UPPERMOST ORDOVICIAN TO LOWER SILURIAN GRAPTOLITE BIOSTRATIGRAPHY OF THE WYE VALLEY, CENTRAL WALES

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ABSTRACT. The graptolite biostratigraphy of the *persculptus* to *magnus* Biozone interval (upper Hirnantian to lower Aeronian) in the Wye valley near Rhayader, central Wales, is described. Possible refinements to the graptolite zonal scheme are indicated, including informal subdivisions of the *acuminatus* and *acinaces* Biozones. Quantitative faunal assessment indicates that diplograptid:monograptid ratios are useful in indicating stratigraphical level. Selected taxa are described, including three new species, *Normalograptus? wyensis*, *Pseudoglyptograptus barriei* and '*Orthograptus*' *cabanensis*.

THE upper Hirnantian to lower Aeronian sequence of central Wales is rich in graptolites, having been laid down in predominantly anoxic, benthos-free bottom conditions. Turbidites, mostly mud-dominated, are interspersed with graptolite-bearing laminated hemipelagic deposits (Cave 1979). The biostratigraphy of the sequence was studied in the early part of this century, by H. Lapworth (1900), Jones (1909), and Davies (1929) in particular, and a number of the standard graptolite zones were established in this region (see Rickards 1976; Zalasiewicz 1990). Though a few later studies (Sudbury 1958; Packham 1962) examined parts of the sequence in detail, further refinement of the graptolite biostratigraphy of this interval took place mostly outside Wales in the UK (the Southern Uplands – Toghill 1968; Howgill Fells – Rickards 1970; the Lake District – Hutt 1974–5) and abroad (Germany – Stein 1965; Schauer 1971; the CIS – Koren' 1973 and references therein; Bornholm – Bjerreskov 1975; China – Chen 1984; the Canadian Arctic – Melchin 1989). The only recently published biostratigraphical section through this interval in Wales is by Baker (1981).

This study comprises a systematic re-examination of the graptolite biostratigraphy of the *persculptus-magnus* Biozone interval in the Wye valley section near Rhayader, augmented by data from other sections. The work was carried out in the course of recent BGS mapping of the Rhayader and Llanilar district of central Wales, and a detailed account of the stratigraphy is given in Davies *et al.* (in press). Ranges of species are given, together with descriptions and illustrations of new taxa and of established taxa in which new morphological information was discerned. Three new species are described. All figured material is lodged with the British Geological Survey, Keyworth, unless otherwise indicated.

STRATIGRAPHY

The interval studied is represented by the argillaceous Cwmere Formation (Cave and Hains 1986) and equivalent arenaceous formations (see Davies *et al.* in press). These comprise turbidite deposits with interspersed graptolite-bearing laminated hemipelagites.

The Cwmere Formation is underlain by the Yr Allt Formation which comprises mainly slumped deposits laid down during the end-Ordovician glacio-eustatic regression (Davies *et al.* in press). The transition from the Cwmere to the overlying Derwenlas Formation is marked by a change from laminated 'anoxic' to burrowed and oxidized hemipelagites, from which graptolites are generally absent. Higher levels within the Derwenlas Formation, though, include graptolitic levels associated with laminated hemipelagites.

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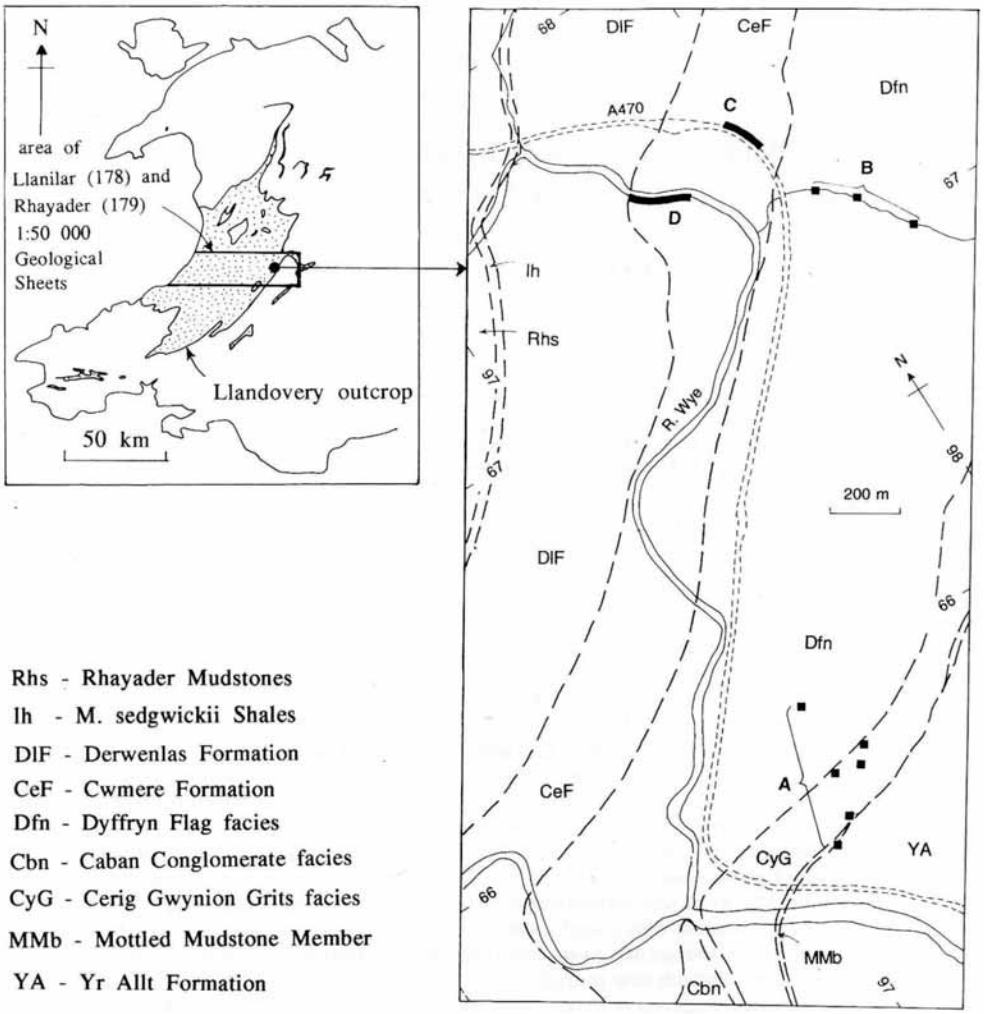


TEXT-FIG. 1. Location of the area examined, and geological map of the Wye valley near Rhayader (after Davies *et al.* in press); taxa from localities A–D are shown in Text-fig. 3.

The lower part of the sequence in the Wye Valley around Rhayader (Text-figs 1, 3) comprises turbidite sandstones (the Cerig Gwynion Grits and Dyffryn Flags facies of the Caban Conglomerate Formation) and these pass up into turbidite mudstones of the Cwmere Formation, which contain increasing proportions of laminated hemipelagite upwards, up to 50 per cent near the top of the sequence.

BIOSTRATIGRAPHY

All the standard graptolite zones of the uppermost Hirnantian, Rhuddanian and Lower Aeronian (Rickards 1976) have been recognized. Text-figure 2 shows the biozonal distribution of species

within the Llanilar–Rhayader district (for further details see Davies *et al.* in press) and Text-figure 3 shows the succession in the Wye Valley section.

Normalograptus? persculptus *Biozone*

This has been recognized in the Mottled Mudstone Member of the Yr Allt Formation and within the overlying Cerig Gwynion Grits. It is characterized by the presence of the zone fossil and abundance of the narrow related form *N? parvulus* (= *Glyptograptus* cf. *persculptus* (*sensu* Williams 1983) together with long-ranging climacograptid species of *Normalograptus* such as *N. normalis*.

Parakidograptus acuminatus *Biozone*

In the Wye valley section (Text-fig. 3), the base of the *acuminatus* Biozone occurs *c.* 40 m above the top of the Cerig Gwynion Grits. It is marked by the incoming of *Akidograptus ascensus*, occurring together with *N? parvulus* and other normalograptids. *Parakidograptus acuminatus* replaces *Akidograptus ascensus* at higher levels in the zone; this is consistent with the informal two-fold zonal subdivision recognized by Rickards (1976), with some authors recognizing two zones at this level based on the relative abundances of these two species (e.g. Bouček, 1953; Tomczykowa 1988). *Normalograptus? persculptus* and *N? parvulus* may not extend to the top of the *acuminatus* Biozone. The former co-occurs with *P. acuminatus* in the Wye valley section (Text-fig. 3), where it is present as a 'late' morphotype, with no median septum on the reverse side (Text-fig. 5B; cf. Davies 1929). Neither *N? persculptus* nor *N? parvulus* have been found with other presumed high *acuminatus* Biozone assemblages, which contain *P. acuminatus* (but not *A. ascensus*) and '*Orthograptus*' *cabanensis* in a section (SN 9198 6317 to SN 9195 6283) adjacent to the Caban-coch reservoir.

Atavograptus atavus *Biozone*

This was recognized originally in the Wye section at Rhayader by H. Lapworth (1900) who termed it the *Monograptus tenuis* Biozone due to a misidentification of the zone fossil. Jones (1909), working in the Rheidol Gorge, rectified this by the proposal of the name *Monograptus* (= *Atavograptus*) *atavus* for this graptolite. Re-examination of Lapworth's type section (Text-fig. 3) suggests that only the upper part of the *atavus* Biozone (little more than 5 m thick) is currently exposed. The assemblage is characterized by *Atavograptus atavus*, *A. gracilis*, and species of *Normalograptus*.

Lagarograptus acinaces *Biozone*

This biozone is 65 m thick within the Wye valley (Text-fig. 3). Two successive assemblages were noted. The lower assemblage contains *L. acinaces* accompanied by normalograptids of a lower Rhuddanian aspect (*N. normalis*, *N. rectangularis*). This is present in the lower 15 m of the *acinaces* Biozone in the Wye valley. The upper assemblage contains *L. acinaces*, accompanied by a more diverse fauna including *Pribylograptus incommodus*, *Pr. sandersoni*, *Pristiograptus fragilis pristinus*, *Coronograptus cyphus cyphus*, *Dimorphograptus confertus confertus*, *Pseudoclimacograptus hughesi* (*sensu* Bulman and Rickards 1968), *Rhaphidograptus toernquisti*, and *Glyptograptus tamariscus*.

Coronograptus cyphus *Biozone*

This was defined originally by H. Lapworth (1900) in the Wye valley section (Text-fig. 3). Subsequent work, however, has shown that the zone fossil, *Coronograptus cyphus cyphus*, ranges down into the *acinaces* Biozone, so that different criteria are needed to determine the *acinaces-cyphus* zonal boundary. Here, the base of the *cyphus* Biozone is drawn at the incoming of monograptids of the *revolutus/austerus* groups (one of the criteria used by Rickards 1976), giving a thickness of the *cyphus* Biozone in the Wye valley of 45 m. Adoption of a '*revolutus* Biozone' in place of the *cyphus* Biozone is a possibility, and this nomenclature has been adopted on Bornholm (Bjerreskov 1975); the appearance of abundant *revolutus/austerus* forms is also clear on the only other recently published graptolite range-chart through Rhuddanian strata in Wales (the Llanystumdwy section: Baker 1981). Other graptolites characteristic of this interval include *Coronograptus gregarius* subspecies (e.g. Text-fig. 8A–B), *Atavograptus strachani* (Text-fig. 10D) and *Normalograptus? wyensis*.

STAGES	Hirnantian	Rhuddanian				Aeronian	
BIOZONES	*persculptus*	*acuminatus*	*atavus*	*acinaces*	*cyphus*	*triangulatus*	*magnus*
Normalograptus? persculptus	X	L					
Normalograptus? parvulus	A	L					
Normalograptus normalis	A	A	X	X			
Normalograptus angustus	X	X	X	X			
Glyptograptus avitus	X						
Normalograptus medius	X	X	X	cf.	?		
Diplograptus aff. modestus primus	X						
Akidograptus ascensus		L					
Parakidograptus acuminatus		U					
'Orthograptus' cabanensis sp. nov.		U					
Rhaphidograptus extenuatus			L				
Atavogratus atavus			X	X	X		
Atavograptus gracilis			X				
Normalograptus rectangularis			X	X	X	X	
Lagarograptus acinaces				A	X		
Glyptograptus aff. *incertus* sensu Hutt 1974				*	*		
Dimorphograptus confertus confertus				U			
Metaclimacograptus hughesi sensu Bulman & Rickards				U			cf
Cystograptus vesiculosus				U			
Pribylograptus sandersoni				U			
Pristiograptus fragilis pristinus				U			
Glyptograptus tamariscus tamariscus				U			cf. →
cf. *'Orthograptus' mutabilis*				U	X		
Rhaphidograptus toernquisti				U(A)	A	A	X
Coronograptus cyphus cyphus				U	X		
Pribylograptus incommodus				U			
Atavograptus cf. *strachani*					X	?	
Monograptus ex gr. *revolutus/austerus*					X	X	
Monograptus austerus cf. *austerus*					X		
Monograptus cf. *sudburiae*					X		
?Monoclimacis sp.					R		
Coronograptus gregarius aff. *miniculus*					X		
Normalograptus? wyensis sp. nov.					X		
Glyptograptus tamariscus cf. *varians*					X		
Pribylograptus cf. *argutus argutus*					X	X	?
Metaclimacograptus undulatus					X	X	X →
Coronograptus gregarius gregarius					?U	X	X →
Monograptus triangulatus triangulatus						X	
Monograptus triangulatus extremus						R	
Monograptus ?aff. *walkerae*						X	
Monograptus sp. 1						X	
Pristiograptus concinnus						X	
Monograptus ex gr. *revolutus*						X	
Monograptus communis communis						X	
Glyptograptus? alternis						X	
aff. *Pseudoglyptograptus vas*						X	
Rastrites sp.						U	
Monograptus communis rostratus						U	
Glyptograptus cf. *enodis enodis*						?	X
Monograptus triangulatus fimbriatus						U	A
Normalograptus? magnus							A
Rastrites longispinus							X →
aff. *Atavogratus strachani*							R
Monograptus chrysalis							X
Pseudoglyptograptus barriei sp. nov.							A

TEXT-FIG. 2. For legend see facing page.

Monograptus triangulatus *Biozone*

Strata referable to the *M. triangulatus* Biozone are 20 m thick in the Wye valley (Text-fig. 3). Triangulate monograptids and *Coronograptus gregarius gregarius* characterize this biozone. A low-diversity interval, in which no triangulate monograptids have been found, is succeeded by faunas including *M. triangulatus extremus*, indicative of a middle *triangulatus* Biozone level (cf. Sudbury 1958; Rickards 1976). *Pristiograptus concinnus*, *Monograptus communis* subspecies, and *Monograptus triangulatus fimbriatus* (= *M. pectinatus* Richter according to Bjerrskov 1975) appear in the upper part of the biozone.

Normalograptus? magnus *Biozone*

The upper part of the Cwmere Formation in the Rhayader/Llanilar district lies within the *magnus* Biozone, 14 m having been proved in the Wye valley (Text-fig. 3). Graptolites from the uppermost Cwmere Formation have also been recovered from the Tynygraig railway cutting (SN 6859 7012) and from a roadside section (SN 7324 7203) near Ysbyty Ystwyth, Dyfed.

The presence of the zone fossil is the principal criterion, and this graptolite is characteristically associated with *Monograptus triangulatus fimbriatus*, *Pseudoglyptograptus barriei* and *Monograptus chrysalis*.

QUANTITATIVE DISTRIBUTION OF MAJOR GRAPTOLITE GROUPS

Graptolite faunas composed exclusively of long-ranging diplograptids of *normalis* type (*Normalograptus*) are common in the Cwmere Formation. Thus, using species ranges alone, imprecise dates spanning much of the Rhuddanian/early Aeronian are obtained. However, this stratigraphical interval is characterized by a marked and progressive increase in graptolite diversity, bringing in the monograptids together with other diplograptid groups. Normalograptid-dominated assemblages should therefore be more common at lower stratigraphical levels, and so could provide a guide to age.

Here, the gross compositions of systematic collections made in the Wye valley (see Text-fig. 3) are compared, to indicate the likelihood of *Normalograptus*-dominated assemblages occurring within different graptolite biozones.

Graptolites from the *persculptus* to the top of the *triangulatus* Biozone were considered. Collections were made at forty two levels in the section, the number of specimens in each collection ranging from two to more than eighty (Text-fig. 4). These were assigned to one of five categories, selected to show the gross composition of the fauna in the most practicable way.

1. *Normalograptus/Glyptograptus*. This category, characterized by proximal end development, includes graptolites of the *normalis* group, together with related forms including those related to *Glyptograptus tamariscus*.

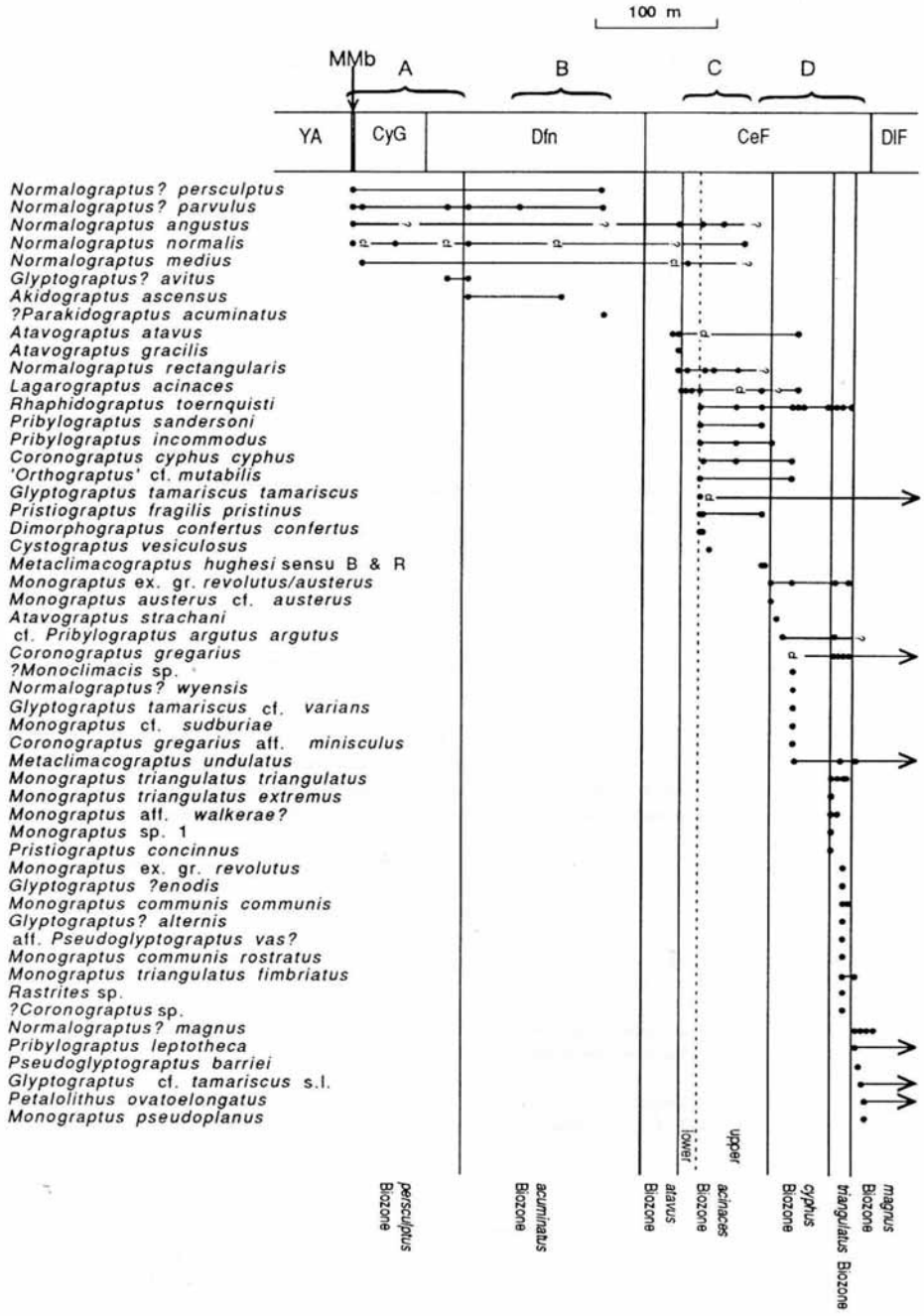
2. Other diplograptids including *Akidograptus*, *Parakidograptus*, *Pseudoclimacograptus*, and *Dimorphograptus* (but excluding *Rhaphidograptus* – see below).

3. *Rhaphidograptus*. A separate category was erected for this genus because of the observed abundance of *R. toernquisti* from the *acinaces* Biozone upwards.

4. *Rhaphidograptus/Normalograptus* undivided. This category is needed because of the difficulty of distinguishing distal fragments of *R. toernquisti* from those of normalograptids, particularly *N. rectangularis*.

5. Monograptids.

TEXT-FIG. 2. Range of graptolite taxa in the Cwmere Formation of the Llanilar–Rhayader district (after Davies *et al.* in press). X, taxon present; A, taxon abundant; R, taxon rare; U, taxon from upper part of zone; L, taxon from lower part of zone; *, taxon from undetermined level within interval marked. Arrow indicates that taxon ranges beyond the limits of this range chart. Abundance estimates are subjective.



TEXT-FIG. 3. For legend see facing page.

The number of graptolites falling into each category was counted for each collected level, converted into a percentage, and then plotted on to a composition-diagram (Text-fig. 4). The total number of graptolites collected at each level was also recorded, and plotted alongside.

The data clearly demonstrate the upward change in overall composition of the graptolite faunas. The *persculptus* and *acuminatus* Biozones are dominated by graptolites of the *normalis* group, and many collections contain nothing else. In the *acuminatus* Biozone, the zone-determining *Akidograptus* and *Parakidograptus* tend to be of sporadic occurrence, and to form only a small part of assemblages.

A marked change occurs at the base of the *acinaces* Biozone. Above this level, other graptolite categories (notably monograptids and *Rhaphidograptus*) form an important part of the assemblages. Out of twenty one collections which included ten or more graptolite specimens, only one did not include any monograptids, and there were none in which neither monograptids nor *Rhaphidograptus* were observed. Out of twenty seven collections containing five or more graptolites, there were only two in which neither monograptids nor *Rhaphidograptus* were observed, and these were both of pre-*cyphus* Biozone age.

Thus, it appears that the gross composition of assemblages can be used, cautiously, to give some evidence of age. Such quantitative comparison of assemblages is not a standard means of correlation in Lower Palaeozoic strata (though it is more commonly used in younger strata, particularly in the Quaternary). The patterns of gross faunal change described here may be expected to provide moderately reliable indications of age within the Welsh Basin, but probably would not help correlation between regions or across facies boundaries.

SYSTEMATIC PALAEONTOLOGY

Repositories. The prefixes BU and SM denote respectively collections of Birmingham University, and the Sedgwick Museum, Cambridge; specimens with prefixes DJ, GSM, JZ, JZB, and Pg are housed at the British Geological Survey, Keyworth, Nottingham, as are other specimens or collections not specified by number.

Genus GLYPTOGRAPTUS Lapworth, 1873, *emend.* Melchin and Mitchell, 1991

Type species. Original designation; *Diplograptus tamariscus* Nicholson, 1868.

Glyptograptus? alternis (Packham, 1962)

Text-figure 6E

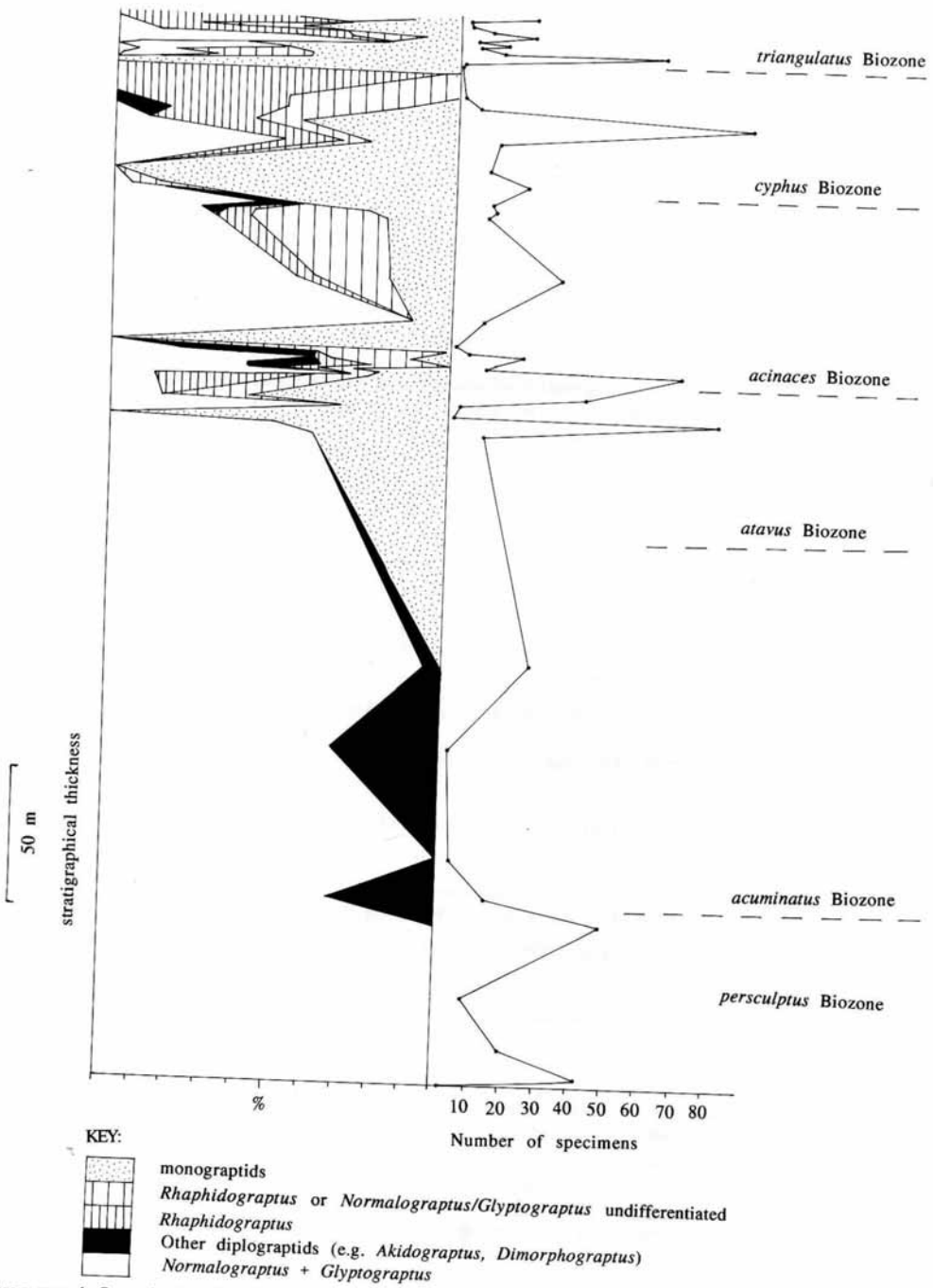
1962 *Climacograptus alternis* sp. nov.; Packham, p. 521, pl. 72, fig. 5, text-fig. 4*f*.
1972 *Pseudoglyptograptus* sp. 3; Rickards, p. 279, text-fig. 3.1.

Holotype. SM A24957, figured by Packham (1962, pl. 72, fig. 5), from the *triangulatus* Biozone of the Rheidol Gorge, Wales.

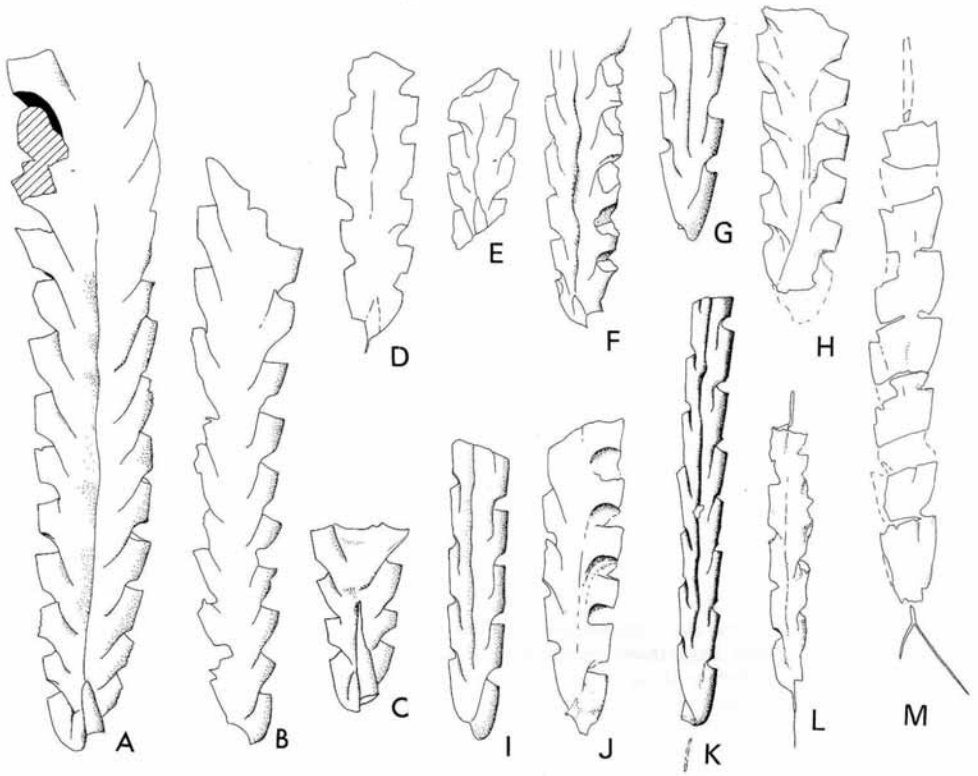
Material. One complete specimen, two incomplete fragments, all preserved in relief, from the *triangulatus* Biozone of the Wye valley section (Text-fig. 3).

Description. Aseptate diplograptid, increasing in width from 0·6 mm proximally to 1·0 mm at theca five and 1·3 mm at theca ten. 2TRDs (= two theca repeat distances; Howe 1983) range from 1·6 mm proximally to 1·8 mm distally. The obverse side has been recognized for the first time. The sicula is visible for 1·1 mm, and

TEXT-FIG. 3. Range-chart of graptolite taxa through the Wye valley section, Rhayader. YA, Yr Allt Formation; MMb, Mottled Mudstone Member; CyG, Cerig Gwynion Grits facies; Dfn, Dyffryn Flags facies; CeF, Cwmere Formation; DlF, Derwenlas Formation. ●, identified; cf., qualified identification; ?, doubtful identification.



TEXT-FIG. 4. Quantitative distribution of major graptolite groups through the Cwmere Formation in the Wye valley section.



TEXT-FIG. 5. A–C, *Normalograptus? persculptus* (Elles and Wood) *s.s.*; all specimens on block JZ 417; *acuminatus* Biozone; Wye valley section (SN 9806 6709). D–J, *Normalograptus? parvulus* (H. Lapworth). D, BU 1293, lectotype; *persculptus* or *acuminatus* Biozone; Gwastaden, Rhayader district. E, BU 829, H. Lapworth coll. F, JZ 2354; lower *acuminatus* Biozone; Nant Paradwys (SN 8919 6702). G, I, lower *persculptus* Biozone; Cerig Gwwynion Quarry (SN 8919 6702). G, JZ 4857; I, JZ 4861. H, JZ 6646; *acuminatus* Biozone; Dolaucothi Gold Mine (SN 6620 4015). J, JZ 8687; *persculptus* Biozone; roadside quarry (SN 8855 6268), near Claerwen Reservoir. K–L, *Normalograptus miserabilis* (Elles and Wood). K, DJ 8828; *acuminatus* Biozone; Wye valley section (SN 9805 6719). L, JZ 2460; *acuminatus* Biozone; east shore of Caban-coch Reservoir (SN 9223 6391). M, *Glyptograptus? avitus*. JZ 4813; Davies, upper *persculptus* Biozone; trackside exposure, Cerig Gwynion Quarry (SN 9722 6577). All figures are × 10.

extends to just above the theca 1^1 aperture; its lateral wall is free for just over half its length below theca 1^2. The thecae approach a glyptograptid morphology, with straight interthecal septa and rounded genicula. The apertures are not well preserved, but appear somewhat everted.

Discussion. The material appears conspecific with the single specimen described by Packham (1962), though there are slight dimensional differences; the latter is a little broader proximally and slightly more densely thecate. The length of the lateral sicula wall exposed beneath th1^2 suggests a relatively high origin for that theca, and thus affinity with the genus *Glyptograptus* rather than *Normalograptus* (see discussion of the latter below).

The material also seems conspecific with the specimen figured by Rickards (1972) as *Pseudoglyptograptus* sp. 3. In that specimen, some distal thecae show concave supragenicular walls;

this feature is not obvious in the material described here. If it is not due to preservation, it may indicate that Rickards' generic determination is more appropriate for this species.

All material assigned to this taxon comes from the middle or upper part of the *triangulatus* Biozone (Packham 1962; Text-fig. 3), making this rare but conspicuous aseptate species of potential biostratigraphical importance.

Glyptograptus? avitus Davies, 1929

Text-figure 5M

Discussion. The scarce material agrees well with Williams' (1983) detailed redescription, the best preserved specimen (Text-fig. 5M) showing the commonly developed bifurcating virgella. As Williams noted, the link with *Parakidograptus* suggested by Davies (1929) seems unlikely. Thecal morphology seems similar to that of the later *tamariscus* group of glyptograptids (cf. Text-fig. 6F; Packham 1962).

Genus NORMALOGRAPTUS Legrand, 1987, *emend.* Melchin and Mitchell, 1991

Type species. By original designation, *Climacograptus scalaris normalis* Lapworth, 1877.

Discussion. The recognition of a distinctive, pointed, non-spinose proximal end in many Ordovician and most Silurian diplograptids was made by Legrand (1987) and Mitchell (1987). Mitchell included proximal developments of his patterns H and I within an emended genus *Glyptograptus* (type species *G. tamariscus*), while Legrand simultaneously proposed the genus *Normalograptus*, based upon *Climacograptus normalis*. Both these genera included species with climacograptid and glyptograptid thecae, effectively rendering these styles of thecal construction (which form a continuum, see Packham 1962) subordinate to proximal end development in generic assignation. Subsequently, Melchin and Mitchell (1991) separated *Normalograptus* from *Glyptograptus* by recognizing subtly different styles of proximal development in the type species of the two genera. The difference depends primarily upon the level of origin of th1^2, that of *Glyptograptus* originating higher on th1^1 than that of *Normalograptus*; this is equivalent to the difference between Pattern I and Pattern H of Mitchell (1987). Melchin and Mitchell's distinction is recognized here. However, it must be stressed that the distinction is difficult to recognize in non-isolated material, and hence assignation to one or other genus is often tentative.

Normalograptus? persculptus (Elles and Wood, 1907)

Text-figure 5A–C

Discussion. This species has been traditionally assigned to *Glyptograptus* and attributed to Salter. The proximal end morphology, though, closely resembles that of *N. normalis* and hence suggests referral to *Normalograptus*; and, as Salter neither figured nor described this species (see discussion in Williams 1983, p. 624) it is felt here that Elles and Wood (1907) should be regarded as the authors.

The name *N? persculptus* is here restricted to the relatively robust forms (widths of up to 2·0 mm in relief material) that compare closely to the type material. This form is relatively rare in the district. The specimen illustrated in Text-figure 5B, from the lower *acuminatus* Biozone, is aseptate on the reverse side of the rhabdosome. This is consistent with Davies' (1929) observations of a progressive delay in the insertion of the median septum in this species. One specimen (Text-fig. 7C) seems to represent an aberrant specimen; there is no median septum on the obverse rather than reverse side and more of the sicula is exposed than normal. It consists of only three thecal pairs, and its early mortality is perhaps related to this developmental 'mistake'.

Normalograptus? parvulus (H. Lapworth, 1900)

Text-figure 5D–J

1900 *Climacograptus parvulus* H. Lapworth, p. 132, fig. 20*a–c*.
1907 *Mesograptus modestus parvulus* (H. Lapworth) Elles and Wood, p. 264, pl. 31, fig. 12*a*, *non c–d*; text-fig. 181*a*, *non b–c*.
1974 *Glyptograptus persculptus* (Salter); Hutt, p. 28, pl. 6, figs 9–12.
1983 *Glyptograptus* cf. *persculptus* (Salter); Williams, p. 625, pl. 66, figs 4–7.
1983 *Diplograptus* aff. *parvulus* (H. Lapworth) Štorch, p. 164, pl. 4, fig. 4, text-fig. 20.
?1986 *Glyptograptus persculptus* (small form) (Salter); Berry, pp. 140, 141, figs 5*h–j*.
1988 *Scalarigraptus angustus* (Perner); Riva, p. 232, fig. 3*d–h*, ?*j–v*, *non a–c*.

Lectotype. BU 1293 (refigured herein, Text-fig. 5D), from the *persculptus* or *acuminatus* Biozone of the Rhayader district, Wales.

Discussion. *Normalograptus? parvulus* resembles *N? persculptus*, but is commonly shorter, narrower (widths of 0·8–0·9 mm proximally, 1·0–1·5 mm distally) and more densely thecate (2TRDs of 1·4–1·8 mm). It also has moderately well-developed genicular hoods (Text-fig. 5G–J) and some specimens show an undulose medium septum (Text-fig. 5E–F), the latter perhaps a result of differential compaction. It appears conspecific with those forms referred by some authors to 'small forms' of *Glyptograptus persculptus* (e.g. Williams 1983), though some of the latter attain greater lengths. The close thecal spacing of *parvulus* distinguishes it from contemporaneous 'climacograptids' such as *Normalograptus normalis* (Text-fig. 6O) where compression has accentuated the genicula of the former (e.g. Text-fig. 5J). *N. miserabilis* (Text-fig. 5K–L; this species name is retained, pending the provision of a detailed redescription of the possibly conspecific species *angustus*: cf. Riva 1988) is narrower (especially proximally), with a more 'elongated' proximal end, generally more widely spaced thecae, more nearly parallel supragenicular walls, and supragenicular walls that take up a greater portion of the ventral margin (supragenicular wall length to apertural height ratios of *c*. 3:1, compared with 2–2·5:1 for *N? parvulus*). More detailed study may show that *N? parvulus* is one end member of a single, variable species that also includes *N? persculptus*, as some 'normalograptid' populations elsewhere show considerable variation in size. If so, then the name *parvulus* (H. Lapworth, 1900) has priority over *persculptus* (Elles and Wood, 1906). For the present, the two are regarded as distinct taxa.

Normalograptus? magnus (H. Lapworth, 1900)

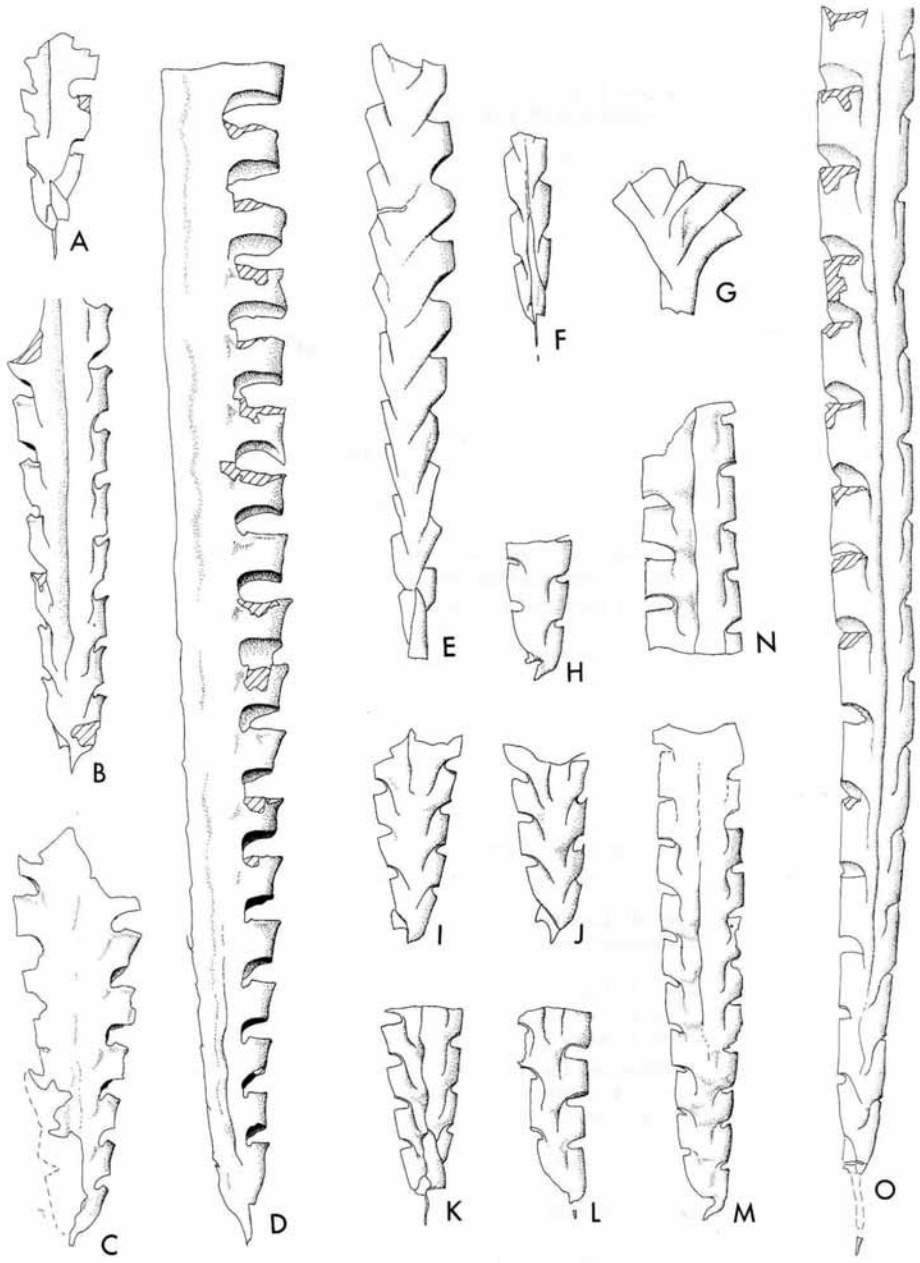
Text-figure 7A–G

1900 *Diplograptus magnus* H. Lapworth, p. 132, text-fig. 21*a–d*.
1907 *Diplograptus* (*Mesograptus*) *magnus* (H. Lapworth) Elles and Wood, p. 266, pl. 31, fig. 14*a–c*, text-fig. 183*a–b*.
1970 *Diplograptus magnus* H. Lapworth; Rickards, p. 35, pl. 3, fig. 8.
1974 *Diplograptus magnus* H. Lapworth; Hutt, p. 32, pl. 5, fig. 6; pl. 6, figs 7–8, 14.
1977 *Diplograptus magnus* H. Lapworth; Rickards *et al*., pl. 3, figs 1, 5 [not described].

Lectotype. BU 1295. Effectively designated Elles and Wood (1907) in their description of pl. 31, fig. 14*a*. The specimen was originally figured by H. Lapworth (1900, text-fig. 21*b*). It originated from the *fimbriatus* (= *magnus*) Biozone of the River Wye section, Rhayader, Wales.

Material. Twenty seven specimens in partial to full relief from the type locality in the Wye valley (Text-fig. 1). Twenty two specimens in slight relief from the *magnus* Biozone in the Tynygraig railway cutting (Text-fig. 1). None of the material shows significant tectonic deformation.

Revised diagnosis. Large diplograptid (s.l.) with proximal end of *Normalograptus* appearance, expanding rapidly from, normally, < 1·0 mm to *c*. 3·0 mm; exceptionally, specimens reach > 4·0 mm in width. Thecae relatively closely spaced (2TRDs of *c*. 1·3–1·4 mm proximally to



TEXT-FIG. 6. A–D, *Pseudoglyptograptus barriei* sp. nov. *magnus* Biozone; Tyn-y-graig railway cutting. A, JZ 8048. B, JZ 8457, holotype. C, JZ 8283. D, JZ 8456. E, *Glyptograptus? alternis* Packham. JZ 9915; *triangulatus* Biozone; Wye valley section. F, *Glyptograptus tamariscus* cf. *varians* Packham. JZB 851; *cyphus* Biozone; Wye

TABLE 1. Dimensions of populations of *Normalograptus? magnus* (in mm).

	Wye Valley	Lectotype	Tynygraig
Width prox.	0·6–0·8	0·7	0·8–1·0
Width th5	1·4–1·8	1·9	1·6–2·0
Width th10	2·0–2·5	2·8	1·7–2·8
Width th20	2·1–3·1	4·1	2·3–3·2
Width max.	?4·1	4·3	3·2
2TRD prox.	1·3–1·5	1·3	1·3–1·5
2TRD th5–7	1·2–1·6	1·5	1·4–1·7
2TRD th10–12	1·4–1·8	1·5	1·5–1·9
2TRD th20–22	1·5–2·0	1·8	1·6–2·1

1·6–2·0 mm distally), approximately glyptograptid throughout, with only slight to imperceptible flattening of genicula distally. Rhabdosome partially septate on the reverse side.

Description. The rhabdosome shows rapid expansion from a moderately slender proximal end; dimensions are given in Table 1. Considerable variation in width was found. The lectotype is the most robust specimen seen, with a maximum width of 4·3 mm; more commonly, maximum widths range from 2·2–3·3 mm. Thecae are sigmoidally curved (approximately 'glyptograptid'), with distinct genicula throughout. There is only slight flattening of the genicula distally; this is more obvious in flattened (Text-fig. 7A–C) than in relief (Text-fig. 7D–G) material. In relief material, apertures appear simple, distally-facing and slightly everted; some flattened material, though, shows traces of what appear to be slender genicular hoods as spine-like processes extending from the geniculum (Text-fig. 7C). The proximal end is of *Normalograptus* aspect, with th1^1 growing downwards below the aperture of the sicula before turning upwards, and th1^2 growing upwards from close to its origin, leaving part of the sicula wall exposed. The sicula is exposed in the obverse side for 1·4–1·5 mm (Text-fig. 7A, F–G); material where it is 'pressed through' shows it to have a total length of *c.* 2·0 mm (Text-fig. 7E). The median septum is complete on the obverse side, wavy over the first five thecal pairs and subsequently straight (Text-fig. 7F–G); on the reverse side it is partial, starting from the level of the eighth thecal pair in the topotype material (Text-fig. 7D).

Discussion. As noted by Hutt (1974), the lectotype is an abnormally large specimen (> 4 mm wide distally), which underlines the considerable variation in maximum width exhibited.

This species is scarcely biform, and thus is not a true '*Diplograptus*' in the old, form-generic, meaning of this taxon. In this respect, it differs from approximately contemporary robust diplograptids such as '*Diplograptus*' *thuringiaceus* Eisel *in* Münch, 1952, and '*Diplograptus*' *tscherskyi tscherskyi* Obut and Sobolevskaya and thus seems not closely related to them, contrary to the suggestion of Melchin and Mitchell (1991). A more similar species is '*Diplograptus*' *fezzanensis* Desio, 1940 (see also Štorch 1983) which, however, appears to have somewhat more strongly geniculate thecae proximally and a smaller (*c.* 1 mm) sicula.

'*Diplograptus*' *magnus* is the type species of *Neodiplograptus* Legrand, 1987, erected to encompass biform diplograptids with 'keroblastic' (i.e. normalograptid s.l.) proximal structure. However, this redescription shows that *magnus* has only a slightly biform character, scarcely more than in species such as *Normalograptus? persculptus* (compare Text-figures 5A–C and 7D–G) and is morphologically dissimilar to truly biform diplograptids such as '*Diplograptus*' sp. 1 (this paper), '*Glyptograptus*' *sinuatus sinuatus* (Nicholson, 1869) and '*D.*' *thuringiaceus*. Thus, it is unsatisfactory taxon upon which to erect the genus intended, and *Neodiplograptus* is here regarded as a junior synonym of

valley section. G, cf. '*Orthograptus*' *mutabilis* Elles and Wood. JZB 819; *cyphus* Biozone; Wye valley section. H–N, *Normalograptus? wyensis* sp. nov. *cyphus* Biozone; Wye valley section. H, L, JZB 791. I, JZB 817. J, JZB 809. K, JZ 9770. M, JZB 792; latex cast of proximal part of holotype. N, JZ 792 (distal part of M). O, *Normalograptus normalis* (Lapworth). JZ 2306; *acuminatus* Biozone; Nant Paradwys, near Rhayader (SN 8919 6702). All × 10.

Normalograptus. It is not assigned to *Glyptograptus*, as the proximal end of *magnus* appears to resemble more that of the *normalis* group of graptolites than that of the *tamariscus* group (compare Text-figure 6F of *G. tamariscus* cf. *varians*).

Normalograptus? wyensis sp. nov.

Text-figure 6H–N

Derivation of name. After the River Wye, on which the type locality is sited.

Holotype. JZB 792 (Text-fig. 6M–N); from the *cyphus* Biozone of the Wye valley section near Rhayader, Wales (Text-fig. 2).

Additional material. Six other well-preserved rhabdosomes from the type locality.

Diagnosis. A medium-sized, moderately densely thecate and rapidly expanding diplograptid with well-developed genicular hoods and a partial, proximally wavy, median septum.

Description. The longest rhabdosome seen is incomplete distally, and is 12 mm long. Widths are 0·6–0·8 mm proximally, 0·9–1·2 mm at th5 and 1·4 mm at th10, being parallel-sided thereafter. 2TRDs are 1·1–1·5 mm proximally, and 1·6 mm at th10–12. The proximal end appears to be of *Normalograptus* type. The sicula is visible for 0·9 mm of its length on the obverse side, with 0·2–0·4 mm of its lateral wall being free below $th1^2$. The proximal few thecae have sigmoidal interthecal septa, sharp genicula, and supragenicular walls which are slightly inclined in most preservational aspects. The apertures are simple, without lappets, though the ventral apertural wall extends to form a genicular hood (Text-fig. 6L). Distal thecae are similar except that supragenicular walls are parallel to the rhabdosome. The median septum extends from the sicula apex on the obverse side and is wavy over the first four thecal pairs, distally becoming straight; on the reverse side it extends from the base of the fourth thecal pair.

Discussion. This species is placed questionably in *Normalograptus*. The waviness of the median septum proximally, and the eversion of the apertures (through the production of genicular hoods), indicates possible affinities with *Clinoclimacograptus* Bulman and Rickards, 1968. However, the straightness of the supragenicular walls, and their outwards leaning in the proximal part of the rhabdosome, suggest otherwise, while genicular hoods have also been observed in normalograptids such as *N? parvulus* (see above).

Comparison with other species is hampered by the lack of detail concerning thecal and median structures in most published accounts. '*Climacograptus*' *rectangularis*, '*C.*' *stenotelus* Churkin and Carter, 1970, and '*C.*' *medius brevicaudatus* Churkin and Carter, 1970, are similar in their rate of expansion, but reach greater widths. '*Climacograptus*' *janischewskyi* Obut, 1949, expands less rapidly. '*Climacograptus*' *scalaris ferganensis* Obut, 1949, has approximately similar dimensions but (as figured by Melchin 1989) has a straight median septum proximally. *Normalograptus normalis* (Lapworth, 1876) (see Text-fig. 6O) and *N? mirneyensis* (Obut and Sobolevskaya, 1967) have more widely spaced thecae.

Genus PSEUDOGLYPTOGRAPTUS Bulman & Rickards, 1968

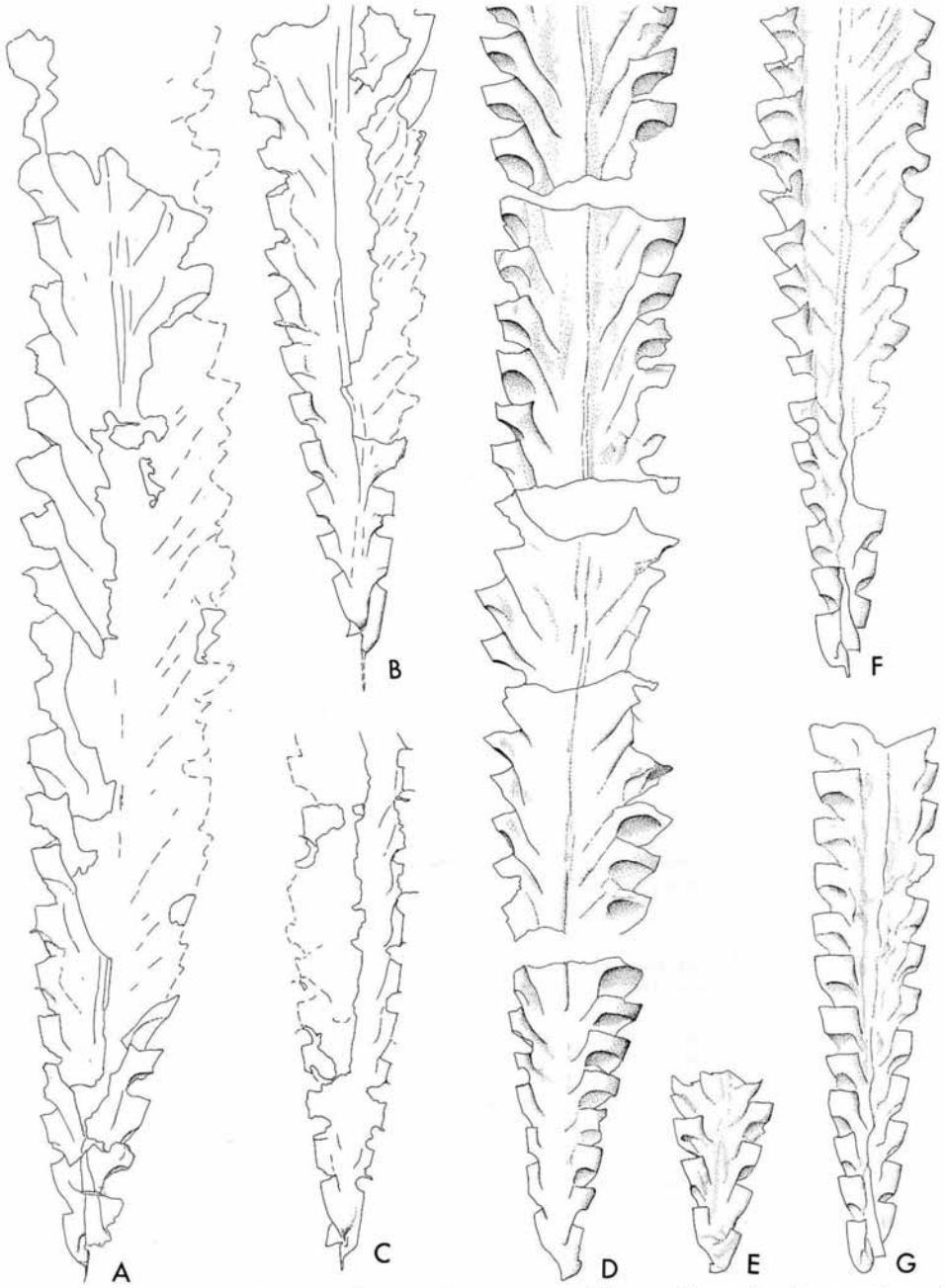
Type species. By original designation, *Glyptograptus* (*Pseudoglyptograptus*) *vas* Bulman and Rickards, 1968.

Pseudoglyptograptus barriei sp. nov.

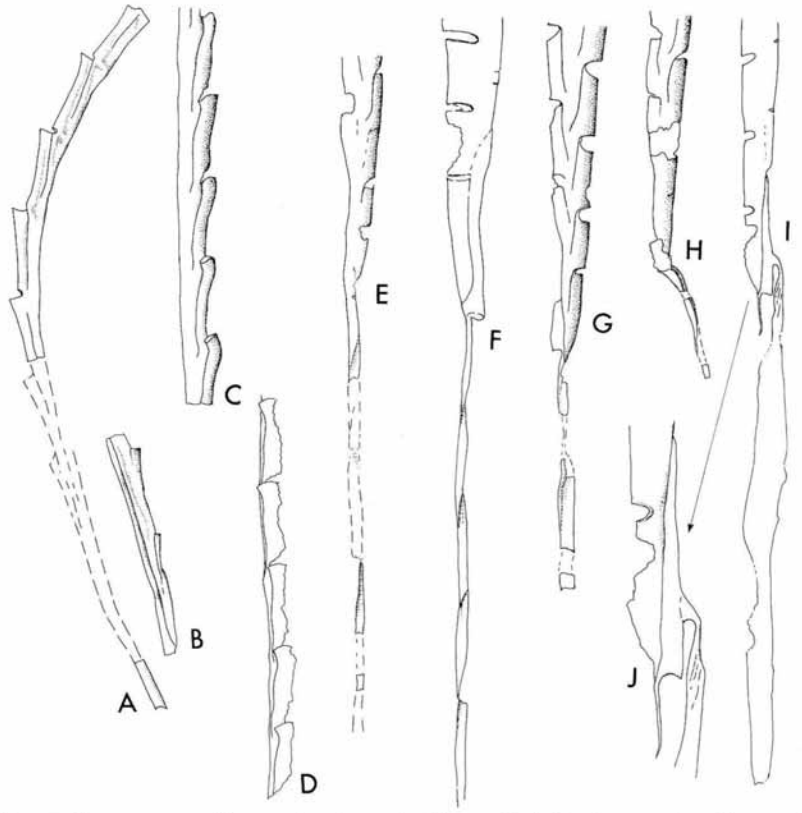
Text-figure 6A–D

1972 *Pseudoglyptograptus* sp. 2; Rickards, p. 278, text-fig. 3.2.

Derivation of name. After Dr Barrie Rickards, who first recognized this species as a distinct taxon.



TEXT-FIG. 7. *Normalograptus? magnus* (H. Lapworth). A–C, *magnus* Biozone; Tynygraig railway cutting. A, JZ 8458. B, JZ 8264. C, JZ 8317. D–G, *magnus* Biozone; Wye valley section. D, DJ 7740. E–F, DJ 7764. G, DJ 7768. All ×10.



TEXT-FIG. 8. A–B, *Coronograptus* aff. *gregarius minusculus* Obut and Sobolevskaya. *cyphus* Biozone; Wye valley section. A, JZ 9764. B, JZ 9765; part/counterpart. C–D, *Pribylograptus sandersoni* (Lapworth). JZB 779; *acinaces* Biozone; Wye valley section. C, lateral view. D, ventral view. E–J, *Rhaphidograptus toernquisti* (Elles and Wood). *triangulatus* or *magnus* Biozone; Tynygraig railway cutting. E, JZ 8057. F, JZ 8229. G, JZ 8065a. H, JZ 8061. I–J, JZ 8060. All ×10 except J, ×20.

Holotype. JZ 8457 (Text-fig. 6B). The specimen, preserved in part relief, originated from the *magnus* Biozone of the Tynygraig railway cutting, Dyfed, Wales (Text-fig. 1).

Additional material. Eleven other specimens from the type locality; two specimens from the *magnus* Biozone of the Wye valley section (Text-fig. 3); two probable specimens from the *magnus* Biozone section at Ysbyty Ystwyth, Dyfed (Text-fig. 1).

Diagnosis. A moderately sized pseudoglyptograptid, increasing in width from under a millimetre proximally to 2·0 mm distally. Thecae with sharp genicula, concave supragenicular walls and marked lappets proximally which become less pronounced distally. Median septum from the second thecal pair, slightly wavy proximally and straight distally.

Description. Widths proximally are 0·7–0·9 mm, 1·1–1·4 mm (rarely to 1·8 mm) at th5, 1·5–1·8 mm at th10 and 2·0–2·1 mm at th20. 2TRDs are 1·3–1·8 mm proximally, 1·6–1·9 mm at th5–7, 1·9–2·0 mm at th10–12 and 2·0 mm at th20–22. The proximal end seems to be of *Normalograptus* type, with part of the lateral wall of the

sicula exposed below th1[2]. The sicula is exposed on the obverse side for 0·6 mm, to just below the th1 aperture (Text-fig. 6A). The proximal five or six thecae are sigmoidally curved, with interthecal septa that are convex outwards, a sharp geniculum and a supragenicular wall that has a concave curvature which is most pronounced just below the aperture. Prominent apertural lappets are developed (though these may be more accurately described as embayed lateral apertural margins, the ventral apertural margin apparently being smooth) (Text-fig. 6B–D). Well-preserved material (Text-fig. 6B) shows the dorsal thecal wall extending upwards to form a genicular hood. Distally, the apertural lappets become much less prominent, and the supragenicular walls somewhat less concave. The median septum begins from the second thecal pair on both the obverse and reverse sides. It is slightly wavy adjacent to the second and third thecal pairs, and is straight distally.

Discussion. The material appears conspecific with the *Pseudoglyptograptus* sp. 2 of Rickards (1972), also from the *magnus* Biozone of the Rhayader area, though Rickards' figured specimen is slightly narrower and more densely thecate distally. *Pseudoglyptograptus* sp. nov. of Melchin (1989) from the Cape Phillips Formation of Arctic Canada is also similar and undoubtedly closely related; it is significantly more robust, though, with a width of 1·1 mm proximally and 2·3 mm at th10. It also occurs at higher levels, equivalent to the *leptotheca* and *convolutus* Biozones of the British sequence (Melchin 1989, table 1 and fig. 4). *Pseudoglyptograptus* sp. 1 of Rickards (1972) also resembles the taxon under discussion in general thecal and rhabdosomal characters, but is considerably narrower.

These taxa differ slightly from the type species of *Pseudoglyptograptus*, *P. vas* (Bulman and Rickards, 1968), in having more distinct genicula and more obvious apertural lappets. The former feature, in particular, means that poorly preserved or compressed material resembles comparably-sized species of *Normalograptus* (e.g. *N. normalis*) rather than *Glyptograptus*.

Genus RHAPHIDOGRAPTUS Bulman, 1936

Type species. By original designation, *Climacograptus törnquisti* Elles and Wood, 1906.

Rhaphidograptus toernquisti (Elles and Wood, 1906)

Text-figure 8E–J

Discussion. Most material of *R. toernquisti* is consistent with the detailed descriptions of Hutt (1975) and Bjerreskov (1975). However, one population from a *triangulatus/magnus* Biozone interval within the Tynygraig railway cutting (Text-fig. 1) shows considerable variability in virgellar form. Most members of this population (Text-fig. 8E–G) possess a virgella similar to that described by Bjerreskov (1975) – an extended structure, up to 12 mm long, that expands away from the sicula to a width of 0·15–0·25 mm and that is twisted into a more-or-less regular clockwise spiral. Bjerreskov's published electron micrograph (1975, pl. 6D) indicates a roughly triangular cross-section in this structure. One specimen from Tynygraig, however, (Text-fig. 8H) shows a curved, horn-like virgella that is strongly thickened at its contact with the sicula, and growing out at an angle to the axis of the rhabdosome. In another, remarkable specimen (Text-fig. 8I–J), the virgella itself is not elongated, and an analogous, but wider, lanceolate structure grows out from the side of the sicula on its antivirgellar side.

This kind of morphological plasticity is unexpected, and further consideration of such phenomena may provide insight into the developmental and skeleton-building mechanisms of graptolites.

Diplograptids of uncertain generic affinity

Graptolites under this heading include: (i) diplograptids with markedly biform thecae and a proximal end of *Normalograptus* (s.l.) type; *Neodiplograptus* was suggested for these by Legrand (1987), but the name is regarded as a synonym of *Normalograptus* (see above); and (ii) diplograptids with a proximal end of *Normalograptus* (s.l.) type and orthograptid thecae distally. No generic or subgeneric name has yet been proposed for this combination of features.

'*Diplograptus*' aff. *modestus primus* Mikhaylova, 1980

Text-figure 9A–C

Material. Eleven specimens from the Cwmere Formation (*?acuminatus-atavus* biozones) at Lan Goch, northeast of Rhayader, Powys (SO 0169 7019).

Description. The rhabdosome is rapidly expanding. Proximal widths are 0·8–1·1 mm, widths at th5 are 1·4–2·1 mm, 2·2–2·5 mm at th10, and up to 2·6 mm distally. 2TRDs are 1·1–1·2 mm proximally, 1·3–1·4 mm at th5–7, and 1·3–1·5 mm at th10–12. The sicula, seen in one specimen (Text-fig. 9C) is 1·6 mm long, reaching to just above the aperture of th2^2. The proximal end appears to be of *Normalograptus* type (*sensu* Melchin and Mitchell 1991). The thecae are biform. The proximal *c.* five thecal pairs are of broadly amplexograptid aspect (though lacking apertural lappets), with sharp genicula, above which the supragenicular walls are outwardly inclined. Distally, the thecae are orthograptid, with straight ventral walls and apertures roughly perpendicular to the thecal axes.

Discussion. The gross rhabdosome shape and thecal spacing of this taxon are similar to that of '*Diplograptus*' *modestus modestus* Lapworth, 1876. Lapworth's figured type of '*D*'. *m. modestus* is missing (Strachan 1971) and the concept of the species has been taken from Elles and Wood's (1907) redescription, in large part illustrated by material from Lapworth's collection. Re-examination of this (?topotype) material has shown that thecae throughout the rhabdosome are essentially uniform, having concave infragenicular walls separated from straight, outward leaning supragenicular walls by distinct genicula; this appears to be a primary feature and not the result of differential compaction following stipe torsion. Thus the material from central Wales is probably not closely related to '*D*'. *m. modestus* (*sensu* Elles and Wood). In its strongly biform nature it resembles '*D*'. *modestus primus* Mikhaylova from the *acuminatus* Biozone of Kazakhstan (figured in Koren' *et al.* 1980) which is narrower, most specimens not exceeding 1·7 mm in width.

'*Orthograptus*' *cabanensis* sp. nov.

Text-figure 9I–L

Derivation of name. After Caban coch reservoir, by which the type locality is sited.

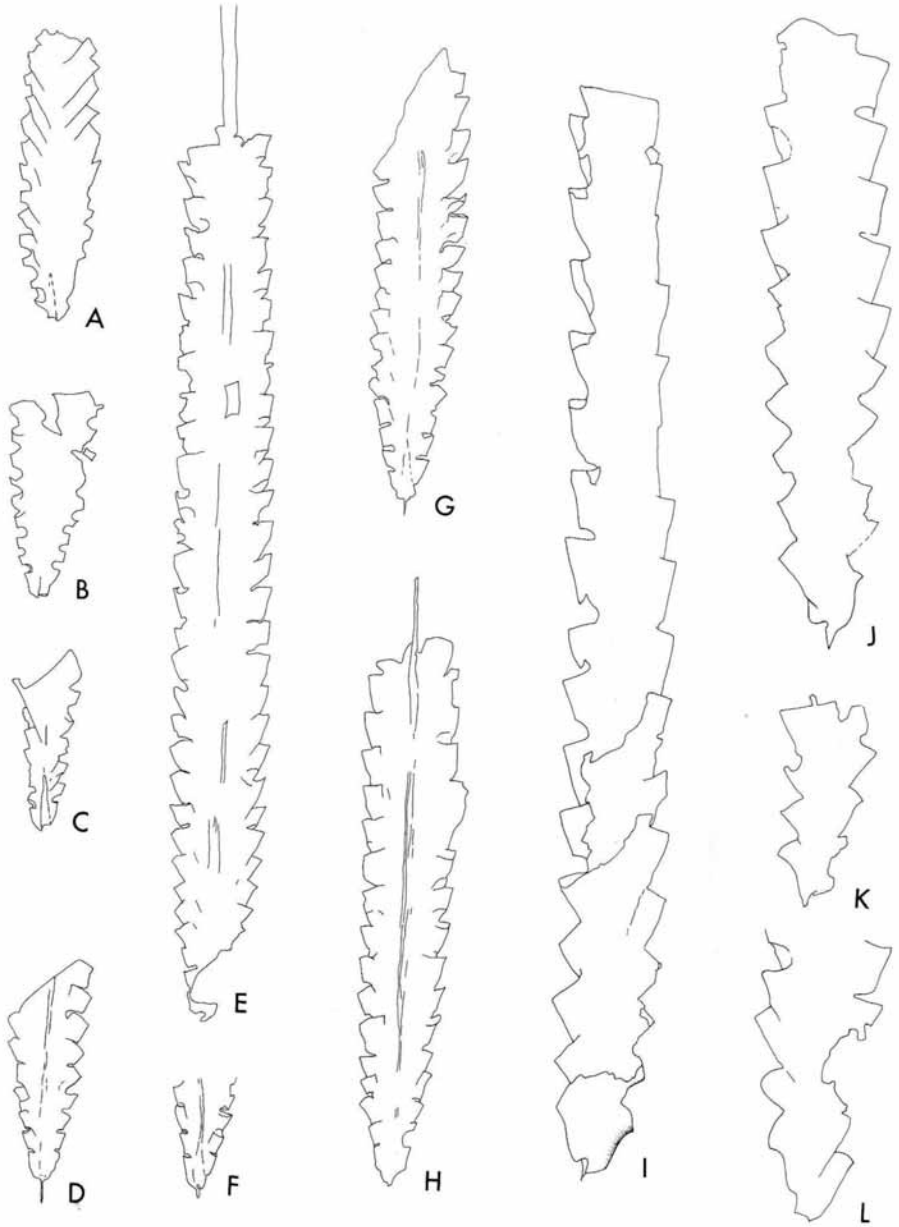
Holotype. DJ 8991 (Text-fig. 9J), preserved in slight relief, and originating from the Cwmere Formation (upper *acuminatus* Biozone) of the Craig Fawr track section (SN 9194 6296) (Text-fig. 1).

Additional material. Seventeen other specimens from the type section (Text-fig. 1); one specimen from a nearby stream section (*c.* SN 9242 6370).

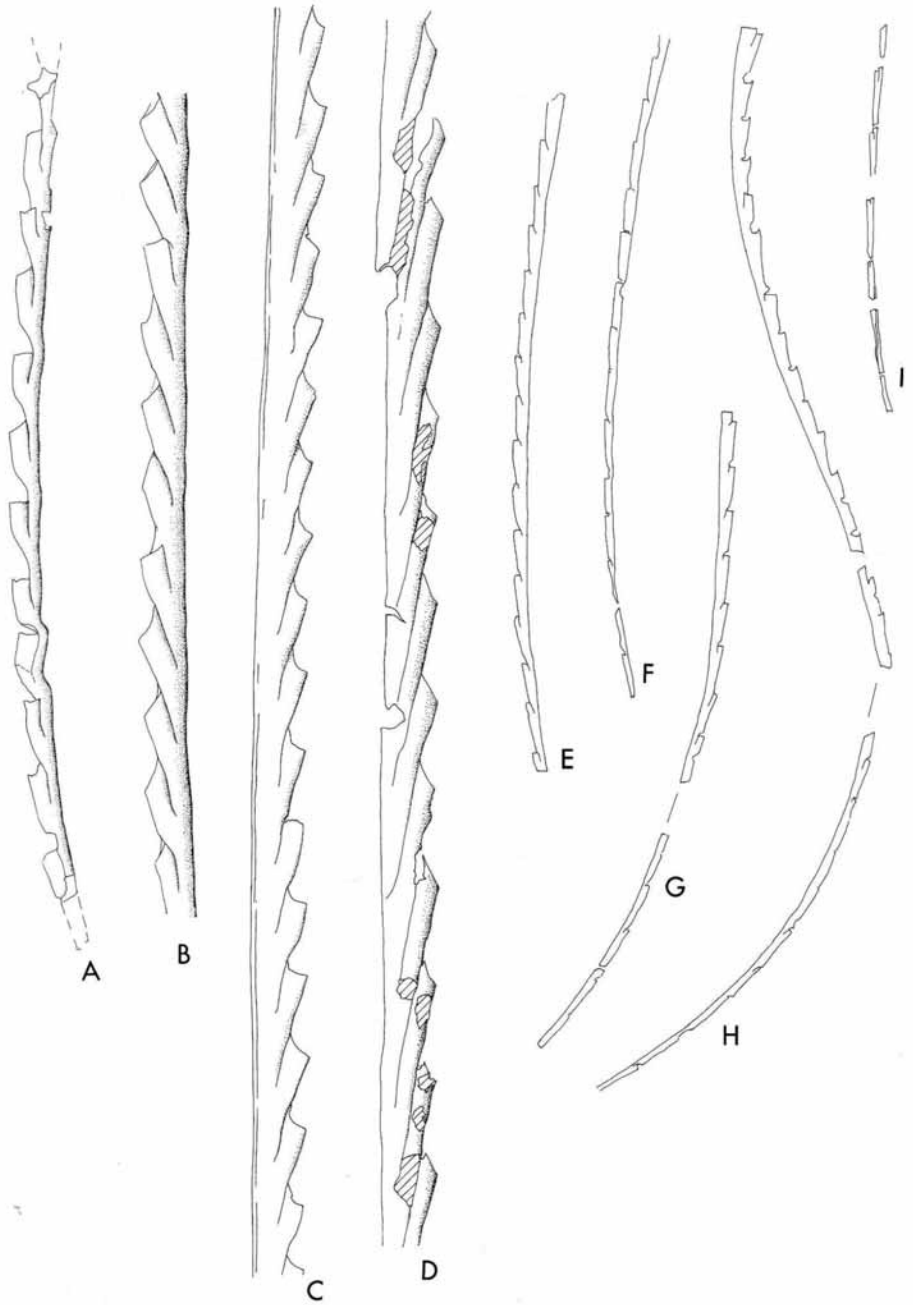
Diagnosis. A graptolite with a relatively wide proximal end of *Normalograptus* type, th1^1 and 1^2 that are everted, and orthograptid thecae subsequently.

Description. Widths are 1·2–1·35 mm at the first thecal pair, 1·7–1·85 mm at the fifth, and 1·7–2·0 mm at the tenth. 2TRDs are 1·55–1·7 mm proximally, 1·8–2·0 mm at th5–7 and 2·2 mm at th10–12. The proximal end appears to be of *Normalograptus* (s.l.) type (*sensu* Melchin and Mitchell 1991), with *c.* 0·3 mm of the sicula wall free below th1^2, and a convex curvature to the proximal ventral walls of th1^1 and 1^2. However, the ventral thecal walls of th1^1 and 1^2 are distinctive in being concavely curved below the apertures, which are everted and appear convex in outline. Distally, thecae appear basically orthograptid, though traces of genicula (possibly compactional artefacts) are visible in some orientations; the apertures also partly 'enclose' the ventral walls of succeeding thecae. Details of the sicula and median septum were not apparent.

Discussion. This species closely resembles the *Orthograptus* sp. nov. of Melchin (1989, fig. 6E–F) from the *atavus* Biozone of Arctic Canada. That species has a narrower proximal end, though, and the apertural portions of th1^1 and 1^2 appear simple, not everted. These differences are also shared by *Gl.* aff. *nanus* Mu and Ni from the *acuminatus* Biozone of Arctic Canada (Melchin 1989, Fig. 5E),



TEXT-FIG. 9. A–C, '*Diplograptus*' aff. *modestus primus* Mikhaylova. Probably *acuminatus* Biozone; Lan Goch; × 5. A, JZ 4666. B, JZ 4660. C, JZ 4662. D–H, *Diplograptus modestus modestus* Lapworth. BU 1292; *atavus* Biozone of Dob's Linn, Scotland; × 5. I–L, '*Orthograptus*' *cabanensis* sp. nov. Upper *acuminatus* Biozone; × 10. I, JZ 2575; Craig Fawr track section. J, DJ 8991, holotype; Craig Fawr track section. K, DJ 8991; Craig Fawr track section. L, DJ 9106; stream by Elan village.



TEXT-FIG. 10. For legend see facing page.

which is also narrower and more densely thecate distally. *Orthograptus illustris* Koren' and Mikhaylova, 1980 from the *acuminatus* Biozone of Kazakhstan (Koren' *et al.* 1980, p. 158) and *Diplograptus* aff. *parvulus* (H. Lapworth, 1900) figured by Štorch (1983, pl. 4, fig. 4; text-fig. 20) from the *ascensus* and *acuminatus* Biozones of Bohemia are further generally comparable, but are smaller and more densely thecate, with simple th1[1] and 1[2].

The '*Orthograptus truncatus abbreviatus*' figured by Hutt (1974, p. 33, pl. 8, figs 9–10; text-fig. 8, fig. 9) from the *acuminatus* Biozone of the Lake District may also be related. *O. truncatus abbreviatus s.s.* is an Upper Ordovician taxon within the *amplexicaule* group of *Orthograptus* (*sensu* Mitchell (1987)), possessing Mitchell's pattern G astogeny. This group reportedly became extinct during the end-Ordovician glaciation (Melchin and Mitchell 1991). The material figured by Hutt is not well-preserved proximally, but possesses a pointed proximal end more reminiscent of *Normalograptus* than of *Orthograptus* and the single proximal thecal spine figured (Hutt 1974, text-fig. 8, fig. 9) may be a preservational feature. In rhabdosome dimensions, it most resembles *Orthograptus* sp. nov. of Melchin (1989).

This group of 'orthograptids', taken as a whole, appears to be stratigraphically useful, seemingly being confined to the *acuminatus* and *atavus* biozones worldwide. The proximal end, with its initial rounding, contrasts with that of later 'orthograptids' (e.g. '*O.*' *insectiformis* and '*O.*' *cyperoides*) where the earliest visible portions of th1[1] and 1[2] are straight, giving a V-shaped outline.

cf. '*Orthograptus*' *mutabilis* Elles and Wood, 1907

Text-figure 6G

cf. 1907 *Orthograptus mutabilis* Elles and Wood, p. 232, pl. 29, fig. 1*a–c*; ?*non* d; text-fig. 153*a–c*.
non 1974 *Orthograptus* aff. *mutabilis* Elles and Wood; Hutt, p. 33, pl. 16, fig. 6; text-fig. 8, fig. 10.

Material. Two probable distal fragments from the *acinaces* Biozone of the Wye valley section (Text-fig. 3); one proximal end from the *cyphus* Biozone of the same section.

Discussion. The single, well-preserved proximal end compares well with the type material, though is also indistinguishable from the proximal parts of early petalograptids (e.g. *P. minor*, *P. ovatoelongatus*), which have been recorded from the succeeding *triangulatus* Biozone in Britain (Hutt 1975; Rickards 1976). The *cyphus* Biozone record of *P. minor* in Germany (Schauer 1971) may also represent this taxon. A close evolutionary connection between '*O.*' *mutabilis* and the petalograptids is highly probable. The stratigraphically younger '*O.*' aff. *mutabilis* of Hutt (1974) is significantly different and may not be closely related; its proximal end is much narrower and the ventral margins of th1[1] and 1[2] are straight, rather than concavely curved.

Genus ATAVOGRAPTUS Rickards, 1974

Type species. By original designation of Rickards 1974, p. 141; *Monograptus atavus* Jones, 1909.

cf. *Atavograptus atavus* (Jones, 1909)

Text-figure 10C

Discussion. Three distal fragments from the *cyphus* Biozone of the Wye valley section (Text-fig. 3) are notable for their poorly defined genicula and marked eversion of the thecal apertures (Text-fig. 10C). In this they differ from 'typical' *atavus* (Text-fig. 10A), though some material from Jones' type

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TEXT-FIG. 10. A–B, *Atavograptus atavus* (Jones). ?*atavus* Biozone; Rheidol Gorge. A, GSM 23710, lectotype. B, Pg 991, Jones Coll. C, cf. *Atavograptus atavus* (Jones). JZ 9775; *cyphus* Biozone; Wye valley section. D, *Monograptus* sp. 1. JZ 9847; *triangulatus* Biozone; Wye valley section. E–I, *Atavograptus gracilis* Hutt. *atavus* Biozone; Wye valley section. E, JZ 9401. F, JZ 9413. G, JZ 9431. H, JZ 9438. I, DJ 8836. A–D ×10, E–I ×5.

collection shows comparable features (Text-fig. 10B). The material also may be closely related to *Monograptus* sp. 1, from the *triangulatus* Biozone of the Wye valley (Text-fig. 10D; see below), which differs in having even more markedly everted thecal apertures and a greater amount of thecal overlap.

Atavograptus gracilis Hutt, 1975

Text-figure 10E–I

1970 *Monograptus* sp. 2, Hutt and Rickards, p. 76, text-fig. 3*e–f*.
1974 *Monograptus* sp. nov. A, Hutt, p. 6.
1975 *Atavograptus gracilis* Hutt, p. 63, pl. 14, fig. 4; text-fig. 14, fig. 4.
non 1982 *Atavograptus gracilis* Hutt; Lenz, p. 48, figs 4A–B, L, 19H–I.

Holotype. SM A60417, from the *atavus* Biozone of School Beck, Lake District, England.

Material. Over twenty fragmentary specimens, preserved in slight relief, from the *atavus* Biozone of the Wye valley section (Text-fig. 2), including one proximal end probably belonging to this species.

Revised diagnosis. Long, slender, gently curved rhabdosome (normally dorsally, rarely ventrally). Maximum width 0·8 mm, usually 0·5–0·6 mm. Probably long, slender sicula. Overlap increases, thecal spacing decreases, distally. Proximal and mesial thecae with fairly sharp genicula and small apertures, distal thecae with more flowing genicula.

Description. A single proximal end, probably referable to this species, has been found (Text-fig. 10I). The sicula is 3·8 mm long and 0·2 mm wide at its base. Th1 originates 1·4 mm from its base, its aperture being 0·7 mm above the sicula apex. Dorso-ventral width varies from 0·175 mm at th1 to 0·225 mm at th4, the 2TRD proximally being 4·0 mm. Overlap proximally is one-eighth. More distal fragments range in width from *c*. 0·2 to 0·5 mm, rarely to 0·6 mm, the increase in width being attained slowly. Most fragments have a gentle dorsal curve, one longer fragment having a moderate ventral curve distally. Thecae are more widely spaced proximally (2TRD *c*. 3·0 mm) than distally (2TRD 2·2–2·5 mm). Overlap increases distally from about one-fifth to one-quarter. Apertures seem simple, and approximately perpendicular to the thecal axis, but they can appear either slightly everted or slightly introverted in different preservational modes. Genicula are present throughout, appearing sharper proximally.

Discussion. Hutt's (1974) material appears conspecific, though attaining somewhat greater maximum widths (to 0·8 mm). The type material was not well enough preserved to show details of the sicula or of the variation in thecal spacing and overlap distally noted here. Lenz's (1982) material ascribed to *A*. cf. *gracilis* is not conspecific, having greater overlap, a shorter sicula, and a more robust proximal portion. *A. gracilis* may be distinguished from *A. atavus* by its narrower rhabdosome, smaller amount of overlap and widely spaced proximal thecae.

The proximal end (Text-fig. 10I), with its long, slender sicula (in contrast to the short sicula of *A. atavus*) suggests a link with *Coronograptus* or *Lagarograptus*.

Genus PRIBYLOGRAPTUS Obut and Sobolevskaya, 1966

Type species. By original designation of Obut and Sobolevskaya (1966, p. 33) *Monograptus incommodus* Törnquist, 1899.

Pribylograptus sandersoni (Lapworth, 1876)

Text-figure 8C–D

1876 *Monograptus Sandersoni* Lapworth, p. 320, pl. 11, fig. 2*a–e*.
1911 *Monograptus Sandersoni* Lapworth; Elles and Wood, p. 404, pl. 39, fig. 10*a–e*; text-fig. 271*a–d*.
1970 *Pribylograptus sandersoni* (Lapworth); Hutt and Rickards, text-fig. 2*b*.
1970 *Monograptus sandersoni* Lapworth; Rickards, p. 66, text-fig. 14, fig. 25.

Lectotype. Specimen (not yet recognized: see Strachan 1971, p. 60) figured by Lapworth (1876, pl. 11, fig. 2*a*), selected by Přibyl (1948).

Material. Three distal fragments, in relief, from the *acinaces* Biozone of the Wye valley section (Text-fig. 3).

Description. The best-preserved fragment has a dorso-ventral width of 0·6 mm and a 2TRD of 2·4 mm. The thecae are gently sigmoidally curved, the most marked, convex, curvature occurring just below the aperture. The apertures are moderately laterally expanded, but otherwise essentially simple, without the development of horns or lappets; they are slightly introverted.

Discussion. This material clearly allows the inference (made by Rickards 1970) of the transitional nature of this species between (probably) *Atavograptus* and 'typical' *Pribylograptus* which possesses distinct lateral horns (Rickards and Rushton 1968). These lateral horns appear to be genuine features and not artefacts of interpretation as stated by Loydell (1991).

Monograptus s.l. sp. 1

Text-figure 10D

Material. Ten distal fragments, in partial to full relief, from the *triangulatus* Biozone of the Wye valley section (Text-fig. 3).

Description. The distal stipe fragments are up to 70 mm long. These are approximately straight, or possess a very slight ventral curvature. Widths range from 0·6 mm to 1·2 mm, and 2TRDs range from 2·1 mm to 2·5 mm (rarely to 2·8 mm). Thecae are long straight tubes, inclined at *c*. 15° to the rhabdosome axis, overlapping by just over a half in the most proximal fragment to two-thirds or just over in most fragments. The apertures are markedly everted, slightly concave in outline, and at an angle of *c*. 45° to the thecal axis.

Discussion. This graptolite to some extent resembles *Lagarograptus acinaces* or *Coronograptus cyphus cyphus* in terms of general dimensions and degree of thecal overlap, but differs in having markedly everted apertures. It differs from *Pristiograptus concinnus* in its greater thecal overlap and more markedly everted apertures. It may be related to the cf. *Atavograptus atavus* (described above) from the underlying *cyphus* Biozone.

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