THE TREMADOC GRAPTOLITE SEQUENCE OF LANCEFIELD, VICTORIA

by R. A. COOPER *and* I. R. STEWART

ABSTRACT. Biostratigraphy of the early Lancefieldian sequence of Lancefield, Victoria, is described. Lancefieldian zonal composition and nomenclature is revised: the earliest zone, La 1, here renamed the Zone of *Dictyonema scitulum* and *Anisograptus*, is comprised of *D. scitulum* Harris and Keble, *D*? *enigma* sp. nov., *Anisograptus compactus* sp. nov., and *A. delicatulus* sp. nov. A newly discovered assemblage with *Psigraptus* and several species of *Clonograptus* has been found in overlying strata and is here given the new zonal designation, La 1.5, *Psigraptus* and *Clonograptus*. The following zone, La 2, *Adelograptus victoriae* and *D. macgillivrayi*, is unchanged from previous usage. All species are described and illustrated. *D. campanulatum* and *Staurograptus diffissus* are both regarded as dubious species. The genus *Kiaerograptus* is discussed and revised to include several biramous Tremadoc species; the genus, together with *Anisograptus* and *Psigraptus* are recorded for the first time in Australasia, and *Staurograptus* is deleted from the record.

The La 1 Zone is correlated with the Matane horizon of Quebec and with the zones of *S. tenuis* and *A. richardsoni* of Yukon and inferred to be of early Tremadoc age. The La 1.5 Zone is correlated with the *C. aureus* Zone and basal part of the *Kiaerograptus antiquus* Zone of Yukon. The La 2 Zone is correlated with the *K. antiquus* Zone (upper part) of Yukon, with Zone 2 *Adelograptus–Clonograptus* of Texas, and is of late Tremadoc age.

THE sequence of graptolites in the Lancefield district has long been taken as a standard for the early Ordovician of Australasia and is the type area for the Lancefieldian Stage. The earliest Lancefieldian Zone, La 1, is of particular interest because it contains the earliest Ordovician graptolite assemblage known in Australasia, and throughout much of the 'Pacific Province'. The graptolites have not been restudied since their original description by Harris and Keble (1928).

The present work forms part of a joint project to examine the lithostratigraphy and biostratigraphy of the Cambrian–Ordovician transition in Victoria on behalf of the Working Group on the Cambrian–Ordovician Boundary (IUGS Commission on Stratigraphy). Stauro Gully and Bryo Gully provide the best sections extending from Goldie Shale (Cambrian) through the La 1 and the La 2 Zones of the overlying Ordovician strata (at present unnamed), and were sampled in detail. During the course of this work a distinctive new asemblage was discovered in strata between those containing the typical La 1 and those containing the typical La 2 assemblages, and is here designated as a new zonal assemblage, La 1.5. The purpose of the present work is to describe fully the La 1 and La 1.5 zonal assemblages and to describe briefly the La 2 species present in the measured sections. The large La 2 zonal assemblage is in need of revision.

All material described here is preserved as replaced casts of flattened rhabdosomes, the usual mode of preservation in Victorian black shales. Tectonic distortion is generally not a problem, but is indicated, where present, in the figured specimens. It is most severe at locality 3—that containing the La 1.5 Zone assemblage. All material is housed in the National Museum of Victoria. Following previous practice in Australasia, the Tremadoc is included in the Ordovician.

[Palaeontology, Vol. 22, Part 4, 1979, pp. 767–797, pls. 102–103.]

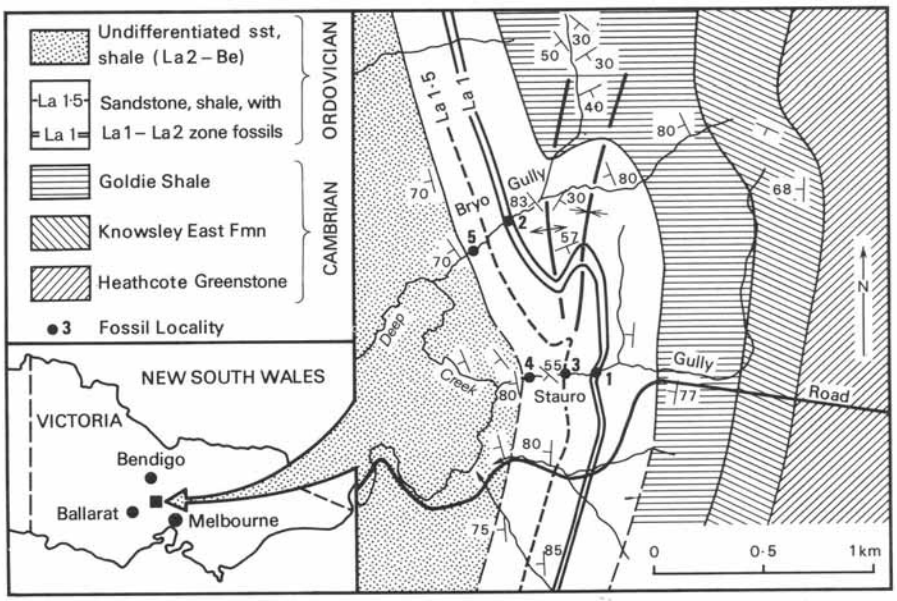
STRATIGRAPHY

Outline of the basement geology of the area around Stauro and Bryo Gullies is shown in text-fig. 1, and generalized stratigraphical columns with fossiliferous horizons, represented by localities 1–5 , are presented in text-fig. 2. A full description of the stratigraphy and structure of the Lancefield district is in preparation by A. H. M. VandenBerg and H. E. Wilkinson who have kindly provided the following notes.

The oldest beds are of Cambrian age and comprise metabasalt, chert, and shale (Heathcote Greenstone) overlain by siltstone, and volcaniclastic sandstone (Knowsley East Formation equivalent), with late Middle Cambrian dendroids in Deep Creek to the south. The overlying chert and shale (Goldie Shale) are also presumed to be of Cambrian age.

A sharp change in lithofacies marks the appearance of the next youngest unit, an unfossiliferous sequence of quartz-rich, slightly micaceous thick-bedded sandstone with minor pale nonsiliceous siltstone at the base, in total 280 m thick. It is overlain by a band of black siliceous shale, 20 m thick, that has yielded La 1 Zone fossils in both Stauro and Bryo Gullies. The base of the sandstone unit has traditionally been taken as the base of the Ordovician in Victoria (Thomas and Singleton 1956) because the sandstones form part of the upper quartz-rich sandstone-shale succession with Ordovician fossils rather than part of the lower chert-shale-volcanics succession with Cambrian fossils.

The La 1 Zone shale band (lower shale unit in text-fig. 2) is overlain by a unit, 60–75 m thick, of unfossiliferous quartz-rich sandstone and black shale (upper sandstone). The next youngest unit, about 220 m thick, is comprised of mainly pale coloured siltstone with rare black shales (upper shale unit). One thin black shale band in the lower part of the unit in Stauro Gully, contains the new La 1.5 Zone fossils,

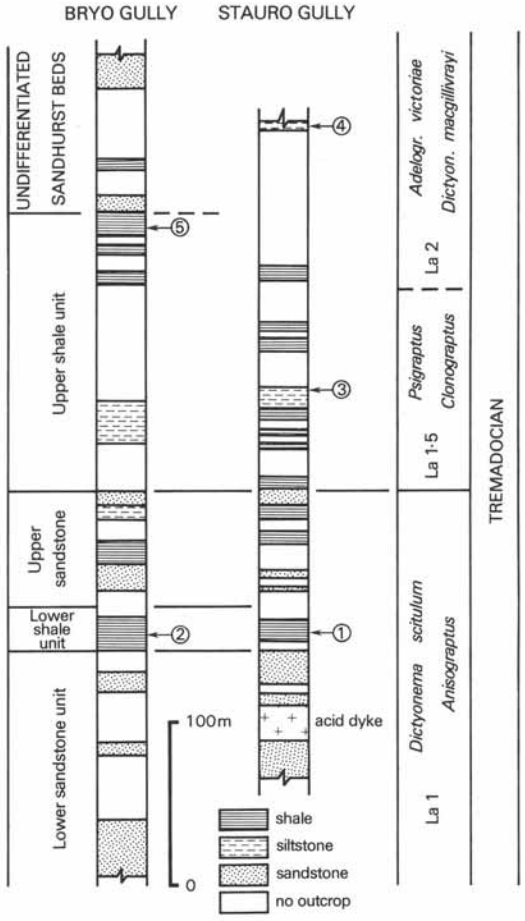


TEXT-FIG. 1. Palaeozoic geology of the area around Stauro and Bryo Gullies, south of Lancefield, Victoria (after a draft map supplied by A. H. M. VandenBerg and H. E. Wilkinson). Fossil localities discussed in this paper are indicated.

and black shale near the top of the unit contains an La 2 zonal association in Bryo Gully. Overlying the siltstone unit is a thick, undifferentiated sequence (undifferentiated Sandhurst Beds) of quartz-rich sandstone and shale. To the north and south of the area shown in text-fig. 1, La 3 Zone and younger fossils are known from the sequence.

PREVIOUS ZONAL SCHEME

Three zones are currently recognized in the Lancefieldian Stage—designated La 1, La 2, La 3 (Harris and Thomas 1938; Thomas, 1960*b*). They are based on the zonal



TEXT-FIG. 2. Stratigraphical columns for sections exposed in Bryo Gully and Stauro Gully (based on draft columns supplied by A. H. M. Vandenberg).

scheme originally proposed for the 'Lancefield Series' by Harris and Keble (1932) and are listed, together with the Harris and Keble scheme, in Table 1.

The La 1 Zone is based on an assemblage described by Harris and Keble (1928) from the 'Staurograptus Bed'. The exact locality from which the original material came was described as follows (Harris and Keble 1928, p. 91): 'the band (approximately 27 chains N. 18° W. from the south-west corner of Allot. 26, Parish of Springfield, on a water reserve) is of hard, black slate intercalated with bands of chert, quartzite and altered sandstone.' From this description and from other comments on the same page it seems clear that the locality lay in what is now known as Stauro Gully, the locality subsequently designated by the Geological Survey of Victoria as 'Locality S61'. It is listed here as locality 1.

During Thomas's (1931) mapping of the Lancefield district (Thomas 1960*a*) a second locality was found in the next gully to the north, named Bryo Gully—'Locality S62'; it is listed here as locality 2. Up to the present work, no further localities representing the zone have been found in Australasia.

TABLE 1. Zonal subdivision of the Lancefieldian Stage by Harris and Keble (1932), Harris and Thomas (1938), Thomas (1960), and this paper. Note: the L5 category of Harris and Keble was erected in anticipation of the discovery of an equivalent to the lower part of the *Dictyonema flabelliforme* Zone of Europe; no such equivalent has been found and the category was abandoned by Harris and Thomas (1938).

	Harris & Keble 1932	Harris & Thomas 1938, Thomas 1960	This paper	
BENDIGONIAN	B5 *T. approximatus* & *T. fuiticosus* (4 st.)	Be1 *T. approximatus* & *T. fruiticosus*	Be1 *T. approximatus* & *T. fruiticosus*	ARENIG
LANCEFIELDIAN	L1 *T. approximatus*	La 3 *T. approximatus*	La 3 *T. approximatus*	ARENIG
	L2 *"B" victoriae* *T. decipiens*	La 2 *Bryograptus*	La 2 *A. victoriae* & *D. macgillivrayi*	TREMADOC
	L3 *D. macgillivrayi* *"B" victoriae*			
			La 1·5 *Psigraptus* & *Clonograptus*	
	L4 *S. diffissus* *D. scitulum* *D. campanulatum*	La 1 *Staurograptus* *D. scitulum* *D. campanulatum*	La 1 *D. scitulum* & *Anisograptus*	
	L5			

The La 1 zonal assemblage of Harris and Keble comprised three species: *Staurograptus diffissus* Harris and Keble, *Dictyonema campanulatum* Harris and Keble, *D. scitulum* Harris and Keble, all confined to the zone.

The La 2 Zone was originally based on the graptolite assemblages at the well-known (but long disused) 'Lancefield Quarry' and other localities in the Lancefield district (L2 and L3 of Harris and Keble 1932, p. 31). The Lancefield Quarry assemblage was described by T. S. Hall (1899) who gave the locality as 'a small quarry a few hundred yards to the north of the now deserted Mount William railway station', that is, about 10 km north of the area shown in text-fig. 1. The zone, which encompasses the L2 and L3 Zones of Harris and Keble (Harris and Thomas 1938), has been recognized widely throughout Victoria and New Zealand. It is characterized by several species of *Clonograptus*, large *Dictyonema* (*D. macgillivrayi*, *D. pulchellum*), *Adelograptus victoriae*, *Tetragraptus decipiens*, *Kiaerograptus pritchardi*, and *K. antiquus*.

The La 3 Zone was erected with Bull Dog Creek in Mornington Peninsula as the 'typical outcrop' (Harris and Keble 1932), and is marked by the appearance of *T. approximatus*, and the less common *T. acclinans*. *A. victoriae*, *T. decipiens*, *K. pritchardi*, and *Clonograptus* persist from the previous zone, but *D. macgillivrayi* and *D. pulchellum* are absent.

REVISED ZONAL SCHEME

During the present work all previous collections from Stauro and Bryo Gullies held by the National Museum of Victoria (including those made by the Geological Survey) have been re-examined. Further collections from all known fossiliferous horizons have been made; two new localities, neither containing graptolites, have been found in La 1 Zone strata and a new locality (text-fig. 1, locality 3) found representing a previously unrecognized fossiliferous horizon between the typical La 1 and La 2 Zone strata (Table 2). The new palaeontological data, together with the detailed mapping and measured sections provides a clearer picture of the earliest Ordovician graptolite sequence in Australasia.

La 1 Zone of Dictyonema scitulum *and* Anisograptus

Taxonomic revision of the La 1 Zone assemblage has resulted in considerable amendment to the list of species present:

1. The holotype of *Staurograptus diffissus* is so poorly preserved that it is not clear that there are 4 rather than 3 primary stipes and generic assignment is thus uncertain. It is questionably referred to the species listed here as *A. compactus* sp. nov. Of the other specimens figured by Harris and Keble (1928) that of their fig. 4 is missing; that of fig. 2 is again too poorly preserved to allow the number of primary stipes to be determined; that of fig. 1 is indeterminate; and that of fig. 3 is the form described here as *A. delicatulus* sp. nov. Among all other La 1 Zone material examined there are no specimens which can be referred unequivocally to *Staurograptus* and occurrence of the genus in Australasia must be regarded as unproven.

2. The holotype of *D. campanulatum* is a rhabdosome that has reached only an early stage of development but appears unlikely to be conspecific with the other specimens in the type series. It is questionably referred to *D.*? *enigma* of this paper. Of the remaining specimens of the type series, all except that of Harris and Keble's (1928) fig. 9 are held by the National Museum of Victoria; except for the specimens of figs. 6 and 8, which are not definitely determinable, all appear to be conspecific with *D. scitulum*.

3. Three additional species are recognized: *A. delicatulus* sp. nov., *A. compactus* sp. nov., and *D*? *enigma* sp. nov.

TABLE 2. Distribution of species in collections from Localities 1–5.

SPECIES \ LOCALITIES	Stauro Gully 1	Bryo Gully 2	Stauro Gully 3	Bryo Gully 5	Stauro Gully 4
Dictyonema scitulum	×	×	.	.	.
D ? enigma	×	×	.	.	.
Anisograptus delicatulus	×	×	.	.	.
A. compactus	×	×	.	.	.
Adelograptus victoriae	.	.	.	×	×
A. sp. nov.	.	.	×	.	.
A ? sp.	.	.	.	×	×
Clonograptus tenellus	.	.	.	.	×
C. sp. *1*	.	.	×	.	.
C. cf. sp. *1*	.	.	×	.	.
C. sp. *2*	.	.	×	.	.
C. sp. *3*	.	.	×	.	.
C. sp. *4*	.	.	.	×	.
C. spp.	.	.	×	×	×
Kiaerograptus antiquus	.	.	.	×	×
Psigraptus lenzi	.	.	×	.	.
Temnograptus sp.	.	.	.	×	×
Tetragraptus bulmani	.	.	.	×	×
T. decipiens	.	.	.	×	.
ZONES	La 1		La 1·5	La 2	

The revised composition of the La 1 Zone assemblage is: *D. scitulum*, *D.*? *enigma*, *A. delicatulus*, and *A. compactus*. Other fossils include *Cariocaris* sp. and other phyllocarid species, unidentified inarticulate brachiopods, and an unidentified arthropod.

In both Stauro Gully (locality 1) and Bryo Gully (locality 2), *Dictyonema* fragments of *scitulum* type are distributed through a band about 140 mm thick; the full assemblage with *A. delicatulus*, *A. compactus*, and *D.*? *enigma* is confined to an interval about 10–20 mm thick and lying 40 mm above the first appearance of *Dictyonema*. The *Anisograptus* species and *D.*? *enigma* generally occur together on the same bedding planes, from which *D. scitulum* is generally absent. Phyllocarids are found through most of the black shale section and, together with unidentified arthropod fragments, have been found at two new localities in the La 1 Zone black shale band to the south of Stauro Gully.

The zone represents the appearance of the first Ordovician graptolites in Australasia.

La 1.5 Zone of Psigraptus *and* Clonograptus

Currently known from a single locality in the Stauro Gully section this zone is defined by the appearance of *Psigraptus lenzi* and several species of *Clonograptus*, here designated *C.* sp. *1*, *C.* cf. sp. *1*, *C.* sp. *2*, *C.* sp. *3*, and *Adelograptus* sp. nov., and

the disappearance of the preceding zone species. The fossils are confined to a thin band, less than 30 mm thick.

The zone marks the appearance of the world-wide early Ordovician genus, *Clonograptus*. The peculiar genus *Psigraptus*, until now known only from Canada (Jackson 1967, 1974) is represented by *P. lenzi* Jackson.

Discovery of the new assemblage poses a problem; it is clearly a distinct assemblage, having no species in common with either the preceding (La 1) or succeeding (La 2) assemblages and cannot be included in either zone as currently defined and used. The assemblage is thus proposed as the basis for a new zone. Because the zonal connotations, La 1, La 2, and La 3 are so well known and so widely used, the connotation La 1.5 (suggested to us by Dr. O. P. Singleton) is used to indicate the homotaxial position of the new zone without upsetting established usage.

La 2 Zone of Adelograptus victoriae *and* Dictyonema macgillivrayi

This zone is unchanged from previous usage and marks the first appearance of a reasonably diverse graptolite fauna. In the collections at hand, the most common forms are *A. victoriae* (includes *Bryograptus clarki* T. S. Hall), *A.* spp., *Tetragraptus decipiens*, and species of *Clonograptus*; the full list also includes *Kiaerograptus antiquus*, *Adelograptus*? sp., *C. tenellus*, *C.* sp. *4*, *Temnograptus* sp., and *Tetragraptus bulmani*.

Correlation

The presence in the La 1 Zone of two species of *Anisograptus*, and siculate *Dictyonema*, together with the absence of *Clonograptus* and *Adelograptus* suggest correlation with the Matane horizon of Quebec described by Bulman (1950) and with the *S. tenuis* and *Anisograptus richardsoni* Zones of the Richardson Mountains sequence in Yukon described by Jackson (1974, 1975); that is with the upper part of the Lower Tremadoc. The zone and its equivalents around the world mark the appearance and, locally, dominance of anisograptids—particularly *Anisograptus*—but precede the appearance of *Adelograptus* and the extreme diversification of *Clonograptus*. They succeed the earliest Tremadoc graptolite zone with *D. flabelliforme parabola*, which has no equivalent in Australasia.

Correlation of the La 1.5 Zone is more difficult. It appears to be matched in the Richardson Mountains sequence of Yukon by strata containing *C. aureus*, *C.* sp., and *P. lenzi*; that is, between the 7760 and 7805 foot levels in the Rock River section described by Jackson (1975). It would thus be equivalent to Jackson's *C. aureus* and basal *Adelograptus antiquus* Zones. Elsewhere there appears to be no closely equivalent graptolite fauna.

The La 2 Zone marks the appearance of a relatively widespread, diverse graptolite fauna, offering the first opportunity for confident precise correlation. The zone is equivalent to the *A. antiquus* Zone (above the 7805 foot level) of the Richardson Mountains in Canada (Jackson 1975) with *A. victoriae*, *K. antiquus* (as defined here), *K. pritchardi*, *D.* cf. *pulchellum*, *D.* cf. *macgillivrayi*, and *T. decipiens*; to Zone 2, *Adelograptus–Clonograptus*, of Texas (Berry 1960) with *A. victoriae*, *T. decipiens*, and several large species of *Clonograptus*; and is of late Tremadoc age.

The La 3 Zone, marked by the appearance of the world-wide species *T. approximatus*, is now generally regarded as of earliest Arenig (Skevington 1963; Jackson 1964; Berry 1967; Strachan *in* Williams *et al.* 1972) rather than late Tremadoc age (Harris and Thomas 1938; Thomas, 1960*b*).

Correlation of the Lancefieldian sequence is discussed more fully by Cooper (1979*b*).

SYSTEMATIC PALAEONTOLOGY

Family DENDROGRAPTIDAE Roemer *in* Frech, 1897
Genus DICTYONEMA Hall, 1851
Dictyonema scitulum Harris and Keble, 1928

Plate 102, figs. 1, 2, 4, 6, 7, 9, 11; text-figs. 3*a–c*, *e*, *f*

1928 *Dictyonema scitulum* Harris and Keble, p. 93, pl. 9, figs. 14–19.
1928 *Dictyonema campanulatum* Harris and Keble (*pars*), p. 92, pl. 9, figs. 9?, 10–13.
?1950 *Dictyonema cyathiforme* Bulman, p. 75, pl. 5, figs. 12–14, 21, 22.

Diagnosis. Rhabdosome siculate, variable in form but generally infundibuliform or cyathiform; small (less than 25 mm long); nema commonly branched or replaced by a bundle of fibres; stipes about 0·3 mm in lateral width, spaced about 13–14 in 10 mm in the mature part of the rhabdosome; dissepiments slender, spaced irregularly in proximal part of rhabdosome but fairly regularly distally, where they are relatively close (about 15–18 in 10 mm); autothecae markedly denticulate.

Holotype. P31912 (Harris and Keble 1928, pl. 9, fig. 19; refigured here, text-fig. 3*a*, Pl. 102, fig. 9). The specimen label indicates holotype; when compared with Harris and Keble's figure, however, the specimen has a more gradually opening rhabdosome and is thus of slightly different proportions. Their figure does not allow detailed close comparison with the specimen but there are several features of correspondence between the two, and there appears to be no other candidate for the holotype. A likely explanation for the difference is that the specimen was tilted about an 'east–west' axis when being photographed for the original paper.

Paratypes. P31893 (Harris and Keble 1928, pl. 9, fig. 18); P31909, P31910, P31911 (Harris and Keble 1928, pl. 9, figs. 14, 15, 17). The original of their fig. 16 is apparently missing.

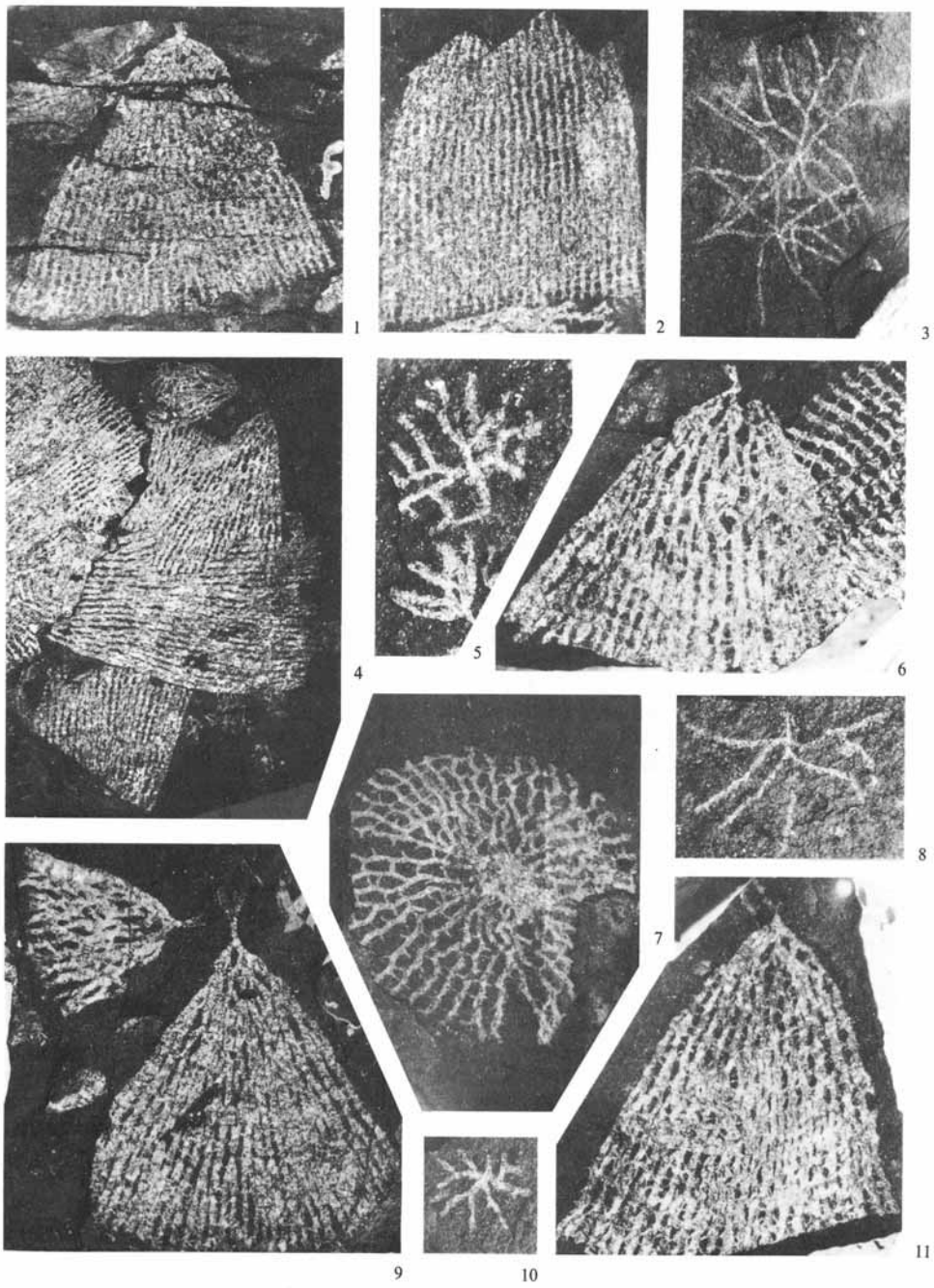
Other material. Over fifty specimens have been collected from Stauro and Bryo Gullies. Many are complete but few are well preserved. None shows thecal details clearly.

EXPLANATION OF PLATE 102

Figs. 1, 2, 4, 6, 7, 9, 11. *Dictyonema scitulum* Harris and Keble. 1, mature rhabdosome, P42694, locality 1, ×2. 2, distal portion of mature rhabdosome in which stipes attain parallelism, topotype, P46891, locality 1, ×2·5. 4, several superposed mature rhabdosomes, P47104, locality 2, ×1·8. 6, two incomplete mature rhabdosomes, topotypes, P46887, locality 1, ×3·5. 7, holotype and immature rhabdosome, P31912, locality 1, ×2·5 (figured Harris and Keble 1928, pl. 9, fig. 19). 9, immature rhabdosome discoidally preserved, P42664, locality uncertain (either 1 or 2), ×3·5. 11, mature specimen, topotype, P46877, locality 1, ×3·5.

Figs. 3, 8. *Anisograptus delicatulus* sp. nov. 3, two mature rhabdosomes, the lower of which is holotype, P47770, locality 1 (paratype, topotype), ×2·7. 8, P44087, locality 2, ×3.

Figs. 5, 10. *A. compactus* sp. nov. 5, paratype, topotype, P44090, locality 1, ×5. 10, immature rhabdosome, P46896, locality 2, ×4.



COOPER and STEWART, Tremadoc graptolites

Description. The rhabdosome is small, compact, and variable in shape, generally ranging from conical to parabolic in outline and opening rapidly in the proximal region. Large rhabdosomes are generally broadly conical or infundibuliform in shape, but a few (e.g. Pl. 102, fig. 2) become nearly parallel sided distally, resembling *D. cyathiforme* Bulman. Rhabdosome length up to 25 mm but commonly about 13 mm.

Sicular dimensions are rarely determinable but sicular length appears to be between 1·2 and 1·8 mm. The nema is commonly branched, the apex of the sicula passing into a bundle of up to six stout fibres reaching 20 mm in length. Similar structures are described by Bulman (1970*b*) in *D. belgicum* and inferred either to represent an attachment organ or to be related to a rhabdosome float of soft tissue. The number of primary stipes is probably three rather than four, with one stipe dividing shortly after its origin.

Stipe width (lateral) averages 0·3 mm (0·25–0·4 mm), a little less than the spaces between adjacent stipes; about 13–14 stipes are counted in 10 mm in the mature part of the rhabdosome.

From very few specimens, autothecae are spaced about 9 in 10 mm in the mature part of the rhabdosome and are markedly denticulate. Dissepiments are slender but are commonly thickened towards the stipe margins, making them look like extended denticulate apertural margins. In the proximal part of the rhabdosome they are very irregularly spaced and commonly obliquely inclined to the stipe axis; they become less irregular in the distal portions of mature rhabdosomes where, in a few specimens (text-fig. 3*f*), they develop an orderly mesh work and are closely spaced (15–18 in 10 mm). Early growth stages (text-fig. 3*e*) indicate that some, if not all, dissepiments are formed as the rhabdosome grows.

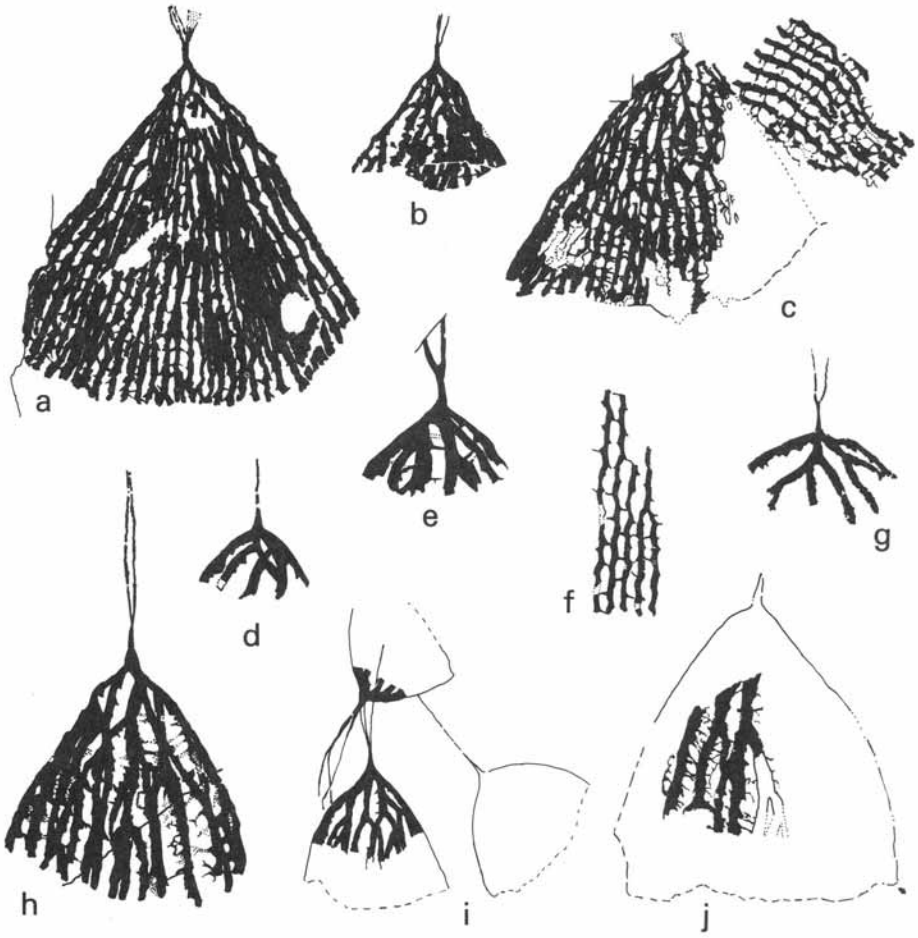
Discussion. The distinctive features of *D. scitulum* are: (1), a small, compact rhabdosome; (2), close spacing of stipes; (3), marked variability in rhabdosome form and in development of dissepiments; (4), the common presence of 'nematic fibres'. The most common rhabdosome form is more or less broadly conical and the parallel sided rhabdosomes represent extreme end members of a widely variable population rather than a distinct population.

Affinity. The parallel-sided rhabdosomes closely resemble *D. cyathiforme* Bulman from Matane, Quebec. From Bulman's figures (1951, pl. 5, figs. 12–14, 21, 22) the Matane form has irregularly spaced dissepiments in the proximal region of the rhabdosome, contrasting with more regular spacing in the distal region, as in the Lancefield specimens. The tendency for dissepiments to be arranged in horizontal rows never reaches, in the Lancefield forms, the regularity attained by the holotype of *D. cyathiforme* (Bulman 1951, pl. 5, figs. 13, 14) and synonymy is not certain.

The apical 'nematic' sheaf of fibres is strikingly like that described in *D. flabelliforme belgicum* by Bulman (1970*b*) but the Lancefield species is considerably more compact. Its small size, triradiate development, more closely spaced stipes and, consequently, dense appearance of the meshwork, readily distinguish *D. scitulum* from *D. flabelliforme parabola* Bulman (1954), the earliest *Dictyonema* in the Oslo sequence.

The paratypes of *D. campanulatum* figured by Harris and Keble (1928, pl. 9, figs. 9–13) are here referred to *D. scitulum*.

Horizon and localities. La 1 Zone of *D. scitulum* and *Anisograptus*; localities 1 and 2. The species is commonly found in profusion on bedding planes, from which other species are apparently absent. It is the most abundant species in the La 1 Zone.



TEXT-FIG. 3. *a–c*, *e*, *f*, *Dictyonema scitulum* Harris and Keble; *a*, P31912 (holotype), mature rhabdosome, ×3; *b*, P42607, locality 2, ×3; *c*, P46887, locality 1 (topotype), mature rhabdosome, ×3; *e*, P46907, locality 1 (topotype), ×5·5; *f*, P47100, locality 1 (topotype), distal fragment of mature rhabdosome, ×3. *d*, *h–j*, *D.*? *enigma* sp. nov.; *d*, P53993; locality 1 (paratype, topotype), growth stage, ×5; *h*, P47159, locality 1 (holotype), mature rhabdosome showing spinose meshwork, ×5; *i*, P52791, P53990, P53991, locality 1 (paratypes, topotypes), group of three rhabdosomes showing parabolic rhabdosome outline, ×3; *j*, P52790, locality 1 (paratype, topotype), portion of mature rhabdosome showing spinose meshwork, ×5. *g*, *D.*? *enigma* sp. nov.? P31903, holotype of *D. campanulatum* Harris and Keble (figured Harris and Keble 1928, pl. 9, fig. 7), ×5.

Dictyonema? enigma sp. nov.

Plate 103, figs. 8, 12, 13, ?3; text-figs. 3*d*, *h–j*, ?*g*

?1928 *Dictyonema campanulatum* Harris and Keble (*pars*), p. 92, pl. 9, fig. 7 (*non* pl. 9, figs. 9–13).

Diagnosis. Rhabdosome small (generally less than 11 mm long), compact, pendent, cyathiform with a rounded apical end; branching close in proximal region but spaced out distally, about 20 subparallel terminal stipes; sicula large and wedge-shaped, nema commonly split into 2 to 4 fibres; lateral stipe width about 0·3 mm, dorsoventral stipe width about 0·4 mm. Thecae spaced about 16 in 10 mm, autothecal apertures denticulate. Fine branching spines commonly developed, apparently from thecal apertural margins, forming a loose meshwork linking adjacent stipes. Dissepiments apparently lacking.

Holotype. P47159.

Paratypes. P46876, P46907, P52771, P52789, P52790, P52791, P52792, P53990, P53991, P53993. More than thirty other specimens are present.

Description. The rhabdosome is small, rarely exceeding 11 mm in length; cyathiform, with a high initial stipe divergence angle giving a parabolic outline. The nema is commonly divided near the sicula into 2, 3, or 4 separate strands up to 10 mm long.

The sicula is wedge-shaped and about 1·3 mm long. There are 3 primary stipes, one of which bifurcates soon after its origin. Branching is rapid with the formation of at least 16–18 stipes at a distance of 6 mm from the sicula; thereafter stipes rarely divide and the rhabdosome has about 20 terminal stipes. Lateral stipe width is generally about 0·3 mm, dorsoventral stipe width generally about 0·4 mm. Thecal details are obscure but autothecal apertures are apparently denticulate and spaced about 8 in 5 mm (*c.* 16 in 10 mm). Fine spines are developed from the stipe margins, possibly from autothecal apertures, and in some relatively well-preserved specimens can be seen to divide and join adjacent spines to form a fine, loose mesh-work spanning the space between adjacent stipes (text-figs. 3*h*, *j*). In a few specimens faint markings hint at the presence of dissepiment-like links, perhaps of soft or incompletely scleritized tissue, between adjacent stipes (text-fig. 3*h*), but definite scleritized dissepiments were not observed.

Discussion. Specimens here distinguished as *D.*? *enigma* differ from *D. scitulum* in lacking dissepiments, in having a more characteristically parabolic, rather than conical, shaped rhabdosome, in rarely exceeding 10 mm in rhabdosome length, and in the development of branching thecal spines and a fine mesh work between adjacent stipes. However, the general similarity between the two is noticeable and the tendency for the nema to divide in each species is striking and suggests a similar method of rhabdosome attachment or flotation. A few specimens are preserved with the stipes displaced and rather disorganized, emphasizing the lack of rhabdosome rigidity resulting from the lack of scleritized dissepiments.

Autothecal apertural spines with forked terminations are described in *D. canadense* Lapworth from Matane by Bulman (1950), but do not appear to form a mesh-work. The nema of the Matane species, like that of *D.*? *enigma* commonly divides into several strands. Well-developed dissepiments, a much larger mature rhabdosome, and quadriradiate development distinguish *D. canadense* from *D.*? *enigma*.

The specimen nominated as holotype of *D. campanulatum* Harris and Keble (1928, pl. 9, fig. 7) possibly represents this species. It is poorly preserved, represents an immature rhabdosome, and its identity is here regarded as indeterminate.

Generic assignment. The possible presence in *D.? enigma* of incompletely scleritized dissepiment-like structures, together with the development of a spinose meshwork linking adjacent stipes, is suggestive of *Dictyonema* rather than *Bryograptus*. Certainly *D.? enigma* and *D. scitulum* seem likely to be less than generically distinct. However, as currently defined (Bulman 1970*a*, p. V39) *Dictyonema* excludes forms without definite dissepiments. The species could, perhaps, be regarded as a *Dictyonema* in which scleritized dissepiments were replaced by soft tissues and a fine spinose meshwork.

Horizon and localities. La 1 Zone of *D. scitulum* and *Anisograptus*, localities 1 and 2.

Genus ANISOGRAPTUS Ruedemann, 1937

Anisograptus compactus sp. nov.

Plate 102, figs. 5, 10; Plate 103, figs. 1, 4, 7, 9; text-figs. 4*a–d, f*, ?*e*

?1928 *Staurograptus diffissus* Harris and Keble (*pars*), pp. 91, 92, pl. 9, figs. 2, 4, 5 (*non* figs. 1, 3).
?1962 *Anisograptus* sp. Obut and Sobolevskaya, pl. 2, fig. 2.

Diagnosis. Rhabdosome small (up to 2 cm in diameter in the Lancefield population), triradiate, horizontal, composed of slender stipes (0·2–0·4 mm wide) branching rapidly up to the sixth order giving up to 36 terminal stipes; thecae (autothecae) spaced about 18 in 10 mm.

Holotype. P46903.

Paratypes. P44089, P44090, P46896, P52788. At least six other specimens are present.

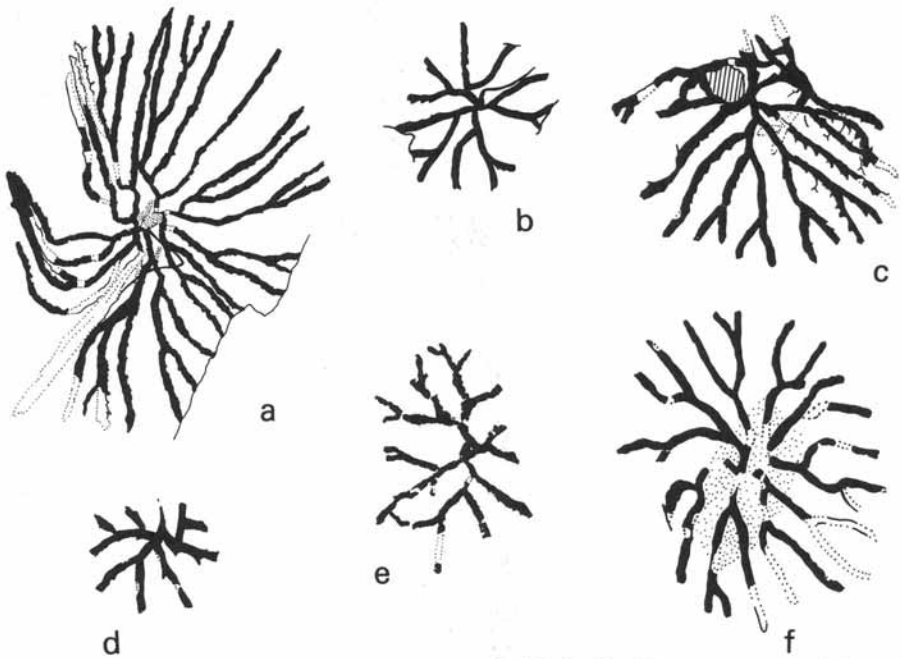
Description. The rhabdosome is very small—the largest specimens reach 20 mm in diameter but most are 10 mm or less—compact and horizontal. It is developed from 3 primary stipes, one usually dividing soon after its origin, giving the rhabdosome a simulated quadriradiate appearance. Dichotomies are fairly regular and rapid with up to 6 orders of stipes giving up to 36 terminal stipes. Stipes of the first one or two orders are very short (generally about 0·4–0·6 mm long) but increase in length with each successive order, and terminal stipes (of third to sixth order) are up to 10 mm long. Small rhabdosomes are somewhat rigid and spidery in appearance, but in larger more mature rhabdosomes the long terminal stipes are rather flexuous. In several rhabdosomes the proximal region is obscured by what appears to be a peridermal film or web (text-fig. 4*f*; Pl. 103, fig. 7).

A relatively stout nema is present in several rhabdosomes, expanding into the apex of the sicula. The sicula is wedge-shaped and about 0·8 mm long. Stipes are about 0·3 mm (0·2–0·4 mm) wide in dorsal view. Autothecae are seldom visible but appear to be slightly denticulate and spaced about 6 in 3·2 mm (*c.* 18 in 10 mm). Traces of fine branching spines on stipe margins, rather like those described in *Dictyonema? enigma* were seen in a few specimens (text-fig. 4*c*).

Discussion. The species is distinguished chiefly by its small size and compact branching habit. Branching is more frequent and more regular than in *A. delicatulus*.

The holotype of *Staurograptus diffissus* Harris and Keble, 1928 (text-fig. 4*e*) is possibly conspecific with the species, in which case the name *diffissus* would have priority. However, the specimen is poorly preserved and details of the proximal region are obscure; its affinity is uncertain and a new name is therefore proposed for the new material. Of the paratypes figured by Harris and Keble, those of their pl. 9 figs. 2 and 4 are likely to represent the species.

With its compact branching habit, slender stipes, small size, and numerous



TEXT-FIG. 4. *a–d, f, Anisograptus compactus* sp. nov.; *a*, P44089, locality 1 (paratype, topotype), largest mature rhabdosome, ×3; *b*, P46903, locality 1 (holotype), ×5; *c*, P46892, locality 1 (paratype, topotype), showing branching spines, ×5; *d*, P46896, locality 2 (paratype), immature rhabdosome, ×3; *f*, P52788, locality 1 (paratype, topotype), mature specimen with proximal film of periderm, ×5. *e*, *A. compactus*?; P13639, holotype of *Staurograptus diffissus* Harris and Keble (figured Harris and Keble 1928, pl. 9, fig. 5), ×5.

EXPLANATION OF PLATE 103

Figs. 1, 4, 7, 9. *Anisograptus compactus* sp. nov. 1, largest mature rhabdosome, paratype, topotype, P44089, locality 1, ×2·8. 4, holotype, with two immature rhabdosomes of *Dictyonema*? *enigma* sp. nov.?, P46903, locality 1, ×5·5. 7, rhabdosome with proximal peridermal film, paratype, topotype, P52788, locality 1, ×3·4. 9, paratype, topotype, P46892, locality 1, ×4·5.

Figs. 2, 10. *A. delicatulus* sp. nov. 2, large mature rhabdosome, P47769, locality 1 (paratype, topotype), ×4. 10, P47768, locality 1 (paratype, topotype), ×3·6.

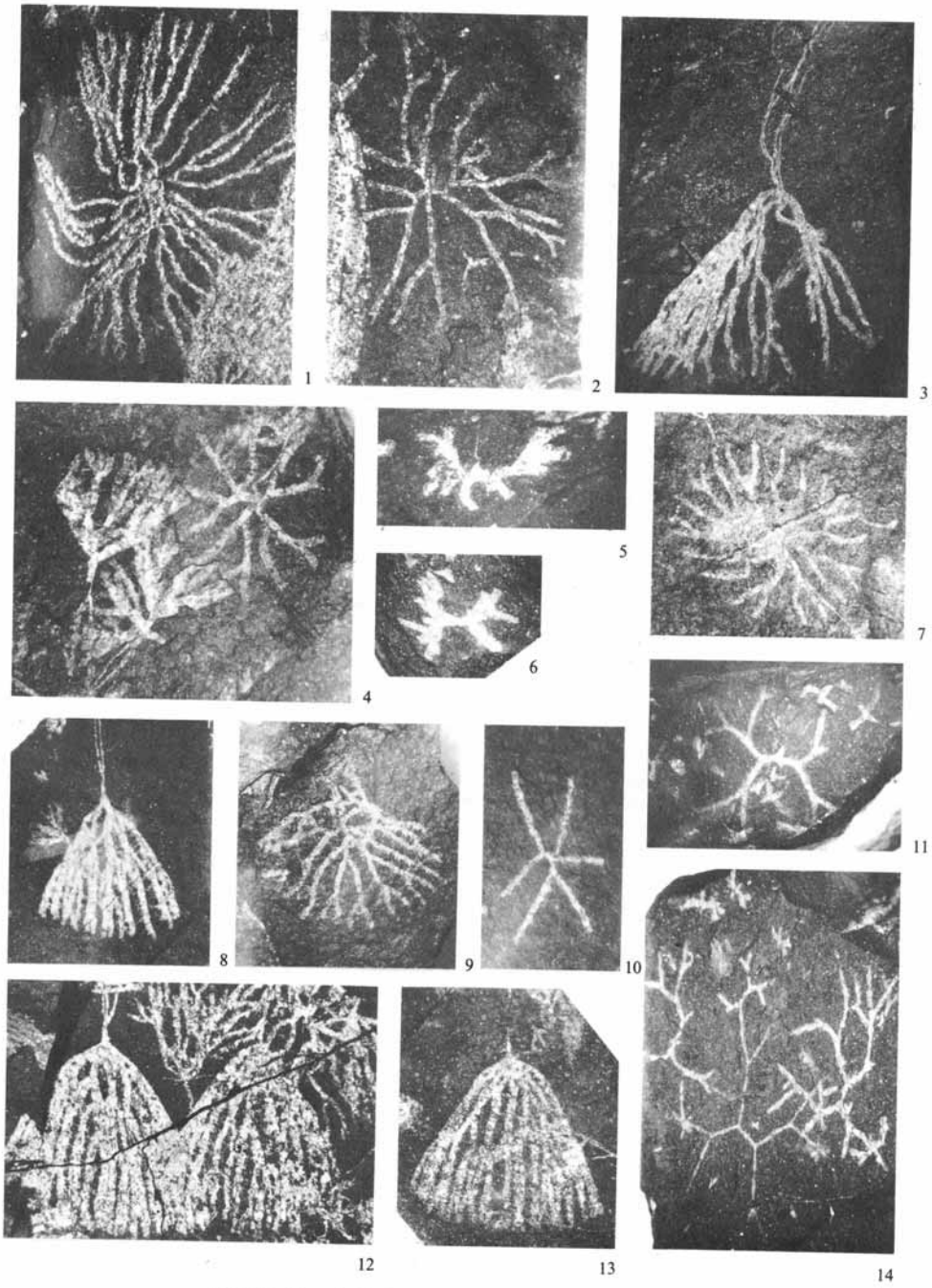
Fig. 3, *D.*? *enigma* sp. nov.? Mature specimen with somewhat disarranged stipes and in which spines were not seen; P42674, locality uncertain (either 1 or 2), ×3.

Figs. 5, 6. *Psigraptus lenzi* Jackson. 5, mature rhabdosome with 3 or 4 stipes, P47110, locality 3, ×4·8. 6, 4-stiped rhabdosome, P47128, locality 3, ×5.

Figs. 8, 12, 13. *D.*? *enigma* sp. nov. 8, holotype, P47159, locality 1, ×3. 12, two mature rhabdosomes, paratypes, topotypes, P52789, locality 1, ×3·3. 13, mature rhabdosome, paratype, topotype, P53992, locality 1, ×3·3.

Fig. 11. *Clonograptus* sp. 1. P42712, locality 3, ×3·5.

Fig. 14. *Clonograptus* sp. 3. Mature incomplete rhabdosome with superimposed rhabdosomes, probably of *Clonograptus* sp. 1; P46850, P52783, P52784, locality 3, ×3.



COOPER and STEWART, Tremadoc graptolites

terminal stipes, *A. compactus* bears strong resemblance to the diminutive *A. richardsoni* Bulman, described from Matane, Quebec (Bulman 1941, pp. 109, 110, pl. 2, fig. 6; text-figs. 2*a*, *b*). The Lancefield species is proportionately even smaller and more compact than the Matane species, however, with more closely spaced autothecae (*c.* 18 in 10 mm rather than 11–12), and differs in possessing a prominent sicula and, occasionally, a stout nema.

The specimen figured as *Anisograptus* sp. from Taimyr, Siberia, by Obut and Sobolevskaya (1962, pl. 2, fig. 2) has the distinctive branching habit of the Lancefield species but, from their figure, is of somewhat larger proportions.

Horizon and localities. La 1 Zone of *D. scitulum* and *Anisograptus*; localities 1 and 2.

Anisograptus delicatulus sp. nov.

Plate 102, figs. 3, 8; Plate 103, figs. 2, 10; text-figs. 5*a*, *b*, *d–h*, *j–l*

1928 *Staurograptus diffissus* Harris and Keble (*pars*), pp. 91, 92, pl. 9, figs. ?1, 3 (*non* figs. 2, 4, 5).

Diagnosis. Rhabdosome triradiate but commonly with pseudo-quadriradiate symmetry, widely variable in form, horizontal to declined, minute (up to 13 mm in diameter in the Lancefield population), composed of relatively few, slender (0·25–0·4 mm in dorsoventral width) stipes; branching pattern widely variable but stipes of first one or two orders very short; sicula prominent (1·5 mm long) and wedge-shaped; autothecae spaced about 17–19 in 10 mm, autothecal apertures slightly denticulate.

Holotype. P47770.

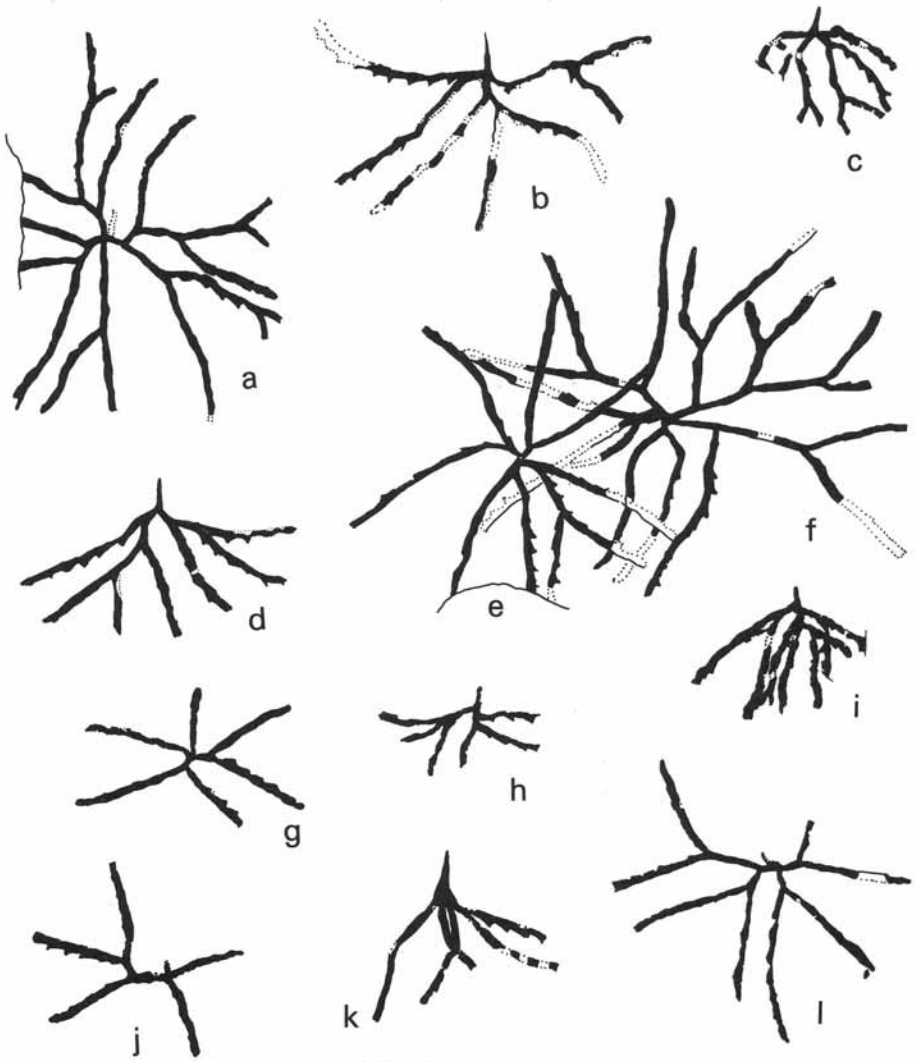
Paratypes. P31902, P42625, P42634, P42641, P42676, P42678, P44087, P47768, P47769, P53999. About ten other specimens are present in the collections.

Description. The rhabdosome is widely variable in form, horizontal to declined, minute (up to 13 mm in diameter) and rather delicate. A zone of branching from 1 to 2 mm from the sicula produces 4 to 8 stipes; thereafter branching is sparse, commonly giving rise to rhabdosomes with about 8 terminal stipes. The largest specimens bear up to 16 terminal stipes. The branching pattern is highly irregular and together with variation due to mode of rhabdosome preservation gives rise to extreme variability in form.

The sicula is long (1·5 mm long in the holotype but a little less in most other specimens), and generally wedge-shaped, with apparently no attached nema.

Stipes are moderately rigid, and dorsal stipe margins undulating in some specimens. Dorso-ventral stipe width 0·35–0·4 mm, lateral stipe width about 0·25–0·3 mm. Thecae (autothecae) are spaced at about 17–19 in 10 mm, thecal apertures are slightly denticulate.

Rhabdosome development. The rhabdosome is developed from 3 primary stipes, one of which commonly bifurcates soon after its origin, sometimes giving the rhabdosome the appearance of having 4 primary stipes. In a few rhabdosomes (text-fig. 5*k*) the apparent 4-stiped origin suggests that they should perhaps be referred to *Staurograptus* rather than *Anisograptus* which, by definition, excludes forms with 4 primary stipes. The rhabdosomes are otherwise indistinguishable from the 3-stiped forms and until the presence of 4 primary stipes can be unequivocally demonstrated, all forms are grouped here as *A. delicatulus*.



TEXT-FIG. 5. *a*, *b*, *d–h*, *j–l*, *Anisograptus delicatulus* sp. nov.; *a*, P47769, locality 1 (paratype, topotype), large mature rhabdosome, × 5; *b*, P44087, locality 2 (paratype), × 5; *d*, P31902, locality 1, paratype of '*Staurograptus diffissus* Harris and Keble' (figured Harris and Keble 1928, pl. 9, fig. 3), × 5; *e*, P47770, locality 1 (holotype), mature rhabdosome, × 5; *f*, P52776, locality 1 (paratype, topotype), mature rhabdosome, × 5; *g*, P47768, locality 1 (paratype, topotype), × 5; *h*, P42634, locality 1 (paratype, topotype), × 5; *j*, P42641, locality 1 (paratype, topotype), × 5; *k*, P42625, locality 2, × 5; *l*, P42676, locality uncertain (either 1 or 2), × 5. *c*, *i*, *A.* cf. *delicatulus* sp. nov.; *c*, P52779, × 5; *i*, P42678, locality uncertain (either 1 or 2), × 5.

Discussion. The population described here includes a wide variety of forms reflecting a wide range of variation in the species. A few rhabdosomes are declined to pendent in habit (text-figs. 5*c*, *i*) rather than the usual horizontal to declined; they appear to have shorter, blunter siculae and may represent a distinct species. They are listed here as *A.* cf. *delicatulus*.

In general habit and size *A. delicatulus* is reminiscent of *S. dichotomous* var. *apertus* Ruedemann described by Bulman (1950); the Lancefield species is distinguished by having more closely spaced thecae (17–19 rather than 11–13 in 10 mm), 3 rather than 4 primary stipes and, generally, a more open rhabdosome with fewer dichotomies. From other anisograptids the Lancefield form is distinguished mainly by its small size, slender stipes, and closely spaced thecae.

The specimen figured by Harris and Keble (1928, pl. 9, fig. 3) as *S. diffissus* is here included in *A. delicatulus*.

Horizon and localities. La 1 Zone of *D. scitulum* and *Anisograptus*, localities 1 and 2.

Genus ADELOGRAPTUS Bulman, 1941

Adelograptus victoriae (T. S. Hall, 1899)

Text-figs. 8*g*, *j*, *l*

1899 *Bryograptus victoriae* T. S. Hall, p. 165, pl. 17, figs. 1, 2.
1899 *Bryograptus clarki* T. S. Hall, pp. 165, 166, pl. 17, figs. 3, 4.
1935 *Bryograptus hunnebergensis* Moberg; Benson and Keble (= *B. pauxillus nom. nud.* Benson and Keble, *in* Benson 1933, p. 403), pp. 269, 270, pl. 30, figs. 1–11, 14?, 15?
1966 *Adelograptus clarki*; Berry, pp. 419–421, pl. 44, figs. 2, 4.
1966 *Adelograptus victoriae*; Berry, pp. 421, 422, pl. 44, fig. 1.

Material. P47086, P47088, P47091, P47096, P52776, P52767, P52768, P53994, P53995, P53996, P53998, and many other specimens.

Description. Rhabdosome habit ranges from declined to pendent. Branching pattern and stipe divergence angle is widely variable, encompassing that described for both *Adelograptus clarki* and *Adelograptus victoriae* by Berry (1966) in his redescription of the type material. One primary stipe generally bifurcates immediately after the first thecal aperture and appears to be always that based on theca 1^1. Bifurcation of the other primary stipe is generally delayed until after formation of two or more thecae. Branching continues to at least the fourth order. Where stipes are clearly seen in profile view dorso-ventral stipe width is 0·7–0·8 mm. Thecae have concave ventral margins and are somewhat denticulate.

Discussion. The distinction of *A. clarki* from *A. victoriae* was discussed by Berry (1966, p. 420) and based mainly on the presence in *A. clarki* of lateral branching (as well as dichotomous bifurcation) and a declined rather than pendent rhabdosome habit, both features said to be not present in *A. victoriae*. In the collections under discussion here, original rhabdosome habit appears to have been variable, ranging from pendent to declined. Rhabdosomes are commonly preserved in a manner which suggests some buckling or bending of stipes during settling on the sea floor or during subsequent burial, as might well be expected with a declined rhabdosome. The original angles of stipe divergence are thus likely to be altered and stipes may be rotated, making an originally dichotomous bifurcation look more like lateral branching.

It therefore seems dubious to maintain a specific distinction based on branching mode or a pendent versus declined rhabdosome habit. In view of the considerable range in original rhabdosome morphology inferred here, we follow Bulman (1941, p. 115) and place *A. clarki* in synonymy with *A. victoriae*. Variation in rhabdosome shape and branching mode has also been noted in Canadian specimens by Jackson (1974, p. 45), who has also concluded that the two are conspecific.

Horizon and localities. La 2 Zone of *A. victoriae* and *D. macgillivrayi*, localities 4 and 5; *A. victoriae* is the most common species at each locality.

Adelograptus sp. nov.

Text-figs. 7*a*, *b*, *c*, *j*

Material. P42716, P47092, P52763, P52782, and several other poorly preserved specimens.

Description. The rhabdosome is somewhat lax and of horizontal to declined habit, and is extremely fragile with up to at least 4 orders of very slender, rather flexuous radiating stipes. Branching commonly appears to be by lateral, rather than dichotomous, division, although this may be a preservational feature. Spacing of branching points is markedly irregular, but the first-order stipes are always the shortest and distal stipes generally the longest. The fourth dichotomy is generally reached within 3·0 mm of stipe length from the sicula.

The sicula is relatively slender, 0·75–0·9 mm long, and 0·1–0·15 mm wide at the aperture. The primary stipes diverge from its middle region, leaving the lower part free and projecting prominently below the funicle in a manner reminiscent of *A.*? *bulmani* Spjeldnaes (1963).

Primary stipes form a relatively straight funicle, ranging from 1·0 to 1·6 mm in length. Stipe (lateral) width is 0·1–0·15 mm; in the most slender specimens it may represent only the chitinized stolon system. Thecae have not been seen.

Discussion. This species is readily distinguished by the extreme tenuity of the stipes, its rather lax and irregularly branching habit, and its prominent slender sicula. It differs from *Clonograptus* sp. nov. *3* further in having more closely spaced dichotomies and a more prominent sicula, and from *A.*? *bulmani* Spjeldnaes in its shorter sicula and smaller over-all proportions.

Generic assignment, like that of *Clonograptus* sp. nov. *3*, is rather uncertain, but with its lax habit and irregular branching the species accords best with *Adelograptus* as currently defined (Bulman, 1941; 1970*a*) rather than *Clonograptus*.

Horizon and locality. La 1.5 Zone of *Psigraptus* and *Clonograptus*, locality 3.

Genus CLONOGRAPTUS Nicholson, 1873

Clonograptus tenellus (Linnarsson), 1871 *sensu lato*

Text-fig. 8*m*

1871 *Dichograptus tenellus* Linnarsson, p. 795, pl. 16, figs. 13–15.
1892 *Clonograptus tenellus*; Moberg, p. 89, pl. 2, figs. 1–3.
1902 *Clonograptus tenellus*; Elles and Wood, p. 83, pl. 11, figs. 2*a–c*.
1909 *Clonograptus tenellus*; Westergård, p. 68, pl. 4, figs. 17, 18, 22?, 24?

Material. P47097, P47093.

Description. The rhabdosome is composed of up to 5 orders of slender stipes, the fifth order being flexuous and relatively long (15 mm+). First-order stipes together form a funicle 3 mm long, stipes of subsequent orders are of progressively increasing length. Branching habit is fairly regular giving rise to a

rhabdosome with moderately good bilateral symmetry. Distally, stipe dorso-ventral width is 0·4 mm; proximally, stipe lateral width is 0·2 mm. Thecae are spaced about 8 in 10 mm, and are denticulate with concave ventral walls and projecting apertural margins which are inclined to the stipe axis at about 70–80°.

Discussion. The identity of *C. tenellus* Linnarsson is rather uncertain; Linnarsson's figures show only two incomplete rhabdosome fragments and a single stipe fragment (Linnarsson 1871, pl. 16, figs. 13–15) and give little idea of rhabdosome morphology. Moberg's (1892) illustrations of specimens from the Swedish Tremadoc, particularly his pl. 2, figs. 1*a*, 1*b*, were taken to indicate the '*forma typica*' by Westergård (1909, caption to pl. 4) and have since been used in preference to Linnarsson's figures for comparison (Bulman and Cooper 1969, fig. 5*e*). Westergård's figures (1909, pl. 4, figs. 17, 18) and comments, however, indicate appreciable variation in stipe length in Swedish populations, and similar variation is noted by Stubblefield (1929, p. 282) and figured by Elles and Wood (1902, pl. 11, figs. 2*a–c*), and is accepted by Bulman and Rushton (1973, pl. 2, fig. 4), in British material. From the material figured in the papers cited, it appears that the '*forma typica*', i.e. the specimen figured by Moberg 1892, pl. 2, figs. 1*a*, 1*b*, may not be a modal specimen, but may represent a rather large example (with relatively long stipes of all orders) of the species. This broader view of the species, as a somewhat variable population, is here indicated by the term *sensu lato* after the name.

Many previous Australasian records of *C. tenellus* are dubious (Bulman and Cooper 1969, pp. 217, 218). The specimen figured here, however, appears to lie within the range accepted by Westergård (1909) and Elles and Wood (1902) for the species and is listed accordingly.

Horizon and locality. La 2 Zone of *A. victoriae* and *D. macgillivrayi*, locality 4.

Clonograptus sp. 1

Plate 103, fig. 11; text-fig. 6*a*

cf. 1909 *Clonograptus tenellus* Linnarsson var., Westergård, pl. 4, fig. 16.

Material. P47112, P47114, P47111, P42695 and several other poorly preserved specimens. None appear to have fully reached maturity of development.

Description. Rhabdosome is comparatively rigid and has at least 4 orders of stipes. Branching habit is fairly regular and stipes are rigidly diverging. Stipe length within any given order is, however, somewhat variable, both within and between specimens.

The sicula is about 1 mm long. The primary stipes form a straight funicle 1·5 mm long. Stipe length of subsequent orders increases progressively. Stipe lateral width is about 0·25–0·3 mm; dorso-ventral width unknown. Thecae have not been observed.

If the early growth stages associated with the specimen of text-fig. 6*a* represent the species, as here thought likely, then some details of proximal structure can be seen. The sicula is 1·2 mm long, has a nema and is somewhat inclined to the axis of symmetry of the rhabdosome. The primary stipes diverge from the mid region of the sicula, so that its lower region protrudes below the funicle.

The primary stipes are slightly declined rather than strictly horizontal and are comprised of one autotheca each.

Discussion. This species is of smaller over-all proportions than most described species of *Clonograptus*; it is comparable with the smallest (fig. 16) of the specimens figured

by Westergård as '*C. tenellus* Var.' (Westergård 1909, pl. 4, figs. 14–16, 19–21, 23, 25, 26, 29) and probably represents a new species.

Until a mature specimen is found and rhabdosome development to 5 or 6 orders of stipes is ascertained, its inclusion in the genus *Clonograptus* should be regarded as provisional.

Horizon and locality. La 1.5 Zone of *Psigraptus* and *Clonograptus*, locality 3.

Clonograptus sp. cf. *C.* sp. 1

Text-figs. 6*b*, *c*

Material. P42710, P46861, P46863, P46872, P47112, P47117, P52783, and several other specimens. All material is tectonically distorted and the dimensions given below are estimates.

Remarks. The material grouped here differs from *Clonograptus* sp. 1 chiefly in having a shorter funicle (about 0·7 mm rather than 1·5 mm in length). Lateral width of distal stipes reaches 0·35 mm and distal thecae are spaced 3 in 2 mm (about 15 in 10 mm). Stipe length within any order beyond the first is variable both within and between specimens, as in *Clonograptus* sp. 1.

The shorter funicle appears to be a persistent feature throughout the group, but because no specimens are free from distortion and because in other respects the group generally matches sp. 1, it is here referred to as *Clonograptus* cf. sp. 1.

Horizon and locality. La 1.5 Zone of *Psigraptus* and *Clonograptus*, locality 3.

Clonograptus sp. 2

Text-figs. 6*e*, *f*, 7*g*

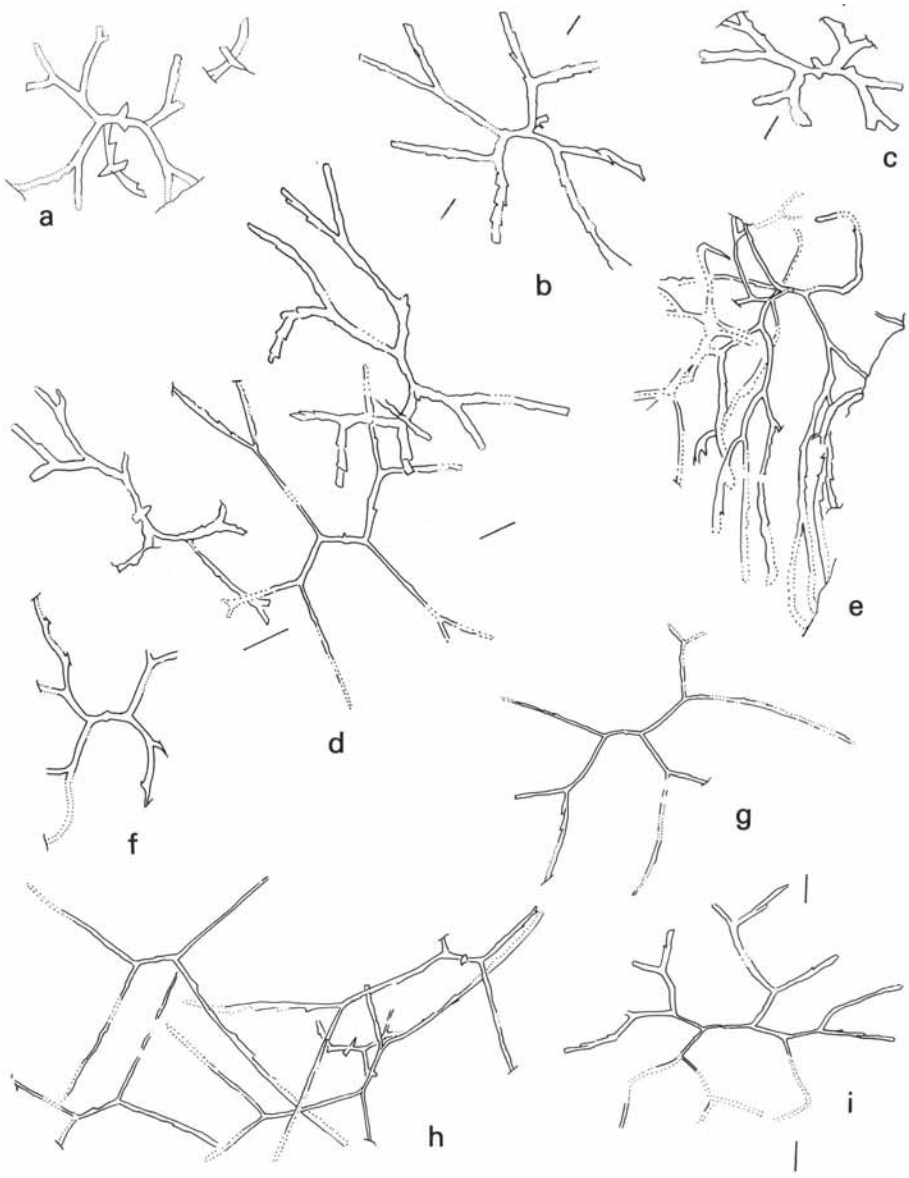
Material. P46858, P42714, P42711, P47123, P47170, P46869, and several other incomplete specimens. No complete mature specimens.

Description. The mature rhabdosome is comprised of up to 5 or 6 orders of stipes, giving up to 30 or more terminal stipes and is thought to have been up to at least 40 mm across. The branching pattern is fairly regular, and the rhabdosome moderately rigid and symmetrical, although appreciable variation in stipe length for any order beyond the first is apparent both within and between specimens.

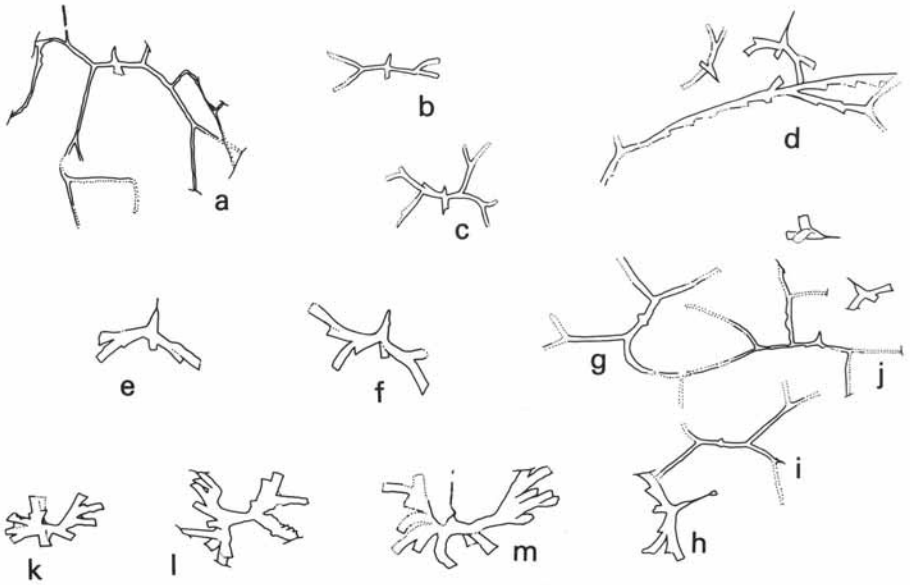
The sicula is inconspicuous but usually visible. First-order stipes together form a relatively straight funicle 1·2 mm long. Stipes of subsequent orders up to the terminal stipes are considerably longer ranging from 1 to 8 mm, and terminal stipes exceed 12 mm in length. Stipes of later orders tend to be longer than those of earlier orders. Lateral stipe width is 0·1–0·2 mm and dorso-ventral stipe width, seen only in terminal stipes, is 0·35 mm. Thecae, seen only in a few terminal stipes, are of low inclination and somewhat denticulate.

Discussion. The specimens grouped as *Clonograptus* sp. 2 have a typical *Clonograptus* rhabdosome with branching to the fifth or sixth order and progressively increasing intervals between dichotomies; the stipes diverge rigidly and become rather flexuous distally. The species is distinguished by its small size and slender stipes in the proximal region. It differs from *Clonograptus* sp. 1 and *Clonograptus* cf. sp. 1 in its narrower stipes, more delicate rhabdosome, and more closely spaced dichotomies.

Horizon and locality. La 1.5 Zone of *Psigraptus* and *Clonograptus*, locality 3.



TEXT-FIG. 6. *a*, *Clonograptus* sp. 1; P42712, incomplete mature rhabdosome with superposed early growth stages of, probably, the same species, ×5. *b*, *c*, *Clonograptus* cf. sp. 1; *b*, P46863, mature rhabdosome, tectonically distorted, ×5; *c*, P47112, tectonically distorted, ×5. *d*, *g*, *h*, *Clonograptus* sp. 3; *d*, P46850, P52783, P52784, mature incomplete rhabdosome with two superposed rhabdosomes, probably of *C.* sp. 1, tectonically distorted, ×5; *g*, P46851, largest mature rhabdosome, ×3; *h*, P46859, P52785, P52786, P52787, group of three rhabdosomes showing highly irregular branching habit, and an immature rhabdosome, ×5. *e*, *f*, *Clonograptus* sp. 2; *e*, P47123, incomplete mature rhabdosome, ×5. *f*, P46858, incomplete rhabdosome, ×5. *i*, *Clonograptus* sp. 3?, P46860, tectonically distorted rhabdosome. All specimens from locality 3. Direction of maximum relative tectonic shortening indicated where appropriate.



TEXT-FIG. 7. *a–c, j, Adelograptus* sp. nov.; *a*, P52782, incomplete mature rhabdosome, ×7; *b*, P52763, growth stage, ×5; *c*, P47092, ×5; *j*, P42716, ×5. *d, e, f, h, Adelograptus* sp.; *d*, P52764, distal and proximal rhabdosome fragments, ×5; *e*, P47116, ×7; *f*, P42662, ×7; *h*, P52775, ×5. *g, Clonograptus* sp. 2, P42714, ×5. *i, Clonograptus* sp. 3, P52774, ×5. *k–m, Psigraptus lenzi*; *k*, P46864, ×5; *l*, P47128, 4-stiped rhabdosome, ×5; *m*, P47110, 3- or 4-stiped rhabdosome, ×5.

Clonograptus sp. 3

Plate 103, fig. 14; text-figs. 6*d*, *g*, *h*, 7*i*, ?6*i*

Material. P46848, P46850, P46851, P46859, P46860, P52774, P52785, P52786, P52787, and several other fragmentary specimens. Most rhabdosomes are incomplete, and most have been tectonically distorted.

Description. The rhabdosome is fragile with very slender stipes, and is up to 20 mm across. The branching pattern is highly variable; dichotomies range from 2 to 4 in number, giving from 4 to at least 15 terminal stipes. The spacing of dichotomies in some specimens (text-fig. 6*d*) is comparatively regular, producing a typical *Clonograptus* rhabdosome form, but in others (text-fig. 6*h*) dichotomies beyond the second are irregularly delayed, resulting in a high degree of rhabdosome asymmetry. Some extreme forms have only 4 or 5 terminal stipes.

The sicula is inconspicuous but is usually visible. The first-order stipes are short and generally form a straight funicle about 1·5 mm long. Stipes of subsequent orders are of progressively increasing length. Maximum (dorso-ventral) width of terminal stipes is 0·3 mm, that (lateral width) of earlier orders about 0·15 mm. Thecae can be seen in the terminal stipes of a few specimens and are long, very narrow tubes inclined at a very low angle and spaced 3 in 2·5 mm.

Discussion. The forms grouped here are distinguished by their highly variable branching habit and extremely slender stipes. A few specimens (e.g. P46860) differ from the main group in having a more regular branching pattern, and approach

Clonograptus sp. 1 in rhabdosome form; their affinities are uncertain and they are listed here as *Clonograptus* sp. 3?

Generic assignment of the group is problematical. The multiramous forms with their rigidly diverging straight stipes and more regular dichotomies are readily accommodated within *Clonograptus*, even though the number of terminal stipes in most rhabdosomes seems unlikely to have exceeded about 10 or 12. The pauciramous forms are interpreted as members of the same population, but in which dichotomy is irregularly suppressed. Their rhabdosome morphology suggests that they would be better placed in *Adelograptus*, and the whole population thus appears to bridge the concepts of the two genera. Because the '*Clonograptus* characters' appear to be dominant, the population is provisionally referred to that genus.

Horizon and locality. La 1.5 Zone of *Psigraptus* and *Clonograptus*, locality 3.

Clonograptus sp. 4

Text-fig. 8*f*

Material. P42578, and several poorly preserved specimens.

Description. The rhabdosome is formed of rather rigid, heavy stipes which branch at regular intervals up to the fifth order, giving rise to good bilateral rhabdosome symmetry. The funicle is 3 mm long and stipes of later orders are of progressively increasing length. Where clearly oriented in profile view, stipes are 1 mm in dorso-ventral width; lateral width is 0·5 mm. Thecae have concave ventral walls and are somewhat denticulate; they are spaced 5·5 in 5 mm (11 in 10 mm).

Discussion. The heavy stipes and compact rhabdosome form distinguish this species in the Lancefield assemblages. It is of similar habit to, but of larger over-all dimensions than *C. kingi* Benson and Keble (1935; Bulman and Cooper 1969). It differs from *C. sarmentosus* (Moberg) variant B of Erdtmann (1967, p. 339, fig. 2, nos. 1368, 1378, 1384, 1390; fig. 3, no. 1384) from St. Michel, Quebec, in having a wider funicle and an over-all closer spacing of dichotomies.

Horizon and locality. La 2 Zone of *A. victoriae* and *D. macgillivrayi*, locality 5.

Genus KIAEROGRAPTUS Spjeldnaes, 1963

Type species. Didymograptus kiaeri Monsen, 1925; by original designation.

Diagnosis (revised). Rhabdosome bilateral, horizontal to declined, second-order branching rare or absent; autothecae of dichograptid type, bithecae present distally in *Kiaerograptus kiaeri*.

The genus, formerly monotypic, is here considered to include the following species: *D. kiaeri* Monsen, 1925; *Leptograptus antiquus* T. S. Hall, 1899; *D. pritchardi* T. S. Hall, 1899; *D. taylori* T. S. Hall, 1899; *K.*? *peelensis* Jackson, 1974; ?*D. primigenius* Bulman, 1950; ?*Adelograptus*? *bulmani* Spjeldnaes, 1963.

Discussion. The affinities of the biramous Tremadoc graptolites have proved difficult to determine. Following his discovery of bithecae in *D. kiaeri* Monsen, Spjeldnaes (1963) suggested that bithecae and anisograptid affinities may be expected in several other similar forms, including *D. pritchardi* T. S. Hall, *D. taylori* T. S. Hall, and

D. novus Berry. Unfortunately, well-preserved specimens in which bithecae could be expected to be seen are not known for any of the three forms. None the less, from their stratigraphical position and general aspect it seems likely to us that their affinities lie with the anisograptids rather than with the dichograptids, in which they are currently classified. The same holds for *L. antiquus* (discussed below) and, possibly, for *D. primigenius* Bulman, in which the presence of bithecae was suspected by Bulman (1950, p. 93). Certainly, the occasional presence of a second-order stipe which can arise from a point any distance along the first-order stipe in both *D. pritchardi* and *L. antiquus* points to a level of inherent morphologic variability characteristic of Anisograptidae but excessive for Dichograptidae. *A.*? *bulmani* Spjeldnaes is described as having two horizontal to slightly reclined stipes (Spjeldnaes 1963, p. 127), but apparently is not represented by mature specimens in which its branching habit can be ascertained. *D. novus* Berry is thought by Braithwaite (1976, pp. 14, 15, pl. 4, figs. 1–5, 9) to be an *Adelograptus* with up to 3 orders of stipes.

Of the current anisograptid genera, *Adelograptus* Bulman and *Kiaerograptus* Spjeldnaes appear to be candidates for accommodating the group of species in question.

Adelograptus is defined (Bulman 1970*a*) to include anisograptids 'developed from two primary stipes by infrequent and irregular branching', the rhabdosome being usually declined or almost horizontal, commonly somewhat lax and flexuous. These features are well shown by the type species, *A. hunnebergensis* (Stubblefield 1929, pp. 273, 278, figs. 3–7) with up to at least 4 orders of stipes. Branching of the second and subsequent orders, although sparse and irregular throughout the rhabdosome, is nevertheless a feature of the species. Thus species such as *L. antiquus* and *D. pritchardi*, in which second-order branching is generally absent and third-order branching unknown, seem inappropriately referred to *Adelograptus* as, clearly, are the other, biramous, species.

Kiaerograptus Spjeldnaes, on the other hand, comprises bilateral rhabdosomes 'composed of two undivided horizontal stipes . . .' (Bulman 1970*a*, p. V41). The definition is here expanded to include species in which second-order branching is rare or absent, thus encompassing the group of species listed above.

The genus *Kiaerograptus* as envisaged here thus comprises a range of thecal forms and is likely to be polyphyletic. We have considerable reservations about establishing yet another graptolite genus based on features of gross rhabdosome morphology. However, until phyletic relationships of the species are determined, the classification proposed here is thought to reflect their inferred anisograptid affinities with minimum change to established nomenclature.

Kiaerograptus antiquus (T. S. Hall, 1899)

Text-figs. 8*d*, *e*

1899 *Leptograptus antiquus* T. S. Hall, p. 166, pl. 17, figs. 5, 6.
?1974 *Adelograptus antiquus*; Jackson, pp. 41, 42, text-figs. 2F, G, H.
1974 *Kiaerograptus* (?) cf. *pritchardi*; Jackson, p. 51, pl. 5, fig. 3, text-figs. 2A, C, D.
1962 *Didymograptus tenuiramous* Obut and Sobolevskaya, pp. 84, 85, pl. 5, fig. 3.

Material. P52778, P47151, P53997, and several other fragmentary specimens.

Description. Rhabdosome formed of 2 or 3 slender flexuous stipes each up to several centimetres in length, and of generally horizontal or declined habit. The sicula is about 1·2 mm long and inclined so that the lower portion lies along one of the 2 primary stipes; the other stipe diverges from the mid region of the sicula. Dorso-ventral stipe width is about 0·5 mm at the thecal aperture but for most of the distance between apertures it is much less (about 0·1–0·3 mm). There is considerable variation in rigidity and robustness of stipes. Those figured (text-figs. 8*d*, *e*) are robust forms; the most slender forms are thread-like and generally are poorly preserved.

Secondary branching is fairly common in the small population at hand. The position from which the secondary stipe arises is highly variable, ranging from a distal location (more than 10 mm from the sicula) to a proximal location (after the first or second theca). In two specimens (including that in text-fig. 8*d*) the secondary stipe arises from very near the sicula itself; preservation of the specimens is insufficiently good to determine whether or not the stipe is a third primary stipe and the rhabdosome is, in fact, tri-radiate.

Thecae are spaced 8–10 in 10 mm, extremely slender for most of their length but markedly flared distally giving the characteristic triangular shape to the apertural region.

Discussion. The specimens described here embrace a similar range in morphological variation to that described in the larger populations of New Zealand material by Cooper (1979*a*). The slender forms closely match the lectotype of *L. antiquus* from Lancefield Quarry (P14241; T. S. Hall 1899, pl. 7, fig. 6; refigured Cooper 1979*a*, fig. 17*j*), whereas the more robust forms with rigid stipes approach *D. pritchardi* T. S. Hall, also from Lancefield Quarry (T. S. Hall 1899, pl. 7, figs. 7, 9; pl. 19, fig. 8; refigured by Berry 1966, pl. 45, fig. 1; pl. 46, fig. 1; and by Cooper 1979*a*, fig. 17*k*). Following Cooper the specimens under study are all referred to *L. antiquus* because they (1), never quite attain the robustness of *D. pritchardi* and (2), because the sicula is strongly inclined, the axis of rhabdosome symmetry passing between the apertural regions of the sicula and theca 1^1 rather than through the sicula as in *D. pritchardi*.

Proximal structure of the species is fully discussed by Cooper (1979*a*) and by Jackson (1974, p. 42).

Specimens from Yukon described as *A. antiquus* by Jackson (1974, pp. 41, 42, text-figs. 2F–H) lack the marked apertural flaring of thecae—a characteristic feature of Australian and New Zealand populations. Jackson's *K.*(?) cf. *pritchardi* (1974, p. 54, pl. 5, fig. 3; text-fig. 2A, C, D), however, closely matches New Zealand (Cooper 1979*a*) and Victorian (this paper) material referred to *A. antiquus*, and is synonymized accordingly.

Generic assignment. The species has generally been referred to the genus *Adelograptus* Bulman, either tentatively (Bulman 1941; Cooper 1979*a*) or without qualification (Jackson 1974), or to *Bryograptus* (Thomas 1960). However, for the reasons discussed above, *L. antiquus* together with the closely related *D. pritchardi* would seem to be more appropriately placed in the genus *Kiaerograptus*.

Horizon and localities. La 2 Zone of *A. victoriae* and *D. macgillivrayi*, localities 4 and 5.

Genus PSIGRAPTUS Jackson, 1967

Diagnosis (revised). Rhabdosome composed of few (2 to 4 or 5) short reclined stipes probably of simple dendroid structure; autothecae are curved, distally isolate tubes; pyritized stolons and bithecae possibly present in *P. lenzi*.

The original diagnosis of Jackson (1967) has been amended only to allow inclusion of the Lancefield forms with more than three stipes.

Psigraptus lenzi Jackson, 1967

Plate 103, figs. 5, 6; text-figs. 7*k–m*

1967 *Psigraptus lenzi* Jackson, p. 319, text-figs. 1C, 1D.

Material. P47128, P47110, P46864, P46867, and three other specimens; all moderately to poorly preserved.

Description. The rhabdosome morphology is highly variable. The sicula is generally long (up to 2 mm), parallel sided, 0·3 mm wide, and bears a nema. The primary stipes appear to originate from a region about 5 mm from the apex of the sicula; they are reclined like those of an isograptid and short, not exceeding 3·5 mm in length. The sicula thus protrudes well below the ventral rhabdosome margin, where it is entirely isolate.

The number of stipes ranges from 3 to 4, or possibly 5, and stipes appear to be highly irregular in growth. Branching takes place rapidly in rhabdosome development, but whether or not there are more than two primary stipes is uncertain in the Lancefield material.

Thecae (presumably the autothecae) are long, parallel-sided, square-ended tubes, 0·2–0·3 mm wide, isolate for at least 50% of their length (up to 0·8 mm). Inclination and curvature of thecae are variable and measurements of stipe dorsoventral width are thus rather meaningless.

Discussion. Rhabdosome and thecal morphology are highly variable, even allowing for irregularities introduced during flattening and burial on the sea floor and subsequent tectonic distortion. The number of stipes and their growth habit are apparently rather irregular and are unlikely to serve as a reliable basis for specific distinction.

The Lancefield material clearly belongs to the genus *Psigraptus* Jackson, previously known only from the Yukon. The two known Yukon species are *P. arcticus*, with 2 stipes, and *P. lenzi* with 3 stipes. The Lancefield forms with 3 stipes are best referred to *P. lenzi* and in view of the variability shown by the Lancefield forms the concept of this species, and of the genus, is here expanded to include forms with up to 5 stipes.

Horizon and locality. La 1.5 Zone of *Psigraptus* and *Clonograptus*, locality 3.

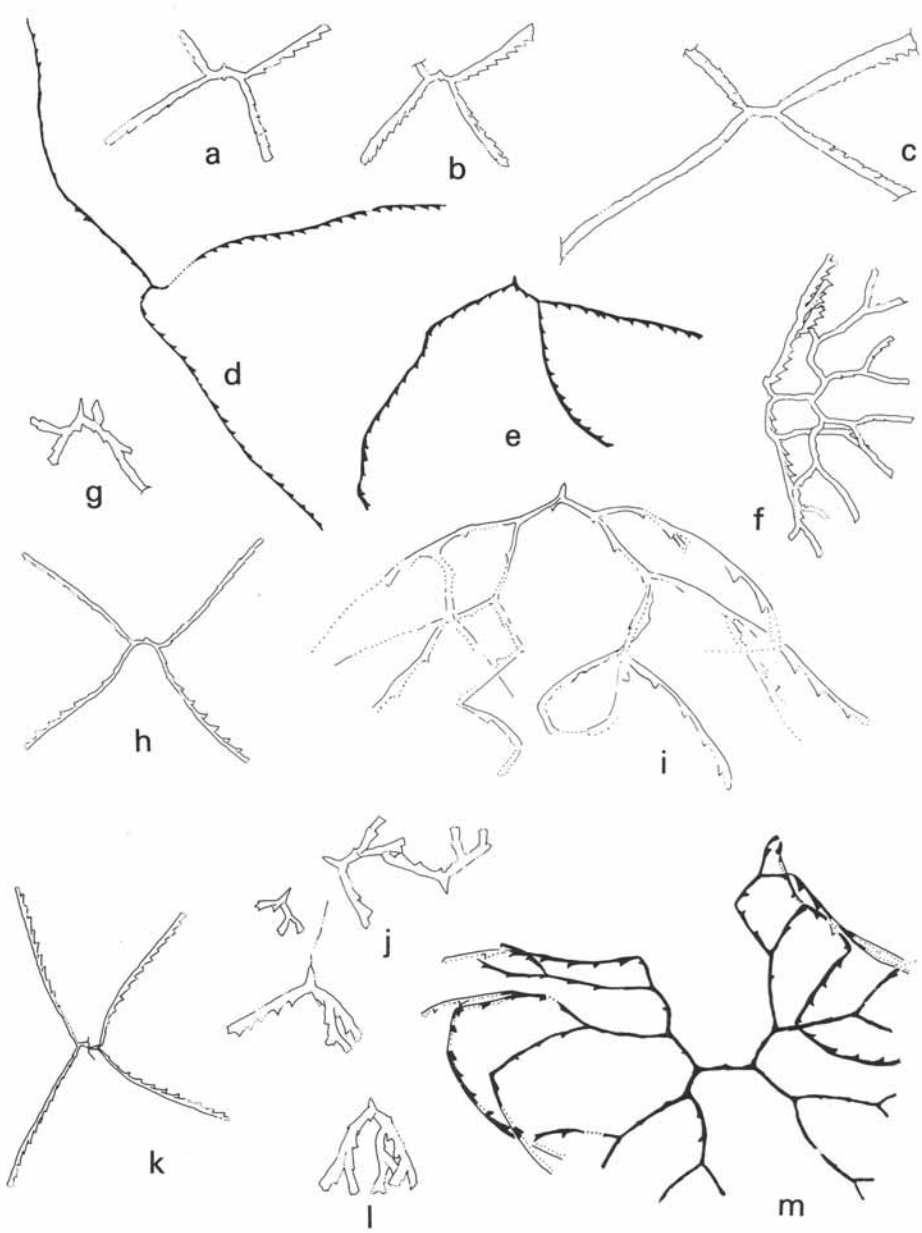
Family DICHOGRAPTIDAE Lapworth, 1873
Genus TEMNOGRAPTUS Nicholson, 1876
Temnograptus sp.

Text-fig. 8*c*

Material. P42579a, P42579b, P42586, P42581.

Description. The multiramous rhabdosome is formed of broad, heavy stipes, with up to at least 3 orders of branching. Short primary stipes with only about 1 theca each form a funicle 2 mm long. Second-order stipes are of variable length within specimens, reaching up to 20 mm, and 1·5 mm in dorso-ventral width. Third-order stipes are probably of similar dimensions. Thecae are slightly denticulate and are inclined at about 40°, apertural margins are inclined at 100°. Thecal spacing is about 11 in 10 mm.

Discussion. Several rhabdosome fragments are preserved and show this form to be closely related to that listed as *Temnograptus* aff. *regularis* (Törnquist) from the *Adelograptus* Zone (La 2 equivalent) in the Aorangi Mine sequence of New Zealand by Cooper (1979*a*). The form is readily distinguished in La 2 Zone assemblages by its broad heavy stipes and narrow funicle, relatively long second-order stipes, and



TEXT-FIG. 8. *a*, *b*, *Tetragraptus decipiens* T. S. Hall; *a*, P47157, locality 5, ×2; *b*, P47153, locality 5, ×2. *c*, *Temnograptus* sp., P42579, locality 4, ×2. *d*, *e*, *Kiaerograptus antiquus* (T. S. Hall); *d*, P47151, locality 5, rhabdosome with third stipe arising from near the sicula, ×2; *e*, P52778, locality 4, specimen with heavy, robust stipes, ×2. *f*, *Clonograptus* sp. 4, P42578, locality 5, ×2. *g*, *j*, *l*, *Adelograptus victoriae* (T. S. Hall); *g*, P52768, locality 4, ×3; *j*, P47096, P52766, P52767, P53998, locality 4, group of 4 rhabdosomes, ×3; *l*, P47091, locality 4, ×3. *h*, *k*, *T. bulmani* Thomas; *h*, P47090, locality 4, ×2; *k*, P47098, locality 4, ×2. *i*, *Adelograptus*? sp., P52777, locality 4, ×3. *m*, *C. tenellus* (Linnarsson) *s.l.*, P47097, locality 4, ×3.

irregular spacing of dichotomies after the first. The specimen figured by Törnquist (1904, pl. 2, fig. 22) as 'undetermined irregular Dichograptidae' from the *D. balticus* Zone in Sweden appears to be closely related to the Australasian form.

Generic assignment is rather uncertain but *Temnograptus* Nicholson appears to be the most suitable genus for *Clonograptus*-like forms with first-order stipes that are conspicuously shorter than stipes of subsequent orders, and generally good bilateral symmetry.

Horizon and localities. La 2 Zone of *A. victoriae* and *D. macgillivrayi*, localities 4 and 5.

Genus TETRAGRAPTUS Salter, 1863

Tetragraptus bulmani Thomas, 1973

Text-figs. 8*h*, *k*

1973 *Tetragraptus bulmani* Thomas, pp. 530, 531, pl. 2, figs. *b*, *c*.

Material. P47090, P52769, P47098, all topotypes.

Description. The rhabdosome is bilaterally symmetrical but is generally preserved in a manner which suggests that its original habit was not strictly horizontal but somewhat declined. The first-order stipes form a funicle 1·7 mm long and 0·4 mm wide. Second-order stipes reach 15 mm in length and are straight or gently curved, concave dorsally; initially they present a lateral view and are 0·35 mm wide, but distally they commonly show torsion and present a dorso-ventral view, where they are 0·7 mm wide.

Thecae are noticeably denticulate, with concave ventral margins and straight apertural margins inclined at about 90° to the stipe axis. They are spaced 8 in 10 mm.

Remarks. The specimens described here differ from Thomas's (1973) description in having a slightly shorter funicle (1·7 mm rather than 2·0 mm), slightly greater dorso-ventral stipe width (0·7 mm rather than 0·5 mm), and slightly less closely spaced thecae (8 in 10 mm rather than 9–10 in 10 mm). However, there is little doubt that only one species is represented and the difference in dimensions is likely to indicate morphological variation in the population sampled.

Distinction of *T. bulmani* from the similar, Bendigonian, species *T. harti* T. S. Hall was not discussed by Thomas (1973) and must remain in some doubt until *T. harti* is adequately described and figured. From Hall's original figures (Hall 1914, text-figs. 5, 6) of the 'cotypes' from Bendigo, *T. bulmani* differs in having a denticulate apertural margin rather than a bluntly angular one. The small rhabdosome size, slender stipes, and markedly denticulate thecal apertures otherwise distinguish the species.

As Thomas has already noted distal stipe fragments are indistinguishable from those of *Kiaerograptus pritchardi* (T. S. Hall).

Horizon and localities. La 2 Zone of *A. victoriae* and *D. macgillivrayi*, localities 4 and 5.

Tetragraptus decipiens T. S. Hall, 1899

Text-figs. 8*a*, *b*

1899 *Tetragraptus decipiens* T. S. Hall, pp. 168, 169, pl. 17, figs. 13–15; pl. 18, figs. 16?, 17–19.
1920 *Tetragraptus decipiens*, Keble, pp. 199–201, pl. 34, figs. 1*a–e*.
1966 *Tetragraptus decipiens*, Berry, pp. 423, 424, pl. 44, figs. 5, 10, 11.

Material. P47157a, P47157b, P47158, P47153, and more than ten other specimens.

Remarks. The present material matches the full descriptions and illustrations by Keble (1920), Berry (1966), and Cooper (1979*a*), except that stipes are generally preserved exposing only part dorso-ventral view, and full dorso-ventral stipe width of 1·0–1·3 mm is rarely seen.

In most rhabdosomes one stipe appears to have been somewhat twisted or rotated on burial. Rhabdosomes generally give the appearance of having originally had a declined habit as described for *T. decipiens bipatens* by Keble and Harris (1934, pp. 170–172) and *T. bulmani* in this paper, rather than strictly horizontal. Their position of rest on the sea floor would then be on the tips of the 4 stipes, with the result that one stipe would be bent when the rhabdosome became flattened.

Horizon and locality. La 2 Zone of *A. victoriae* and *D. macgillivrayi*, locality 5.

Acknowledgements. We gratefully acknowledge comments on the manuscript from T. A. Darragh, P. A. Jell, A. H. M. VandenBerg, R. B. Rickards, D. E. Jackson, and H. E. Wilkinson. Our colleagues H. E. Wilkinson and A. H. M. VandenBerg kindly supplied us with the geological map and stratigraphical data and, together with T. A. Darragh, assisted with collecting. Collections of the National Museum of Victoria were kindly made available to us by T. A. Darragh, Deputy Director.

APPENDIX

Details of fossil localities 1–5, as supplied by A. M. VandenBerg, are as follows (all distances measured in direct line).

Locality 1. 473 m up Stauro Gully from its confluence with Deep Creek. This is almost certainly the original locality of Harris and Keble and was designated 'Locality S61' by Thomas (1960*a*). Recollected by I. Stewart, R. A. Cooper, T. A. Darragh, A. H. M. VandenBerg, H. W. Wilkinson, 1971–1977.

Locality 2. 472 m up Bryo Gully from its confluence with Deep Creek; designated 'Locality S62' by Thomas (1960*a*). Recollected by I. Stewart, R. A. Cooper, T. A. Darragh, H. E. Wilkinson, A. H. M. VandenBerg, 1976–1977.

Locality 3. 319 m up Stauro Gully from its confluence with Deep Creek. Collected by I. Stewart, 1976.

Locality 4. 96 m up Stauro Gully from its confluence with Deep Creek; designated 'Locality S68' by Thomas (1960*a*). Recollected by I. Stewart, A. H. M. VandenBerg, 1976–1977.

Locality 5. 203 m up Bryo Gully from its confluence with Deep Creek; designated 'Locality S48' by Thomas (1960*a*). Recollected by I. Stewart, T. A. Darragh, R. A. Cooper, 1976–1977.

REFERENCES

BENSON, W. B. N. and KEBLE, R. A. 1935. The geology of the regions adjacent to Preservation and Chalky Inlets, Fiordland, New Zealand. Part IV. Stratigraphy and palaeontology of the fossiliferous Ordovician rocks. *Trans. R. Soc. N.Z.* **65,** 244–294.

BERRY, W. B. N. 1960. Graptolite faunas of the Marathon region, west Texas. *Publs Bur. econ. Geol. Univ. Tex.* **6005,** 1–179, pls. 1–20.

—— 1966. A discussion of some Victorian Ordovician graptolites. *Proc. R. Soc. Vict.* **79,** 415–448.

—— 1967. Comments on correlation of the North American and British Lower Ordovician. *Bull. geol. Soc. Am.* **78,** 419–428.

BRAITHWAITE, L. F. 1976. Graptolites of the Pogonip Group of western Utah. *Spec. Pap. geol. Soc. Am.* **166,** 1–106, pls. 1–21.

BULMAN, O. M. B. 1941. Some dichograptids of the Tremadocian and Lower Ordovician. *Ann. Mag. nat. Hist.* Ser. 11, **7,** 100–121.

—— 1951. Graptolites from the *Dictyonema* Shales of Quebec. *Q. Jl geol. Soc. Lond.* **106** (for 1950), 63–99, pls. 4–8.

—— 1970*a*. *Treatise on Invertebrate Paleontology. Part V, Graptolithina with sections on* Enteropneusta *and* Pterobranchia. 2nd edn., xxxii+V163. Geological Society of America and University of Kansas Press.

BULMAN, O. M. B. 1970*b*. A new *Dictyonema* fauna from the Salmien of the Stavelot Massif. *Bull. Belg. Ver. Geol., Paleont., Hydrol.* **79,** 213–224.

—— and COOPER, R. A. 1969. On the supposed occurrence of *Triograptus* in New Zealand. *Trans. R. Soc. N.Z.* (Geol.) **6,** 213–218.

—— and RUSHTON, A. W. A. 1973. Tremadoc faunas from boreholes in central England. *Bull. geol. Surv. Gt Br.* **43,** 1–33, pls. 1–7.

COOPER, R. A. 1979*a*. Ordovician geology and graptolite faunas of the Aorangi Mine area, north-west Nelson, New Zealand. *Bull. geol. Surv. NZ.* Paleont. **47,** 1–121, pls. 1–19.

—— 1979*b*. Sequence and correlation of Tremadocian graptolite assemblages. *Alcheringa*, **3,** 7–19.

ELLES, G. L. and WOOD, E. M. R. 1902. A monograph of British graptolites. Part 2—*Dichograptidae*. *Palaeontogr. Soc.* [*Monogr.*] i–xxviii, 55–102, pls. 5–13.

ERDTMANN, B. D. 1967. A new fauna of early Ordovician graptolites from St. Michel, Quebec. *Can. J. Earth Sci.* **4,** 335–355.

HALL, T. S. 1899. Victorian graptolites: Part 2. The graptolites of the Lancefield Beds. *Proc. R. Soc. Vict.* **11,** 164–178.

—— 1914. Victorian graptolites, Part 4. Some new or little-known species. Ibid. **27,** 104–118.

HARRIS, W. J. and KEBLE, R. A. 1928. The *Staurograptus* Bed of Victoria. Ibid. **40,** 91–95, pl. 9.

—— —— 1932. Victorian graptolite zones with correlations and description of species. Ibid. **44,** 25–48.

—— and THOMAS, D. E. 1938. A revised classification and correlation of the Ordovician graptolite beds of Victoria. *Min. Geol. J. Vict.* **1** (3), 62–72.

JACKSON, D. E. 1964. Observations on the sequence and correlation of Lower and Middle Ordovician graptolite faunas of North America. *Bull. geol. Soc. Am.* **75,** 523–534.

—— 1967. *Psigraptus*, a new graptolite genus from the Tremadocian of Yukon, Canada. *Geol. Mag.* **104,** 317–321.

—— 1974. Tremadoc graptolites from Yukon Territory, Canada. *In* RICKARDS, R. B., JACKSON, D. E. and HUGHES, C. P. (eds.). Graptolite studies in honour of O. M. B. Bulman. *Spec. Pap. Palaeont.* **13,** 35–58, pl. 5.

—— 1975. New data on Tremadoc graptolites from Yukon, Canada. *Palaeontology*, **18,** 883–887.

KEBLE, R. A. 1920. Victorian graptolites. Some subzonal forms of the lower Bendigo and upper Lancefield zones. *Rec. geol. Surv. Vict.* **4,** 195–202, pls. 33, 34.

—— and HARRIS, W. J. 1934. Graptolites of Victoria; new species and additional records. *Mem. natn. Mus. Melb.* **8,** 166–183.

MOBERG, J. C. 1892. Om skiffern med *Clonograptus tenellus* Linnarsson, dess fauna och geologiska ålder. *Geol. Fören. Stockh. Förh.*, **14,** 87–102, pl. 2.

OBUT, A. M. and SOBOLEVSKAYA, R. F. 1962. Early Ordovician graptolites from Taimyr. *Trudȳ nauchno-issled. Inst. Geol. Arkt.* **127,** 65–85. [In Russian.]

SKEVINGTON, D. 1963. A correlation of Ordovician graptolite-bearing sequences. *Geol. För. Stockh. Förh.* **85,** 298–319.

SPJELDNAES, N. 1963. Some Upper Tremadocian graptolites from Norway. *Palaeontology*, **6,** 121–131, pls. 17, 18.

STUBBLEFIELD, C. J. 1929. Notes on some early British graptolites. *Geol. Mag.* **66,** 268–285.

THOMAS, D. E. 1960*a*. Lancefield, part sheets 818 and 828 Zone 7. *Australia 1:31,680*, publ. Dept. Mines, Melbourne. (Manuscript maps dated 1930–1931.)

—— 1960*b*. The zonal distribution of Australian graptolites. *J. Proc. R. Soc. N.S.W.* **94,** 1–58.

—— 1973. Two new graptolites from Victoria, Australia. *Geol. Mag.* **109,** 529–532, pls. 1, 2.

—— and SINGLETON, O. P. 1956. The Cambrian stratigraphy of Victoria. *In* El Sistema Cámbrico, su paleogeografía y el problema de su base. *C.r. 20th Int. geol. Congr., Mexico, 1956*, **2,** 149–163.

TÖRNQUIST, S. L. 1904. Researches into the graptolites of the lower zones of the Scanian and Vestrogothian *Phyllo-Tetragraptus* Beds. *Acta Univ. Lund.* **40** (2), 1–29, pls. 1–4.

WESTERGÅRD, A. H. 1909. Studier öfver Dictyograptusskiffern. Ibid. Ser. 2, **5,** 1–79, pls. 1–5.

WILLIAMS, A., STRACHAN, I., BASSETT, D. A., DEAN, W. T., INGHAM, J. K., WRIGHT, A. D. and WHITTINGTON, H. B. 1972. A correlation of Ordovician rocks in the British Isles. *Spec. Rep. geol. Soc. Lond.* **3,** 1–74.

R. A. COOPER
N.Z. Geological Survey
P.O. Box 30368
Lower Hutt
New Zealand

I. R. STEWART
Department of Zoology
Monash University
Victoria
Australia

Manuscript received 14 August 1978
Revised manuscript received 6 February 1979