DEVONIAN (FRASNIAN) GONIATITES FROM WATERSIDE COVE AND STAVERTON WOOD, SOUTH DEVON

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Waterside Cove, south of Paignton, is famous for a goniatite fauna first noted by J. E. Lee in 1877 from a level known as the Saltern Cove Goniatite Bed. This was shown in 1972 to be a sedimentary slump in early Famennian shales. In this paper the fauna is revised and illustrated and includes the genera: *Archoceras, Manticoceras, Serramanticoceras*, *Trimanticoceras*, *Delphiceras, Clauseniceras, Crickites, Tornoceras, Linguatornoceras, Crassotornoceras* and *Aulatornoceras. Ling. holwilli* n. sp., *Aulat. tumidum* n. sp. and *Retrotornoceras alobatum* gen. et sp. nov. are named and described. The age of the fauna is late Frasnian, corresponding to Upper Devonian UD I-K,L. A more limited fauna is also described from Staverton Wood, near Totnes, which includes *Acanthoclymenia, Nordiceras? middletoni* n. sp. and *Tornoceras* n. sp. It is of earlier Frasnian age, probably UD I-C,D.

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INTRODUCTION

The two Upper Devonian goniatite faunas described here both belong to the Frasnian Stage. The first, from Waterside Cove (SX 896 587), near Paignton, is the largest both in variety and size and it is also the longest known, having been described briefly by J.E. Lee in 1877, but not subsequently. The fauna belongs to the late Frasnian, apparently from equivalents of the interval between the Lower and Upper Kellwasserkalk levels (Upper Devonian, UD I-K,L). The second fauna from Staverton Wood (SX 806637), near Totnes, was discovered and first mentioned by Middleton (1960) and is described here for the first time. It is from earlier Frasnian levels (UD I-C,D).

The faunas of both localities represent levels poorly known elsewhere in the world. That from Waterside Cove, which occurs within a sedimentary slump of early Famennian age as shown by Van Straaten and Tucker (1972), includes elements only well known from Indiana and New York State and, more recently, from Morocco. The Staverton Wood fauna is a new faunal complex with two of the three taxa new to science.

Abbreviations

The following abbreviations are used for museum repositories: BGS GSM, British Geological Suryey, Geological Survey Museum, Keyworth; NHM, Natural History Museum, London; SM, Sedgwick Museum, Cambridge; OUM, Oxford University Museum (the prefix D to the collection number indicates that it is from the author's collection); NCM, National Museum of Canada, Ottawa; Senk. M., Senckenberg Museum, Frankfurt am Main. The following abbreviations are used for measurements: D, diameter; WH, whorl height; WW, whorl width; Wh, distance between the venter and the corresponding impressed depth, UW, umbilical width. For tornoceratid sutures the lateral lobe is analysed by measuring the distance from the tangent on the ventro-lateral saddle to the tangent on the latero-umbilical saddle, giving a line Lw, lobe width. A parallel line at the tangent of the lateral lobe gives right-angled lobe height, Lh. A line at right angles from this tangent crossing the first gives a distance to the tangent of the latero-umbilical saddle of Al, a measure of asymmetry of the lateral lobe. The position of the base of the lateral lobe, positioned at a distance Sl from the umbilicus to a mid-point of the ventral lobe, may be referred to as the flank lobe index, Sl/P; ratios are expressed as percentage. Measurements are in millimetres.

WATERSIDE COVE

Waterside Cove is a name coined by Anniss (1927) for a small cove immediately north of Saltern Cove, near Goodrington, south of Paignton (Scrutton, 1978, fig. 15). It is historically important because it was the first locality in England where Upper Devonian goniatite faunas were recognised. These faunas were collected from the south side of the cove (SX 8955 5868). Curiously on the north side of Waterside Cove Lower Devonian rocks crop out and the adjacent railway cutting was where Champernowne first recognised Lower Devonian rocks in England: a major east-west tectonic dislocation passes across Waterside Cove separating the two areas.

A collection made by Admiral Bedford was described by Lee (1877, 1881) from the north side of the small headland separating Waterside Cove from the larger Saltern Cove. Lee compared the fauna with that of the Büdesheimer Schiefer of the Eifel, a well-known German Upper Devonian (Frasnian) goniatite locality. Ussher (1890) added little during his survey of the district but gave a revised list of fossils in the Torquay Memoir (Ussher 1903, p. 106). A summary was given by Schindewolf (1922, p. 197). The coves were examined in detail by Anniss (1927) who recorded detailed measurements of the succession and gave a fresh faunal list of the goniatites with determinations by L.F. Spath who also correlated the level with the Büdesheimer Schiefer. In the second edition of the Torquay Memoir, Lloyd (1933, p. 486) listed the records of Anniss. Some years later Spath recognised a form thought to be new in a fauna submitted to him by D.T. Donovan who described it as *Archoceras angulatum* (Donovan, 1943). The fauna was revised by House (1958, 1963) and a more detailed account is given here. The term Saltern Cove Goniatite Bed which is often used, applies to the levels yielding common goniatites which includes the overhanging cornice at the point of the headland and the succeeding four metres of shales. Maps of the locality are given in Van Straaten and Tucker (1972, figs 1-2) and Scrutton (1978, fig. 15).

The faunal evidence suggests that the Devonian generally youngs northward from the southern side of Saltern Cove into Waterside Cove with Givetian and early Frasnian faunas in the southern part of Saltern Cove (Van Straaten and Tucker, 1972; Scrutton, 1978) and Famennian in Waterside Cove (House, 1963) with *Entomozoe (Nehdentomis)* and *Richterina*, considered to be mid-Famennian in age just south of the contact with the Lower Devonian (Emsian). Slates predominate through

[1] EDITORS NOTE: Sadly Professor House died on August 6th 2002.

the northern part of Saltern Cove and Waterside Cove. However, all is not simple, since a few metres west of the Goniatite Bed, Holwill (1966) recognised a conglomerate bed with Middle Devonian and other blocks which he interpreted as a level of ejecta resulting from volcanic activity (the bed was named Holwill's Conglomerate by House (in House *et al*., 1977)). Then van Straaten and Tucker (1972) identified conodonts of the Famennian *quadrantinodosa* Zone (now *marginifera* Zone) of the Famennian in the Goniatite Bed and explained the goniatite occurrences as resulting from the sedimentary slumping of upper Frasnian argillaceous sediments during early Famennian deposition. They also dated some blocks in Holwill's Conglomerate as Frasnian. A review of the Devonian succession was given by Scrutton (1977, 1978) and a summary of the conodont records through the succession in the coves was given by Drummond (1985, p. 41) who records *crepida* and *marginifera* conodont zones of the early/middle Famennian from a sample immediately below the Goniatite Bed. Revision of the goniatite fauna is given here in the light of work in many parts of the world, particularly the U.S.A., Germany and North Africa. It is argued that the fauna is consistent with an age within the goniatite Zone of *Crickites holzapfeli* and that it contains nothing of the age indicated by the conodonts.

The material available for study is considerable. There is a large collection made by Lee presented to the British Museum (NHM) in 1885, and an even larger collection presented by Champernowne in 1909. The Sedgwick Museum (SM) has material collected by Whidborne. The L.G. Anniss collection was kindly lent to the author and, with his permission, passed to the Geological Survey (BGS) where it is now numbered Zs 845-916. Some material was donated by the author to the Sedgwick Museum, but the author's main collection, added to by several donations, is to be deposited in the Oxford University Museum (OUM). The current goniatite faunal list comprises the following forms:

Archoceras varicosum (Drevermann)
Arch. angulatum (Donovan)
Arch. ussheri (House)
Manticoceras lamed (G. and F. Sandberger) Group
Mant. cf. *adorfense* Wedekind
Serramanticoceras aff. *serratum* (G. and F. Sandberger)
Trimanticoceras cf. *retrosum* (G. and F. Sandberger)
Delphiceras aff. *unduloconstrictum* (Miller)
Clauseniceras sp.
Crickites holzapfeli Wedekind
Tornoceras typum (G. and F. Sandberger)
Linguatornoceras "ovatum" (Frech)
Linguatornoceras holwilli sp. nov.
Crassotornoceras annissi House and Price
Retrotornoceras alobatum gen. et sp. nov
Aulatornoceras auris (G. and F. Sandberger) Group
Aulat. bickense Wedekind
Aulat. cf. *paucistriatum* (d'Archiac and de Verneuil)
Aulat. tumidum sp. nov.

In addition there is a fauna of bactritids, orthocones and buchiolids not discussed here. All material is preserved as haematitic internal moulds with no evidence for the shell or external mould impressions. Descriptions only apply to Devon material unless otherwise stated.

Systematic descriptions

Family Anarcestidae.

Remarks: Korn (2001, p. 207) has named a family Atlantoceratidae for *Atlantoceras* with which *Archoceras* has been compared, and Aboussalam and Becker (2001, p. 96) have named the same group the family Archoceratidae. The priority and status of these still has to be determined.

Genus *Archoceras* Schindewolf (1937, p. 243).

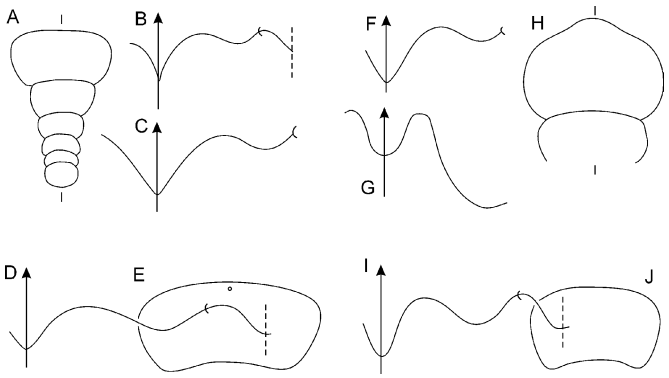

Figure 1. *Archoceratids from Waterside Cove. A-E.* Archoceras varicosum *(Drevermann). All specimens from Waterside Cove. A. Cross reconstructed section of the inner whorls based on OUM D233. B. Suture at 6 mm diameter of OUM D233. C. Suture at 8 mm diameter based on OUM D208, all x 10. D,E. Whorl section and suture of OUM D241, X 18. F-H,* Archoceras ussheri *(House). F. Suture at 8 mm diameter. G. growth lines on the body chamber at 12 mm diameter. H. Cross section of the outer whorl at 12 mm diameter also showing the preceding whorl based on the holotype SM H1534, Whidborne Collection (after House, 1963), x 6.25. I,J.* Archoceras angulatum *Donovan. Suture and whorl section based on the holotype, BGS GSM 63381, x 13.3.*

Type species: *A. paeckelmanni* Schindewolf, by original designation.

Diagnosis: Conch micromorphic, serpenticonic with imperforate umbilicus. Whorls depressed and angular to well-rounded, in some with ventro-lateral furrows. Growth lines biconvex, often prosiradiate on flanks, with high salient on the outer flanks. Constrictions may or may not be present, but in some follow growth lines, in others are backwardly directed across the flanks. Suture with very broad and large V-shaped or bell-shaped ventral lobe; lateral lobe subumbilical from earliest stages; deep median dorsal lobe. Sutural formula: ELI.

Archoceras varicosum (Drevermann, 1901, p. 140).

Plate 1L, Figures 1A-E.

This is the commonest *Archoceras* in the Waterside Cove fauna and is well represented in museum collections. Material includes SM H1532, 3, BGS GSM 63383,4, OUM D208, 225, 233, 234, and there are also good specimens in the NHM.

Dimensions: BGS GSM 63384, D = c. 8.3; WW = 2.2; WW = 3.2; UW = c. 4.9. BGS GSM 63383, D = 10.0; WH = 2.5; WW = 3.9; UW = 5.4. OUM D208, D = 11.8; WH = 3.3; WW = c. 4.7; UW = 6.7. SM H1532, D = 12.0; WH = c. 2.8; WW = c. 4.2; UW = 7.0.

Description: Shell ontogeny is illustrated in Figure 1A-D. Protoconch small, sub-elliptical, about WW = 0.8, and D = 0.5. The first whorl is tightly coiled about it with a moderate impressed depth which subsequently decreases relative to the whorl height (Figure 1A). The whorl section of the first and second volutions is well-rounded and depressed with the ventral area strongly arched. By the third volution the outline of the adult is established. By D = 6 (fifth volution) the venter is noticeably flatter, although still slightly arched, and the lateral areas well rounded but sloping inward to the umbilical seam. Up to D = 12 (the largest known from Devon) the outer parts become more rounded until all trace of the original flattening is lost and the maximum whorl width draws nearer to the umbilical seam reaching 20% across the flanks.

The pattern of growth lines on the earliest whorls has not been seen, but by 8 mm diameter the adult pattern is reached in which

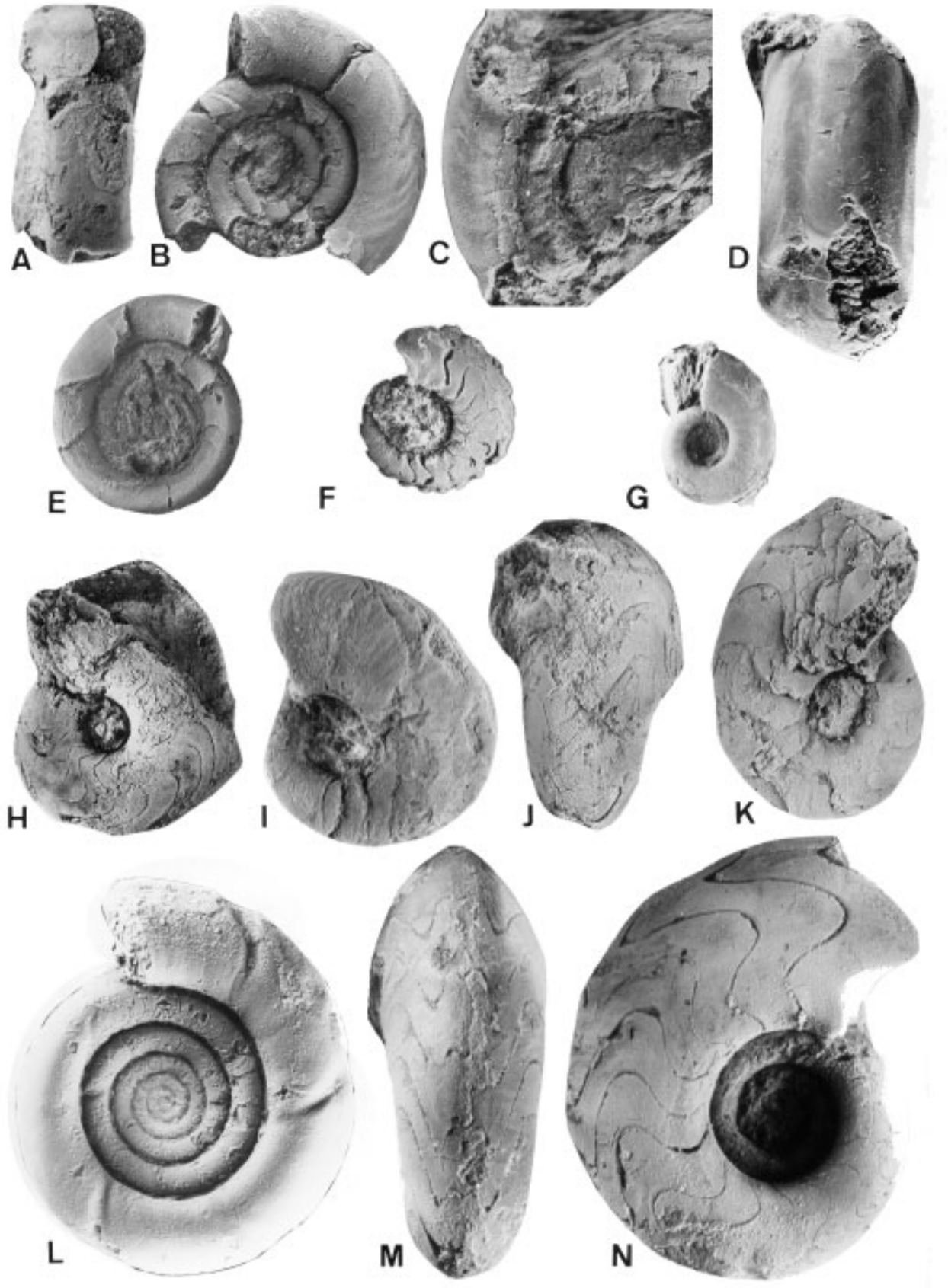

Plate 1. *Frasnian goniatites from Waterside Cove. A,B.* Archoceras angulatum *Donovan. Ventral and lateral views of BGS GSM 63381, the holotype, x 6. C,D.* Arch. ussheri *House. Ventral and lateral views of the holotype, SM H1534, x 6. E.* Arch. angulatum Donovan. *Lateral view of a paratype, NHM c40153, x 6. F.* Serramanticoceras *aff.* serratum *(G. and F. Sandberger). Lateral view of OUM D312, x 6. G.* Trimanticoceras *cf.* retrorsum *(G. and F. Sandberger). Lateral view of NHM C49454, x 3.7. H.* Manticoceras *cf.* adorfense *Wedekind. Lateral view of OUM D299, collected by K. Joysey, x 2.3. I-K.* Crickites holzapfeli *(Wedekind). I. Lateral view of OUM D202, x 6. J,K. Ventral and lateral views of NHM C18436, x 4. L.* Archoceras varicosum *(Drevermann). Lateral view of OUM D208, x 3. M,N.* Delphiceras *aff.* unduloconstrictum *(Miller). Ventral and lateral views of BGS Anniss Collection, x 6.*

the growth lines swing markedly and concavely forward across the lateral areas to form rounded salients on the outer parts of the venter and a mid-ventral sinus. Constrictions follow the course of the growth lines and first appear at about D = 4 and thenceforth occur regularly at between three and four per whorl being more frequent in the outer whorls.

The prosuture and earliest sutures have not been seen, but by D = 3.5 (MRH D233) the adult pattern is established with a wide v-shaped ventral lobe, 0.5 mm deep, which curves convexly outward to form a rounded saddle on the ventro-lateral shoulders: across the lateral slopes there is a shallow and rounded lateral lobe, 0.15 mm deep. The umbilical seam lies slightly ventral to the crest of the umbilical saddle and there is a v-shaped ventral lobe. The adult suture remains similar in general proportions (Figure 1C) with a tendency for the ventral lobe to become flat-sided in some specimens but somewhat convex in others. The base of the ventral lobe is sometimes acute, sometimes slightly rounded.

Remarks: This species was originally described by Dreverman (1901) as a gastropod but Schindewolf (1937, p. 249, 250) and Gallwitz (1938) demonstrated the true relations. Earlier, Wedekind (1913, 1917) had recognised this form under the name *Gephyroceras bickense* and Anniss (1927, p. 496) used the name *Mant. bickense*. The shell of the holotype (Dreverman, 1901, pl. 16, figs. 10, 10a) shows peculiar thickenings associated with constrictions which agree in outline with the growth lines. All the Devon specimens are internal moulds but could well have formed such thickenings in the shell of the outer whorls. Comments on the genus have been given by Becker (1993, p. 174).

Archoceras angulatum (Donovan, 1943).

Plate 1A,B,E, Figures 1 I,J.

This species was first recognised by L.F. Spath amongst specimens sent by D.T. Donovan who subsequently described it. The holotype is BGS GSM 63381 and there are paratypes BGS GSM 63382 and NHM C40153. Other material includes BGS GSM 92711, OUM D239, 261, and a specimen in the Anniss Collection is now in the BGS (BGS Zs 912).

Dimensions: NHM C40153, D = 7.9; WH = 1.8; WW = 3.1; UW = 4.4. BGS GSM 92711, D = 7.7; WH = 2.1; WW = 2.0; UW = 4.1. OUM D239, D = 4.7; WH = 1.4; WW = 2.5; UW = c. 2.7.

Description: The largest of these specimens, and the holotype, may be adult since they show sutural approximation (as noted by Donovan) but there is a disturbed pattern in NHM C40153. The body chamber on one specimen (BGS GSM 92711) occupies a complete whorl. The relative proportions of the whorl sections are somewhat variable but in general the WW/WH ratio decreases outwards. Also, as Donovan noted, the adult venter is flatter in some cases than others. In the juvenile (BGS GSM 63382) the venter is particularly flat and the ventro-lateral shoulder sharp.

Archoceras ussheri House, 1963.

Plate 1C,D, Figures 1F-H.

A description was published by House (1963, p. 16,17, pl. 3d, figs 6a-c). With *A. schlosseri* (Gallwitz, 1938), this is the only archoceratid with paired ventro-lateral furrows but it differs from *schlosseri* in the wider umbilicus (UW/D = 58%) and more depressed whorls (WH/WW = 60%) in the holotype (SM H1534), the only known specimen.

Family Gephuroceratidae.

Genus *Manticoceras* Hyatt (1884, p. 317).

Type species: *Goniatites simulator* Hall, by original designation.

Diagnosis: Shell evolute in inner whorls, subevolute to involute in outer whorls, often large (rarely above 12 cm). Whorl section with rounded venter and laterally compressed. Suture with three pointed or rounded lobes between a small v-shaped ventral lobe and deep dorsal lobe. Large ventro-lateral saddle. Growth lines biconvex. Sutural formula EmE1L:UI.

Remarks: This is a genus with over forty named species and subspecies. Formerly it was a carpet-bag genus, but now forms with particular shell forms have been placed in separate genera. This is an internationally widespread mid- and late- Frasnian genus and is well represented in the collection with specimens under D = 15, except for a single phragmocone chamber from the cornice at the seaward end of the section.

Manticoceras lamed (G. and F. Sandberger, 1850, p. 90) Group.

This internationally common mid- and late- Frasnian form is not well represented in the collections. It replaces, in the name for the group, *Mant. cordatum* over which it has priority, *cordatum* being relegated to subspecific rank within *lamed.* Miller (1932, p. 331) designated a lectotype for the species which was illustrated by House and Ziegler (1977, pl. 2, fig. 15-17). Representatives from Waterside Cove include: NHM 49433, 6.

Manticoceras cf. *adorfense* Wedekind (1913, p. 54).

Plate 1H.

Dimensions: OUM D299, D = 17.1; WW = 6.8; WH = 9.2; UW = 3.2.

Description: Shell form subevolute, laterally compressed with stout whorl section with rounded venter and flanks diverging convexly to a maximum width close to the rounded umbilical shoulder. Suture with large median saddle in the ventral lobe reaching 60% of the height of the large rounded laterally-placed ventro-lateral saddle. Lateral lobe outside the seam becoming acute in outer whorls.

Remarks: This species is significantly stouter than the *Mant. lamed* Group. The German material is thought to have come from Oberdevon Iϑ at Adorf (House and Ziegler, 1977). Only the single described specimen collected by Dr. K. Joysey is available from Devon.

Genus *Serramanticoceras* Becker *et al.* (1993, p. 300).

Type species: Goniatites serratus Steininger 1849, by original designation.

Diagnosis: Compressed Gephuroceratids with flattened flanks, venter rounded, flat or tabular or with a slight median groove, with periodic thickenings on the inside of the shell at the venter giving a serrated margin on the internal mould. Growth lines strongly biconvex, with high ventro-lateral salient. Suture as in *Manticoceras*.

Remarks: Few species but the type species is divided into several subspecies (Clausen, 1969; Becker *et al*., 1993, p. 300). Well represented in the Devon collections but with only small specimens.

Serramanticoceras aff. *serratum* (Steininger, 1849, p. 27).

Plate 1F, Figure 2C, D.

Dimensions: OUM D312, D = 5.2; WH = c.2.5; WW = c.2.0; UW = c.2.1. NHM C18433, D = 10.7; WH = c. 3.2; WW = c. 5.0; UW = 2.8.

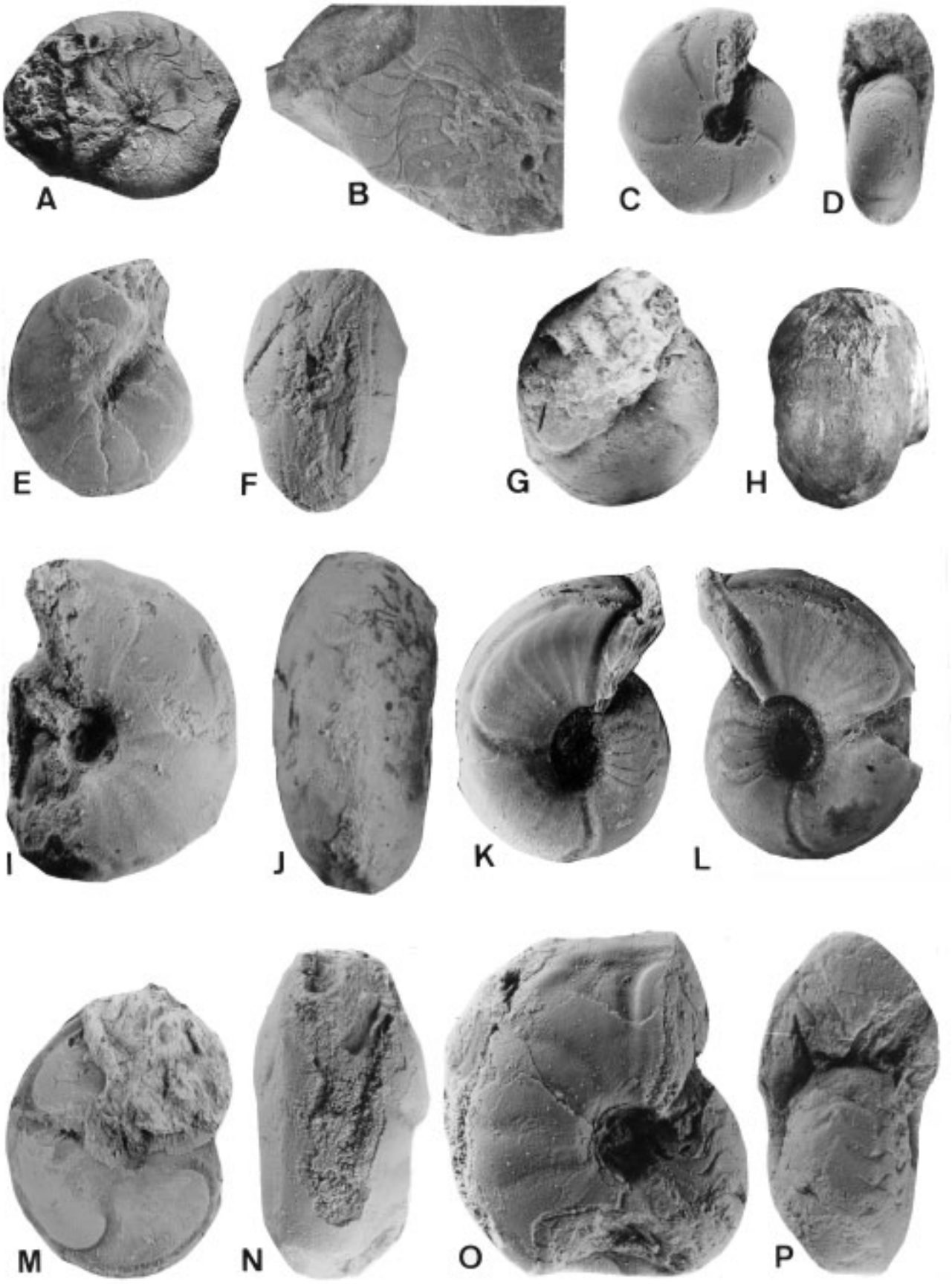

Plate 2. *Frasnian goniatites from Waterside Cove. A.* Linguatornoceras *cf.* holwilli *House sp. nov. Lateral view of NHM c1846, x 4. B.* Tornoceras *cf.* typum *(G. and F. Sandberger). Lateral view of OUM D253, x 4. C,D.* Retrotornoceras alobatum *House gen. et sp. nov. Lateral and ventral views of the holotype NHM c18448, x 5. E-H.* Aulatornoceras tumidum *House sp. nov. E,F. Lateral and ventral views of BGS Anniss Coll. 9, x 5. G,H. Lateral and ventral views of holotype NHM C18440, x 5. I,J,0,P.* Aulatornoceras auris *(Quenstedt) Group. I,J. Lateral and ventral views of OUM D267, x 10. O,P. Lateral and ventral views of NHM C18448, x 6. K,L.* Aulatornoceras *cf.* paucistriatum *(d'Archiac and de Verneuil). Lateral views of SM H1525, x 6. M,N.* Aulatornoceras bickense *Wedekind. Lateral view of BGS Anniss Collection 10, x 10.*

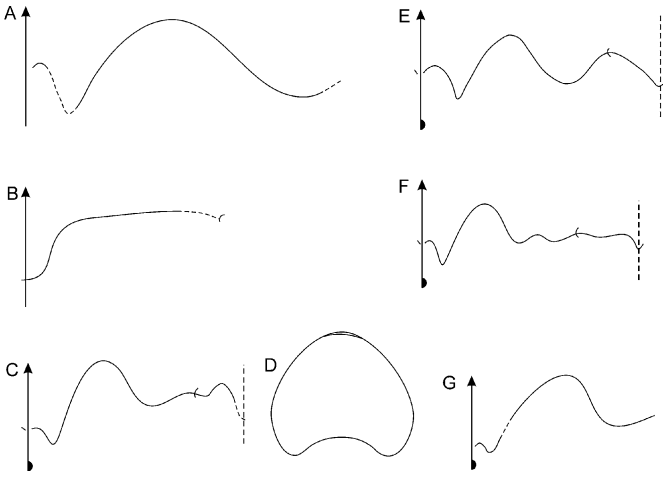

Figure 2. *Gephuroceratids from Waterside Cove and Galmpton Point and acanthoclymeniids from Staverton. A,B.* Crickites holzapfeli *Wedekind. A. Ssuture at 11 mm diameter. B. Growth lines at 7 mm diameter. Both based on NHM C18436 (after House, 1963), x 10. C,D.* Serramanticoceras *aff.* serratum *(G. and F. Sandberger). Suture cross section at 5 mm diameter, based on OUM D312, x 12.5. E.* Acanthoclymenia forcipiferum *(G. and F. Sandberger), reversed suture based on BGS GSM 95229 from a quarry SW of St John Baptist Chapel, Staverton Wood, collected by G.V. Middleton, x 10. F.* Nordiceras *?* middletoni *House sp. nov., reversed suture based on BGS GSM 95230, the holotype, from the same quarry and also collected by G.V. Middleton, x 7.4. G.* Manticoceras *sp., reversed suture of a specimen from Galmpton Point, due NNE of Warren House, 4 miles S of Paignton based on OUM D.401, x 10.*

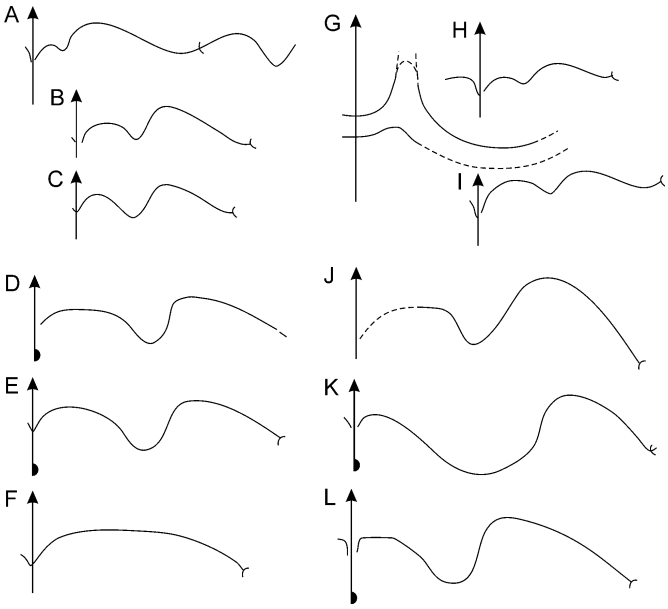

Figure 3. *Tornoceratids from Waterside Cove unless otherwise stated. A-C.* Aulatornoceras auris *(Quenstedt) Group. A. Suture at 1.9 mm diameter based on OUM D1107 from Büdesheim. B. Suture at 6 mm diameter based on NHM C18445. C. Suture at 12 mm diameter based on OUM D1080 from Büdesheim. A-C all x 4.2. D,E.* Linguatornoceras ovatum *(Frech). D. Reversed suture based on SM H1526. E. Reversed suture based on NHM C18461. Both x 8.5. F.* Retrotornoceras alobatum *House gen. et sp. nov., suture at 4.2 mm diameter based on holotype NHM C18448, x 16.8. G-I.* Aulat. *cf.* paucistriatum *(d'Archiac and de Verneil) G. Course of a constriction at 6 mm diameter. H. Suture at 4 mm diameter. Both based on OUM D246. I. Suture based on SM H1525; all x 10. J.* Aulat. tumidum *sp. nov., suture based on NHM C49448, x 23. K.* Tornoceras *sp. nov., reversed suture based on BGS GSM 95228 from Staverton Wood, x 6.1. L.* Linguatornoceras holwilli, *reversed suture based on the holotype, OUM D224, x 4.95.*

Description: Shell form sub-involute, laterally compressed, with open umbilicus and serrated venter. Whorl section in juvenile rotund with a slight impressed area (Figure 2D). Ventral serrations (OUM D312) number 19 per whorl at D = 5.3 but are reduced in prominence in outer whorls and may disappear in the adult (NHM C.18433). Growth lines biconvex, with shallow lateral sinus and prominent projecting and rounded ventro-lateral salient which passes back to a sinus over the venter with which the serration grooves are coincident. Wrinkle layer striae pass radially across the flanks and number 6-7 in 0.4 mm in the mid flanks at 5 mm diameter (NHM C. 18433). The median ventral saddle reaches 30% of the rounded asymmetric ventro-lateral saddle by 7 mm diameter and the steep slope of that saddle passes to a well-rounded lateral lobe. Dorsal suture with rounded subumbilical and deep median lobe.

Remarks: The only figured specimen of Steininger (1853, p. 43, pl. 1, figs 10, 10a) is from Büdesheim and topotypes in the author's collection (OUM D1305,6, D1300) differ from the Devon specimens in having a more rotund whorl at comparable diameters. Topotypes also show a rather tabular venter with the edges of the serrations well-defined which the Devon specimens do not show. Clausen (1969) described and illustrated Büdesheim examples.

Genus *Trimanticoceras* House (in House and Ziegler, 1977, p. 87).

Type species: Manticoceras cinctum Glenister, 1958 by original designation.

Diagnosis: Gephuroceratids with strong to moderate spiral grooves on the outer mid-flanks, in some changing in outer whorls to well-rounded flanks and venters with no grooves. Growth lines strongly biconvex with prominent outer flank salient positioned in the spiral grooves (if present). Suture as in *Manticoceras*.

Trimanticoceras cf. *retrorsum* (von Buch, 1832, p. 181)

Plate 1G.

Dimensions: NHM C.49454, D = 6.5, WH = 2.7, WW = c.2.4, UW = 2.0.

Description: NHM C.49454 shows a sub-evolute, laterally compressed shell with all whorls visible. Whorl section rounded-triangular, with narrowly rounded venter with a slight concavity on the outer flanks. Maximim WW $^1/_3$way from umbilical seam. Growth lines well marked as slight ridges which slope back across the rounded umbilical wall and then forward to form a ventro-lateral salient and a shallow sinus on the venter. Wrinkle layer striae number 6 in 0.4 mm on the mid flanks at D = 6.0 and slope steeply apicad. Median ventral saddle of suture reaches 25% of the asymmetric lateral saddle. Dorsal suture (seen on OUM D319) with subumbilical and median lobes.

Genus *Clauseniceras* Becker and House (1993, p. 114).

Type species: Crickites expectatus Wedekind (1913, p. 71, pl. 7, figs 2,3) by original designation.

Diagnosis: Gephuroceratids of median size, laterally compressed except for earliest stages, with growth lines linear on flanks and with a ventral sinus. Some internal moulds show fine ribbing in the early whorls. Suture as in *Manticoceras.*

Clauseniceras sp.

There are small and inadequate specimens in the collections which are referred here, especially NHM 1753a,f, which show

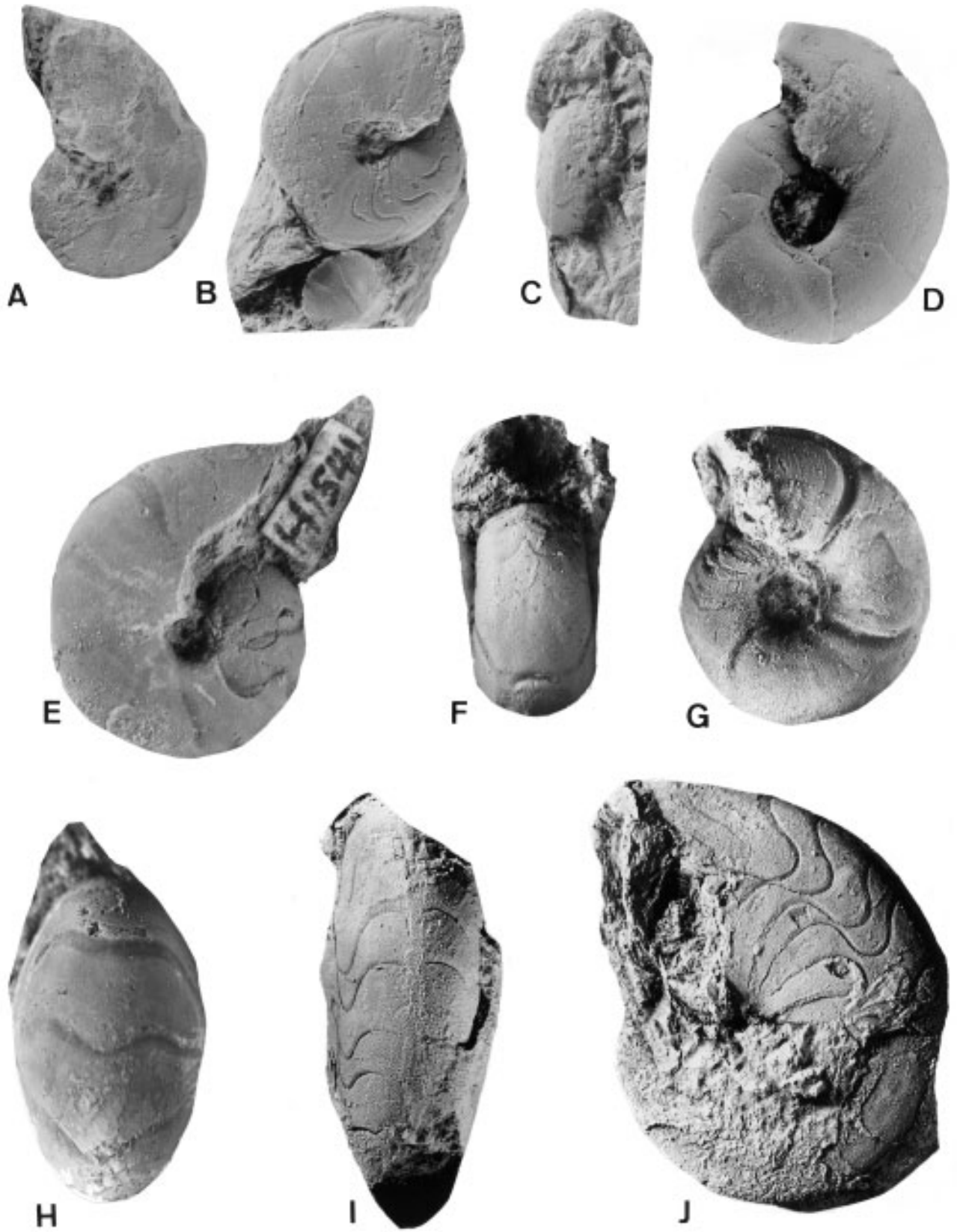

Plate 3. *Frasnian goniatites from Waterside Cove. A.* Aulatornoceras *sp. Lateral view of OUM D231, x 3.6. B,C.* Aulatornoceras auris *(Quenstedt) Group. Lateral and ventral views of a specimen figured by Lee (1877), NHM C49451, x 4. D.* Retrotornoceras alobatum *House gen et sp. nov. Lateral view of NHM C18451, x 8. E,H.* Crassotornoceras annissi *House and Price. Lateral and ventral views of the holotype, SM H1541, x 5.74. F,G.* Aulatornoceras paucistriatum *(d'Archiac and de Verneuil). Ventral and lateral views of OUM D241, x 8. I,J.* Linguatornoceras holwilli *House sp. nov. Ventral and lateral views of the holotype, OUM D224, x 4.5.*

fine ribbing in the early stages. These resemble *Clauseniceras delphiense* Kindle (1901, p. 577, pl. 3, figs 1,1a) where the ribs are shown in the internal mould. In this feature it differs from similar ornament in the early-stage shells of *Manticoceras* where internal moulds are smooth. In *Clauseniceras* therefore the shell is corrugated.

Genus *DELPHICERAS* Becker and House (2000, p. 140).

Type species: Manticoceras unduloconstrictum Miller, 1938, by original designation.

Diagnosis: Gephuroceratids of small-size which are subinvolute to moderately involute, with rounded venters and periodic constrictions on the internal moulds. Growth lines biconvex. Suture as in *Manticoceras.*

Remarks: The original name, *Delphinites* (Becker and House, 1993, p. 114), proved to be a junior synonym (of Sayn, 1901) and *Delphiceras* is the replacement name.

Delphiceras aff. *unduloconstrictum* (Miller, 1838, p. 123).

Plate 1M,N.

Dimensions: BGS Anniss Collection (i), D =13.0; WH = 6.5; WW = 5.7; UW = 4.5. BGS Anniss Collection (ii), D = 8.0; WH = c. 1.6; WW = 3.7; UW = c. 3.5.

Description: BGS Anniss Collection (i): subinvolute, laterally compressed, with wide open umbilicus. Below D = 10 mm, WW > WH, and the section is depressed with well-rounded flanks and less well-rounded venter. Above D = 10 mm, the section becomes sub-triangular. Growth lines poorly seen, passing back from the umbilicus to form a rounded sinus on the lateral areas. Four constrictions per whorl only prominent near the venter. Suture with a wide and diverging mid-ventral lobe, the median saddle within it reaching 12% of the height of the rounded ventro-lateral saddle at D = 7.5 mm diameter increasing to 33% by D = 13 mm. The umbilical seam centres slightly ventrad of the umbilical lobe: with a deep v-shaped dorsal lobe.

Remarks: Differing from *Delph. unduloconstrictum* (Miller, 1938, p. 123, pl. 27, figs 7-9) in the much less rapidly expanding whorls, and from *Delph. cataphractum* (Clarke, 1898, p. 87, pl. 6, figs. 3-9) in the larger size, and differing from both in the forming slight ventro-lateral groove-like impressions. Like *delphiense* the constrictions are best developed near the venter.

Genus *CRICKITES* Wedekind (1913, p. 70).

Type species: Crickites holzapfeli Wedekind, by subsequent designation of Wedekind (1917, p. 130).

Diagnosis: Small to quite large gephuroceratids, with shell more rotund than in *Manticoceras,* and usually rounded sub-rectangular in whorl section. Growth lines pass convexly backwards from the umbilicus across the flanks to form a broadly rounded ventral sinus. Suture as in *Manticoceras*.

Crickites holzapfeli Wedekind (1913, p. 72).

Plate1I,K, Figures 2A,B.

Dimensions: NHM C18436, D = 11.0; WH = 4.9; WW = 6.5; UW = 2.4. OUM D202, D = c. 9.0; WH = c. 3.5; WW = c. 4.5; UW = c. 2.0. NHM C59446, D = c. 6.5; WH = c. 3.0; WW = 4.3.

Description: Small examples only are available. Sub-involute to sub-evolute, slightly compressed; large specimens rather rotund. Whorl section below D = 10 rather depressed with flattened venter and flanks converging from a maximum width close to the umbilicus. At larger diameters the whorl section becomes more rotund, but still depressed, and the venter more rounded. Growth lines convex and prominent, forming raised lirae on the mould, not seen near the umbilicus, then sweeping convexly across the flanks but then turn back to form a ventral sinus. Growth line lirae occur with a frequency of 6 per 1.6 mm on the ventro-lateral shoulder at D = 9 (OUM D202). Small mid-ventral saddle in the ventral lobe which diverges to form a well-rounded symmetrical saddle. Umbilico-lateral saddle shallow, and still rounded at the maximum diameter seen. Dorsal suture not observed.

Remarks: The type material of Wedekind was much bigger than this material, but agrees with it well in growth line and shell pattern. There has been no adequate description of other material apart from large specimens described by Matern (1931) from Belgium, so the complete ontogeny from small to large material is still undescribed. Matern designated neotypes, but the original material was probably in Göttingen, invalidating the selection.

Family Tornoceratidae.

Genus *TORNOCERAS* Hyatt (1884, p. 320).

Type species: By original designation, *Gon. uniangularis* Conrad.

Diagnosis: Laterally compressed, involute tornoceratids with closed umbilicus and biconvex growth lines, sometimes simplifying at maturity. Suture with small ventral lobe, with lateral adventitious lobe arising during ontogeny, primary lateral lobe approximately centred on the seam and with a deep v-shaped dorsal lobe. Sutural formula EALI.

Tornoceras cf. *typum* (G. and F. Sandberger, 1851, p. 103).

Plate 2B.

This typical form is represented by many poor examples in the collections. Formerly listed as *Tornoceras simplex* in past literature, the types of that species are of uncertain assignment, and the *typum* name of G. and F. Sandberger (1851, p. 103, pl. 10, fig. 14, refigured and chosen as lectotype by Becker, 1993, pl. 3, figs 1,2) is now preferred. However, notes by the author on the lectotype in the Wiesbaden Museum indicate that the suture is very incorrectly drawn, and there is only a slight arching of the ventro-lateral saddle to lateral lobe. Thus *T. typum* approaches *Linguatornoceras*. As with the American *Torn. uniangulare*, characteristics are the asymmetry of the first and second lateral saddles such that the ventral slopes of both slope dorsad. The useful review of the Tornocerataceae by Becker (1995) unfortunately does not extend back into the Frasnian, and Clausen's review of the Büdesheim fauna did not include the group. A statistical analysis of sutural form in these forms is needed.

Genus *LINGUATORNOCERAS* House (1965, p. 91).

Type species: Gon. retrorsus var. *lingua* (G. and F. Sandberger, 1852, p. 109) by original designation.

Diagnosis: Tornoceratids like *Tornoceras* but with a lingulate lateral lobe and with orad convexity between the ventro-lateral saddle and the lateral lobe. In early forms with lateral lobe simply lingulate but with pointed lobes and ventro-lateral furrows and flattened venters in later forms.

Remarks: Originally described as a subgenus of *Tornoceras.* See discussion in Becker (1993, p. 186). A sequence from *Tornoceras* exists, and an orad arching of the ventro-lateral saddle to lateral lobe slope of the suture is taken as the transition point.

Linguatornoceras "ovatum" Frech (1902, p. 47).

Figure 3 D,E.

Dimensions: OUM D308, D = 5.8; WH = c. 3.3; WW = c. 3.6. OUM D249, D = c. 7.2; WW = c. 4.7. NHM C18461, D = 9.4; WH = 6.0; WW = 5.2. SM H1526, D = 11.2; WH = 6.4; WW = 6.0. The umbilicus in each case is closed.

Description: Shell form above D = 7.0, involute with closed umbilicus and slightly laterally compressed. Whorl section ovate, with maximum width close to the umbilicus, with convex flanks and rounded venter. Growth lines not traced. In some with evidence of spiral lines near the venter. Suture with v-shaped ventral lobe and distinctive rather flat-topped ventro-lateral saddle. Lateral lobe linguiform with ventrad face of lateral saddle rather steep with dorsad face convexly sloping to umbilicus.

Remarks: This species was named as *Torn. simplex* mut. *ovata* by Frech (1902, p. 47, pl. 3(2), figs 21a,b) and came from Büdesheim. Frech thought he was dealing with *Gon. ovatus* of Münster, but it is a new form, here left unnamed, and under Frech's reference, until better material is available. The form of the lateral lobe (A) clearly refers it to *Linguatornoceras* but the ovate cross section clearly distinguishes it from the flat-sided *Linguat. linguum*.

Linguatornoceras holwilli sp. nov.

Plate 3I,J, Figure 3L.

Diagnosis: Differing from other species of *Linguatornoceras* in the flatter converging flanks and the virtual absence of a ventral lobe.

Name: Named in honour of F. Holwill for his contribution on Waterside Cove geology.

Dimensions: OUM D224, D = 16.3; WH = 9.3; WW = c.7.7; WW/WH = 83%; Al/Lw = 62%; Lh/Lw = 33%; Sl/P = 64%. OUM D298, D = 8.8; WH = 5.2; WW = 3.8; WW/WH = 73%. BGS Anniss Collection (12), D = 9.6; WH = 5.8; WW = 4.2; WW/WH = 72%. NHM c49438, D = 7.7; WH = c. 4.8; WW = c. 3.2; WW/WH = 76%.

Description: Holotype OUM D224. Shell form involute, laterally compressed with rather flat flanks, rounded venter and closed umbilicus. Maximum shell width close to the umbilicus and flanks converge ventrad. Growth lines not seen. Suture with a ventral lobe which is only a slight septal deflection caused by the siphuncle, which has parallel siphuncular sutures unrelated to a ventral lobe. Lateral lobe lingulate and asymmetric with a steep umbilicad face. Primary lateral lobe centred on the seam.

Remarks: This species raises again the problem of the transition from *Tornoceras* to *Linguatornoceras.* It differs markedly in sutural statistics from *Torn. contractum* Glenister (in which Lh/Lw = 42%; Al/Lw = 56%) and from *Lobo. clausium* Glenister (Lh/Lw = 66%; Al/Lw = 53%) and from both in the absence of a ventral lobe (other than the siphuncle sutures) (statistical data taken from published sutures, Glenister, 1958). The arching of the suture from the ventro-lateral to lateral lobe is taken as the generic indicator but further statistical analysis of the tornoceratid suture is badly needed.

Genus *CRASSOTORNOCERAS* House and Price (1985, p. 165).

Type species: Tornoceras ausavense crassum Matern, 1931, by original designation.

Diagnosis: Small Tornoceratidae with subglobular inner whorls and small open umbilicus with three to eight constrictions per whorl following the biconvex course of the growth lines. Some showing weak ribs. Sutures simple tornoceratid with small lingulate lateral lobe.

Remarks: The genus has been reviewed by House and Price (1985) where other species of the genus are listed. Becker (1993a) has additionally described early Famennian representatives.

Crassotornoceras annissi House and Price (1985, p. 168).

Plate 3E, H.

A description was given when the species was described and need not be repeated. The holotype is SM H1541.

Genus *RETROTORNOCERAS* House n. gen.

Type species: R. alobatum House sp. nov.

Name: To indicate a retrograde step in tornoceratid sutural ontogeny.

Diagnosis: Small *Crassotornoceras*-like tornoceratids but without developing a lateral adventitious lobe. Sutural formula: E(?A)LI.

Remarks: The delayed development of an adventitious lobe may be a feature of immaturity, but, if so, it is delayed far more than known in similar late Frasnian forms. A comparison is with *Tornia* (House, 1970) and *Kirsoceras* (Bogoslovskiy, 1971), Famennian tornoceratids, which also simplify their ventral suture with either a broad and shallow, or broad and deep lateral lobe respectively. There is at present no evidence that the form here described is related to either of those.

Retrotornoceras alobatum n. sp.

Plate 2C,D, 3D, Figure 3F.

Name: To draw attention to the absence of a tornoceratid lateral lobe (A).

Dimensions: Holotype, NHM. C18448, D = 7.3; WH = 3.8; WW = 3.5; UW = c. 1.1. NHM C18452, D = 6.0; WH = 3.6; WW = 2.9; UW = c. 0.9.

Diagnosis: Small tornoceratid similar to *Crassotornoceras* but with extremely simple sutures without evidence of adventitious lobes (ELI).

Description: Shell form involute, laterally compressed, with well-rounded venter. Around D = 4.5 mm, WW = WH, subsequently relative whorl height increases and the lateral slopes becomes flatter but the venter remains broad and well rounded. The body chamber occupies rather less than a complete whorl.

Remarks: It seems important to give taxonomic acknowledgement of this unusual form. When only a couple of specimens like this were known there was always the possibility that it was a pathological feature, but there are also many specimens in the NHM collections which should be referred here. Additional material includes NHM C1841, possibly NHM C49437 and a specimen in the BGS Anniss Collection.

Genus *AULATORNOCERAS* Schindewolf (1922, p. 188).

Type species: Gon. auris Quenstedt (1854, p. 64) by original designation. Neotype for *Aulat. auris* designated by House and Price (1985, p. 170).

Diagnosis: Tornoceratids with ventro-lateral furrows and usually tabular venters, involute, with a small, open umbilicus. Typically with indented, festoon-like, biconvex growth bands on the flanks and on the venter.

Aulatornoceras auris (Quenstedt, 1854, p. 64) Group.

Plate 3B,C, Figures. 3A-C.

Dimensions: See Table 1.

Description: Shell form involute, somewhat laterally compressed, with open umbilicus. Whorl section shows a tabular venter with well-marked ventro-lateral furrows on each side. Flanks then slope convexly outward to a maximum width close to the umbilical shoulder. Growth lines pass forward from the umbilicus forming a slight umbilico-lateral salient and on to a shallow lateral sinus; they then swing markedly forward, forming a prominent and elongate lappet in the ventro-lateral grooves and then sharply back to a deep ventral sinus.

Remarks: The original specimen of Quenstedt (1846, p. 64, pl.3, figs 7a-c) having not been traced, a neotype was designated by House and Price (1985, figs 1-4) as SM H9942, a specimen collected by the author from Büdesheim, Eifel, Germany. Waterside Cove material includes NHM C49451, C18445, OUM D203, D206, D244 and D267.

Aulatornoceras cf. *paucistriatum* (d'Archiac and de Verneuil, 1841, p. 339).

Plate 2K,L, 3F,G, Figures 3G-I.

Dimensions: SM H1528, D = 8.7; WH = 3.5; WW = 4.6; UW = c. 2.5. OUM D 241, D = 6.8, WW = 4.0, UW = 1.9.

Description: Shell form subinvolute, laterally compressed. Whorl section well rounded, with ventro-lateral furrows above 6 mm diameter. Lateral areas well rounded with maximum WW slightly dorsal of the mid-flanks. Impressed depth 34% at D = 8.7. Body chamber seen for ¾ whorls. Growth lines pass radially and rather flexuously out from the umbilicus and sweep forward into the ventro–lateral saddle furrows where they form a prominent projecting salient. Three or four constrictions per whorl coincide approximately with the growth lines (Figure 3G). Suture forms a small v-shaped ventral lobe with a well-rounded ventro-lateral saddle and subacute lateral lobe (A) even at small diameters (Figure 3H,I). Umbilico-lateral saddle wide with a lateral lobe centred outside the seam.

Remarks: These forms may be distinguished from *Aulat. bickense* by the wider umbilicus and from *Aulat. auris* by the more evolute form, the presence of regular constrictions and the absence of occasionally strong growth lines. Material in addition to that described includes OUM D246, D311. Many years ago the author examined the type material of d'Archiac and de Verneuil from Adorf and Oberscheld, Germany, then housed in the École des Mines, Paris. It was clear that their illustrations were reconstructions from incomplete specimens, but the relevant material showed that the shell was preserved. The Devon material of internal moulds (as in *Aulat. auris*, Plate 2O) thus shows the constrictions which are not seen on the external shell nor shown on the holographs.

Aulatornoceras bickense Wedekind (1917, p. 137).

Plate 2M,N

Dimensions: OUM D247, D = 4.0; WW = 2.5; WH = c.0.4. OUM D 265, D = 4.3; WW = 3.0; WH = 2.0; UW = c. 0.6. NHM c 49439, D = 3.2; WW = 2.2; WH = 1.7; UW = c. 0.3.

Dimensions	D	WH	WW	UW
From Waterside Cove:				
NHM C49451	10.6	4.1	c.5.0	c.1.5
NHM C18445	c.9.8	4.8	5.0	1.6
OUM D203	c.7.7	4.0	c.5.5	? 1.0
OUM D267	6.7	3.4	3.3	1.0
From Büdesheim				
OUM D1078	9.7	4.1	c.4.7	2.0
SM H9943 neotype	9.2	4.2	4.7	1.7
SM H9943	c.16.0	9.3	7.3	c.2.4
OUM D1081	6.8	3.5	4.2	0.8

Table 1. *Statistics of specimens of* Aulatornoceras auris *(Quenstedt) Group from Waterside Cove and Büdesheim (Eifel district, Germany). SM H9943 is the neotype for the species and subspecies designated by House and Price (1985). D, diameter; WH, whorl height; WW, whorl width; UW, umbilical width.*

Description: Shell form rotund and involute with very small umbilicus. Whorl section rounded with a maximum width close to the umbilicus. Impressed depth about 45%. Growth lines swing gently forward across the lateral areas and ventro-laterally sweep sharply forward to a prominent salient which passes back to a ventral sinus. Constrictions number 3-5 per whorl and apparently follow the course of the growth lines. Sutural elements of the adult are established even by D = 2.4 and consist of a small v-shaped ventral lobe, a rounded ventro-lateral saddle and a lateral lobe passing to a well-arched latero-umbiliocal saddle whose ventrad face is particularly steep. Additional specimens include BGS GSM 86993, ?BGS GSM 86994.

Remarks: This species was named as a variety of *Aulat. auris*, but not figured by Wedekind (1917, p.137) for specimens like *Aulat. auris* but with 3-4 constrictions. A fuller descripton was given by Matern (1931, p. 31).

Aulatornoceras tumidum sp. nov.

Plate 2E-H, Figure 3J.

Name: After the subglobular shell form.

Diagnosis: Small aulatornoceratines similar to *Aul. auris* but subglobular and with closed umbilicus and with periodic constrictions on the flanks but no festoons. Holotype NHM c18440.

Dimensions: NHM C18440, D = 8.9, WH = 5.5, WW = 6.5, UW = ?0. NHM C49448, D = 5.3, WH = 3.5, WW = 3.8, UW = ?0.

Description: Shell form involute, rotund, with well-rounded outline and closed, or almost closed, umbilicus. Whorl section subcircular, depressed, widest close to the umbilicus. Venter rather flat, bordered by ventro-lateral furrows. Growth lines pass slightly forward from the umbilicus and then sweep back to form a wide, shallow, lateral sinus but in the juvenile form they are more rectiradiate over the lateral areas, passing forward in furrows to form a long lappet and return to a sinus which is slightly orad to the radius from the lateral sinus. Suture forms a small v-shaped ventral lobe, a flat-topped, ventrally sloping ventro-lateral saddle, a subacute lateral lobe (A) and a very highly arched umbilico-lateral saddle.

Remarks: The tumid and rounded form and closed umbilicus clearly separate this from related forms and from *Crassotornoceras*. In addition to the described specimens there are several in the BGS Anniss collection.

COMMENTS ON THE AGE OF THE WATERSIDE COVE FAUNA

The early comparisons were with the Upper Devonian Büdesheim fauna (Lee, 1877; Anniss, 1927; Spath in Lloyd, 1933) from near Prüm in the Eifel Mountains Germany, then known especially through the work of Steininger (1853) and Sandberger (1849-1856). The discovery of *Crickites holzapfeli* Wedekind, the zone fossil of Frasnian to Iδ (House, 1963), indicated that the fauna was younger than the main Büdesheim fauna, which was in part monographed by Clausen (1969). Re-examination of material from a pyritic level in the New Albany Shale of Indiana described by Kindle (1901) indicated a close affinity with the Waterside Cove fauna since it contains, in modern terms, *Archoceras*, *Clausenicera*s and *Delphiceras* now known to be distinctive elements of the fauna. Attention to this affinity was drawn by House (1962), and to the occurrence of *Delphiceras* in the Lower Hanover Shale of New York (where the underlying Pipe Creek Shale is taken as the equivalent of the Lower Kellwasser Kalk) by House and Kirchgasser (1993). Becker (1993b) drew attention to the flood appearance of *Archoceras* after the Lower Kellwasser Kalk of Germany. Although that genus survives into the early Famennian (Becker, 1993a), the Waterside Cove fauna is fully consistent with a similar late Frasnian age. There is no evidence in the fauna to indicate elements other than those expected in Upper Devonian UD I-K,L (Becker and House, 2000). Two undescribed faunas may give more precision in the future. Firstly the Büdesheim area has been trenched and detailed collecting from a section has been made for the first time. Secondly, in southern Morocco, east of Taouz, near Ouidane Chebbi, close to the Algerian border, a new haematitic fauna from above the Lower Kellwasser equivalents was discovered by R.T. Becker and the author during recent field work. Published results for these localities are not available. Nevertheless the Waterside Cove fauna is an extraordinarily rich representation from the late Frasnian (Becker and House, 2000, p. 130) and for the Lower to Upper Kellwasser Kalk interval is at present the best described. How so unique and time-constrained a goniatite fauna should form part of an intraformational slump of early Famennian age remains a mystery.

STAVERTON WOOD

The fauna described here was collected by G.V. Middleton during the mapping of the country between Newton Abbot, Ashburton and Dartington for his PhD thesis (Middleton, 1954). The locality is a quarry NW of St John Baptist Chapel, Staverton, two miles NW of Totnes. The goniatites were obtained from shales interbedded with thin limestones and tuffs (SX 806637) above the railway line (Middleton, 1960, p. 194). Middleton presented his collection to the BGS. It comprises a distinctive early Frasnian fauna not known elsewhere in SW England. The fauna was listed by House (1963, p. 7), but the terminology is here revised and the fauna described for the first time. The present faunal list is as follows:

Acanthoclymenia aff. *forcipifera* (G. and F. Sandberger)
Nordiceras? middletoni House sp. nov.
Tornoceras sp. nov.

Systematic descriptions

Family Acanthoclymenidae.

Genus *ACANTHOCLYMENIA* Hyatt (In Eastmann and Zittel, 1900, p. 584).

Type species: Clymenia (Cyrtoclymenia) neapolitina (Clarke, 1892, p. 57), by original designation.

Diagnosis: Gephuroceratacean laterally compressed with a tabular venter and ventro-lateral furrows of varying strength. Suture with medium to rather high ventral saddle, asymmetrical mid-lateral saddle, umbilical lobe and dorsal lobe only. Suture $E_m E_1 LI$.

Remarks: Probeloceras is currently distinguished by the more asymmetrical and rather sigmoidal lateral saddle and an incipient, or developed, subdivision in the dorsal suture with a sharpening of lobes towards maturity.

Acanthoclymenia aff. *forcipifera* (G. and F. Sandberger, 1850, p. 81, as *Gon. forcipifer)*

Plate 4E, Figures 2D,E.

Dimensions: Figures approximate because of distortion of the specimen. BGS GSM 95229, D = c. 14.0; WH = 5.7; Wh = 4.2; WW = 3.9: D = c. 8.5; WH = c. 3.0; WW = 2.5.

Description: Shell form sub-evolute, discoidal. Whorl section with flat ventral band (1.9 wide at D = 14.0) curving sharply over to the flanks which slope gently and convexly out to a maximum width close to the umbilical shoulder. Growth lines and wrinkle layer not traced. Suture forms a large median saddle in the ventral lobe which is rather wider than the ventral band and reaches 50% of the height of the slightly asymmetric ventro-lateral saddle. The lateral lobe is rounded and passes to a saddle centred on the seam. V-shaped dorsal lobe.

Remarks: The holotype of the Sandberger brothers, from the Wiesbaden Museum, was refigured by House and Ziegler (1977, pl. 3, figs 28, 29) and is said to come from Mühlengrube, Eibach, but the source horizon has not been located. The German holotype has a more asymmetric and narrower flank saddle than the Devon specimen (the shell form dimensions of the holotype are: D = 18.0; WW = 4.7; WH = 8.5; UW= 5.0). The wide number of German records from the middle and upper Frasnian need revising.

Genus *NORDICERAS* Bogoslovski (1955, p. 1104).

Type species: Prolecanites timanicus Holzapfel (1899) by original designation.

Diagnosis: Strongly compressed laterally, sub-involute to sub-evolute conchs with flattened or tightly-rounded venter. Biconvex growth lines. Suture with a small ventral lobe and four lobes between it and the umbilical seam. Ventral sutural formula; either $E_m E_2 E_1 LU$ or $E_1 E_3 E_2 LU_1$ with $U_2 I$ expected in the dorsum (Becker *et al*., 2000, p. 85).

Nordiceras? middletoni House sp. nov.

Plate 4C, Figure 2F.

Diagnosis: Like *Nordiceras timanicum* but with one less ventro-lateral lobe and more clearly defined ventro-lateral furrows.

Dimensions: One specimen only, BGS GSM 95230, D = 8.2; WH = 4.2; WW = 2.8; UW = c. 1.0.

Description: Shell form subinvolute and discoidal. Whorl section with a flattened ventral band (1.0 mm wide at D = 8.2) which turns sharply over to the flanks which diverge to a maximum width $^2/_3$ across the flanks. Close against the ventral band and on the flanks are paired ventro-lateral furrows. Umbilical wall rounded. At maximum diameter seen impressed depth is about 30%. Growth lines not traceable. Suture with ventral lobe with median saddle within reaching 33% of the rounded ventro-lateral saddles. Lateral and subumbilical lobes well rounded. Dorsal suture with subumbilical and median lobe ($E_m E_1 LU_1 U_2 I$).

Remarks: Apart from the lack of a rounded venter, and the rather low height of the median saddle this form could be placed in *Koenenites*; but such features are now regarded to be important. The shell form indicates affinity to *Acanthoclymenia*. The suture shows, however, an intermediate state between that genus and *Nordiceras*, but having one more ventro-lateral lobe than *Acanthoclymenia* and one less than the type of *Nordiceras*. However, it clearly shows a gephuroceratacean suture with a large lateral saddle. Perhaps this provides an origin for the Nordiceratidae which has hitherto been problematical. Rather than burden the literature with yet another generic name, it is recommended that the new species be included in the genus *Nordiceras* at least until more information is known about this rare group.

Family Tornoceratidae.

Genus *TORNOCERAS* Hyatt (1884, p. 320).

Type species: by original designation, *Gon. uniangulare* Conrad.

Tornoceras sp. nov.

Plate 4A,B, Figure 3K.

Diagnosis: Differing from other described species of *Tornoceras* in the very broad lateral lobe (A) and the narrow, high and asymmetric latero-umbilical saddle.

Dimensions: BGS GSM 95228, D = 13.1; WH = 8.0; Wh = 4.3; WW = 6.2; WW/WH = 77%: D = 9.6; WH = 4.9; WW = 3.6.

Description: Shell form involute with closed umbilicus, laterally compressed with rounded venter. Whorl section ovoid with maximum width close to the umbilicus with flanks converging convexly to the venter. Impressed depth 54% at D = 13.1. Growth lines not seen. Suture forming a very small v-shaped ventral lobe passing to a depressed ventro-lateral saddle and very broad lateral lobe. Latero-umbilical saddle highly arched,

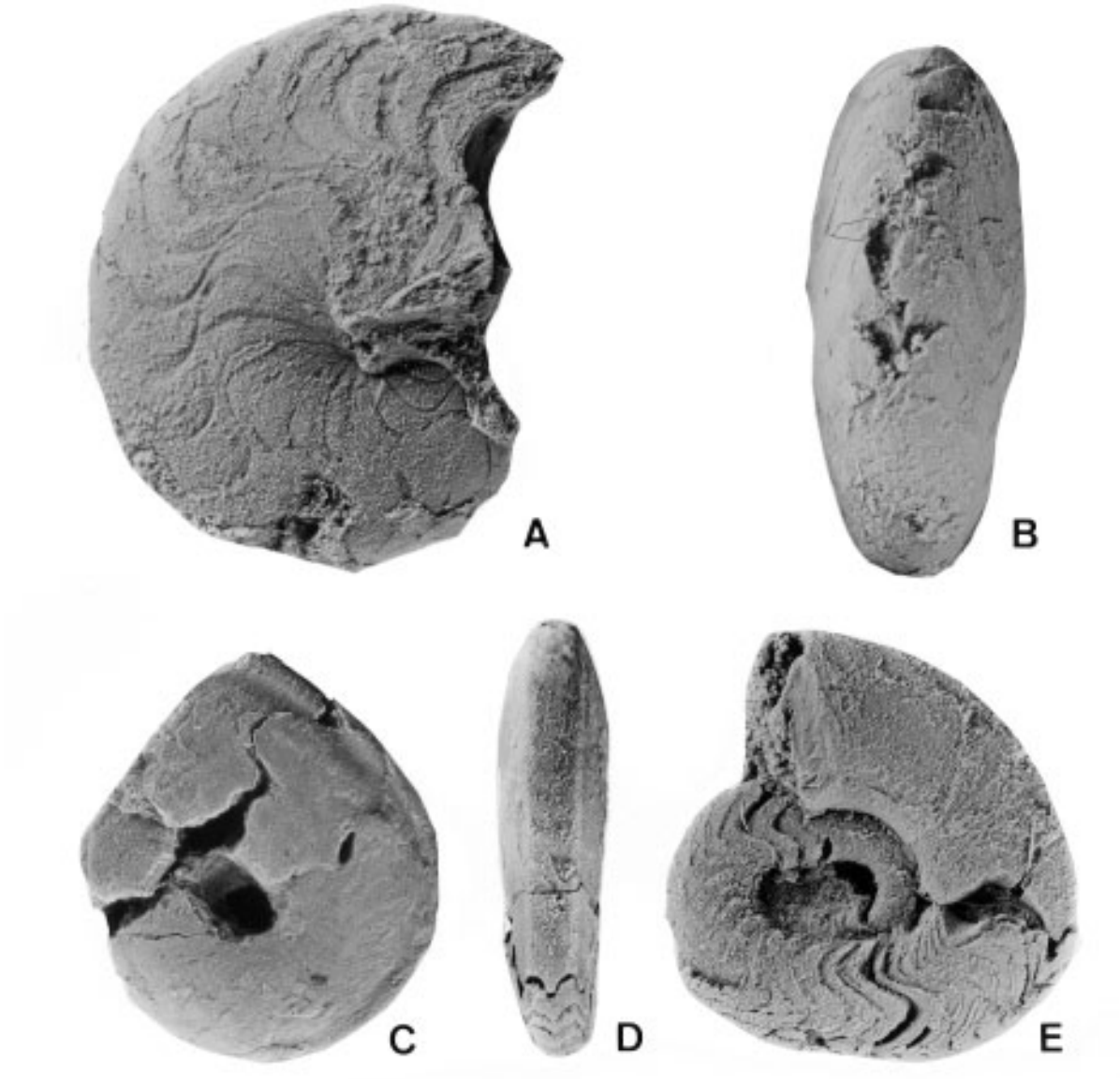

Plate 4. *Frasnian goniatites from Staverton Wood. All specimens collected by G.V. Middleton. A,B.* Tornoceras *sp. nov. Lateral and ventral views of BGS GSM 95228, x 4. C.* Nordiceras? middletoni *House sp. nov. Lateral view of the holotype, BGS GSM 95230, x 6. D,E.* Acanthoclymenia forcipiferum *(G. and F. Sandberger). Ventral and lateral views of BGS GSM 95229, x 2.*

asymmetrric and very short. Umbilical lobe (L) centred on the seam, arched subumbilical saddle and deep and rounded dorsal lobe.

Remarks: So short a latero-umbilical saddle is exceptional in *Tornoceras* although common in the rather homeomorphic *Holzapfeloceras* which differs in ontogeny and in having an open umbilicus.

Comments on the age of the Staverton Wood fauna

Acantho. forcipifera is recorded in the Frasnian as high as the Kellwasser Kalk and so assignment of this limited fauna, with two new forms, carries limitations. *Acanthoclymenia* commences in UD I-A, and the *Tornoceras*, being otherwise unknown, is unhelpful. If the assignment as a primitive *Nordiceras* is accepted, then this would suggest an age well before the advanced forms from the Timan which are thought to be of UD I-F to I-G age (Becker *et al.*, 2000; House *et al.*, 2000). Thus an age around UD I-C,D is possible. Gephuroceratids are common in shales below the inverted limestones between Galmpton Point and Brixham and one is figured here (Figure 2G) but that fauna, whilst showing abundant *Manticoceras* has nothing more precise to date it, although it would appear to correspond to levels early in the Frasnian shales of Saltern Cove.

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