

## DEVONIAN (GIVETIAN) GONIATITES FROM WOLBOROUGH, BARTON AND LUMMATON, SOUTH DEVON



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The locality of Wolborough, near Newton Abbot produced a rich Givetian fauna monographed by Phillips and Whidborne. The goniatite faunas and type material are revised herein and representatives of the genera *Agoniatites*, *Maenioceras*, *Sobolewia*, *Wedekindella*, *Foordites* and *Tornoceras* are described. The fauna belongs to the Middle Devonian *Maenioceras molarium* Zone or MD II-B. The later Givetian goniatite fauna from Lummaton and Barton, Torquay, is revised and representatives of the genera *Agoniatites*, *Maenioceras*, *Wedekindella* and *Tornoceras* are described. The fauna belongs to the Middle Devonian *Maenioceras terebratum* Zone or MD II-C. Some comments are made on related faunas elsewhere.

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### INTRODUCTION

The widespread distribution of Middle Devonian limestones and shallow-water facies in many areas of the world has meant that deeper-water and pelagic facies are generally poorly known internationally. Thus the Middle Givetian goniatite Zone of *Maenioceras molarium* is still best known from a single locality in South Devon, that at Wolborough, near Newton Abbot. Although originally described by Phillips (1841) and Whidborne (1892-1907) the goniatite faunas have not been systematically revised and many types have never been photographically illustrated. Part of the aim of this work is to remedy that situation. In addition, faunas of the later mid-Givetian Zone of *Maenioceras terebratum* from Barton and Lummaton are also considered allowing the documentation of the Devon material.

### Abbreviations

The following abbreviations are used for museum repositories throughout: BGS GSM, British Geological Survey, Geological Survey Museum, Keyworth; NHM, Natural History Museum, London; SM, Sedgwick Museum, Cambridge. 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; ratios are expressed as percentages. Measurements are in millimetres.

### WOLBOROUGH QUARRY

The quarry referred to in older literature as Wolborough is that now much degraded (SX 8522 7047) on the east side of the A381 due east of Wolborough church, on the southwest outskirts of Newton Abbot. The initial goniatite descriptions were by Phillips (1841): he used the name 'Newton Bushel' or 'Newton' for the locality. He states that the collection he described was that of Mr Austin (later famous under the name Godwin-Austin) then living at Ogwel House. Phillips described the following species as new: *Goniatites transitorius* (Phillips, 1841, p. 140, pl. 60, fig.

227) and *Gon. excavatus* (Phillips, 1841, p. 121, pl. 50, figs 232a,b, pl. 60, fig. 232).

Whidborne (1889) had much more material from Wolborough when he wrote that part of his monograph (Whidborne, 1888-1907) and this included material in the collections of the Torquay Museum, the Geological Survey, the Vicary collection and his own collecting. He described the following species as new: *Gon. obliquus* Whidborne (1889, p. 56, pl. 5, figs 1-3) *Gon. molarium* Whidborne (1889, p. 64, pl. 5, fig. 11), *Gon. psittacinus* Whidborne (1889, p. 29; 1889, p. 72, pl. 6, figs 9-13), *Gon. nuciformis* Whidborne (1889, p. 29; pl. 6, figs 7, 7a, 7b, pl. 7, figs 1, 1a) and *Goniatites bughesi* Whidborne (1890, p. 69, pl. 6, figs 2, 2a, 1, 1a). Foord and Crick (1897) undertook some revision of the goniatites, in particular naming two varieties of *Gon. molarium*, *apertum* and *intermedium*.

In the first edition of the Newton Abbot Memoir, Ussher (1903, p. 13, 21), described the locality, and gave the full list of the enormous fauna by then known from the quarry. He noted the many forms in common with Lummaton. The determinations were taken from the monographs of Phillips and especially Whidborne. Subsequently the only significant contribution was the naming of the characteristic fauna as the goniatite *molarium* Zone by House (1963, p. 5) and of the recognition that equivalents might be found in the record by Holzapfel (1895, p. 309) of *Maenoceras* [= *Maenioceras*] *excavatum* in the Lower Stringocephalen-schichten at Wildungen, and comparison with a fauna collected by House (1962, 1978) in the Appalachians near Hayter's Gap, Virginia.

The relations of the limestones in the quarry were discussed by Selwood *et al.* (1984, p. 49, 50) in the second edition of the Newton Abbot Memoir who suggest that the limestones are thrust over purple slates. Conodonts obtained by Selwood *et al.* (1984) from the foot of the massive limestones they refer as probably belonging to the conodont *varcus* Zone. As revised herein, the current goniatite faunal list comprises the following:

- Agoniatites transitorius* (Phillips)
- Agon. cf. transitorius* (Phillips)
- Agon. obliquus* (Whidborne)
- Agon. cf. costulatus* (d'Archiac and de Verneuil)
- Agon. sp.*
- Sobolewia nuciformis* (Whidborne)
- Sob. cf. cancellata* (d'Archiac and de Verneuil)
- Wedekindella psitticina* (Whidborne)
- Wedekindella sp. nov.*
- Maenioceras molarium molarium* (Whidborne)

<sup>1</sup> EDITORS NOTE: Sadly Professor House died on August 6th 2002.

- Maen. molarium apertum* (Foord and Crick)
- Maen. molarium intermedium* (Foord and Crick)
- Maen. molarium contractum* House n.subsp.
- Maen. aff. terebratum* (G. and F. Sandberger)
- Maen. aff. decheni* (Kayser)
- Maen. sp. juv.*
- Tornoceras* sp.

All specimens are preserved in coarse, crystallised limestone as internal moulds with no trace of shell.

*Systematic descriptions*

Family Agoniatitidae.

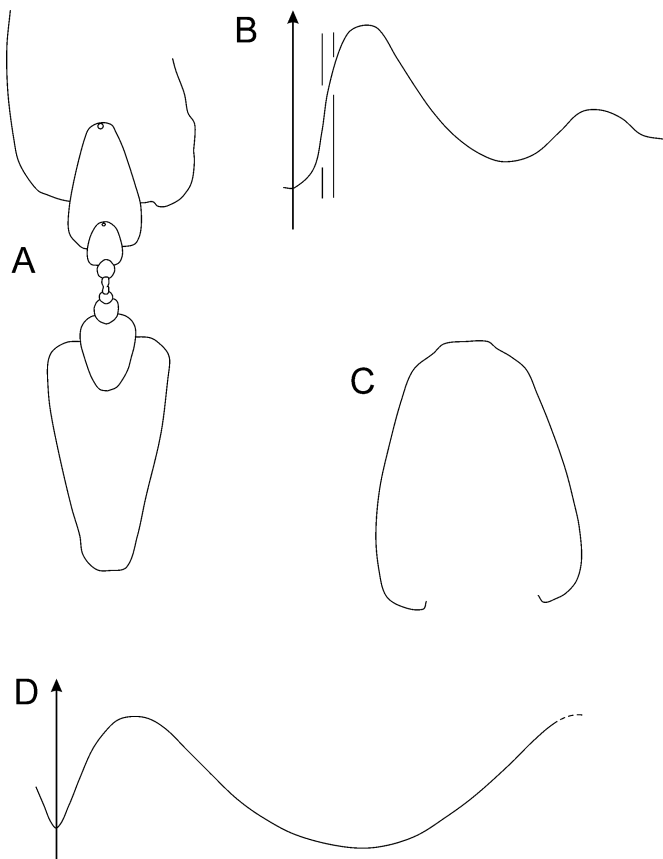
Genus *AGONIATITES* Meek, 1877.

*Type species: Goniatites vanuxemi* (Hall, 1879) by original designation.

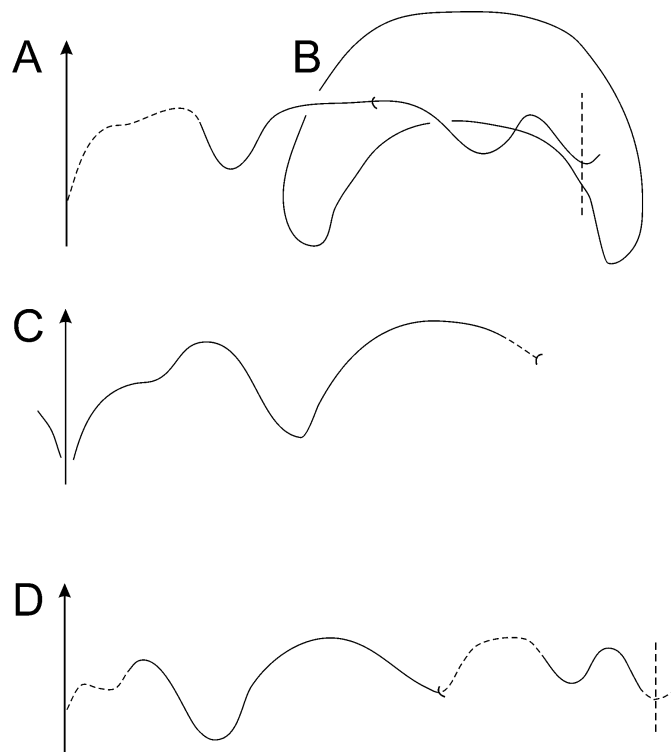
*Diagnosis:* Agoniatitids, laterally compressed in outer whorls, with ventro-lateral furrows. Inner whorls sometimes stout and ribbed. Open umbilicate, subevolute to subinvolute. Biconvex growth lines. Suture with ventral lateral and dorsal lobes, the last sometimes with a saddle. Sutural formula, ELI (or II).

*Agoniatites obliquus* (Whidborne, 1889, p. 56, pl. 5, fig. 3 (non 1,2)).

Plate 1D,G,H, Figure 1D.



**Figure 1.** Agoniatitids from Barton, Lummaton and Wolborough quarries. A. *Agoniatites cf. obliquus* (Whidborne). Cross section based on NHM C3793, from Barton Quarry, x 0.47. B,C. *Agoniatites fulgurialis* (Whidborne). Growth lines and whorl cross-section at 28 mm diameter, based on SM H4132 from Lummaton Quarry, B, x 2.9; C, x 2.5. D. *Agoniatites obliquus*. Suture slightly reconstructed based on the lectotype, BGS GSM 7114 from Wolborough Quarry, x 6.

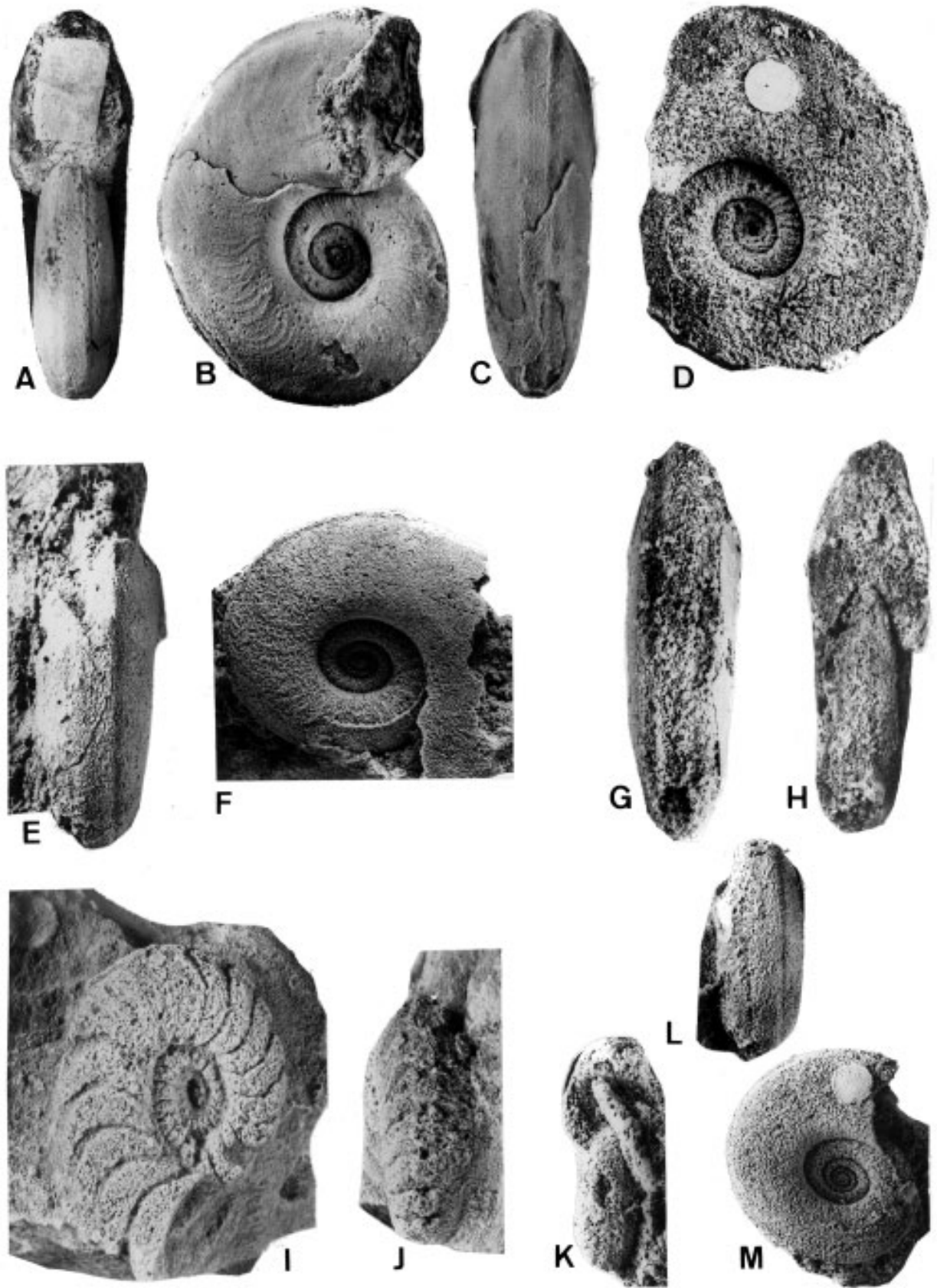


**Figure 2.** *Maenioceras* from Wolborough and Lummaton quarries. A,B. *Maenioceras molarium apertum* (Foord and Crick). Reversed suture and whorl section of the holotype; where dotted the specimen is abraded. BGS GSM 7112, x 2.6. C. *Maenioceras decheni* (Kayser). Suture based on a specimen from Lummaton Quarry, formerly in the Geology Department, University of Exeter collections, x 4.8. D. *Maenioceras aff. decheni* (Kayser), BGS 7117, x 2.2.

*Dimensions:* BGS GSM 7114, here designated lectotype: D = 35.0 (max.); WH = 15.5; WW = 10.8; UW = 10.0: D = 28.0; WH = 12.2; WW = c.7.8; UW 8.7.

*Description:* The lectotype is a poorly preserved internal mould in coarse crystalline limestone. Seen to be septate to D = 30.0. Shell form sub-evolute and discoidal. Whorl section with a flattened band on the venter (3.9 broad at D = 32) with furrows on either side. Impressed depth 29% at maximum diameter, lateral areas diverge from ventro-lateral furrows to a maximum width close to the umbilical shoulder. Inner whorls not clearly seen but more rotund in cross section. Ornamentation in the form of close-set, slightly backwardly-directed ribs over the umbilical shoulder in early whorls. In the outer whorls traces of growth lines are seen which slope forward on the outer flanks towards the ventro-lateral flanks, elsewhere not traced. Suture illustrated in Figure 1D; dorsal suture not seen.

*Remarks:* Other cotypes are not with certainty included in the species; they include NHM C1740 figured by Whidborne (1890, pl. 5, fig. 2). A specimen from Barton mentioned by Whidborne (1890, pl. 5, fig. 2) and Foord and Crick (1897 p. 375) is illustrated here (Figure 1A) and conforms to the species. The species is close to *Agon. fulgurialis* but significantly more compressed and it is much more slender than *Agon. vanuxemi*. Holzapfel (1895) treated both *fulgurialis* and *obliquus* as varieties of "*Gon. inconstans*" Phillips, but the name *inconstans* was invalid since it was a homonym for a species Phillips named earlier which is a Namurian *Reticuloceras* from near Exeter. Wedekind (1917) considered both as varieties of *Agon. oxynotus*. A statistical analysis of the Agoniatitidae is needed to advance the matter.



**Plate 1.** *Goniatites* from Lummaton and Wolborough. A-C. *Agoniatites fulgurialis* (Wbidborne). Two ventral views and a lateral view of the lectotype, from Lummaton Quarry, SM H4132, x 2. D, G, H. *Agoniatites obliquus* Wbidborne). Lateral and two ventral views of the lectotype, BGS GSM 7114, from Wolborough Quarry, x 2. E, F, I, J, K-M. *Agoniatites transitorius* (Phillips). E, F. Ventral and lateral views of the holotype figured by Phillips (1841), BGS GSM 7115, x 2. K-M. Ventral and lateral views of NHM c23707, x 2. All from Wolborough Quarry.

*Agoniatites transitorius* (Phillips, 1841, p. 140, fig. 227).

Plate 1 1E,F,I,J-M.

**Dimensions:** The holotype, BGS GSM 7115, D = c. 25.0; WW = c. 9.0; WH = c. 10.0; UW = c. 9.0. The specimen is preserved as a distorted, fully septate internal mould in coarse crystalline limestone.

**Description:** Shell form of the holotype sub-evolute, laterally compressed. Whorl section rounded, with traces of a ventral band and ventro-lateral furrows. Maximum whorl width  $\frac{2}{3}$  way across flanks towards the umbilicus. Umbilical shoulder rounded and wall steep. Slight impressed area. Suture with a very small v-shaped lateral lobe, a broad, rounded lateral lobe on the flanks with an umbilical saddle centred on the seam. Only the first part of dorsal lobe visible. No trace of ornament.

**Remarks:** In view of the poor state of the holotype it is necessary to follow Whidborne in defining the species taking into account the form of similar topotypes. These include NHM C23707 (figured Plate 1E,F) and NHM 36279 (Plate 1K-M). These show a quite comparable shell form and the ornament gives evidence of slight ribbing on the early whorls which forms a shallow lateral sinus. Other specimens (SM. A6793, Plate 2A, SM. H3405, 6) conform to the species. This species has less strong ornamentation than *Agon. costulatus* and differs from *Agon. obliquus* and *Agon. fulgurialis* by being more rotund at comparable diameters.

*Agoniatites* cf. *costulatus* (d'Archiac and de Verneuil, 1842, p. 341, pl. 26, figs 3,3a,3b).

**Remarks:** Some specimens of Whidborne (1890, pl. 5, figs, 5,5a, 6,6a,6b), although small, seem to show the characteristic ornament of d'Archiac & de Verneuil's specimen from Brilon, Germany. The figure of Whidborne (1890, pl. 6, fig. 8) seems not to be specifically assignable.

Family Holzapfeloceratidae.

Genus *WEDEKINDELLA* Schindewolf (1928, p. 311).

**Type species:** *Goniatites retrorsus* var. *brilonense* Kayser (1872, p. 664, pl. 25, figs 2a-e).

**Diagnosis:** Anarcestaceans with imperforate umbilicus, adult involute or subinvolute with biconvex growth lines. In some with periodic constrictions. Suture with a ventral lobe and a lateral lobe migrating in early ontogeny from an umbilical to a lateral position and with a dorsal lobe in which a dorsal saddle develops before maturity.

*Wedekindella psittacina* (Whidborne, 1889, p. 29; 1890, p. 72, pl. 6, figs 9-13).

Plate 2E-H, Figure 4B.

**Dimensions:** Of lectotype here designated, figures approximate: NMH C9010, D = 20.0; WH = 8.8; WW = 10.3; UW = 1.5; D = 14.4; WH = 8.3; WW = 9.5; UW = 1.2.

**Description:** The lectotype is involute, somewhat laterally compressed and ellipsiconic. Growth lines not seen. Suture with a small v-shaped ventral lobe, a shallow umbilico-lateral saddle and a median dorsal saddle within a wide dorsal lobe.

**Remarks:** There are numerous specimens from Wolborough which have been referred to *Gon. psittacinus* but the lectotype described above is one of the few to show the dorsal saddle and thus enable the form to be firmly referred to *Wedekindella*. The species is remarkable for its ellipsoidal form. Whidborne thought

Dimensions	D	WH	Wh	WW	UW	WW/D%
NHM C9023	16.7	7.8	3.3	12.0	1.8	72
NHM C9024	15.6	7.6	3.1	11.8	1.4	75.5
NHM C9025	11.7	5.7	2.8	8.6	c.1.0	73.5
NHM C9026	c.19.5	c.8.8	c.4.0	c.14.9	c.1.2	c.76.4
NHM C9027	10.6	4.8	2.6	8.5	c.0.9	80.0
NHM C9028	28.5	11.8	c.4.0	13.8	2.3	54
NHM C9029	21.7	12.3	4.6	14.5	c.2.0	67
NHM 36624	10.4	5.2	2.2	7.2	c.2.0	69

**Table 1.** Statistics of cotypes of *Sobolewia nuciformis* (Whidborne) based on specimens from Wolborough. Lectotype here chosen as NHM C9023. D, diameter; WH, whorl height; Wh, distance between the venter and the corresponding impressed depth; WW, whorl width; UW, umbilical width.

this shape original, and this view is supported by general rarity of such distortion at Wolborough and the absence of cracks or breaks on the lectotype. The absence of constrictions places it also in a special position and this it shares with *Wedekindella* n. sp. described below. The following are original cotypes: BGS GSM, 95337,8, 95426,7, NHM 36623, c1741, c1804, c15473,4,6, c9010,1, c9012,3,4, c9015,6,9, c9017,19,20-22. Most of the cotypes are not determinable generically, and one, NHM c5670, is here referred to *Tornoceras*.

*Wedekindella* n. sp.

Plate 2K,L, Figure 4A.

**Dimensions:** Of BGS GSM 7118: D = 15.8; WH = 9.0; Wh = 4.1; WW = c.8.7; UW = 1.0.

**Remarks:** This specimen differs from other non-constricted members of the genus in the subacute lateral lobe.

Family Sobolewiidae.

Genus *SOBOLEWIA* Wedekind 1913b.

**Type species:** *Goniatites cancellatus* d'Archiac and de Verneuil by monotypy.

**Diagnosis:** Anarcestaceans globular to slightly laterally compressed in form with small or closed umbilicus and convex growth lines or developing weak biconvexity in older specimens. Suture very simple with ventral lobe and linear to slightly lobate ventral suture with an umbilical lobe on the seam and a wide dorsal lobe. Formula E(A)LI.

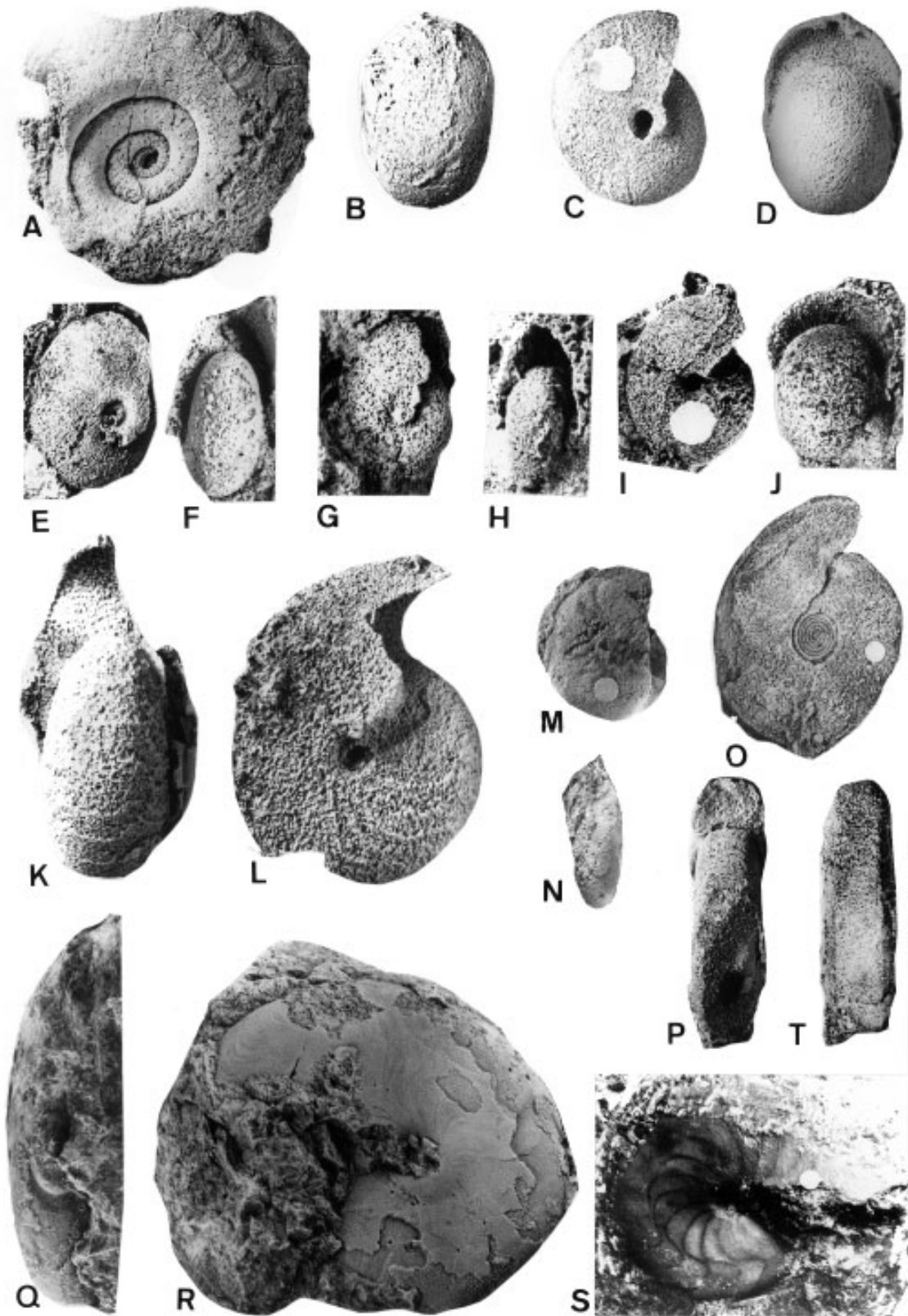
*Sobolewia nuciformis* (Whidborne, 1889, p. 29; 1890, p. 77, pl. 6, figs 7,7a,7b, pl. 7, fig. 1,1a.).

Plate 2B-D, I-J.

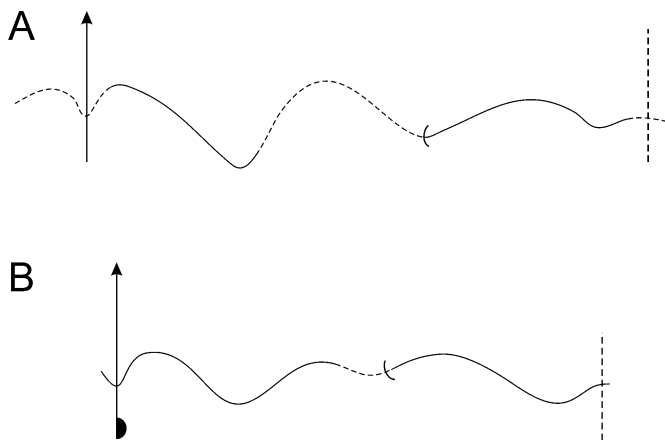
**Dimensions:** See Table 1.

**Description:** Based on NHM C9023, here selected as lectotype. Shell form involute, sub-globular. Whorl section crescentic, with a broad, rounded venter and ventro-lateral area. Whorl width closest to the umbilicus. Body chamber not seen. Suture with perhaps a small ventral lobe (Whidborne thought there was none but his draughtsman thought otherwise). Suture then passes almost radially to the umbilicus where it crosses the umbilical seam to form a very broad, rounded dorsal lobe. Septae 3.5 apart at the venter at D = 12.6.

**Remarks:** Differing from the genotype in being much more globular, also in not having a closed umbilicus. However, the drawing of d'Archiac and de Verneuil (1842) appears to show growth lines indicating a testate specimen. Their collection, seen in the L'École des Mines, Paris, did not contain a *Sobolewia*, but



**Plate 2.** *Goniatites* from Wolborough, Lummaton and Barton quarries. A. *Agoniatites* cf. *transitorius* (Phillips). Lateral view of SM A6793, x 1. B-D, I, J. *Sobolewia nuciformis* (Whidborne). B-D, Ventral, lateral and ventral views of NHM C9023, x 2. I, J, Lateral and ventral views of NHM C9024, x 2.1. All from Wolborough Quarry. E-H, *Wedekindella psittacinus* (Whidborne). E, F, Ventral and lateral views of a syntype, BGS GSM 95427, x 2. G, H, lateral and ventral views of a syntype, BGS 95426, x 1.1. All from Wolborough Quarry. K, L. *Wedekindella* sp. nov. Ventral and lateral views of BGS GSM 7118, x 4. from Wolborough Quarry. M, N. *Wedekindella brilonense aratum* (Whidborne). Lateral and ventral views of NHM C1802 from Barton Quarry, x 1. O, P, T. *Maenioceras molarium molarium* (Whidborne). Lateral and ventral views of the lectotype from Wolborough, NHM C1803a, x 1. Q, R. *Wedekindella brilonense brilonense* (Kayser). Ventral and lateral views of a specimen labelled as from "Newton Busbel", BGS GSM 86992, x 2. S. *Tornoceras hughesi* (Whidborne). The lectotype from Lummaton Quarry, NHM C1528, x 1.



**Figure 3.** *Wedekindella* from Wolborough Quarry. A. *Wedekindella* n. sp. Suture of BGS GSM 7118, x 2.9. B. *Wed. psittacina* (Whidborne). Reversed suture of NHM c9010 at D = 20, x 3.1.

the other material showed that their diagrams were largely reconstructions. Schmidt (1951) showed that *Sob. rotella* and *Sob. denckmanni* develop biconvex growth lines in later whorls. A close analogue, in shell form, is *Sob. virginiana* House (1962), but that is a larger form.

*Sobolewia* cf. *cancellata* (d'Archiac and de Verneuil, 1842, p. 339, pl. 25, figs 6,6a,6b).

**Dimensions:** NHM C15476, D = 14.6; WW = c.8.4; WH = 8.5; Wh = 3.1.

**Description:** Shell form involute, periphery well rounded, with apparently closed umbilicus. Septate up to last half whorl. Traces of suture indicate a small v-shaped ventral lobe and a broad, flat only slightly concave lateral lobe.

**Remarks:** A single specimen among the cotypes of *Sob. nuciforme* is more laterally compressed and has a closed umbilicus and thus conforms to the genotype.

Family Maenioceratidae.

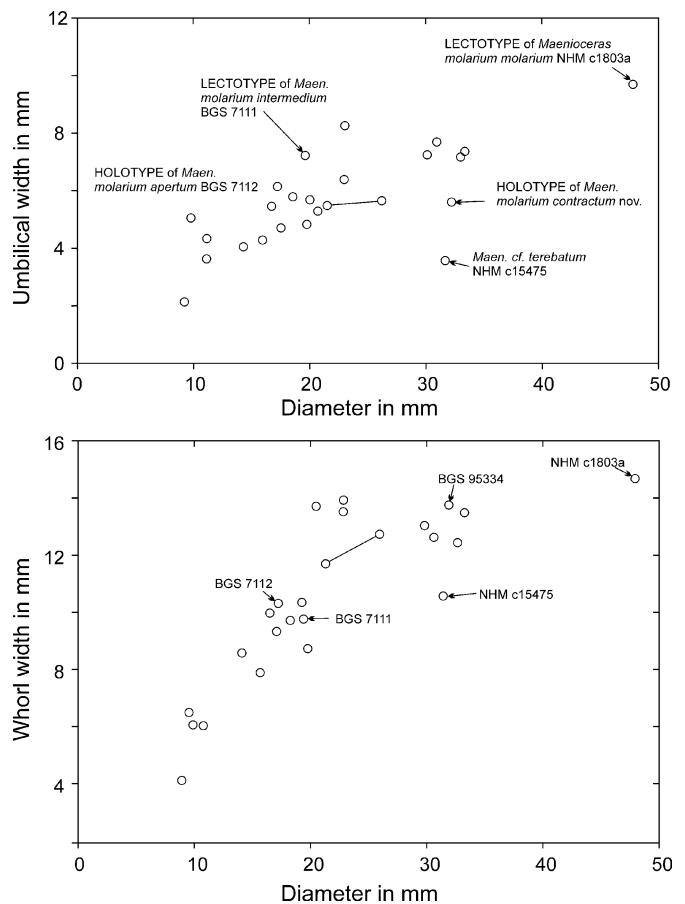
Genus *MAENIOCERAS* Schindewolf (1933, p. 104).

**Type species:** *Gon. terebratus* G. and F. Sandberger (1850, p. 99, pl. 5, figs 3a-d).

**Diagnosis:** Anarcestaceans with subevolute to involute shell. Typically with ventro-lateral furrows and platyconic. Growth lines biconvex with prominent lappets. Early lateral lobe migrates laterally to adult position and adventitious lobes develop in the ventral lobe and umbilical lobes develop in the dorsal lobe during ontogeny. Sutural formula: EmE1L U1U2(U3)I.

*Maenioceras molarium* (Whidborne, 1890).

The maenioceratids from Wolborough form a variable suite ranging from a wide open umbilicate to an almost closed umbilicus. Phillips (1841, p. 121) named some as *Gon. excavatus*, but five years earlier he had given that name to a Carboniferous form. Whidborne therefore erected the name *molarium* and referred to the specimen figured by Phillips (NHM C1803a) as the type specimens (Whidborne, 1890, p. 65) thus establishing a lectotype. Two species were named by Foord and Crick (1897, p. 125-7) from the known material and these are considered subspecies here, and another, *contractum*, is here added. The statistical summary (Figure 4) suggests a continuous range of variation in the shell form among the Wolborough specimens of *Maenioceras* but to clarify the taxonomy, the separate type material is treated individually. Unfortunately there is no stratigraphic sequence



**Figure 4.** Diagram showing statistical data and variation in the *Maenioceras molarium* (Wedekind) Group. All specimens are from Wolborough Quarry, Newton Abbot, South Devon.

for the Wolborough taxa but that may be found elsewhere.

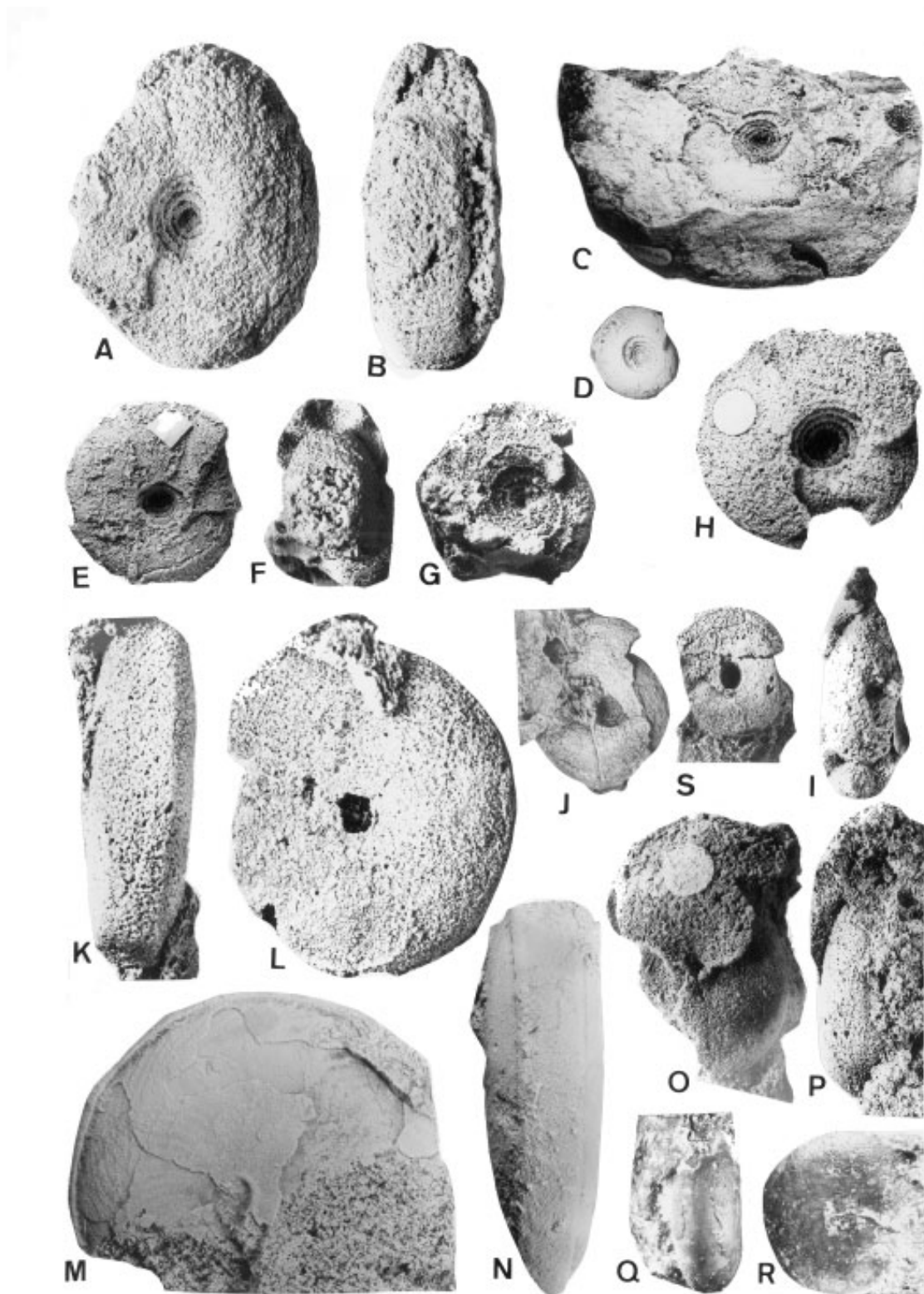
*Maenioceras molarium molarium* (Whidborne, 1890, p. 64, pro Phillips, 1841, p. 121, pl. 50, figs 232a,b).

Plate 3A-C,E, Figure 4.

**Dimensions:** Lectotype, NHM C1803a, selected by Whidborne (1890, p. 64): D = 49 max.; D = 38.7; WW = 14.6; UW = 9.7.

**Description:** Shell form subinvolute and markedly flat-sided. Umbilicus opening regularly. Whorl section almost quadrangular with parallel sides and flattened band on the venter (8.9 at D = 49). Maximum WW is reached 1/2 way across flanks and sides then become parallel up to the low umbilical walls. Sutures and growth lines not seen.

**Remarks:** A sequence of transitional specimens can be arranged between the subspecies here described. The lectotype is the largest specimens known and it is not easy to determine the relation to smaller material. However, in *molarium molarium* the umbilicus opens regularly and the flanks are parallel for at least 50% of their height above D = 18. In *molarium intermedium*, the whorl section is more rounded and the umbilical width tends to expand outwards. In *molarium apertum* the whorl section is very depressed and trapezoidal in outline. In *molarium contractum* (n. ssp.) the umbilical is almost closed and the form described here as *Maen. cf. terebratum* shows almost complete closure and a whorl form very close to that species. Whether these subspecies have time significance has still to be determined. The Lectotype is also figured by Becker and House (1994, pl. 6, figs 21-23).



**Plate 3.** *Goniatites* from Wolborough, Lummaton. A-C, E. *Maenioceras molarium molarium* (Whidborne). A, B, Lateral and ventral views of a syntype, BGS GSM 95333, x 2. C, Lateral view based on BGS GSM 95330, x 1.05. E, Lateral view of NHM C40311, x 1. All specimens from Wolborough Quarry. D. *Maenioceras* sp. juv. from Wolborough, BGS GSM 95341 x 1.9. F, G. *Maenioceras molarium apertum* (Whidborne), holotype from Wolborough of the subspecies from Wolborough, BGS GSM 7112, x 2. H, I. *Maenioceras molarium intermedium* (Foord and Crick). Lateral and ventral views of a syntype from Wolborough, NHM C30306b, x 2. J, S. *Maenioceras molarium contractum* House n. ssp. From Wolborough. J, Lateral view of BGS 95332, x 1. S, Lateral view of the holotype, BGS GSM 95334, x 1. K, L. *Maenioceras* cf. *terebratum* (G. and F. Sandberger). Ventral and lateral views of NHM C15475, from Wolborough, x 2. M, N. *Maenioceras terebratum* (G. and F. Sandberger). Lateral and ventral views of a specimen from Lummaton Quarry, formerly in the Geology Department, University of Exeter collections, BGS GSM 87235, x 2. O, P. *Maenioceras* aff. *decheni* (Kayser). Lateral and ventral views of BGS GSM 7117 from Wolborough Quarry, x. 2. Q, R. *Maenioceras decheni* (Kayser). Ventral and lateral views of a specimen from Lummaton Quarry, formerly in the Geology Department, University of Exeter collections, BGS GSM, 9724 x 2.

*Maenioceras molarium apertum* (Foord and Crick, 1897, p. 126, fig. 59, pro Whidborne, 1890, pl. 5, figs 12,12a,b).

Plate 3F,G, Figures 2A,B.

*Dimensions:* The holotype, BGS GSM 7112, D = c.17.2; WH = 6.0; UW = 10.3; UW = 6.0; Wh = 3.3.

*Description:* The holotype, and only specimen referred here, is subevolute, trochoidal, with a wide regularly opening umbilicus. Whorl section trapezoidal, with a broad ventral band (5.0 broad at D = 17.2) and with convex ventro-lateral area sloping out to a maximum whorl width close to the umbilicus (Figure 2B). Umbilical shoulder well rounded and wall very short. Suture shows a poorly preserved ventral lobe and traces of a shallow adventitious lobe towards the ventro-lateral saddle. Lateral lobe linguiform and subangular. Slight trace only of an umbilical lobe (U1). Dorsal elements reflect ventral suture with rounded subumbilical and median dorsal lobes.

*Maenioceras molarium intermedium* (Foord and Crick, 1897, p. 125).

Plate 3H,I.

*Dimensions:* NHM 30306b, here selected lectotype: D = 18.4; WH = 8.2; WW = 9.8; UW 5.8. BGS GSM 7111 and NHM C30306c are also cotypes.

*Description:* Based on the cotypes. Shell form subinvolute to subevolute, trochoidal with an open umbilicus expanding slightly outwards. Whorl section rounded in outer whorls with trace of flattened ventral band (4.5 at D = 19.5 on BGS 7111). Ventro-lateral areas convex with flanks flat towards the umbilical shoulder. The inner whorls are probably more depressed and reniform in cross section.

*Maenioceras molarium contractum* House n. subsp.

Plate 3J,S.

*Diagnosis:* Distinguished from other subspecies by the umbilicus which tends to be cylindrical or contracting in the later whorls rather than expanding.

*Name:* To draw attention to the distinctive umbilicus.

*Dimensions:* The holotype, BGS GSM 95334: D = 32.2; WH = 13.5; WW = 13.8; UW = 5.6. Paratype, BGS 95331: D = c.17.3; WH = 6.0; WW = c.9.3; UW = 4.7.

*Description:* Shell form involute, laterally compressed with parallel sides and flattened venter. Umbilicus open, expanding in early whorls, later contracting relatively or actually. Whorl section compressed, ventral band slightly convex, ventro-lateral shoulder convex, sloping to a maximum width on parallel flanks which continue to the abrupt umbilical shoulder.

*Remarks:* This subspecies represents a stage towards *Maen. terebratum* or the similar but more slender *Maen. tenuis* (Holzapfel, 1895, pl. 6, figs 8,8a, refigured Becker and House, 1994, pl. 6, figs 14,15) which may best be regarded as a subspecies of *Maen. terebratum*.

*Maenioceras cf. terebratum* (G. and F. Sandberger, 1850, p. 99, pl. 5, figs. 3a-d).

Plate 3K,L.

*Dimensions:* NHM C15475: D = 31.5, WH = 15.0; WW = c.11.7; UW = c. 3.6.

*Remarks:* This is the only specimen in the large Wolborough fauna approaching *Maen. terebratum*, the name fossil of the overlying *terebratum* Zone. The lectotype for the Sandberger brothers species was refigured and selected by Becker and House (1994, pl. 6, fig. 16).

*Maenioceras aff. decheni* (Kayser, 1872, p. 665, pl. 26, figs 1a-d).

Plate 3O,P, Figure 2D.

*Dimensions:* BGS GSM 7117: D = 24.5; WH = 12.2; WW = c.12.5; UW = c.12.5; UW = c.1.2: WW = 10.3; WW = c.10.5; Wh = 4.9.

*Description:* The shell form of BGS GSM 7117 is involute, rotund and rather compressed. Umbilicus probably closed in the shell (open in the mould). Whorl section ovate, widest midway across the flanks. Impressed depth about 50%. Venter well-rounded with no trace of ventro-lateral grooves. Inner whorls almost globular. Suture shows a trace of a v-shaped ventral lobe with an adventitious lobe formed on the ventral part of the ventro-lateral saddle. Lateral lobe spatulate, subangular. Latero-umbilical saddle arched. Dorsal suture with rounded subumbilical and median dorsal lobes.

*Remarks:* Whidborne (1890, p. 77) was at a loss to name this specimen, but the dorsal suture is identical with that figured by the Sandbergers among the cotypes of *Maen. terebratum*. The specimen differs from *Maen. decheni* and from Lummaton specimens of that species in having a more ovate whorl section which is not flat sided and a less angular later lobe. It probably deserves a new specific name.

Family Tornoceratidae.

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

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

*Tornoceras* sp.

A single specimen, NHM c5670, an unfigured cotype of *Wed. psittacinum* (Whidborne) is referred here.

### Comments on the Wolborough fauna

The abundant and varied Wolborough fauna is especially distinctive because of the abundance of forms related to *Maenioceras molarium*. Formerly the Middle Devonian *Maenioceras* Stufe was taken to correspond to the Givetian stage. New definition of stage boundaries has changed this. The Middle/Upper Devonian boundary was taken at a much higher level when revised by the IUGS (Klapper *et al.*, 1987; House *et al.*, 2000) when a Global Stratigraphic Section and Point (GSSP) was chosen at Puech de la Suque, in the Montagne Noire, southern France. This change meant that most of the faunas with *Pharciceras*, formerly taken by goniatite workers as Upper Devonian I of Wedekind (1913a, 1917) became Middle Devonian in age, and House (1985) termed the Givetian faunas the *Pharciceras* Stufe and this became the upper generic division of the Givetian (MD III of Becker and House, 2000). Much work for the definition of the Eifelian/Givetian boundary led to a new definition based on a GSSP at Mech Irdane, Morocco (Walliser *et al.*, 1995; Walliser, 2000) where it was shown that *Maenioceras cf. koeneni* (Frech) occurs just below the new base of the Givetian. Thus the base of the *Maenioceras* Stufe (MD II of Becker and House, 2000) lies fractionally below the GSSP level. The early maenioceratid faunas are included in a Zone of *Maenioceras undulatum* (Roemer, 1850). The Wolborough faunas represent the best development of the overlying Zone of

*Maenioceras molarium*. The relations with the overlying Zone of *Maenioceras terebratum* will be discussed in the next section.

The data of Phillips (1841) and Whidborne (1890) enabled Holzapfel (1895, p. 309) to recognise "*Maen. excavatus*" (= *Maen. molarium*) in the Lower Stringocephalenschichten at Wildungen, Germany. House (1962) recognised *Maen. sp.* as an open umbilicate form from the Millboro Shale north of Hayter's Gap, Virginia where *Sobolewia virginiana* also occurred which is similar to, but larger than, the Wolborough *Sob. nuciformis*. Later that maenioceratid was referred to *Maen. cf. molarium* (House, 1978, p. 9) and named as Appalachian Fauna 9. As shown in the review of Becker and House (2000, p. 124), the Molarium Zone may also be recognised in Morocco, possibly Bolivia, and possibly the northern Timan, Russia. It is a zone very poorly known internationally in comparison to other Devonian ammonoid zones.

## LUMMATON

Lummaton Quarry (SX 914665), near St. Mary Church, Torquay, was the source for goniatites described by Whidborne (1889, 1890). The local geology was described, and a long list of the fossils given by Ussher (1903, p. 65-68), in the first edition of the Torquay Memoir, and a revised account appeared in the second edition (Lloyd, 1933, p. 75). Whidborne described the following goniatites from Lummaton: *Gon. fulguralis* Whidborne (1889, p. 59, pl. 5, figs 4,4a), *Gon. hughesi* Whidborne (1889, p. 69, pl. 5, fig. 1 non 2,3). Later Foord and Crick (1897, p. 120) named *Torn. whidbornei* for a specimen figured by Whidborne (1890 pl. 6, fig. 3).

This century, in the 1950's, a collection of over a dozen *Tornoceras* was made by Prof. J.E. Prentice, but there was nothing new. During 1957/8, however, a singularly important collection was assembled by Mr A. Vincent of the then Geology Department, University of Exeter which included *Agoniatites cf. costulatus*, *Maen. terebratum*, *Maen. decheni*, *Tornoceras sp.* which were reported by House (1959, 1963, p. 6). Collecting by Dr E.B. Selwood yielded additional material and the conclusion that the faunas probably come from black bituminous limestones associated with, but not actually from, the actual Lummaton Shell Bed (Selwood, 1966). This level is still exposed at the south end of the quarries although the quarry floor has been used as an infill site. Matthews (1970) studied the conodont fauna of this level and concluded that it belongs to the *varcus* Zone and the occurrence of *Polygnathus linguiformis linguiformis zeta* has been taken to indicate the Middle or Upper *varcus* Zone age (Scrutton, 1978, p. 40). The following goniatites have been recognised at Lummaton:

*Agoniatites fulguralis* (Whidborne)  
*Agoniatites cf. costulatus* (d'Archiac and de Verneuil)  
*Maenioceras terebratum* (G. and F. Sandberger)  
*Maenioceras decheni* (Kayser)  
*Maen. cf. decheni* (Kayser)  
*Tornoceras hughesi* (Whidborne)

These faunas differ from those of Wolborough in preserving the shell, albeit much recrystallised, and thus showing the external ornament. As a result the sutures are poorly shown.

### Systematic descriptions

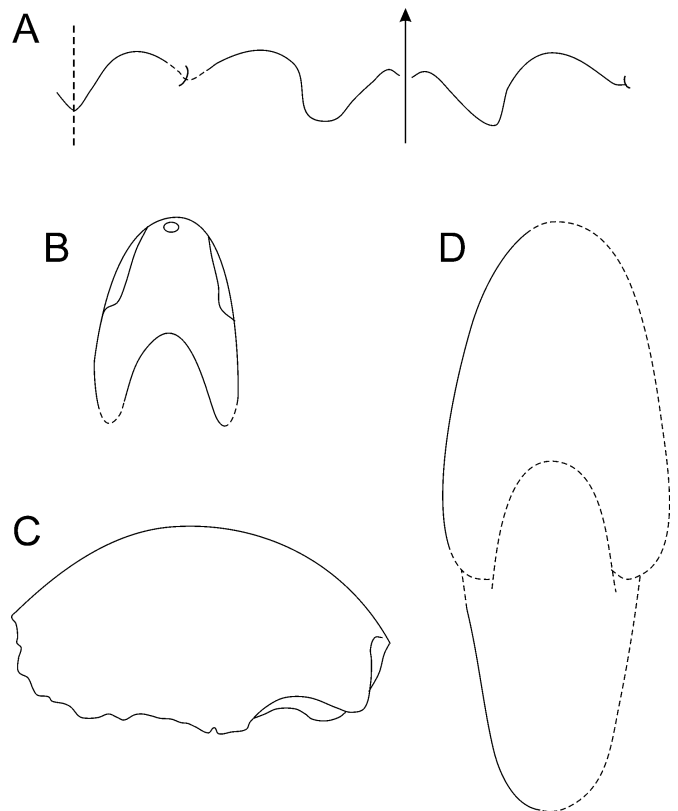
Family Agoniatitidae.

Genus AGONIATITES.

See details above.

*Agoniatites fulguralis* (Whidborne, 1889, p. 59, p. 5, figs 4,4a).

Plate 1A-C, Figures 1B,C.



**Figure 5.** *Tornoceras hughesi* (Whidborne). A-D. *Tornoceras hughesi* (Whidborne). A. Suture, B. Cross-section, C. Lateral view of part of the body chamber, all based a specimen collected by J.E. Prentice from a block though to come from above the stromatoporoid limestone at Lummaton Quarry, King's College Collection KC r375, x 0.72. D. Outline based on a cotype from Lummaton Quarry, SM H1433, x 0.71.

**Dimensions:** All based on the lectotype, here designated, SM H4132. Dmax = 33.0. D = 32.6; WH = 15.0; WW = 10.8; UW = 9.8 (internal mould). D = 22.0; WH = 9.6; WW = 9.3; UW 6.6 (testate). D = c.15.0; WH = 6.2; WW = 6.3; UW = 4.8 (testate).

**Description:** Shell subevolute and subdiscoidal, open umbilicate. Whorl section with flattened ventral band (2.6 at D = 22) bounded by slight ventro-lateral furrows. Lateral areas slope convexly out to a maximum width close to the umbilicus. Umbilical shoulder rounded and wall steep. Moderate impressed area. Whorl height exceeds width above D = 17. Growth lines form fine biconvex lirae 1 mm apart at D = 25. They pass forward from the umbilicus to form a salient just beyond the umbilical shoulder and curve sharply forward to a marked projecting salient near the ventro-lateral shoulder and return to a very deep linguiform ventral sinus. The septate portion of the holotype is testate so the suture is not seen.

**Remarks:** Only two specimens were known to Whidborne. The second specimen, NHM 23707, is a poor polished specimen which cannot be referred here with certainty. No other material is available.

Family Maenioceratidae.

Genus *Maenioceras* see comments above.

*Maenioceras terebratum* (G. and F. Sandberger, 1850, p. 99, pl. 5, figs 3a-d).

Plate 3 M,N.

**Dimensions:** Specimens formerly in the Geology Department, University of Exeter and now in the BGS GSM collections. (i) GSM 87235 (figured House, 1963, pl. 2, figs h,i.), D = 41; WH = 23.8; Wh = 12.2; WW = 13.0; UW = 2.1. (ii) GSM 87236, D = 22.5; WH = 12.4; Wh = 6.0; WW = 8.0; UW = 1.7. (iii) GSM 87237, D = 20.5; WH = 10.0; WW = 8.7; UW = 2.8. (iv) GSM 97238 D = 25.0; WW = 9.7.

**Description:** Shell form involute with small open umbilicus, laterally compressed with flattened venter and parallel sides. Whorl section shows a flat, raised, ventral band, 6.0 wide at D = 31 (i) with ventro-lateral furrows on each side. Growth lines pass forward across the umbilical shoulder to form a salient on the inner flanks and an angular sinus  $\frac{2}{3}$  the way across the flanks; they then sweep well forward to form a projecting salient in the ventro-lateral furrow; course over the venter not seen. Sutures not seen.

**Remarks:** A lectotype for *Maen. terebratum* was selected and figured by Becker and House (1994, pl. 6, fig. 16). The original cotypes in the Wiesbaden Museum leave much to be desired, the larger specimen is abraded and the smaller one shows no ornament, but did enable the Sandberger brothers to reconstruct a suture. However, the Lummaton material agrees well with specimens referred here from the Rhenish Schiefergebirge and Morocco.

*Maeneceras decheni* (Kayser, 1872, p. 665, pl. 26, figs 1a-d).

Plate 3Q,R, Figure 2C.

**Dimensions:** Two specimens now in the BGS GSM from the Geology Department, University of Exeter. (i) GSM 87243, D = c.19.0; WH = 9.5; WW = 8.2; UW = ?1.0. (ii) GSM 87244, D = 15.0; WH = 8.4; WW = c.6.8.

**Description:** Shell form involute, laterally compressed with rather flat sides, with well-rounded venter and almost closed umbilicus. Whorl section widest close to the umbilicus and flanks convexly converging towards the rounded venter. Growth lines not seen. Suture with v-shaped ventral lobe, adventitious lobe on the ventral slope of the ventro-lateral saddle, angular ventral lobe and arched umbilico-lateral saddle. Dorsal suture not seen.

**Remarks:** The figured specimen agrees well with Kayser's figures, but the other specimens, compared with the species, shows a depressed conical depression at the umbilicus.

Family Tornoceratidae.

Genus *Tornoceras*.

See comments above.

*Tornoceras hughesi* (Whidborne, 1889, p. 29, 1890, p. 67, pl. 6, figs 2,2a).

Plate 2S, Figure 5A-D.

**Dimensions:** The lectotype type, NHM C1528a, D = 55, WH = c.35; WW = c.18; UW = 0. SM H 4135, D = KC r375, WH = c.30.5; WW = c.32; UW = 0. KC r377, D = 63; WH = 37.5. KC r380, D = 62, WH 37.5, WW = c.20.

**Description:** Shell form completely involute, laterally compressed. Whorl section ovate, with widest width close to the umbilicus. Lateral areas sloping convexly towards the well-rounded venter. Growth lines poorly seen, apparently passing radially out from the umbilicus to the ventro-lateral area where they sweep forward to a slight salient and back to a sinus on the venter. Dorsal wrinkle layer seen in some specimens sloping backward from the umbilicus at a low angle. Suture forms a small

v-shaped ventral lobe passing almost directly to a deep, rather narrow, well-rounded lateral asymmetric lobe. Latero-umbilical saddle highly arched, the ventral slope almost concentric to the umbilicus. Dorsal suture with a median lobe. The holotype has seven chambers in the last half whorl.

**Remarks:** When Whidborne described this species he included within it forms with less undulating sutures and more prominent wrinkle layer epidermids which Foord and Crick (1897) later separated as *Torn. whidbornei*. They expressly excluded from their synonymy a larger specimen figured by Whidborne (1890, pl. 6, figs 1,1a), SM H1433 (Figure 5D), but that does appear to conform to the species. Figures 5A-C are based on a topotype of *Torn. hughesi* collected by J.E. Prentice which has the following sutural statistics: Lh/Lw = 50%, Al/Lw = 50%. The holotype of *Torn. whidbornei* (Foord and Crick, 1897, p. 120) yields the following sutural statistics: Lh/Lw = 50%; Al/Lw = 43%. This does not seem adequate to separate it from *Torn. hughesi* and it is regarded as a junior synonym.

### Comments on the age of the Lummaton fauna

The careful analysis of the conodonts of Lummaton Quarry by Castle (1985, p. 26) indicates the presence of Lower and Middle *varcus* Zone faunas, but only the latter in the region where the goniatites are known (Castle's localities 11 and 12), confirming the dating of Matthews (1970). The critical *Maenioceras terebratum* is the guide to Middle Devonian MD II-C in the terminology of Becker and House (1994, 2000). More precision on the range of the genus *Maenioceras* has been given by work in Morocco, where late Eifelian forms are recognised (Becker and House, 1994; Walliser *et al.*, 1995), but those and the fauna of the *molarium* Zone are clearly different from the Lummaton fauna. The genus *Afromaenioceras*, elaborates above the *terebratum* Zone, in MD II-D, and that genus is not known at Lummaton. Thus the level is that of the *terebratum* Zone ss. Abousalam and Becker (2001, p. 95) report *Maenioceras* as co-occurring with *Pharciceras*, the guide to the overlying division, MD III, apparently at a yet higher level.

### BARTON

Around the village of Barton, one mile north-west of St. Mary Church, Torquay, Devonian limestones crop out as a small inlier surrounded by Permian rocks. The famous quarry at Barton (SX 913671), Torquay, has produced a limited goniatite fauna. Whidborne described *Goniatites aratus* (1889, p. 29; 1889, p. 66, pl. 6, 16, 16a) from here and illustrated a large specimen under the name *Goniatites obliquus* (Whidborne, 1890, p. 5, fig. 2). Also a specimen now thought to be a *Tornoceras* (Whidborne, 1890, pl. 6, fig. 17). The goniatite fauna known comprises the following:

*Wedekindella brilonense* (Kayser) *arata* (Whidborne)  
*Agoniatites* cf. *obliquus* (Whidborne)  
? *Tornoceras* sp.

The quarry was briefly discussed by Ussher (1913, p. 44) and in more detail by Scrutton (1978, p. 40). Castle (1985) analysed the conodont succession and demonstrated that it carried across the Givetian/Frasnian boundary. The site is now built upon and there are few accessible exposures. In view of the conodont zonal range demonstrated by Castle (1985) and the fact that no new material is available the biostratigraphic contribution here by goniatites is minimal.

Systematic descriptions

Genus *AGONIATITES*.

See details above.

*Agoniatites cf. obliquus* (Whidborne).

Figure 1A.

*Dimensions:* NHM C3793, D = 110; WW = 29; WH = 56; Wh = 44; UW = 22.

*Remarks:* This large specimen was mentioned by Whidborne. It shows inner whorls that are comparable with *Agon. obliquus*. It shows that the later whorls may approach oxyconic form but that the venter is not acute, and comparisons with *Agon. oxynotus* by Wedekind (1917) are not supported.

*Wedekindella brilonense* (Kayser) *aratum* (Whidborne, 1889, p. 29, 1890, p. 66, pl. 6, figs 16, 16a).

Plate 2M,N.

*Dimensions:* Lectotype, here designated, NHM C1802, D = 25.3; WH = 12.7; WW = ?10.0; UW = c.2.5. Cotype NHM C48908, D = 15.2; WH = 9.0, = WW = 8.0; UW = c.1.0.

*Description:* Shell form involute, laterally compressed. Flanks flat and parallel-sided with maximum width close to the umbilicus. Venter well-rounded. Umbilicus probably closed in the adult. Constrictions number five per whorl (NHM C1802) and form a slight salient close to the umbilical shoulder, a shallow sinus on the flanks, a rather pointed ventro-lateral salient and a deep and rounded median ventral sinus.

*Remarks:* The validity of separating this form even as a subspecies may be questioned. Whidborne compared his specimens with the figures of Kayser (1872, p. 664, pl. 25, figs 2a-c). The umbilical shoulder of *Wed. brilonense*, as figured by Kayser, projects more than in the Devon specimens, but this may be due to the fact that the shell is better preserved. As for the number of constrictions, Kayser's figure suggests there are five, but their separation suggests there are six in the outer whorl. But other experience of the species indicates this is variable. Foord and Crick (1897, p. 117) referred *aratum* to *Tornoceras*, but the ontogeny, known from Schindewolf (1933, p. 101) and material from Cornwall, shows a quite different development. Both cotypes were collected by J.E. Lee. Noticeably, the *Wedekindella* material from the earlier level at Wolborough shows no constrictions.

### Comments on the age of the Barton fauna

This limited fauna is referred to the Middle Devonian Terebratum Zone, MD II-C, the level to which *Wedekindella brilonense* is restricted. But the conodont evidence (Castle, 1985) indicates that the wide range of strata formerly exposed at Barton ranges from the Middle or Lower *varcus* to the Lower *asymmetricus* conodont Zone. So the Middle/Upper Devonian boundary falls within the sequence (House *et al.*, 2000).

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