster bank series of Rosenkrantz, 1934, p. 21). The Rævekløft Member comprises coarse sandstones indicative of a high energy environment (see fig. 2 of Dam, 1990). The Ostreaelv Member comprises shelf and subaqueous shelf sandstones (fig. 2 of Dam, 1990) with uplift in the source area providing the coarse clastics. The intervening Gule Horn Member was probably deposited in a lower energy, shallow, possibly intertidal, environment (Surlyk *et al.*, 1973; Dam, 1990).

The belemnites described below were recovered from the Rævekløft and Ostreaelv members, collected from southeastern Jameson Land and southern Liverpool Land. The specimens were accurately located by Rosenkrantz in his paper (Rosenkrantz, 1936), although using in some cases informal geographical names. These localities are given in fig. 1.

## Systematic descriptions

All specimens are housed in the Geologisk Museum, Copenhagen (GM), unless otherwise stated. The Geologisk Museum prefix MGUH denotes specimens in the type and figured collection. Other repositories: BMNH, Natural History Museum, London, England; GPIT, Geologisches und Paläontologisches Institut, Tübingen,

Germany; OUM, Oxford University Museum, Oxford, England; WM, Whitby Museum, Whitby, England. For explanations of the terminology used below, see Doyle & Kelly (1988) and Doyle (1990). The classification used below follows that given in the appendix to Doyle (in press). Approximate size (length) ranges are given by the terms small (<50 mm), medium (50–80 mm) and large (>80 mm). Measurements (in mm): L, total preserved length; l, length from protoconch to apex; Dv, dorsoventral diameter at the protoconch; Dl, lateral diameter at the protoconch; Dvmax, maximum dorsoventral diameter; Dlmax, maximum lateral diameter; x, distance from apex to position of maximum inflation of the rostrum. For brevity, in most of the synonymies only the original valid description (denoted thus\*), the most recent references (with full synonymy), and the citations of Rosenkrantz (1936) traceable to individual specimens still present in the Geologisk Museum are given. The symbol v indicates the type and/or figured specimens have been examined. Subj., subjective synonym; obj., objective synonym. The approximate location of Rosenkrantz's collecting stations are given in text-fig. 1.

Class Cephalopoda Cuvier, 1794

Subclass Coleoidea Bather, 1888

Order Belemnitida Zittel, 1895

Suborder Belemnitina Zittel, 1895

Family Belemnitidae d'Orbigny, 1845

Subfamily Belemnitinae d'Orbigny, 1845

*Nannobelus* Pavlow, 1913

(= *Prototeuthis* Lemoine, 1915, obj.; non *Nannobelus* Saks & Nal'nyaeva, 1970)

Type species: *Belemnites acutus* Miller, 1826, by original designation.

Diagnosis: Small conical to cylindrical Belemnitinae; outline and profile symmetrical, conical to cylindrical; apex acute; transverse sections subquadrate to pyriform; apical grooves absent, though apex may bear striae; lateral lines two faint subparallel depressions on each flank; apical line ortholineate; phragmocone penetrates one-quarter to one-third rostrum.

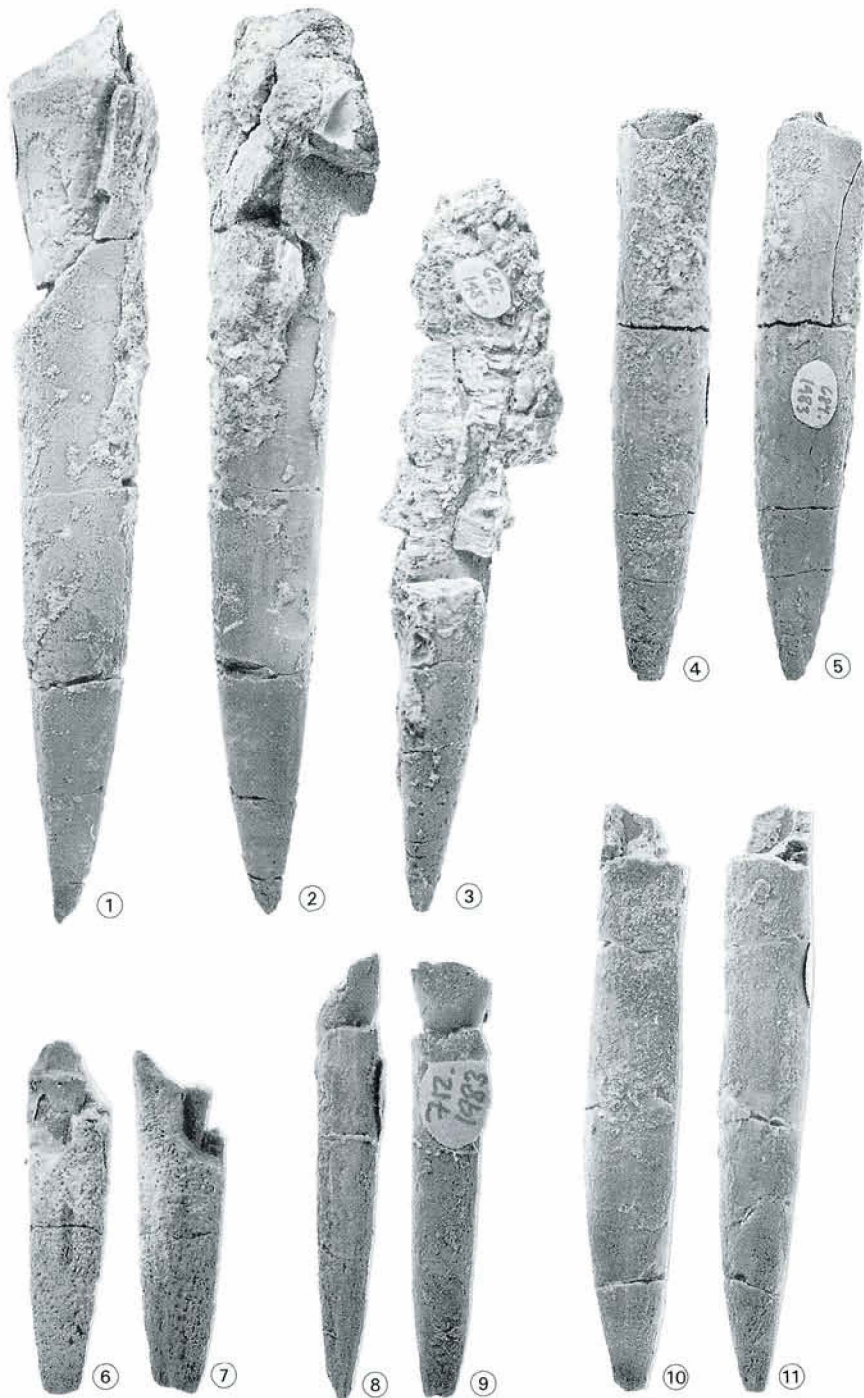


Plate 1. Figs 1-5, *Pseudohastites apicicurvata* (Blainville): 1, 2, ventral outline and profile, MGUH 20673, x1; 3, profile, MGUH 20674, x1; 4, 5, ventral outline and profile, MGUH 20675, x1. Figs 6, 7, *Nannobelus* sp., ventral outline and profile, MGUH 20672, x1.5. Figs 8, 9, *Nannobelus* cf. *alveolatus* (Werner), ventral outline and profile, MGUH 20671, x1.5. Figs 10, 11, *Passaloteuthis?* sp., ventral outline and profile, MGUH 20676, x1.

Range: Lower Sinemurian to Lower Pliensbachian of Europe (Britain, Germany, France, Italy, Denmark (Bornholm: GM 1879.742, *N. acutus?*), Sweden, Bulgaria, Czechoslovakia), Turkey, ?North Africa and East Greenland. Siberian "*Nannobelus*" of Toarcian age (Saks & Nal'nyaeva, 1970) are endemic homeomorphs now grouped in the genus *Arcobelus* Saks, 1967 (Doyle, in press).

*Nannobelus* cf. *alveolatus* Werner, 1912

Pl. 1, figs 8, 9.

cf.\*1912 *Belemnites alveolatus* Werner, p. 109, pl. X, figs. 2, 3.

v1936 *Prototeuthis* cf. *pennicillata* (Dum.); Rosenkrantz, p. 30 (MGUH 20671).

cf.1951 *Passaloteuthis alveolata* (Werner); Troedsson, p. 242, pl. XXIV, figs 1, 2 only.

cf.1962a *Belemnites alveolata* Werner; Schwelger, p. 14, text-fig. 10 (most up-to-date reference).

Type specimens: Syntypes, the originals of Werner (1912, pl. X, figs. 2, 3), Lias  $\beta$ , Heiningen, Württemberg, Germany.

Material: Rævekløft Member, Jameson Land. Kap Stewart coast profile, bed a, MGUH 20671.

Dimensions:	L	l	Dv	DI
MGUH 20671	39.3	25.2	6.4	-

Description: A single, small, elongated (L = 39.3 mm) *Nannobelus*. The specimen is weathered on one flank, but is otherwise largely well-preserved. The profile is symmetrical and cylindrical, but with the impression of slight "waist" developed in the alveolar region. The outline is symmetrical and cylindrical. Transverse sections of the rostrum are pyriform with a broad venter. The apical region is devoid of grooves. The phragmocone penetrates up to one-third of the rostrum.

Remarks: The elongate form of this rostrum militates against a placement within either the acutely conical *N. acutus* (Miller) or the more robust *N. engeli* (Werner). In addition, although it resembles juvenile belemnites of the genera

*Passaloteuthis* or *Pseudohastites*, this specimen may safely be assigned to the genus *Nannobelus* because it lacks any vestige of apical grooves. The specimen closely resembles *N. alveolatus* (Werner), which is equally elongated, but it is only tentatively assigned to this species because it does not possess a clear, subhastate form (e.g. Werner, 1912, pl. X, fig. 3).

The species *Belemnites pennicillata* Sowerby, as figured by Dumortier (1869, pl. IV, fig. 15), and cited by Rosenkrantz (1934), approaches this *N. alveolatus* in form, but is more robust than the present specimen with a slightly inflated venter and well-defined lateral lines.

*Nannobelus* sp.

Pl. 1, figs 6, 7.

Material: Rævekløft Member, Liverpool Land. Igtåjingmît (Igtarajivit), MGUH 20672; Kumait, ?GM 1983.689.

Description and remarks: Of the two specimens, only one, MGUH 20672, can be definitely assigned to *Nannobelus*. The other, GM 1983. 689, represents a fragmentary rostrum with a penetrative phragmocone which cannot be assigned with certainty to this genus. Specimen MGUH 20672 is poorly preserved and slightly leached, but it presents a symmetrical and conical profile and outline, with what was probably an acute apex. The transverse sections are compressed (Dv:DI 0.9). In general form, MGUH 20672 approaches *N. acutus* (Miller), but *N. acutus* is not commonly as compressed as this specimen (e.g. Doyle & Marriotti, in press). In this way MGUH 20672 approaches the much larger species *N. engeli* (Werner, 1912, pl. X, fig. 4).

*Pseudohastites* Naef, 1922

(= ? *Catateuthis* Nal'nyaeva, 1967, subj.; *Propassaloteuthis* Riegraf, 1980, subj., non *Pseudohastites* Lang, 1928 (= new genus))

Type species: *Belemnites scabrosus* Simpson, 1866, by original designation. The type specimen of the type species was recently refigured by Doyle (1990, text-fig. 13).

Diagnosis: Medium to large, elongate subcylindrical, cylindrical or subhastate Belemnitinae;

outline symmetrical, cylindrical to cylindrical-conical; profile asymmetrical to symmetrical, subhastate to cylindrical; apex attenuated; transverse sections subquadrate to elliptical with flattened flanks; two short dorsolateral apical grooves restricted to apical region; apical striae common; lateral lines distinct, two elongate subparallel depressions separated by a ridge; apical line ortholineate to goniolineate; phragmocone penetrates one-third to one-quarter rostrum.

Range: Lower Pliensbachian to Lower Toarcian of Europe (Britain, Germany, France, Bulgaria, Czechoslovakia, Sweden, Portugal), Turkey, USSR (Siberia) and East Greenland.

*Pseudohastites apicicurvata* (Blainville, 1827)

Pl. 1, figs 1–5 and 8, 9.

\*1827 *Belemnites apicicurvata* de Blainville, p. 76, pl. 2, fig. 6.

v1936 *Passaloteuthis* cf. *apicicurvata* [sic] (de Blainville); Rosenkrantz, p. 55 (MGUH 20673); p. 58 (GM 1983.674); p. 59 (*Passaloteuthis* cf. *apicicurvata* [sic], MGUH 20674); p. 102 (GM 1983.705); p. 104 (GM 1983.705).

non1951 *Passaloteuthis apicicurvata* (Blainville); Troedsson, p. 243, pl. XXIV, figs 4, 5 (= ? *Passaloteuthis ima* Lang, 1928).

v1962b *Belemnites apicicurvata* Blainville; Schwegler, p. 123, text-fig. 18.

v1974 *Belemnites paxillosus apicicurvata* Blainville; Schuman p. 24, pl. 2, figs 9–13; pl. 3, figs 1. 2 (full synonymy).

Type specimen: Neotype, selected Lang (1928, p. 205), BMNH C.29521, Bed 120d, Belemnite Marls (*Tragophylloceras ibex* Zone), Westhay Water, Dorset, England.

Material: Rævekløft Member, Jameson Land. Tancrediakløft, 140 m, GM 1983.699 (juvenile); Albuen, MGUH 20673; Goniomyakløft, GM 1983.674, 1983.675; mouth of Vardekløft, MGUH 20674; Constable Pynt, MGUH 20675; Astartekløft, ?GM 1983.692–1983.698 (fragments). Rævekløft Member, Liverpool Land. Kumait, GM 1983.686 (juvenile), 1983.688, 1983.689, ?1983.690; Igtåjngmit (Iqterajivit), GM 1983.705, 1983.706.

Dimensions:	L	l	Dv	DI
MGUH 20673	121.8	65.7	16.2	15.7
20674	101.2	68.2	12.0	–
20675	78.2	59.7	13.3	12.7
GM 1983.675	97.2	76.7	12.7	–

Description: Medium to large, cylindrical-conical *Pseudohastites*. Outline symmetrical, cylindrical-conical, flanks weakly divergent adorally from an acute to attenuated apex, becoming parallel in the stem region. Profile broadly similar to outline, cylindrical-conical, with little inflation of venter. Transverse sections elliptical, but with lateral flattening. Apex exhibits only weakly developed dorsolateral apical grooves. Lateral lines where preserved, are in the form of a narrow ventrolateral depression bordered by a broader dorsolateral depression above. Phragmocone penetrates one-third of the rostrum. Juvenile elongate and cylindrical to weakly cylindrical-conical.

Remarks: This species is well-known in the Lower Pliensbachian of Europe and is characterised by its elongate and attenuated apex. The Greenland specimens closely resemble those figured by Lang (1928) and Schumann (1974) from Europe.

*Passaloteuthis* Lissajous, 1915

(= *Holcoteuthis* Stolley, 1919, subj.)

Type species: *Belemnites bruguieriana* d'Orbigny, 1842 (= *Belemnites bisulcata* Blainville, 1827, subj.), by original designation.

Diagnosis: Medium to large, cylindrical to weakly subhastate Belemnitinae; outline symmetrical, cylindrical, cylindrical-conical to weakly subhastate; profile similar to outline, but inflated, asymmetrical to symmetrical; transverse sections subquadrate to circular; two short dorsolateral grooves restricted to apical region; short apical striae common; lateral lines indistinct, two weak subparallel depressions with weak ridge; apical line goniolineate; phragmocone penetrates one-third rostrum.

Range: Pliensbachian to Lower Toarcian of Europe (Britain, Germany, France, Italy, Sweden, Bulgaria, Czechoslovakia), Turkey, USSR, Chile and ?East Greenland.

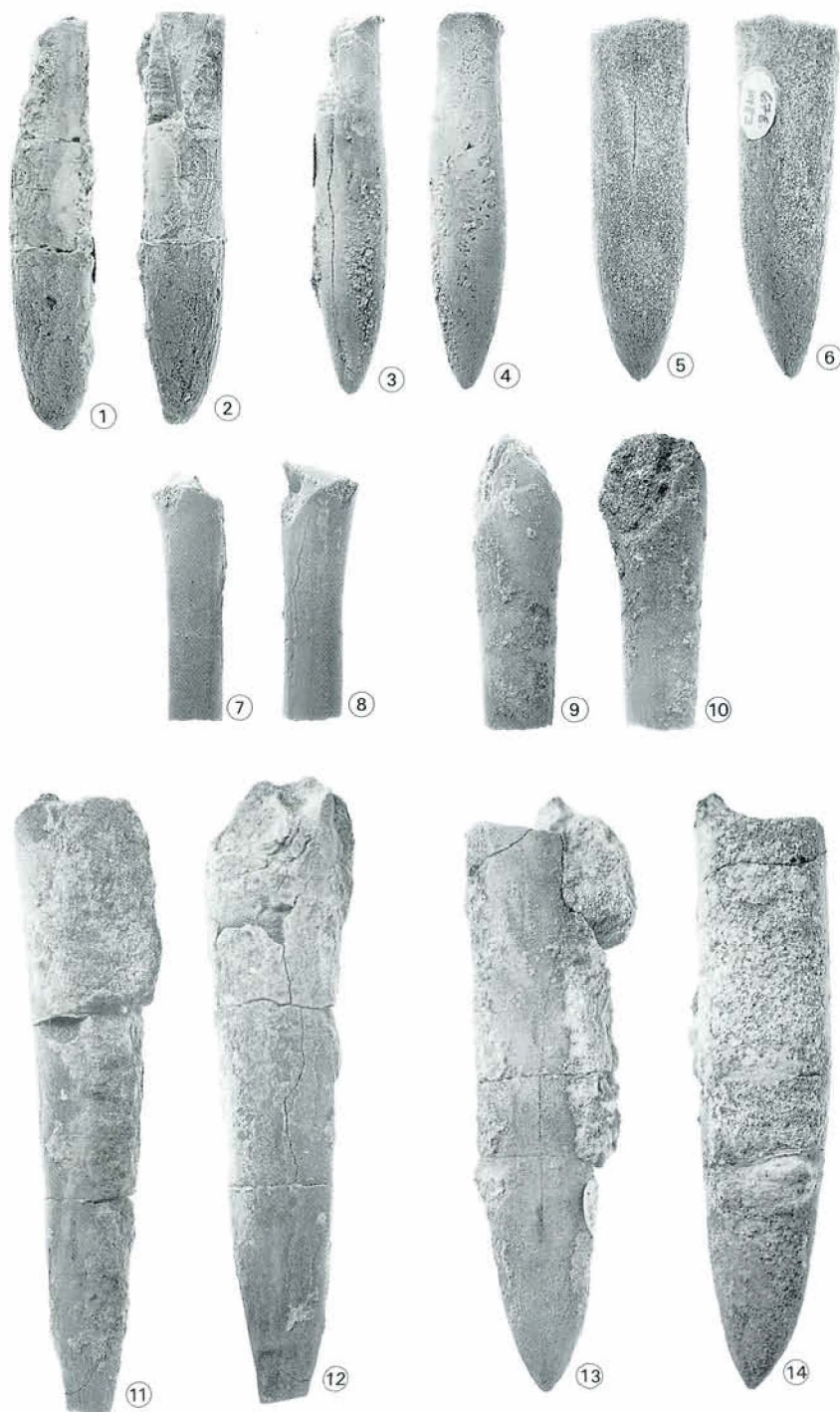


Plate 2. Figs 1, 2, *Gastrobelus?* aff. *ventroplanus* (Voltz), profile and ventral outline (apex distorted), MGUH 20688, x1. Figs 3, 4, *Gastrobelus?* sp., ventral outline and profile, MGUH 20687, x1. Figs 5, 6, "*Parabrachybelus*" *subaduncatus* (Voltz), ventral outline and profile, MGUH 20687, x1. Figs 7–10, hastitid? indet.: 7, 8, ventral outline and profile, MGUH 20690, x1.5; 9, 10, ventral outline and profile, MGUH 20691, x1.5. Figs 11, 12, *Acrocoelites* (*Toarcibelus*) cf. *quenstedti* (Oppel), ventral outline and profile, MGUH 20678, x1. Figs 13, 14, *Parapassaloteuthis polita* (Simpson), ventral outline and profile, MGUH 20677, x1.

*Passaloteuthis?* sp. nov.

Pl. 1, figs 10, 11.

v1936 *Passaloteuthis* cf. *apicurvata* [sic] (de Blainville); Rosenkrantz, p. 104 (MGUH 20676).

Material: Rævekløft Member, Liverpool Land. Igtåjngmit (Igerajivit), MGUH 20676.

Dimensions:	L	l	Dv	DI	Dvmax	Dlmax	x
MGUH 20676	81.0	59.9	11.6	11.8	11.9	13.0	36.4

Description: Medium sized, subhastate, depressed *Passaloteuthis?* The outline is symmetrical and subhastate with Dlmax almost at the mid-point of the rostrum (at 36.4 mm from the incomplete apex). The flanks weakly diverging adorally from the acute apex to this point, converging to the position at (1) before weakly diverging again. In profile the rostrum is almost symmetrical and cylindrical, venter and dorsum weakly diverging from the acute apex. The transverse sections are depressed and almost subquadrate, but with a greater ventral width than dorsum. The apex bears two very faint dorsolateral apical grooves largely restricted to the apical tip. Lateral lines are present as a narrow, relatively incised, elongate dorsolateral depression with an indistinct ventrolateral depression beneath it. The phragmocone penetrates one-quarter of the rostrum.

Remarks: This rostrum is unusual in possessing a characteristically depressed transverse section. The form of cross-sections is a valuable specific character (Doyle & Kelly, 1988) and, largely, depressed sections are unknown in the genus *Passaloteuthis*. However, the overall form of the rostrum, its shape and grooves indicate close affinity to this genus. For these reasons, the specimen is only tentatively assigned to *Passaloteuthis*, and although possibly representative of a new species, the single specimen available militates against the formal erection of a new taxon.

*Parapassaloteuthis* Riegraf, 1980

Type species: *Belemnites zietenii* Mayer-Eymar, 1884, by original designation.

Diagnosis: Small to large, robust cylindrical to weak subhastate Belemnitinae; outline symmetrical, cylindrical to weak subhastate; profile similar to outline, though asymmetrical; apex obtuse to mucronate, recurved; transverse sections subquadrate to quadrate, uncompressed; two, weak to moderate, short dorsolateral grooves confined to apical region; lateral lines two parallel depressions, dorsal one broad and deep, extending from apical grooves, ventral one weak and indistinct; apical line cyrtolineate; phragmocone penetrates one-third to one-half rostrum.

Range: Upper Pliensbachian to Lower Toarcian of Europe (Britain, Germany, France, Czechoslovakia) and East Greenland.

*Parapassaloteuthis polita* (Simpson, 1866)

Pl. 2, figs 13, 14.

v\*1866 *Belemnites politus* Simpson, p. 216.

v1936 *Megateuthis* sp.; Rosenkrantz, p. 62 (GM 1983.681); p. 83 (MGUH 20677).

v1990 *Parapassaloteuthis polita* (Simpson); Doyle, p. 27, pl. 5, figs 3-9 (full synonymy).

Type specimen: Lectotype, selected Doyle (1990, p. 27), WM 2047, *Dactylioceras commune* Subzone, High Whitby, North Yorkshire, England.

Material: Ostreelv Member, Jameson Land. Vardekløft, 382 m, GM 1983.681; Nathorst Fjeld, 494 m, MGUH 20677.

Dimensions:	L	l	Dv	DI	Dvmax	Dlmax	x
MGUH 20677	85.6	59.6	18.6	14.9	19.2	15.9	45.5

Description: Medium sized, cylindrical to subhastate *Parapassaloteuthis*. Outline symmetrical to weakly subhastate, flanks moderately diverging from an acute but rounded apex to a point of maximum lateral diameter at the mid-point of the rostrum, weakly converging and then flaring adorally. Profile asymmetrical but cylindrical with a slightly greater inflation of the venter. Transverse sections compressed, with flattened flanks and weakly curving venter and dorsum. No apical grooves developed; specimen

surface too poorly preserved to observe lateral lines. The phragmocone penetrates one-third of the rostrum.

Remarks: This specimen is morphologically close to the type specimen of this species (WM 2047) from the Toarcian of North Yorkshire, England.

Subfamily Megateuthidinae Saks and Nal'nyaeva, 1967 (*nom. correct. ex. Megateuthinae* Saks and Nal'nyaeva, 1967)

*Acrocoelites* Lissajous, 1915

Type species: *Belemnites oxyconus* Zieten, 1831, by original designation.

Diagnosis: Small and delicate to large and robust, conical, cylindrical or cylindrical Megateuthidinae; outline symmetrical, conical, cylindrical or cylindrical; profile asymmetrical, conical or cylindrical, venter inflated; transverse sections compressed elliptical to subquadrate; apex characterised by two dorsolateral grooves and a single ventral groove; short epirostrum bearing striae may be present; lateral lines comprise two broad depressions separated by a weak ridge; phragmocone penetrates one-quarter to one-half rostrum; apical line goniolineate.

Range: Lower Toarcian to Aalenian of Europe (Britain, France, Germany, Portugal, Bulgaria, Czechoslovakia), Turkey, USSR (Siberia, Caucasus), North America (Alberta), Spitsbergen, East Greenland.

Subgenus *Toarcibelus* Riegraf, 1980

Type species: *Belemnites quenstedti* Opperl, 1856, by original designation.

Diagnosis: Large, robust, cylindrical to cylindrical *Acrocoelites*; transverse sections subquadrate; apical grooves well-defined, ventral groove reduced in some species; apex striated; phragmocone penetrates one-quarter rostrum.

Range: Lower Toarcian to Aalenian of Europe (Britain, France, Germany, Bulgaria, Czechoslovakia), USSR (Siberia), East Greenland.

*Acrocoelites (Toarcibelus) cf. quenstedti* (Opperl, 1856)

Pl. 2, figs 11, 12.

cf.\*1856 *Belemnites Quenstedti* Opperl, p. 363.

v1936 *Megateuthis rhenana* (Opperl); Rosenkrantz, p. 89 (?GM 1983.713).

cf.v1969 *Belemnites quenstedti* Opperl; Schwegler, p. 188, text-fig. 74.

cf.v1990 *Acrocoelites (Toarcibelus) quenstedti* (Opperl); Doyle, p. 36, pl. 8, figs 3, 5-7 (full synonymy).

Type specimen: Neotype, selected Doyle (1990, p. 37), original of Schwegler (1969, text-fig. 74), GPIT (unregistered), Aalenian, Boll, Württemberg, Germany.

Material: Ostreaelv Member, Jameson Land. Mountain near Lejrelv, 630-660 m, MGUH 20678; Umnigmakberg (Umimmak Fjeld), 345-360 m, ? GM 1983.713.

Dimensions:	L	l	Dv	DI
MGUH				
20678	85.3	59.6	16.6	15.6

Description: Medium sized, cylindrical *Acrocoelites (Toarcibelus)* Outline symmetrical, cylindrical to acutely conical, flanks weakly diverging from an acute apex. Profile asymmetrical, cylindrical with an almost flat dorsum and weakly inflated venter. Transverse sections compressed elliptical becoming laterally inflated adorally. Apex weathered in this specimen, but section exposed at the fractured apex indicates at least two dorsolateral apical grooves. Phragmocone penetrates and estimated one-third of the rostrum.

Remarks: In overall size and form this specimen approaches *A. (T.) quenstedti*, but its acute apex and almost conical outline allow only a tentative referal to this species.

Subgenus *Odontobelus* Naef, 1922

Type species: *Belemnites pyramidalis* Zieten, 1831, by original designation.

Diagnosis: Medium, robust conical to cylindrical *Acrocoelites*; venter inflated; apex acute

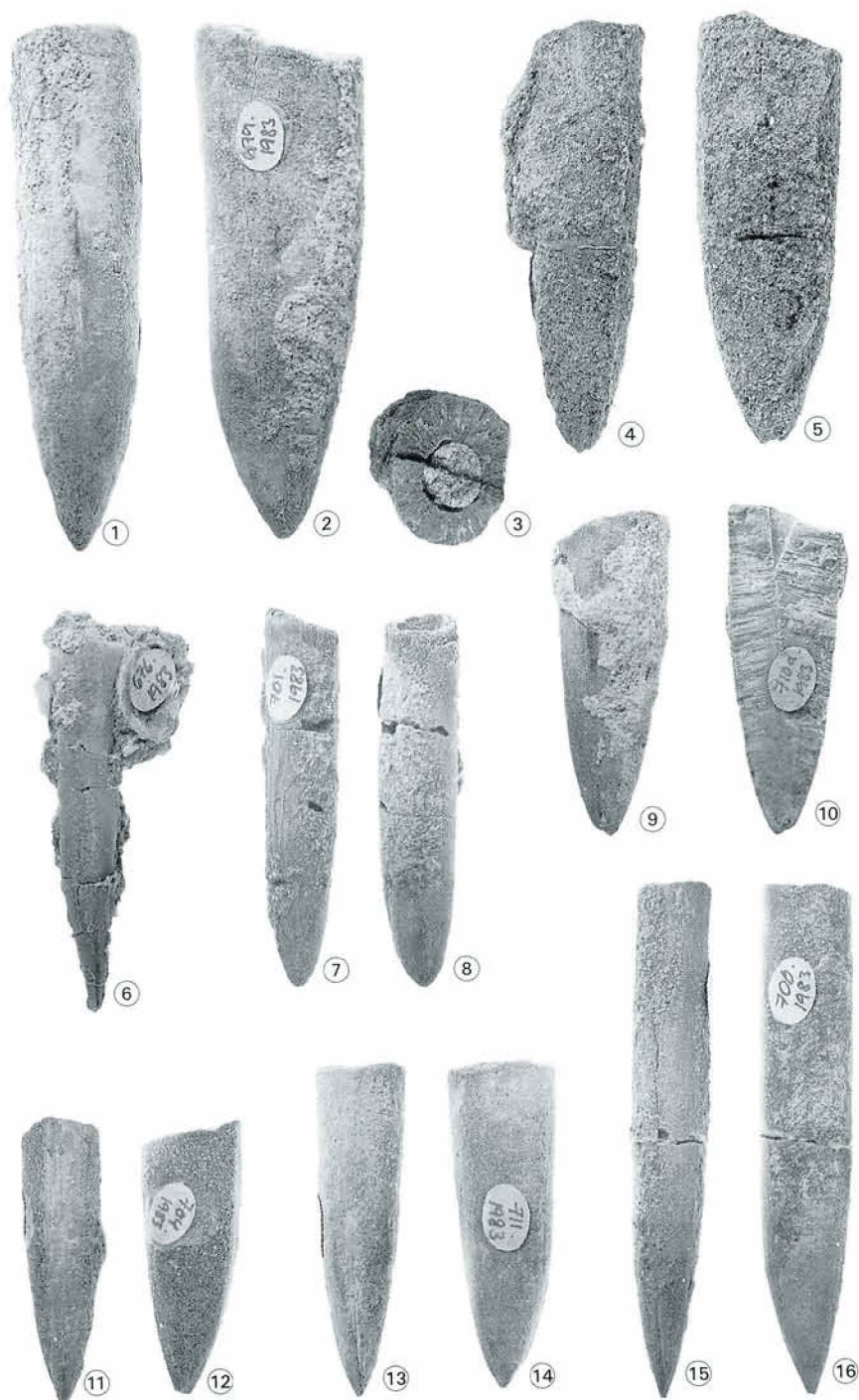


Plate 3. Figs 1-5, 9, 10, *Acrocoelites (Odontobelus) vulgaris* (Young & Bird): 1, 2, elongate form, ventral outline and profile, MGUH 20679, x1; 3-5, short form, alveolar section, ventral outline and profile, MGUH 20680, x1; 9, 10, short form, profile and transverse section, MGUH 20681, x1. Fig. 6, *Acrocoelites* sp. juv. (juvenile *Acrocoelites (Toarcibelus) trisulculosus* (Simpson)?), profile, MGUH 20682, x1. Figs 7, 8, *Simpsonibelus expansus* (Simpson), ventral outline and profile, MGUH 20683, x1. Figs 11-16, *Simpsonibelus lentus* (Simpson): 11, 12, ventral outline and profile, MGUH 20684, x1; 13, 14, ventral outline and profile, MGUH 20685, x1; 15, 16, ventral outline and profile, MGUH 20686, x1.

to relatively obtuse; transverse sections compressed elliptical; ventral apical groove commonly reduced; phragmocone penetrates one-half rostrum.

Range: Toarcian of Europe (Britain, Germany, France, Bulgaria, Czechoslovakia, Portugal), USSR (Siberia) and East Greenland.

*Acrocoelites (Odontobelus) vulgaris* (Young & Bird, 1822)

Pl. 3, figs 1–5, 9, 10.

\*1822 *Belemnites vulgaris* Young & Bird, p. 258, pl. 14, fig. 1.

v1936 *Megateuthis* sp.; Rosenkrantz, p. 62 (MGUH 20680); p. 82 (MGUH 20679).

v1969 *Belemnites tripartitus crassus* Quenstedt; Schwegler, p. 199, text-fig. 82.

v1990 *Acrocoelites (Odontobelus) vulgaris* (Young & Bird); Doyle, p. 44, pl. 11, figs 6–8; pl. 13, figs 6, 7; pl. 14, figs 4–6; pl. 15, figs 2, 3 (full synonymy).

Type specimen: Neotype, selected Doyle (1990, p. 44), OUM J. 15397, Alum Shales (*Hildoceras bifrons* Zone), Whitby, North Yorkshire, England.

Material: Ostreaelv Member, Jameson Land. Vardekløft, MGUH 20680; Nathorst Fjeld, MGUH 20679; Hjørnefjeldet, MGUH 20681.

Dimensions:	L	l	Dv	DI
MGUH 20679	69.9	69.9	23.1	17.8
20680	57.1	44.2	19.8	–
20681	46.0	36.5	15.7	12.9

Discription: Medium sized, cylindrical *Odontobelus*. Outline cylindrical to cylindrical, with flanks diverging from an acute apex, becoming almost parallel in the stem region. Profile asymmetrical, venter inflated and conical to cylindrical. Venter and dorsum inflated and arcuate, curving adapically to an acute apex. Transverse sections compressed elliptical. Surface of rostra poorly preserved, but in specimen MGUH 20681 at least two dorsolateral apical grooves are preserved. Phragmocone penetrates

up to one-third of the rostrum, the apical line is goniolineate.

Remarks: In overall form, these belemnites approach *A. (O.) vulgaris*, although they can also be favourably compared with *A. (O.) levidensis* (Blake) (see Doyle, 1990, pl. 15, figs 4–7). However, the compressed transverse sections of these rostra, and their inflated profiles, indicates close affinity with *A. (O.) vulgaris*. Specimen MGUH 20679 is elongate relative to specimens MGUH 20680 and MGUH 20681. This phenomenon was also noted in *A. (O.) vulgaris* specimens from England by Doyle (1990, p. 45), who suggested the possibility of the two forms representing sexual dimorphs of a single biological species.

*Acrocoelites* sp. juv.

Pl. 3, fig. 6.

Material: Ostreaelv Member, Jameson Land. Harris Fjeld (loose block), MGUH 20682.

Dimensions:	L	l	Dv	DI
MGUH 20682	55.1	27.6	8.3	7.5

Discussion: The single specimen is representative of a juvenile *Acrocoelites*, possible of the subgenus *Toarcibelus*. Only the left profile is well-preserved in this specimen, the right profile being obscured by a coarse sandstone matrix. The preserved flank exhibits an acutely conical rostrum with an attenuated apex. The outline can be interpreted as cylindrical in form. The profile exhibits a well-developed dorsolateral apical groove with striations. Lateral lines are indistinct, but comprise a ventrolateral flattening with a barely discernable dorsolateral line above it.

Althoug incomplete, the morphology of this juvenile is reminiscent of juvenile specimens of the species *Acrocoelites (Toarcibelus) trisulculosus* (Simpson) (e.g. Doyle, 1990, pl. 9, fig. 5). The distinctive striated apical grooves and inflated venter are characteristic of the juvenile of this species.

*Simpsonibelus* Doyle, 1991

Type species: *Belemnites expansus* Simpson, 1855, by original designation.

Diagnosis: Small to medium, hastate to subhastate Megateuthidinae; outline symmetrical, hastate to subhastate; profile asymmetrical, arched, hastate; position of maximum inflation in stem third of rostrum; apex acute to attenuated; transverse sections depressed to compressed, subquadrate in alveolar region, rounded adapically; well-defined ventral groove restricted to apex, broadening adorally, two less distinct dorsolateral apical grooves also present; short, mid-dorsal groove may be present, not attaining anterior border, lacks splitting surface; lateral lines two parallel narrow depressions separated by weak to moderate ridge; apical line cyrtolineate; phragmocone penetrates one-quarter to one-fifth rostrum.

Range: Toarcian of Europe (Britain, Germany) and East Greenland.

*Simpsonibelus expansus* (Simpson, 1855)

Pl. 3, figs 7, 8.

v\*1855 *Belemnites expansus* Simpson, p. 31.

v1984 *Dactyloteuthis* (*Catateuthis*) aff. *inaudita* (Voronez); Riegraf *et al.*, p. 161, pl. 12, fig. 9.

v1991 *Simpsonibelus expansus* (Simpson); Doyle, in press (full synonymy).

Type specimen: Holotype, WM 2685, Alum Shales, *Peronoceras fibulatum* – *Catacoeloceras crassum* subzones, Whitby, North Yorkshire, England.

Material: Ostreaelv Member, Jameson Land. Nathorst Fjeld, 543 m, MGUH 20683.

Dimensions:	L	l	Dv	DI	Dvmax	Dlmax	x
MGUH							
20683	53.3	36.7	10.9	10.3	11.0	10.3	29.0

Description: This specimen is representative of a small, weakly subhastate *Simpsonibelus*. The outline is symmetrical and barely subhastate with the position of maximum lateral inflation at the mid-point of the rostrum, and an acute apex. The profile is almost symmetrical, and subhastate, but with weakly inflated venter and rounded apex. The transverse sections are compressed elliptical in the apex and stem, becoming depressed in the alveolar region, with a flat dorsum in this posi-

tion. The apex bears a well-defined ventral apical groove, and two less well-defined, shorter and broader dorsolateral apical grooves. The phragmocone penetrates approximately one third of the rostrum, and the apical line is strongly cyrtolineate.

Remarks: Although the compressed sections in the apical and stem regions of this specimen are uncommon in British representatives of this species (Doyle, 1991), the depressed alveolar section and short robust form distinguishes it from *Simpsonibelus lentus* (Simpson).

*Simpsonibelus lentus* (Simpson, 1855)

Pl. 3, figs 11–16.

v\*1855 *Belemnites lentus* Simpson, p. 34.

v1936 *Megateuthis* cf. *quenstedti* (Oppel); Rosenkrantz, p. 93 MGUH 20685).

v1984 *Dactyloteuthis* (*Catateuthis*) *inaudita* (Voronez); Riegraf *et al.*, p. 159, pl. 12, figs 5–8.

v1991 *Simpsonibelus lentus* (Simpson); Doyle, in press (full synonymy).

Type specimen: Holotype, WM 54, Alum Shales, *Hildoceras bifrons* Zone, Whitby, North Yorkshire, England.

Material: Ostreaelv Member, Jameson Land. Nathorst Fjeld, 543 m, MGUH 20686, MGUH 20684; Hjørnefjeldet, loc. 5, 320–425 m, MGUH 20685.

Dimensions:	L	l	Dv	DI	Dvmax	Dlmax	x
MGUH							
20686	69.1	53.7	12.7	10.5	12.8	10.7	42.8

Description: Medium sized, cylindrical to subhastate *Simpsonibelus*. Of the three specimens, only MGUH 20686 is preserved with apex, stem, and a portion of the alveolar region, and the description is based on this rostrum. Specimens MGUH 20684 and MGUH 20685 comprise only apical regions. Outline symmetrical, barely subhastate to cylindrical with flanks diverging from an acute apex only in the apical region. Profile asymmetrical, with an inflated venter, and barely subhastate, the maximum dorsoventral diameter in the adapical portion of the stem region. Transverse sections very compressed and elliptical for

the length of the rostrum. Apex characterised by a well-defined ventral apical groove and two less well-defined dorsolateral grooves. The flanks are too abraded to reveal lateral lines. The alveolus penetrates an estimated one-quarter of the rostrum, and the apical line is cyrtolineate.

Remarks: The form of the three specimens, despite their imperfection, matches closely that of the type specimen (WM 54) from the Toarcian of the North Yorkshire, England.

"*Parabrachybelus*" Riegraf, 1980

Type species: *Belemnites subaduncatus* Voltz, 1830, by original designation.

Discussion: This taxon was formally erected, as a subgenus of *Brachybelus* Naef, by Riegraf (1980) to contain the type species, following the discussion of its taxonomic position by Schwegler (1971, p. 100). In his discussion, Schwegler illustrated the overall *Passaloteuthis*-like morphology of *Belemnites subaduncatus*, comparing it with older Jurassic species of *Pseudohastites*. However, both Schwegler (1971) and Riegraf (1980) concluded that *Belemnites subaduncatus* was closely related to the genus *Brachybelus* (a junior homonym of *Brachybelus* Stål, Insecta, replacement name *Brevibelus* Doyle, 1991). Schwegler (1971) indicated that flattening of the flanks and excentricity of the alveolus allied *B. subaduncatus* with that genus, while Riegraf (1980) pointed to the apparent "furchenlose" (groove-less) condition of the apex as a valuable character. The present specimen described below, which is close to the original of Voltz (1830, pl. III, fig. 2), has relatively well-developed grooves, unknown in *Brevibelus* (see Doyle 1991), and any similarity in crosssectional form and excentricity of the apical line is not sufficient to ally *B. subaduncatus* with this genus.

Thus, as Schwegler (1971) has already noted, the true affinity of *B. subaduncatus* is elusive. The grooves and form of the apex ally it with both *Passaloteuthis* Lissajous (Pliensbachian-Lower Toarcian) and *Megateuthis* Bayle (Upper Toarcian-Bajocian). Schwegler (1971) suggests that the presence in some specimens of an apparent ventral apical groove was proof that it was closely related to *Acrocoelites*. The same

kind of grooves also occur in the genus *Passaloteuthis* (e.g. Riegraf *et al.*, 1984), but are probably not of great value in taxonomy given their transitory nature. What is clear from the foregoing discussion, is that *Belemnites subaduncatus* is not closely related to *Brevibelus*. Therefore, given that the present study rests on a single imperfect specimen, as a contingency "*Parabrachybelus*" is tentatively employed here as a nominal genus, more related in form to the genus *Megateuthis* than to *Brevibelus*. Confirmation of the status of "*Parabrachybelus*" will rest with a study of a more comprehensive collection of representatives of the type species.

"*Parabrachybelus*" *subaduncatus* (Voltz, 1830)

Pl. 2, figs 5, 6.

- \*1830 *Belemnites subaduncatus* Voltz; p. 48, pl. III, fig. 2.
- 1830 *Belemnites subaduncatus* Voltz; Zieten, p. 27, pl. XXI, fig. 4
- 1902 *Belemnites subaduncatus* Voltz; Janensch, p. 124, pl. XII, fig. 5 (non fig. 6 = ?*Megateuthis rhenana* (Oppel)).
- v1936 cf. *Passaloteuthis subaduncata* (Voltz); Rosenkrantz, p. 84 (MGUH 20687).
- v1971 *Belemnites subaduncatus* Voltz; Schwegler, p. 100, text-fig. 109.
- v1980 *Brachybelus* (*Parabrachybelus*) *subaduncatus* (Voltz); Riegraf, p. 152.

Type specimens: The original specimens of Voltz (1830) have been destroyed by fire (M. Wolf, pers comm. 1983). A neotype should be selected for this species, but this action is not appropriate in the present paper.

Material: Ostreaelv Member, Jameson Land. Nathorst Fjeld, 543 m, MGUH 20687.

Remarks: A single specimen comprising a fragment of an apical region (L = 48.7) of an apparently cylindrical or cylindrical rostrum. From the fragment preserved, the outline appears cylindrical with flanks becoming parallel rapidly from the apex, while the profile appears more cylindrical, with an acute and slightly recurved apex in this view. The transverse section at the fractured, adoral, end of the specimen is rounded subquadrate and compressed, typical of

the species. The apex is also characteristic, bearing two short but incised dorsolateral apical grooves, but has well-defined apical striae on the venter and dorsum which are not recorded by other authors.

Family Hastitidae Naef, 1922

*Gastrobelus* Naef, 1922

Type species: *Belemnites ventroplanus* Voltz, 1830, by original designation.

Discussion: This genus is relatively poorly known and defined. The type species possesses a distinctive morphology with a rounded, bulbous and yet depressed hastate rostrum which lacks apical grooves and has a characteristic flattened venter. These characters were highlighted in the original generic diagnosis of Naef (1922, p. 235). However, the concept of the genus was extended by Schumann (1974) who included within it the species *Belemnites faseolus* Dumortier and *Belemnites virgatus* Mayer. Both species contrast greatly with the type and are not easily contained within the genus, being distinctly compressed with acute apices and even apical grooves. More reasonable is the inclusion of *Belemnites subdepressus* Voltz, and *Belemnites umbilicatus* Blainville in the genus by Riegraf (1980, p. 145), as they are characterised by rounded apices and depressed transverse sections. This interpretation is followed here.

The inclusion of the genus *Gastrobelus* Naef in the family Hastitidae follows J. A. Jéletzky (pers comm. 1986) and is tentatively based on the hastate form of the rostrum and the rounded, grooveless apex. Further study, particularly of the lateral lines, is necessary to confirm this, but the two present specimens add little to the debate.

The belemnites described below are hastate with weakly depressed to compressed transverse sections and rounded apices. *Gastrobelus?* aff. *ventroplanus* is relatively characteristic of the genus, and although *Gastrobelus?* sp. is less so, it is included within it because it is unrepresentative of other hastitid genera.

*Gastrobelus?* aff. *ventroplanus* (Voltz, 1830)

Pl. 2, figs 1, 2.

aff.\*1830 *Belemnites ventroplanus* Voltz, p. 40, pl. 1, fig. 10.

aff.1965 *Belemnites ventroplanus* Voltz i.e.S; Schwegler, p. 78, text-fig. 48.

aff.1974 *Gastrobelus ventroplanus* (Voltz); Schumann, p. 39, pl. 4, figs 10–13 (full synonymy).

Type specimens: The original specimens of Voltz (1830) have been destroyed by fire (M. Wolf, pers comm. 1983). A neotype should be selected for this species, but this action is not appropriate here.

Material: Rævekløft Member, Jameson Land. Mouth of Astartekløft, MGUH 20688.

Dimensions:	L	l	Dv	DI	Dvmax	DI <sub>max</sub>	x
MGUH							
20688	57.9	41.8	10.1	10.8	10.9	11.6	25.6

Description: Medium sized, hastate *Gastrobelus?*. Outline symmetrical, subhastate. Profile asymmetrical, subhastate with weakly inflated venter, Position of maximum inflation is in the central stem region of the rostrum. Apex obtuse and rounded, but with a pathological deformity in this specimen displacing the apex towards the right flank. Transverse sections depressed sub-circular in the stem region becoming subquadrate in the alveolar region. There are no apical or alveolar grooves present. Although preserved in a coarse matrix, the left flank displays an elongate lateral depression corresponding to a portion of the lateral lines. The apical line is cyrtolineate. Phragmocone penetrates one-third of the rostrum.

Remarks: This specimen approaches *G. ventroplanus* in the bulbous form of its rostrum, and its subcircular transverse sections. It clearly has a cyrtolineate apical line and has a slightly depressed transverse section. However, the typical examples of this species (e.g. Voltz, 1830, pl. 1, fig. 10; Dumortier, 1869, pl. 5, figs 5–7) have a much more pronounced ventral flattening, and therefore it can not be assigned to this species with any certainty.

*Gastrobelus?* sp.

Pl. 2, figs 3, 4.

Material: Rævekløft Member, Jameson Land. Dusén Bjerg (Dusén Fjeld), 550 m, MGUH 20689.

Dimensions:	L	I	Dv	DI	Dvmax	DI <sub>max</sub>	x
MGUH							
20689	52.3	36.9	10.1	9.2	10.7	10.1	23.8

Description: Medium sized hastate rostrum with affinities to *Gastrobelus*. Outline symmetrical, hastate with an acute apex. Profile similar to outline. Position of maximum inflation in stem third of rostrum. Transverse sections compressed and subquadrate for the length of the rostrum, being most quadrate in the alveolar region. The apex is smooth and devoid of grooves apart from a false "groove" eroded along a fracture plane. Mid-dorsal in the alveolar region is another groove. This could represent a primary alveolar groove, but it is eroded and could equally be an artifact of preservation. Lateral lines are difficult to determine, but the left flank has a pronounced flattening over most of its mid-part. The apical line is weakly cyrtolineate. The phragmocone penetrates one third of the rostrum.

Remarks: This specimen is not easily contained within the genus *Gastrobelus*. Particularly problematical are the acute apex and the compressed transverse section of this specimen. The pronounced hastate form is suggestive of *Hastites*, but the specimen is much too robust and squat to sanction assignment of this genus. The genus *Pleurobelus* Naef is characterised by a compressed rostrum with a quadrate alveolar section, but without an acute apex. On balance the present specimen is assigned to *Gastrobelus*? because of its robust hastate form, although with due hesitancy.

Hastitid? indet.

Pl. 2, figs 7-10.

v1936 *Hastites*? sp.; Rosenkrantz, p. 102 (MGUH 20690, 20691).

Material: Rævekløft Member, Liverpool Land. Kumait, MGUH 20690. 20691.

Discussion: Two fragments of the alveolar regions of hastitid? rostra are present in the collec-

tion. Specimen MGUH 20690 is most like a hastitid, close in fact to the genus *Hastites*. It is slender and flares at the adoral-most part of the rostrum. The transverse sections are slightly compressed with flattened flanks. There is no evidence of the former presence of a bulbous stem apart from a slight flaring. Most important though is the presence of a pair of closely parallel lateral lines along each flank (*Doppellinien*), characteristic of some members of the Hastitidae and of the Belemnopseina in the younger Jurassic and Cretaceous. Specimen MGUH 20691 is more robust and compressed, but again displays the characteristic lateral lines.

### Stratigraphical significance of the belemnite fauna

The original collections made by Rosenkrantz (1934) form the basis for most published age determinations of the Neill Klint Formation, the fossiliferous horizons of the Rævekløft and Ostræelv members providing the lower and upper control. This dating has been based upon the few specimens of ammonites that Rosenkrantz was able to obtain, along with extrapolation of lithotypes and the association of certain bivalve species.

Belemnites have been used in recent zonal schemes for parts of the Early Jurassic in other regions (Stoyanova-Vergilova, 1977; Doyle, 1990), and have considerable further potential as Jurassic biostratigraphical tools. Although there are relatively few belemnites surviving in Rosenkrantz's original collection, Dam (1989) records that they are not uncommon, in the Rævekløft Member at least, and their presence in the Neill Klint Formation provides a further control on the dating of this sequence.

*Rævekløft Member*- Within the Rævekløft Member, Rosenkrantz (1934) found that fossils were restricted to certain fossiliferous levels punctuated by largely barren intervals. This has been confirmed by the observation of later workers (e.g. Dam, 1989, fig. 2). Rosenkrantz was able to identify two divisions: a lower, or *Uptonia jamesoni* division, with a diverse molluscan (mostly bivalve) fauna of 150 species, and an upper division containing approximately 20 molluscan spe-

SIN.	LOWER PLIENSCHACHIAN										UPPER PL.				
	jamesoni			ibex				devoel			margaritatus				
raricost.	1	2	3	4	5	6	7	8	9	10	11	12	13		
	Nannobelus spp.			Pseudohastites apicicurvata										Lang, 1928 Palmer, 1972	SOUTHERN ENGLAND
	Hastites spp.														
	Pseudohastites apicicurvata										Hastites spp.			Schumann, 1974	NORTHERN GERMANY
	Gastrobelus sensu Schumann										G. ventroplanus				
	Nannobelus acutus			Pseudohastites apicicurvata										Werner, 1912 Riegraf, 1980	SOUTHERN GERMANY
	N. engeli			Hastites spp.											
	N. alveolata			Gastrobelus spp.											BULGARIA
	G. ventroplanus														
	Nannobelus spp.			Pseudohastites apicicurvata										Stoyanova-Vergilova, 1977	
	Gastrobelus ventroplanus														

Text-fig. 2. European stratigraphical ranges of the belemnite species from the Rævekløft Member. Biostratigraphical zones from Dean *et al.* (1961). Sin., Sinemurian; Pl., Pliensbachian. Subzones: 1, *Phricodoceras taylori*; 2, *Polymorphites polymorphus*; 3, *Platyleuroceras brevispina*; 4, *Uptonia jamesoni*; 5, *Tropidoceras masseanum*; 6, *Acanthopleuroceras valdani*; 7, *Beaniceras luridum*; 8, *Aegoceras maculatum*; 9, *Aegoceras capricornus*; 10, *Oistoceras figulinum*; 11, *Amaltheus stokesi*; 12, *Amaltheus subnododus*; 13, *Amaltheus gibbosus*. For *N. alveolata*, read *N. alveolatus*.

cies, including rare specimens of *Beaniceras* and *Aegoceras*. Although Rosenkrantz considered that this upper division was representative of the *Tragophylloceras ibex* Zone, Callomon (1960, p. 261) later identified the *Aegoceras* as representative of the *maculatum* group, indicative of the lowermost *Prodactylioceras davoei* Zone. All the belemnites recovered from the Rævekløft Member by Rosenkrantz were apparently collected from the *Uptonia jamesoni* division.

The European stratigraphical ranges of Rævekløft Member belemnite species are given in text-fig. 2. *Nannobelus* ranges in age from the Sinemurian to the earliest Pliensbachian, *Uptonia jamesoni* Zone, across Europe. In southern Germany, only the species *N. alveolatus* (Werner) and *N. engeli* (Werner) are known to extend into the *Uptonia jamesoni* Zone (Riegraf, 1980), and this is apparent in Scania also (Troedsson, 1951). In Turkey, *N. acutus* (Miller) has been recorded from an otherwise distinctive *Uptonia jamesoni* Zone fauna (Doyle & Mariotti, in press). The specimens recorded from the Rævekløft Member include MGUH 20671, probably representative

of *N. alveolatus*, from the lowest bed (bed a) of the coast profile at Kap Stewart. The stratigraphical range of this species in Germany (text-fig. 2) is consistent with a *Uptonia jamesoni* Zone age for at least the basal part of Rævekløft Member, although the paucity of specimens prevents firm conclusions.

The commonest belemnite in the Rævekløft Member appears to be *Pseudohastites apicicurvata* (Blainville) given the specimens still available, and the records given by Rosenkrantz (1934). Co-occurring in some sections are hastitids of the genera *Gastrobelus?* and hastitid indet. The distinctive *P. apicicurvata* and *Gastrobelus?* provide an important age control (text-fig. 2). In Germany (Schumann, 1974; Riegraf, 1980) and England (Lang, 1928; Palmer, 1972) these belemnites are unknown in rocks older than the *Tragophylloceras ibex* Zone (text-fig. 2), while for Bulgaria, Stoyanova-Vergilova (1977) designated a "*Catateuthis apicicurvata*" belemnite zone approximately equivalent to the *Tragophylloceras ibex* and *Prodactylioceras davoei* zones, succeeding two zones based on the occurrence of *Nannobelus*. The species *Gastrobelus ventroplanus* is known only from the *Prodactylioceras davoei* to *Amaltheus margaritatus* zones in Germany and Bulgaria (text-fig. 2). Činčurová (1979, p. 30) gave only an Early Pliensbachian age for the occurrence of *P. apicicurvata* in Czechoslovakia, but noted that it occurs above strata containing *Nannobelus alveolatus* and *N. engeli*. This is strong evidence that Rosenkrantz's *Uptonia jamesoni* bed has an age range of *Uptonia jamesoni* to at least *Tragophylloceras ibex* and possibly early *Prodactylioceras davoei* Zone age (text-fig. 2).

*Ostreaelv Member*- The Ostreaelv Member yielded a greater diversity of ammonites to Rosenkrantz (1934) than the older Rævekløft Member. These ammonites to Rosenkrantz (1934) than the older Rævekløft Member. These ammonites are typical of the Toarcian and comprise mainly species of *Pseudolioceras* with some *Dactylioceras* (including *D. groenlandicum* Rosenkrantz, figured but not described by Rosenkrantz, 1934, pl. 5, figs 4, 5). With the aid of these ammonites, Rosenkrantz (p. 118) distinguished *Hildoceras bifrons*, *Grammoceras striatulum* and *Pleydellia aalensis* zones (= *Hildoceras bifrons*,

LOWER TOARCIAN					UPPER TOARCIAN						
falcifer.		bifrons			variabilis	thouars.		levesquei			
1	2	3	4	5	6	7	8	9	10	11	
											GREAT BRITAIN Doyle, 1990, 1991

Text-fig. 3. European stratigraphical ranges of belemnite species from the Ostreaelv Member. Biostratigraphical zones from Dean *et al.* (1961) and Howarth (1978). Subzones: 1, *Harpoceras exaratum*; 2, *Harpoceras falciferum*; 3, *Dactylioceras commune*; 4, *Peronoceras fibulatum*; 5, *Catacoeloceras crassum*; 6, *Grammoceras striatulum*; 7, *Pseudogrammoceras fallaciosum*; 8, *Phlyseogrammoceras dispansum*; 9, *Dumortieria levesquei*; 10, *Dumortieria moorei*; 11, *Pleydellia aalensis*.

*Grammoceras thouarsense* and *Dumortieria levesquei* zones) based mainly on species of *Pseudolioceras*. Howarth (1978, p. 249) has summarised the correlation of Arctic successions using *Pseudolioceras*. Most interpretations, including that of Rosenkrantz, correlate the first major occurrence of diverse *Pseudolioceras* in the Arctic regions (with *P. compactile* (Simpson)) with the *Grammoceras striatulum* Subzone in Europe (e.g. Frebald, 1975, table 1). However, Howarth (1978) proposed that a better correlation was with the top of the *Peronoceras fibulatum* Subzone (*Hildoceras bifrons* Zone), as most "species" of *Pseudolioceras* could be accommodated within the single nominal species *P. lythense* (Young & Bird). Given this interpretation, the Ostreaelv Member could be given a solely Early Toarcian (*Hildoceras bifrons* Zone) age, rather than an Early and Late Toarcian age as originally indicated by Rosenkrantz.

As for the Rævekløft Member, the belemnite fauna provides an additional control on the dating of the Ostreaelv Member. Belemnites are perhaps more diverse in the Toarcian than at any other time (e.g. Riegraf *et al.*, 1984; Doyle, 1990, 1991), and recent work has proved their worth in Jurassic biostratigraphy (Stoyanova-Vergilova, 1977; Doyle, 1990). The ranges of Ostreaelv

Member species in Europe are given in text-fig. 3. Palaeontologically, one of the fullest Toarcian sequences collected by Rosenkrantz (1936) in Jameson Land is that exposed in Nathorst Fjeld (Rosenkrantz, 1934, p. 80, pl. 12). At his locality 2 on Nathorst Fjeld, Rosenkrantz collected a specimen of *Parapassaloteuthis polita* at an altitude of 494 m, and another of "*Parabrachybelus*" *subaduncatus* from 509 m. These species have restricted ranges and are not known to be widespread throughout Europe. However, *P. polita* is only recorded from the latest *Harpoceras falciferum* Zone or earliest *Hildoceras bifrons* Zone (*Dactylioceras commune* Subzone) in Britain (Doyle, 1990), while "*P. subaduncatus*", so far recorded only from mainland Europe, has a range probably restricted to the *Dumortieria levesquei* Zone (Riegraf, 1980; text-fig. 3). This proves the presence in the Ostreaelv Member of strata of early *Hildoceras bifrons* Zone to *Dumortieria levesquei* Zone age, which is consistent with the ranges of the other belemnite species recorded from this member, *Acrocoelites vulgaris*, *Simpsonibelus expansus*, *S. lentus* and *A. quenstedtii* (text-fig. 3). This in turn is broadly consistent with Rosenkrantz's (1934) observations.

Furthermore, the presence of *Parapassaloteuthis polita* in the Ostreaelv Member confirms that strata of *Dactylioceras commune* Subzone age (the oldest subzone of the *Hildoceras bifrons* Zone) are represented in southeastern Jameson Land. That still older strata may be present in the Ostreaelv Member is indicated by two separate lines of evidence. The presence of beds of *Harpoceras falciferum* Zone age, is suggested by the single, possible juvenile *Acrocoelites* (*Toarcibelus*) *trisulculosus* (Simpson), a species restricted to the *Harpoceras falciferum* Zone in Europe (text-fig. 3). Beds of *Dactylioceras tenuicostatum* Zone age might also be present in the Ostreaelv Member. This observation is based on the presence of the ammonite Ostreaelv Member. This observation is based on the presence of the *Dactylioceras groenlandicum* Rosenkrantz aff. *semicelatum* (Simpson) recorded from the lower beds of the Ostreaelv Member at Nathorst Fjeld (Rosenkrantz, 1934). These beds did not apparently yield belemnites. It has been assumed that this *Dactylioceras* is representative of the younger *Hildoceras bifrons* Zone (Rosenkrantz, 1934),

but it is the opinion of M. K. Howarth (pers comm. 1991) that this form is indeed close to *Dactylioceras semicelatum* (Simpson), a subzonal index for the top *Dactylioceras tenuicostatum* Zone in Europe (Howarth, 1973). This species has a broad range in morphology, including robust individuals resembling *Catacoeloceras* (Howarth, 1973, pl 7–9), and it is therefore feasible that the *Dactylioceras*-bearing beds of the Ostreaelv Member are older than first thought. Further study of the ammonite fauna, beyond the scope of this paper, is required for confirmation of these observations.

### Palaeobiogeographical significance of the belemnite fauna

The significance of this fauna to belemnite biogeography has already been briefly touched upon elsewhere (Doyle, 1987, in press; Doyle & Mariotti, in press), but for completeness a summary of its significance is given below.

The palaeogeography of Jameson Land in Early Jurassic times has been illustrated by Surlyk *et al.* (1981), Dam (1989, 1990) and Surlyk (1990). Its position was in a seaway that linked the European shelf areas with that of the boreal seas, and as has already been noted by Rosenkrantz (1934) the corresponding faunas are close to those of Europe. The Early Pliensbachian belemnite fauna of Jameson Land represents the most northerly true belemnite fauna known for this interval, as belemnites are not found in Siberian and other Arctic successions prior to the Toarcian (Saks & Nal'nyaeva, 1970, 1975). The reason why belemnites were unable to penetrate past Greenland at this time is not clearly understood (Doyle, in press), but by the Toarcian, a time of marine transgression, they had successfully colonised the Siberian and other high Arctic basins (Saks & Nal'nyaeva, 1970; Doyle, 1987, in press).

Both the Early Pliensbachian and the Toarcian faunas are identical in specific content to those of Europe, and of the Toarcian fauna, only *A. (T.) trisulculosus*, possibly identified as a juvenile from Harris Fjeld, is present also in the Siberian basin, emphasising the endemicity of the Siberian Toarcian belemnite fauna at this time (Saks & Nal'nyaeva, 1970, 1975; Doyle, in press).

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### Dansk sammendrag

Belemnitter indsamlet i 1920'erne fra den nedre jurassiske Neill Klint Formation på Østgrønland bliver her beskrevet for første gang.

Der findes to forskellige belemnit faunaer. Rævekløft Member indeholder *Nannobelus*, *Pseudohastites*, *Passaloteuthis?*, *Gastrobelus?* samt en hastitid form. Dette indikerer en alder svarende til nedre pliensbachien (*Uptonia jamesoni* til *Prodactioceras* Zonerne) for den mollusk rige nedre fauna.

Ostreaelv Member indeholder *Parapassaloteuthis*, *Acrocoelites (Toarcibelus)*, *A. (Odontobelus)*, *Simpsonibelus* og "*Parabrachybelus*". Dette indikerer en toarcien alder (*Hildoceras befrons* til *Haugia variabilis* Zonen). Imidlertid antyder tilstedeværelsen af *Parapassaloteuthis* en ældste alder svarende til *Dactylioceras commune* Subzonen. Et løst eksemplar af en formodet juvenil *Acrocoelites trisulculosus* antyder at Ostreaelv Member kan række tidsmæssigt ind i *Harpoceras falCIFerum* Zonen.

Pliensbachien arterne er identiske med vesteuropæiske former og er de hidtil nordligst forekommende. Toarcien arterne har størst affinitet til vesteuropæiske former og adskiller sig fra den aldersmæssigt tilsvarende sibiriske belemnitfauna, der udvikles på dette tidspunkt og som er endemisk.

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