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Taxonomic and biostratigraphical significance of the Tremadoc graptolite fauna from northern Yukon Territory, Canada

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Abstract – Twenty-two graptolite species are described from the Tremadoc portion of the Road River Group. In a 220 m thick, graptolite-rich section on Peel River, six graptolite biozones are recognized which in ascending order are: *Staurograptus dichotomus, Anisograptus matanensis, Adelograptus* cf. *A. tenellus, Adelograptus antiquus, Kiaerograptus pritchardi* and *Paradelograptus kinnegraptoides*. The *Psigraptus* fauna appears to be confined to a single bedding-plane within a thick interval dominated by *Adelograptus* cf. *A. tenellus*, and for this reason we propose a new zone characterized by the latter species rather than identify a *Psigraptus* Biozone as in China. The *Adelograptus* cf. *A. tenellus* Biozone has yielded *Adelograptus*? *bulmani* Spjeldnaes 1963, which we propose as the type species for the new genus *Ancoragraptus*. Graptolites recorded from the Tremadoc of the Yukon for the first time are: *Ancoragraptus bulmani, Clonograptus magnificus, C*. cf. *C. multiplex, C*. cf. *C. rigidus, Hunnegraptus copiosus, Kiaerograptus*? *bulmani* and *K*? *kutchini* sp. nov.

Keywords: Ordovician, Tremadocian, Graptolithina, Yukon.

1. Introduction

The existence of richly fossiliferous graptolitic shales in the Richardson Mountains was first noted by Professor C. R. Stelck while working on the Canol Project (Canadian American Northern Oil Line) in the 1940s. This project looked at the possibility of building a pipeline for oil supplies at the time that Japan declared war on the United States of America. Stelck's collecting resulted in a publication on graptolites by Decker, Warren & Stelck (1947). During the 1950s, Amoco, British American, Triad (BP), Chevron, Imperial, Shell and Texaco were involved in a rush to assess the petroleum potential of Arctic Canada, and the Geological Survey of Canada was mapping the region. Many of the fossil collections found their way to the University of Alberta for age determination by Professors Warren and Stelck, and these materials played an important part in our initial studies on the Early Ordovician graptolite biostratigraphy.

This paper is concerned primarily with Early Tremadoc biostratigraphy and graptolites of Yukon Territory but also describes some Late Tremadoc species that were omitted from Jackson & Lenz (2000). The bulk of the material described is from a 220 m thick succession of the Road River Group in the Upper Canyon on Peel River (Figs 1, 2). The Upper Canyon section and to a lesser extent that on Rock River (Jackson & Lenz, 1999) are the best sampled Tremadoc sequences in Yukon Territory, and our knowledge of the graptolite zonation comes from these two localities. The Upper Canyon section is one of the few places in the world that the graptolitic Tremadoc is totally exposed and the vertical stratigraphical ranges can be plotted in detail (Fig. 3). There are several other well-exposed river and stream sections that cut through the Lower Ordovician outcrops around the Richardson Anticlinorium. Oil companies have visited these localities but their collecting was more in the nature of spot-checks.

In the deep-water facies of the Richardson Trough, the Tremadoc–Late Cambrian boundary is poorly known and the stratigraphical succession on Rock River (HS-29 and ZB-19) illustrates the nature of the problem. Here, the graptolitic Tremadoc is 190 m thick down to the first occurrence of *Staurograptus dichotomus*. This biozone is underlain by a thick section of shales, carbonates and chert yielding inarticulate brachiopods, sponge spicules, trilobites and dendroid graptolites. It is thought that these carbonates are of Late Cambrian age based on comparison with Trail River, where Berry & Norford (1976) identified, from homotaxially equivalent beds, *Dendrograptus*, '*Dictyonema*' and *Callograptus* in association with Late Cambrian (Dresbachian) trilobites.

A comparable stratigraphy exists in the Mackenzie Mountains (64° 42′ N, 130° 48′ W) where Fritz, Norford & Tipnis (*in* Cecile, 1982, pp. 65–78) were able to show that a sequence of Tremadoc graptolite faunas in the Duo Lake Formation was underlain by Late Cambrian Franconian trilobites and conodonts in the Rabbitkettle Formation. Much more

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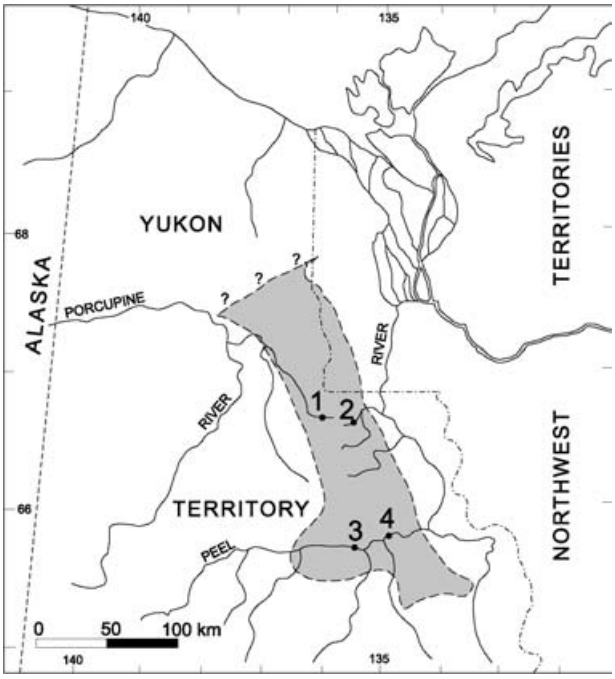

Figure 1. Map of northern Yukon and adjacent Northwest Territories showing location of important sections in the graptolite-rich Road River Group and location of the Richardson Trough (stippled) during the Tremadoc. 1, Rock River; 2, Tetlit Creek; 3 and 4, Upper and Lower Canyons respectively on Peel River.

work needs to be done before we will be able to draw the Cambrian–Ordovician boundary at the same stratigraphical level as it has recently been fixed in western Newfoundland (Cooper, Nowlan & Williams, 2001).

2. Measured sections through the Tremadoc

Apart from the Upper Canyon collections, we have used many specimens from ten oil company collections made between 1958 and 1968. All of these early collections were measured in feet whereas sections PR1, 2 and 3 were measured in metres. These data are preserved in our descriptions as a means of retrieving the collections. Collections PR1 to 3 and ZB-19 are held by the University of Western Ontario, London, Ontario, and the rest are housed by the University of Alberta, Edmonton, Alberta.

Upper Canyon, Peel River (65° 53′ N; 135° 35′–45′ W)
HS-32 measured by Amoco, 1958 (Jackson & Lenz, 1962, fig. 2), 10 collections.
PR1-61-7 measured by Imperial, 1961, 6 collections.
68-PLR-1 measured by British American, 1968, 24 collections.
UPC-2 measured by Texaco, 1968, 9 collections.
PW-13J and PW-15J measured by D. E. Jackson, 1969 (Jackson, 1974, appendix 1), 24 collections.
PR1, PR2 and PR3 measured by A. C. Lenz, 1980 (Jackson & Lenz, 1999, 2000), 48 collections.

Figure 2. Aerial view (upstream) of the Upper Canyon on Peel River when the water level was very low. Strata in foreground are of Cambrian age. Arrow indicates the position of the measured sections PR1-3 in the Tremadoc.

Lower Canyon, Peel River (65° 56′ N; 134° 51′ W)
LPC-3 measured by Texaco, 1968, 14 collections.
PR-4 measured by A. C. Lenz, 1980, 10 collections.

Tetlit Creek (type section of the Road River Group) 66° 44′ N; 135° 46′–48′ W)
FA-8 measured by J. F. S. Anderson and D. E. Jackson, 1959 (Unit 1b of Jackson & Lenz, 1962, p. 36), 3 collections.

Rock River (66° 48′ N; 136° 8′–19′ W)
HS-29 measured by Amoco, 1958, 2 collections.
U-16 measured by Union, 1960, 1 collection.
ZB-19 measured by A. C. Lenz, Chevron, 1963 (Jackson & Lenz, 1999, fig. 2), 14 collections.

3. Biostratigraphy

The graptolite zonal scheme that we use for the Tremadoc grew out of the studies of Jackson & Lenz (1962), Jackson (1974, 1975) and Jackson & Lenz (1999, 2000). Today, six graptolite biozones are recognized, which in ascending order are: *Staurograptus dichotomus, Anisograptus matanensis, Adelograptus*

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Table 1. Stratigraphical distribution of graptolites described in this paper

Taxa	Biozones 1	2	3	4	5	6
Chigraptus supinus	+					
Staurograptus dichotomus	+					
Anisograptus cf. *A. canadensis**		+				
" *matanensis**		+				
Bryograptus? sp.		+				
Adelograptus cf. *A. tenellus*			+			
*Ancoragraptus bulmani**			+			
Psigraptus arcticus			+			
" *lenzi*			+			
" cf. *P. lenzi*			+			
Araneograptus cf. *A. macgillivrayi*					+	
" *pulchellus*					+	+
Kiaerograptus? *bulmani**					+	
" *peelensis*					+	
" sp. A*					+	
" *kutchini* sp. nov.*					+	
Clonograptus aureus					+	
" *magnificus**					+	+
" cf. *C. multiplex**					+	+
" cf. *C. rigidus**					+	
Paradelograptus aff. *P. kinnegraptoides**						+
*Hunnegraptus copiosus**						+

Biozones 1 to 6 are: 1 – *Staurograptus dichotomus*; 2 – *Anisograptus matanensis*; 3 – *Adelograptus* cf. *A. tenellus*; 4 – *Adelograptus antiquus* (none described herein); 5 – *Kiaerograptus pritchardi*; 6 – *Paradelograptus kinnegraptoides*. New records are marked with an asterisk. For a complete record of the graptolites recorded in the Tremadoc see Figure 3.

cf. *A. tenellus, Adelograptus antiquus*, *Kiaerograptus pritchardi* and *Paradelograptus kinnegraptoides* followed by the Arenig *Tetragraptus approximatus* Biozone (Table 1). This sequence of zones, established in the Upper Canyon on Peel River, cannot be recognized in its entirety at any other locality in Yukon Territory due to the lack of detailed sampling. This is illustrated by the fact that in the Upper Canyon section (PR1, 2 and 3) we collected Tremadoc graptolites from 48 levels, whereas on Rock River, the next best sampled section, only 14 were recorded and other sections have even fewer.

3.a. *Staurograptus dichotomus* Biozone

A review of all the data available on Early Tremadoc faunas in northern Yukon Territory confirms the existence of a *Staurograptus dichotomus* Biozone overlain by the *Anisograptus matanensis* Biozone, thus bringing the Yukon zonal scheme into line with the international zonation proposed by Cooper *et al*. (1998). The *S. dichotomus* Biozone is a replacement for the *S. tenuis* Subzone of Jackson (1974). We draw the base of the zone under PR1-0 m in the Upper Canyon (Fig. 3) where the quadriradiate anisograptids *Staurograptus dichotomus* and *Chigraptus supinus* first occur. These two forms extend upwards to the base of the overlying *Anisograptus matanensis* Biozone at PR1-6 m. Confirmation that these zones can be separated comes from two other collections, namely, the Upper Canyon collection PW-15J (Jackson, 1974) and Rock River collection ZB-19 (Jackson & Lenz, 1999).

The absence of the *Rhabdinopora* fauna remains to be explained. It may result from our failure to examine the sub-*Staurograptus* beds in sufficient detail or it may be facies controlled. Very recently, the senior author was able to examine a collection from the Misty Creek Embayment (Cecile, 1982) in the Mackenzie Mountains made by the Geological Survey of Canada, in which *Staurograptus* was found associated with the first record of the dendroid *Rhabdinopora* in northwest Canada.

3.b. *Anisograptus matanensis* Biozone

In the Upper Canyon section, the base of this zone is marked by the first occurrence of *Anisograptus matanensis* at PR1-6 m and this species, together with *Staurograptus*, ranges upwards to PR1-14 m, giving the zone a thickness of at least 10 m. Additional forms in this zone include *A*. cf. *A. canadensis* and *Bryograptus*? sp. The zone is also recorded on Rock River in collection ZB-19, 125F (Fig. 3). The overlapping relationship of *Staurograptus* and *Anisograptus* is seen in three collections from the Richardson Mountains, unlike Green Point, Newfoundland, where the two ranges are separated by 9 m of non-graptolitic strata.

3.c. *Adelograptus* cf. *A. tenellus* Biozone

The biozone is known from Rock River, Tetlit Creek and Upper Canyon of Peel River. The unit is a modification of the *Adelograptus* Zone of Jackson (1974) and represents the measured sections PW-15J,

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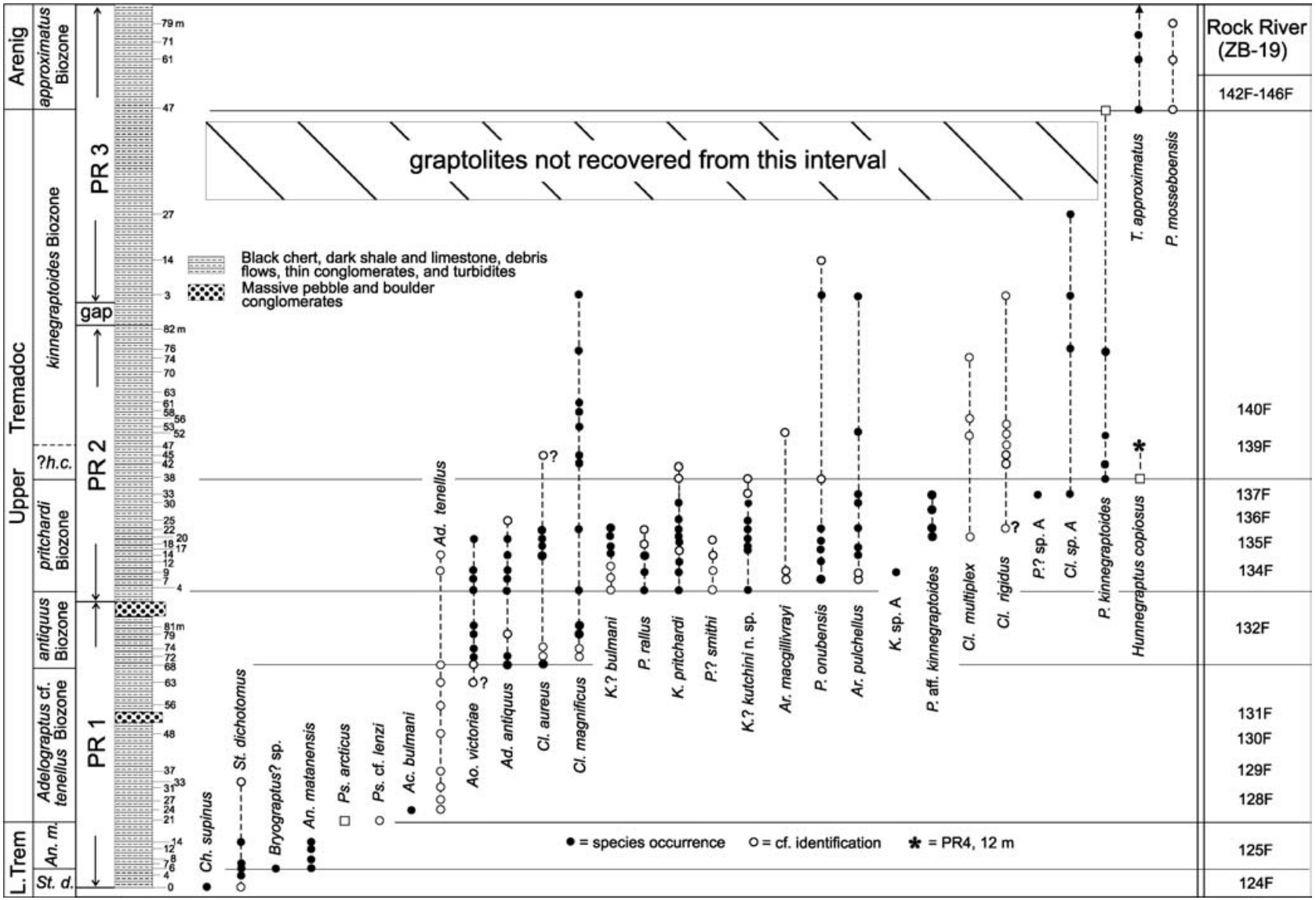

Figure 3. Stratigraphical ranges of all Tremadoc graptolites from the Upper Canyon section on Peel River in Yukon Territory combining data in this paper with that in Jackson & Lenz (2000). Approximate correlation of collections from Rock River is shown in right hand column. *Ac.* = *Ancoragraptus, Ad.* = *Adelograptus, An.* = *Anisograptus, An.m* = *Anisograptus matanensis* Biozone, *Ao.* = *Aorograptus, Ar.* = *Araneograptus, Ch.* = *Chigraptus, H. c.* = *Hunnegraptus copiosus* Biozone, *K.* = *Kiaerograptus, P.* = *Paradelograptus, Ps.* = *Psigraptus, St.* = *Staurograptus, St.d* = *Staurograptus dichotomus* Biozone.

49–88 ft plus PW-13J, 0–30 ft given in Jackson (1974, p. 58, appendix II). As presently defined, the *A*. cf. *A*. *tenellus* Biozone embraces the *Clonograptus*–*Adelograptus* interregnum of Jackson & Lenz (1999).

In Yukon Territory, the base of the *Adelograptus* cf. *A. tenellus* Biozone is drawn under the first appearance of *Adelograptus* and/or *Psigraptus* (see Fig. 3). In the Upper Canyon, *Psigraptus* cf. *P*. *lenzi* occurs at PR1-21 m marking the base of the zone, and at 24 m is the first appearance of *Adelograptus* cf. *A*. *tenellus* in association with *Ancoragraptus bulmani*. The *tenellus*-like *Adelograptus* ranges upwards to just above the first appearance of *Aorograptus victoriae* at PR1-63 m that marks the base of the *antiquus* Biozone, giving a thickness of 45 m.

On Rock River, the biozone is more than 35 m thick and begins with *A*. cf. *A. tenellus*, followed by *Psigraptus arcticus* and *P. lenzi* overlain by the long-ranging *A*. cf. *A. tenellus*. In both Yukon Territory and China (Wang & Erdtmann, 1986), *Psigraptus* appears to be confined to a very thin stratigraphical interval and it seems advisable to include these occurrences together rather than having two separate biozones based on these two genera.

3.d. *Adelograptus antiquus* Biozone

This biozone is recognized only in the Upper Canyon of Peel River where it has a thickness of about 30 m and yields the first appearance of *Adelograptus antiquus* and *Aorograptus victoriae* as well as *Clonograptus* spp. This zone and the overlying *K. pritchardi* Biozone could be considered subzones of the *A. victoriae* Zone, however, the eponymous species of that zone is rather rare in the Yukon.

3.e. *Kiaerograptus*? *pritchardi* Biozone

The zone is recorded in both the Upper and Lower Canyons on Peel River, as well as from Rock River. The biozone contains a rich assemblage of newcomers in addition to holdovers from the *antiquus* Biozone and is composed of *Araneograptus* cf. *A. macgillivrayi, A. pulchellum, Kiaerograptus*? *pritchardi, K*? *bulmani, K*? *peelensis, K*? *kutchini* sp. nov., *K*? sp. A, *Clonograptus aureus, C. magnificus, Paradelograptus rallus, P. onubensis, P.* aff. *P. kinnegraptoides* and *P*? *smithi.* The thickness of the zone in the Upper Canyon section is about 33 m.

3.f. *Paradelograptus kinnegraptoides* Biozone

This biozone was proposed by Jackson & Lenz (2000) to embrace an interval in the Upper Canyon of about 100 m thick between the richly fossiliferous *pritchardi* Biozone and the *Tetragraptus approximatus* Biozone. The total assemblage of the zone consists of *Paradelograptus kinnegraptoides*, *Araneograptus* cf. *A. pulchellus* and the large clonograptids *C*. *magnificus, C*. cf. *C. multiplex* and *C*. cf. *C. rigidus*. Subsequent to our proposal, we have been able to add *Hunnegraptus copiosus* to the biozonal assemblage, and this indicates that at least the lowermost part of the *kinnegraptoides* Biozone is equivalent to the *Hunnegraptus copiosus* Biozone of Sweden.

In the Richardson Trough, the early Arenig zone of *Tetragraptus approximatus* overlies the *kinnegraptoides* Biozone and is marked by the appearance of the zonal designate which is abundant in all sections. The best collection through the *approximatus* Biozone was made in the Lower Canyon (PR4) by A. C. Lenz, who recorded *T. approximatus* at 14 levels through 50 m of section. Contrary to Maletz & Egenhoff's (2001) claim that the zone is ill-defined in the Yukon, we have found it to be one of the most abundant and readily recognizable biostratigraphical units in the entire graptolitic facies.

3.g. Notes on correlation

The international correlations shown in Figure 4 are in good agreement with those presented by Cooper (1999, fig. 2) and we confine our remarks to some slight differences that are evident to us. Cooper correlates the *Staurograptus dichotomus* Biozone with the *Rhabdinopora flabelliforme parabola* Zone of Newfoundland, implying that a gap exists in the sequence in Yukon Territory. This correlation is at odds with what is known of the ranges of the nominate species at Green Point, where *praeparabola* is associated with *Staurograptus dichotomus* (Erdtmann, 1988). Instead, we suggest that the *S. dichotomus* Biozone is equivalent to both the *praeparabola* and *parabola* Biozones of Green Point and Norway. The correlative units in China are likely to be the *Rhabdinopora*? *taojiangensis* Zone and the overlying *R. f. parabola* Zone (Wang & Wang, 2001), both characterized by quadriradiate anisograptids.

The overlying *Anisograptus matanensis* Biozone is widely recognized on the basis of the first appearance of triradiate anisograptids, such as in Norway, Britain, China and Australia, as well as the Yukon, and there is no question of the contemporaneity of these zones.

The *A*. cf. *A. tenellus* Biozone of the Yukon represents Cooper's Assemblage 3 and Wang & Wang's (2001) Bio-event 3 in the earliest Late Tremadoc. It yields the same low-diversity assemblage of horizontal biradiate anisograptids as does the *A*. *tenellus* Zone of Britain, Norway and Sweden, as well as the La 1b of Australia. The *Psigraptus* fauna occurs within this biozone in Yukon Territory, north China and Australia, and this puts a constraint on its correlation elsewhere, namely, the lower part of Assemblage 3 (*sensu* Cooper, 1999).

Assemblage 4 of Cooper and Bio-event 4 of Wang & Wang commences with the *Adelograptus antiquus* Biozone in the Richardsons, which correlates with the

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	Yukon	W. Newfoundland	NE China	Australia	Britain	Sweden	Norway	Bolivia	International
UPPER TREMADOC	*P. kinnegraptoides*								
	?H. copiosus					*H. copiosus*	?	*H. copiosus*	*H. copiosus*
	K. pritchardi	?		*Araneograptus*	*Ar. murrayi*	*Ar. murrayi*		*Ar. murrayi*	*Ar. murrayi*
		Ao. victoriae		*K. pritchardi* upper La2		*K. supremus*		*K. supremus*	*Kiaerograptus*
	Ad. antiquus	?	?	*Ao. victoriae* lower La2		*Br. kjerulfi*	*Bryograptus*	*Ao. victoriae*	*Ad. antiquus*
	Adelograptus cf. *tenellus*		*Clonograptus-Adelograptus*	*Adelograptus-Psigraptus*	*Ad. 'tenellus'*	*Ad. 'tenellus'*	*Ad. 'tenellus'*	?	*Adelograptus*
			Psigraptus						
LOWER TREMADOC	*Anisograptus matanensis*	*Rh. f. anglica*			*Rh. f. anglica*		*Rh. f. anglica*		*Rh. f. anglica*
		An. matanensis	*Anisograptus*	*Anisograptus*	*Rh. f. flabelliformis*	*Rh. f. flabelliformis*	*Rh. f. flabelliformis -Anisograptus*		*An. matanensis*
	Staurograptus dichotomus	*Rh. f. parabola*	*Rh. f. parabola*		*Rh. f. parabola*	*Rh. f. socialis*	*Rh. f. socialis*		*Rh. f. parabola*
		Rh. f. praeparabola	*Rh. f. taojiangensis*				*Rh. f. praeparabola*		*Rh. f. praeparabola*
SOURCES	Jackson and Lenz 1962, 1999, 2000	Fortey et al. 1982; Erdtmann 1988; Williams and Stevens 1991; Cooper et al. 1998	Zhao and Zhang 1985; Lin 1986; Wang and Erdtmann 1987; Zhao, Lin and Zhang 1988; Chen et al. 1988	Cooper and Stewart 1979; Vandenberg and Cooper 1992	Bulman 1927, 1954; Bulman and Rushton 1973; Stubblefield and Bulman 1927; A.H. Cooper et al. 1995	Hede 1951; Lindholm 1991	Bulman 1954; Bruton et al.1982; Maletz and Erdtmann 1986	Maletz, Egenhoff and Erdtmann 1999	Cooper et al. 1998

Figure 4. Correlation of the Tremadoc graptolite zones in Yukon with those in other parts of the world. *Ad.* = *Adelograptus*, *An.* = *Anisograptus*, *Ao.* = *Aorograptus*, *Ar.* = *Araneograptus*, *Br.* = *Bryograptus*, *f.* = *flabelliforme*, *H.* = *Hunnegraptus*, *K.* = *Kiaerograptus*, *Rh.* = *Rhabdinopora*.

La 2 (lower) of Victoria, Australia. On both continents, the *antiquus* Biozone carries the earliest occurrences of *A. antiquus* and *Aorograptus victoriae*. The overlying *K*? *pritchardi* Biozone correlates with the La 2 (upper) based on the first occurrence of the genus *Kiaerograptus.* In the Yukon, the genus is represented by *K*? *pritchardi*, *K*? *bulmani*, and *K*? *kutchini*. Other First Appearance Data (FADs) include *Paradelograptus onubensis*, *Araneograptus* spp. and large clonograptids. This assemblage represents Bio-event 4 of Wang & Wang and is therefore equivalent to Cooper's *Kiaerograptus* Zone within Assemblage 4.

The upper part of Assemblage 4 underlies the *Tetragraptus approximatus* Biozone in Yukon Territory, and Jackson & Lenz (2000) proposed a new zone based on the incoming of *Paradelograptus kinnegraptoides* embracing a stratigraphical interval some 100 m thick directly below the *approximatus* Biozone. At that time, no equivalents could be recognized elsewhere in the world, however, subsequently we have found three specimens of *Hunnegraptus copiosus* in the lowermost part of the zone indicating that at least this part of the *kinnegraptoides* Biozone is equivalent to the *H. copiosus* Zone of Sweden.

4. Systematic descriptions

All figured specimens described in this paper have been deposited with the Geological Survey of Canada, Ottawa. References are also made to specimens housed in the following institutions: GSC – Geological Survey of Canada; MDM – Mines Department Museum, Melbourne; MUGD – Melbourne University Geology Department; OU – Otago University, Dunedin, New Zealand; PMO – Paleontologisk Museum, Oslo; UA – University of Alberta, Edmonton, Alberta; UWO – University of Western Ontario, London, Ontario.

Figures 6, 9, 10 and 12 were made using the Adobe Photoshop program whereby the images and backgrounds were reversed to enhance the contrast.

Order GRAPTOLOIDEA Lapworth
(*in* Hopkinson& Lapworth, 1875)
Family ANISOGRAPTIDAE Bulman, 1950
Genus *Chigraptus* Jackson & Lenz, 1999
Chigraptus supinus Jackson & Lenz, 1999
Figures 5a–c; 6a–c

1999 *Chigraptus supinus* sp. nov. Jackson & Lenz, pp. 155–7, fig. 4a–e.

Type species. Holotype GSC 117664 from the lower part of the *Staurograptus dichotomus* Biozone at PR1-0 m in the Upper Canyon section, Peel River.

Material and occurrence. Fifteen flattened specimens are available from the lower part of the *Staurograptus dichotomus* Biozone at PR1-0 m.

Description. Rhabdosome small, quadriradiate, horizontal to slightly reclined, up to 11 mm diameter with up to four, but some with only two or three unbranched first-order stipes. The sicula is 2.0–2.4 mm long and 0.25 mm across the aperture, distal half is free and symmetrically disposed relative to the stipes. A sicular bitheca is seen and bithecae are probably present throughout the colony. Proximal autothecae are isolate and strongly down-curved, free for 1.0 mm with 0.2–0.3 mm wide apertures. Distal autothecae are less curved and less isolate and there are 4 in 5 mm.

Remarks. This monotypic genus has been found in only one collection on Peel River in 1980, and the reason for its scarcity might be that it was collected from beds that are only accessible when the river is extremely low. The fact that it occurs associated with *Staurograptus* puts an Early Tremadoc age beyond doubt. No other dendroid can be confused with this species when the quadriradiate nature of the rhabdosome is seen; however, when the proximal end is obscure, it could be mistaken for *Psigraptus*. Presently, it is known only from Yukon Territory. The genus is described as having a horizontal rhabdosome, but two specimens exist amongst the topotypes that are pendant due to taphonomic effects.

Genus *Staurograptus* Emmons, 1855
Staurograptus dichotomus Emmons, 1855
Figures 5d–g; 6d–f, i

1855 *Staurograptus dichotomus* n. sp. Emmons, p. 109, pl. 1, fig. 21.
1962 *Staurograptus dichotomus* var. *apertus* Jackson & Lenz, p. 37.
1974 *Staurograptus tenuis* n. sp. Jackson, pl. 5, fig. 1; text-fig. 1G, H.
1998 *Staurograptus dichotomus* Emmons; Cooper *et al.*, pp. 22–5, figs 22a–s,w, x; 25a, b, e (accompanied by a complete synonymy).

Type specimen. Believed to reside in the New York State Museum. The type locality is the Taconic Shale of Rensselaer County, New York.

Material and occurrence. About 30 mostly flattened specimens are available from the *Staurograptus dichotomus* Biozone in the Upper Canyon, Peel River at PR1-0 m, 7 m and 14 m as well as PW-15J at 5 ft.

Description. Rhabdosome small, quadriradiate, horizontal with branching to the fourth-order. The colony attains a diameter of up to 12 mm and there may be as many as 15 terminal stipes or as few as five. Sicula slender, 0.9 mm long with nema. First-order branches are 0.6–3.1 mm long with one to three autothecae, second-order are 0.8–3.8 mm long and branched third-order are up to 20 mm long. Autothecae in profile view are 0.3–0.4 mm wide across thecal aperture, the free ventral walls are inclined at 10–15° and the thecal spacing is 8.5–11 per cm. Bithecae are seen in one specimen.

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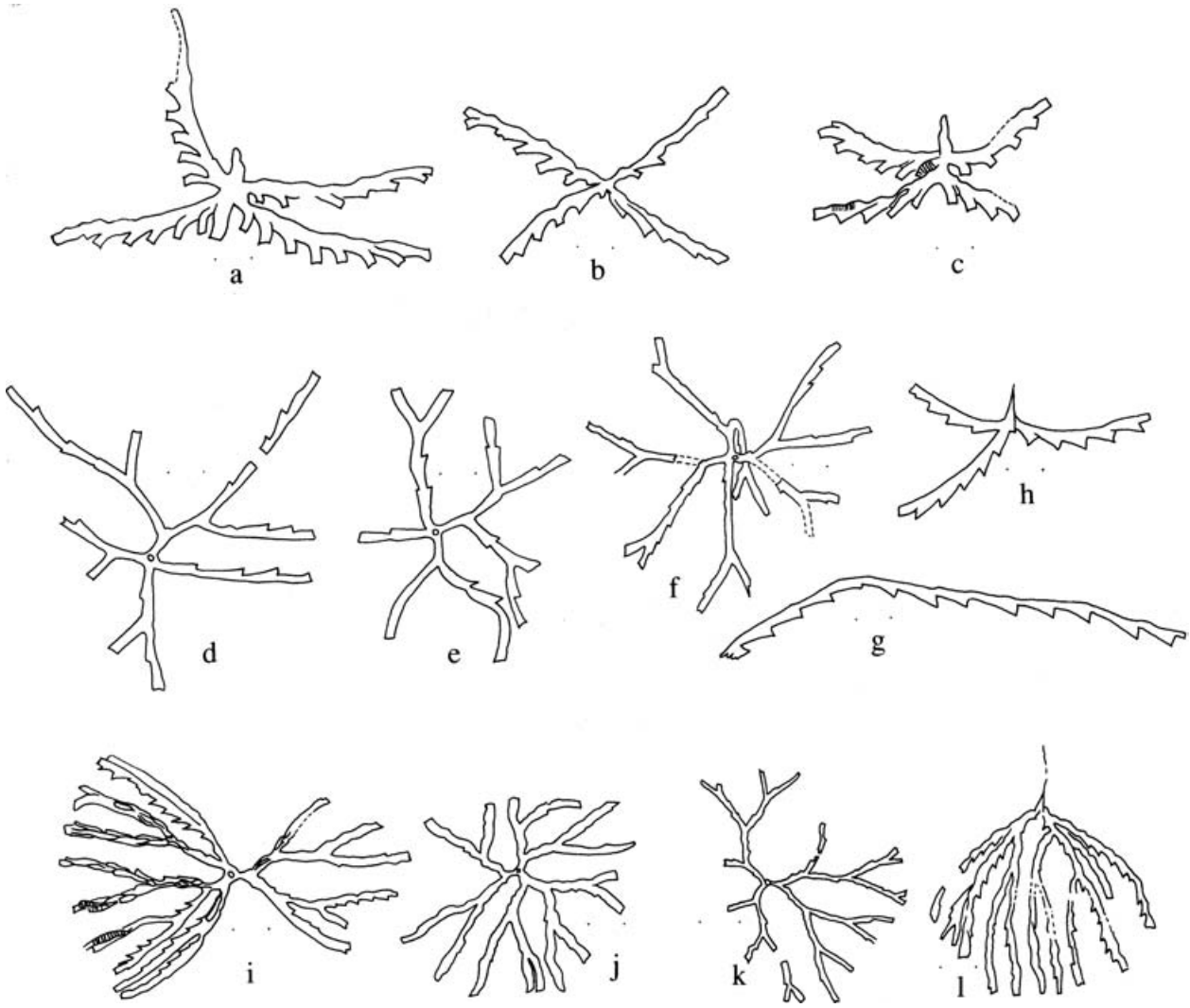

Figure 5. (a–c) *Chigraptus supinus* Jackson & Lenz. (a) GSC 117665; (b) GSC 117664 holotype, (c) GSC 117668 from PR1-0 m, Upper Canyon, Peel River, × 5. (d–g) *Staurograptus dichotomus*. (d) GSC 123166; (e) GSC 123167; (g) GSC 123169, PR1-7 m, × 5; (f) GSC 123168, PW-15J at 5 ft, Upper Canyon, Peel River, × 5. (h) *Anisograptus* cf. *A. canadensis* GSC 94798 from FA-8 at 70 ft, Tetlit Creek, × 5. (i–k) *Anisograptus matanensis* Ruedemann. (i) GSC 123175, HS 32 at 3110 ft, × 5; (j) GSC 123176 and (k) GSC 123177 from PR1-12 m. (l) ? *Anisograptus matanensis* GSC 123178, ZB-19-135F, Rock River, × 5.

Remarks. Yukon specimens seem to be immature because no specimen displays dissepiments or any branching beyond the fourth-order (cf. Erdtmann, 1988). Jackson (1974) described *Staurograptus tenuis* as a new species, but Erdtmann (1988) has shown that *S. dichotomus* Emmons is extremely variable and that *S. tenuis* is a junior synonym. Erdtmann alluded to the distal migration of branching with time resulting in a colony with only four stipes. Such pauciramous forms occur in the PR1-7 m collection in the Upper Canyon section.

Genus *Anisograptus* Ruedemann, 1937

Anisograptus cf. *A. canadensis* (Bulman), 1950

Figure 5h

cf. 1950 *Triograptus canadensis* sp. nov. Bulman, p. 88, pl. vii, figs 18–21, pl. viii, figs 7, 9; text-fig 4j, k.

1962 *Triograptus* sp. Jackson & Lenz, pp. 36–7.

Figure 6. (a–c) *Chigraptus supinus* Jackson & Lenz, 1999. All from PR1-0 m. (a) GSC 117666, × 10; (b) GSC 117667, × 5; (c) GSC 117665, × 5. (d–f, i) *Staurograptus dichotomus* Emmons, 1855. (d) GSC 123170, PR1-6 m, × 2.5; (e) GSC 123171, PR1-8 m, × 2.5; (f) GSC 123172, PR1-14 m, × 5; (i upper) GSC 123173, (i lower) GSC 123174, PR1-7 m, × 2.5. (g, h, j–l, n) *Anisograptus matanensis* Ruedemann, 1937. (g) GSC 123178, ZB-19, 125F, × 5; (h1) GSC 123180, (h2) GSC 123181, ZB-19, 125F, × 5; (j1) GSC 123182, (j2) GSC 123183, ZB-19, 125F, × 5; (k) GSC 123184, PR1-12 m, × 5; (l) GSC 123185, PR1-14 m, × 5, (n) GSC 123186, × 5; (m, o) *Ancoragraptus bulmani* (Spjeldnaes, 1963). (m) GSC 123190, PR1-24 m, × 5; (o) GSC 123191, PR1-24 m, × 10. (p) *Bryograptus*? sp., GSC 123205, PR1-6 m, × 2.5. (q) *Psigraptus* cf. *P. lenzi* Jackson, 1967, GSC 117669, PR1-21 m, × 5.

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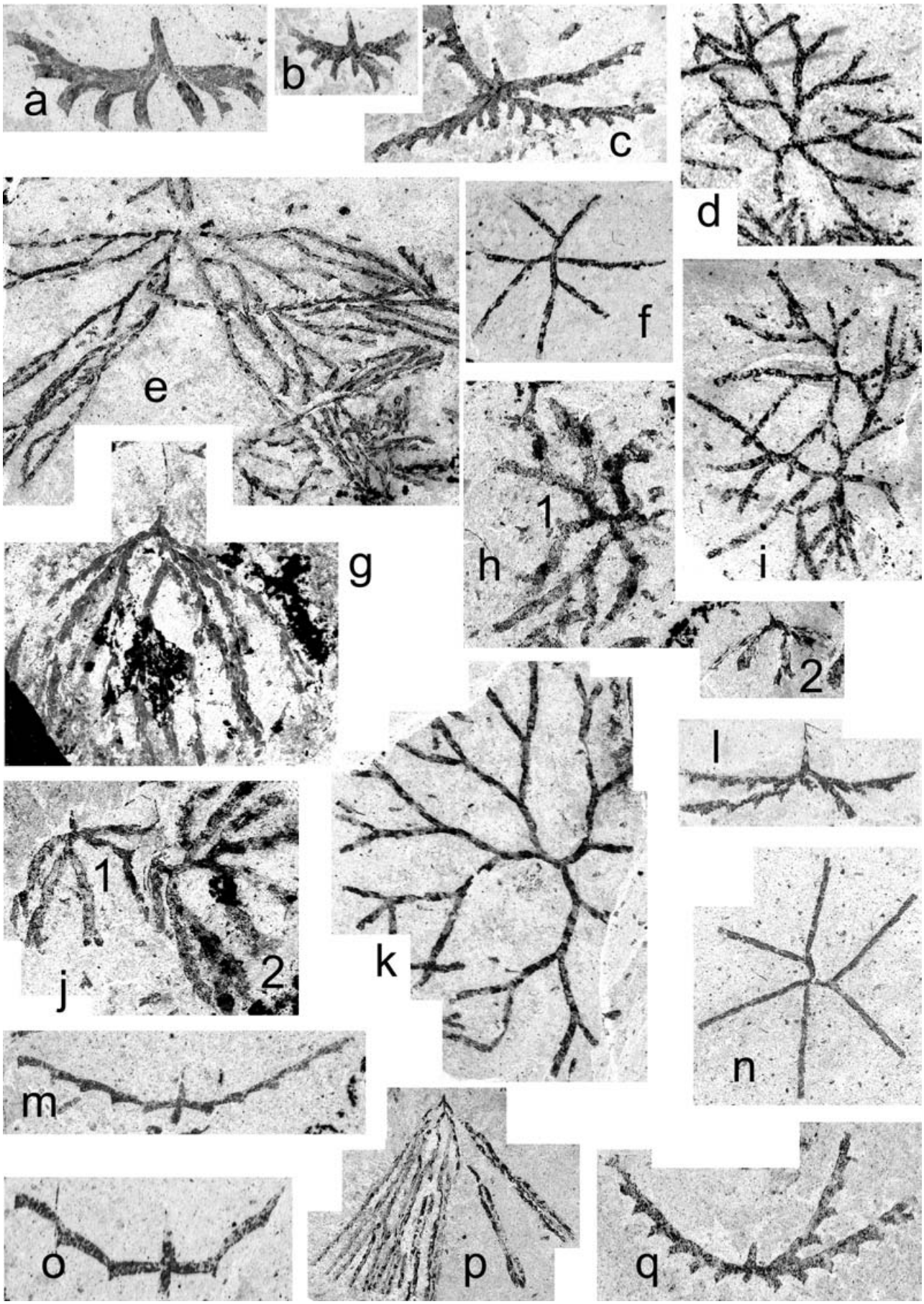

Figure 6. For legend see facing page.

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Material and occurrence. A single specimen GSC 94798 from the *Anisograptus matanensis* Biozone on Tetlit Creek Unit 1b of the Road River Group, field no. FA-8 at 70 ft.

Description. Rhabdosome small, declined, consisting of three short unbranched primary stipes, each stipe having five to six autothecae. The sicula is 1.4 mm long and narrowly conical. The autothecae have a profile width of 0.5 mm, the free ventral walls are about 0.75 mm long, inclined at 20° and the thecal rate is 6.5 in 5 mm.

Remarks. There seems no reason to retain the genus *Triograptus* of Bulman, 1950, because *Anisograptus* includes all triradiate anisograptids with just three terminal stipes. The specimen described has a narrower stipe width than the type material which could be accounted for by the immature nature of the Yukon specimen.

Anisograptus matanensis Ruedemann, 1937
Figures 5i–k,?l; 6g, h, j–l, n

1937 *Anisograptus matanensis* n.sp. Ruedemann, p. 62, figs 6–9.
1962 *Anisograptus* cf. *richardsoni* Bulman; Jackson & Lenz, pp. 37, 44.
1974 *Anisograptus richardsoni Bulman*; Jackson, p. 39, 41, text-figs 1e, f.
1998 *Anisograptus matanensis* Ruedemann; Cooper *et al.*, pp. 28, 29, figs 21b–d, 24, 25k–m (with a complete synonymy).
2001 *Anisograptus matanensis* Ruedemann; Wang X. & Wang C., figs 4G, 5B.

Type specimen. Type specimen comes from Matane, Quebec, and is probably housed in the New York State Museum.

Material and occurrence. Ten flattened and two pyritized specimens are available including UA 1200–1203, field no. HS-32 at 3109 ft and figured specimens GSC 123175–123186, all from the Upper Canyon, Peel River at PR1-6 m, 12 m and 14 m in the *Anisograptus matanensis* Biozone, where it is associated with *Staurograptus dichotomus* at some levels. The species is also known from GSC loc. C-89098 in the Elmer Creek Formation in central Yukon Territory (Cecile, 2000).

Description. Rhabdosome horizontal, triradiate not exceeding 20 mm diameter with up to 17 terminal third- and fourth-order branches. First-order branches are of similar length, namely 0.5–0.8 mm, second-order lengths are 0.6–3.5 mm and third-order 2.3–3.0 mm. Autothecae are seldom seen in profile, but GSC 123175 shows they are 0.5–0.8 mm wide across thecal apertures and have a thecal density of 12 in 10 mm. Pyritized stipes show plaited autothecae and bithecae. Stipe reduction occurs in the highest occurrence of the species at PR1-14 m, where *A. matanensis* var. *tetragraptoides* Bulman occurs. Cooper *et al*. (1998) consider the latter to be an intraspecific varient of *A. matanensis*.

Remarks. The small size, compact branching and thecal spacing distinguish this species from all other species of *Anisograptus.* Mention should be made of a specimen that might be referred to *Anisograptus matanensis* GSC 123178 (Fig. 5l) having a pendant rhabdosome, a sicula 1.6 mm long, stipe width 0.8 mm and denticulate thecal apertures. This form is associated with *Staurograptus dichotomus*.

Genus *Bryograptus* Lapworth, 1880
Bryograptus? sp.
Figure 6p

Material and occurrence. One flattened specimen GSC 123205 from the *Anisograptus matanensis* Biozone at PR1-6 m, Upper Canyon, Peel River.

Description. Rhabdosome small, declined, 17 mm long and 16 mm wide with branching to the fifth-order resulting in twenty terminal stipes. Sicula poorly preserved but at least 1.2 mm long from which arise three primary branches. The profile width of the terminal stipes is 0.35–0.4 mm, autothecae are inclined at about 20° and have concave denticulate apertures. The thecal rate is estimated to be 15–16 in 10 mm. No dissepiments are seen.

Remarks. Wang & Wang (2001) also report the genus from correlative beds in the *A. matanensis* Zone in Hunan, China.

Genus *Adelograptus* Bulman, 1941
Adelograptus cf. *A. tenellus* (Linnarsson, 1871)
Figures 9i, j, l–o; 11f, g

cf. 1871 *Dichograptus*? *tenellus* Linnarsson, p. 795, pl.16, figs 13–15.
1962 *Clonograptus tenellus* Linnarsson?; Jackson & Lenz, p. 37.
1991 *Adelograptus* cf. *A. tenellus* (Linnarsson); Williams& Stevens, pp. 33–4, pl. 2, figs 2, 3; text-figs 13A–J.

Material and occurrence. Twenty flattened specimens from PR1-24 m, 31 m, 37 m, 48 m, 56 m, 63 m and 68 m in the Upper Canyon, Peel River, as well as eleven specimens from Rock River, ZB-19 at 128F, 129F, 131F and possibly 132F and two specimens from Tetlit Creek, FA-8 at 20 ft. In the Upper Canyon, the species ranges through 44 metres of the *Adelograptus* cf. *A. tenellus* Biozone and disappears in the lower part of the *pritchardi* Biozone at PR2-14 m. In its earliest occurrence in Peel River, it is associated with *Psigraptus* cf. *P. lenzi*, but on Rock River the *tenellus*-like species underlies occurrences of *Psigraptus*.

Description. Rhabdosome small, horizontal, biradiate with branching to the fifth-order and attaining a maximum diameter of 23 mm. The sicula is 1.0 to 1.75 mm long and in the juvenile stage is furnished with

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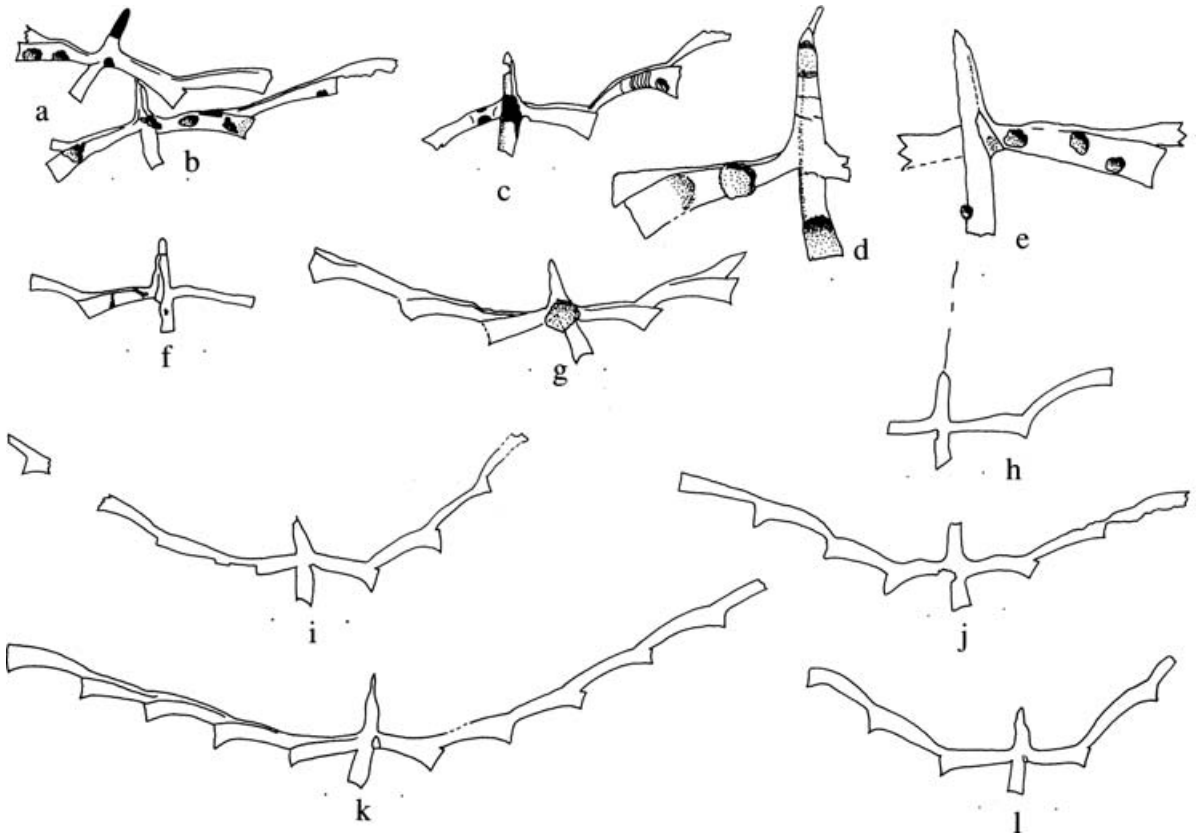

Figure 7. (a–l) *Ancoragraptus bulmani* (Spjeldnaes). (a) PMO 72835f; (b) PMO 72835a (holotype); (c) PMO 72835d; (d) PMO 72835d; (e–g) are topotypes; all from the Alum Shale Formation, Bødalen, Norway. Note sicular bitheca in (e). (h) GSC 123187; (i) GSC 123188; (j) GSC 123189; (k) GSC 123190 with bitheca between sicula and th1[1]; (l) GSC 123191, all from PR1-24 m, Upper Canyon, Peel River. All × 10, except (d), (e), are × 20.

Table 2. A comparison of the biocharacters of *Adelograptus tenellus* and *A*. cf. *A. tenellus*

	Adelograptus tenellus	*A*.cf. *A. tenellus*
Length of funicle	3.0–6.0 mm	2.0–5.5 mm
” 2nd order	3.0–8.0 mm	1.0–4.0 mm
” 3rd order	5.0–> 12.0 mm	1.6–3.2 mm
” 4th order	7.0–> 13.0 mm	2.0–3.0 mm
” 5th order	> 15 mm	not seen
Stipe width	0.25–0.75 mm	0.3–0.7
Thecal rate	9–10	9–10

a long nema. The funicle is horizontal to declined, 2.0 to 5.5 mm long comprising 2 to 6 thecae. Subsequent orders are 1.0 to 4.0 mm long, 1.6 to 3.2 mm long, 2.0 to 3.0 mm long and fifth-order are unbranched. The stipes are 0.3 to 0.7 mm wide in profile. The free ventral walls of the autothecae are straight, about 1.2 mm long and inclined at 10–20°. Thecae are spaced at 9–10 in 10 mm. Bithecae may be present.

Remarks. The work of Maletz & Erdtmann (1986) on *Adelograptus tenellus* showed that the species is very variable. The Yukon form has a similar stipe width and thecal spacing but differs in having a shorter funicle and more closely spaced branching (see Table 2). We consider it to be conspecific with *Adelograptus* cf. *A. tenellus* described by Williams & Stevens (1991) from the *Aorograptus victoriae* Zone of Newfoundland.

Genus *Ancoragraptus* nov.

Derivation of name. From *ancora* (Latin) meaning anchor, referring to the general shape of the rhabdosome.

Type species. Adelograptus? *bulmani* Spjeldnaes 1963, PMO 72835a from the ‘upper part of the Ceratopyge Shale (Zone 3ab)’ at Bødalen, Oslo District, Norway. In a recent paper by Maletz & Egenhoff (2001), this species is said to occur in the *Aorograptus victoriae* Zone in the upper Alum Shale.

Diagnosis. Rhabdosome small, slightly reclined, with two short, undivided first-order branches. The sicula is long, erect, symmetrically disposed relative to the first pair of autothecae, with the distal one-half of the metasicula free. A sicular bitheca is common and reduced bithecae may be present on the stipes. Autothecae with strong curvature, some autothecal apertures tend to be slightly isolate.

Remarks. Spjeldnaes (1963) and Maletz (1992) both suggested that *Adelograptus*? *bulmani* should be assigned to a genus other than *Adelograptus*. Indeed, Maletz & Egenhoff (2001) place it in *Kiaerograptus*.

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This procedure results in the genus *Kiaerograptus* containing two species named after Bulman namely, one by Spjeldnaes (1963) and another by Thomas (1973). It is our opinion that the Spjeldnaes species is so distinctive as to warrant the proposal of the new genus *Ancoragraptus*.

Ancoragraptus bulmani (Spjeldnaes, 1963)
Figures 6m, o; 7a–l

1963 *Adelograptus*? *bulmani* sp. nov. Spjeldnaes, pp. 127–30, pl. 18, figs 1–8; text-figs 3, 4.

Norwegian material:

Type specimens. Holotype PMO 72835 a, paratypes 72835 b–i, 72836 a, b all from the upper part of the Ceratopyge Shale about 0.4–1.8 m below the Ceratopyge Limestone near Slemmestad, Oslo.

Material and occurrence. About 50 specimens, mostly proximal ends, preserved in partial relief on two small pieces of shale. According to Maletz & Egenhoff (2001), the species is assigned to the *Aorograptus victoriae* Zone in the upper part of the Alum Shale which is much younger than it is in the Yukon. A recent examination of this material showed that the species is associated with fragments of a branched dendroid with long narrow stipes 0.15 mm wide and thecae like those of *Adelograptus tenellus*.

Description. Rhabdosome small, comprising two short, reclined, unbranched first-order stipes with up to six autothecae per stipe. The sicula is erect, narrowly conical, 1.3–1.4 mm long including a short rutellum and 0.25 mm across the aperture. The sicula can be divided into a short prosicula only 0.1 mm long and a much wider metasicula that is 1.2 mm long. Theca 1^1 originates very high up the sicula, grows downward adjacent to the metasicula wall for 0.5 mm, then diverges almost at right angles and gives rise to a sicular bitheca whose aperture is at the level of where the free ventral wall of $th1^1$ meets the wall of the metasicula. The first pair of autothecae diverge from the sicula about mid-length, are 1.0–1.15 mm long and are slightly declined; thereafter each successive autotheca becomes progressively more reclined. The autothecae have strong convex curvature along the dorsal margin of the stipe, and saddles occur at the level of the thecal apertures. Three thecae are traversed in an imaginary cross-section through the stipe near the thecal apertures. The prothecal width is 0.1 mm and the width of the stipe across the thecal aperture is 0.5 mm. The free ventral walls of the autothecae are concave and there is evidence that the thecal apertures are slightly isolate. The thecal rate is estimated to be 4 in 5 mm and the thecal overlap is one-half.

Remarks. There is a striking similarity between the Yukon form and *Adelograptus*? *bulmani* Spjeldnaes except for their size (see Table 3). However, an examination of the type specimens of the Norwegian species shows that they are conspecific and the problem of the size difference disappeared when it was realized that Spjeldnaes' (1963) magnifications are in error. The holotype (pl. 18, fig. 10) said to be × 25 is actually × 42.

Table 3. A comparison of the biocharacters of *Ancoragraptus bulmani* from Yukon and Norway

	Yukon	Norway
Sicula length	1.1–1.5 mm	1.25–1.4 mm
Length $th1^1$	0.76 mm	1.0–1.15 mm
Length $th1^2$	1.0 mm	1.15 mm
Prothecal width	0.15 mm	0.1 mm
Stipe width	0.44 mm	0.5 mm
Thecal rate	4–5 in 5 mm	4–5 in 5 mm
Thecal overlap	.5	.5

Yukon material:

Material and occurrence. Fourteen flattened specimens, including GSC 123187–123191, on a single bedding plane in the *Adelograptus* cf. *A. tenellus* Biozone at PR1-24 m.

Description. Rhabdosome small, consisting of two slender, reclined, unbranched, first-order stipes, each about 5 mm long. Sicula narrowly conical, upright, 1.1–1.5 mm long and 0.15–0.2 mm in diameter, furnished with a short rutellum and a nema which in GSC 123187 is 2.7 mm long. A sicular bitheca is probably preserved in GSC 123190. The first pair of thecae diverge about midway down the sicula leaving the distal portion of the metasicula free for 0.45–0.6 mm. The length of the free ventral wall of $th1^1$ is 0.7–0.85 mm and that of $th1^2$ is 0.88–0.92 mm. The dorsal edges of the stipes are undulating with a saddle opposite each thecal aperture; the free ventral walls of the thecae are concave and 0.7–1.0 mm long. Prothecae are 0.13–0.15 mm wide and the metathecae are 0.4 mm wide across the thecal apertures, and these are occasionally seen to be slightly isolate. Thecae spaced at 4.5–5 in 5 mm and overlap slightly less than one-half.

Remarks. This is the first record of the species outside of Norway and occurs in the *Adelograptus* cf. *A. tenellus* Biozone which is stratigraphically lower than the occurrence near Oslo. When allowances are made for the fact that the Bødalen material is in relief, the Yukon specimens agree well with the types from Norway. The only difference is that the lengths of the free ventral walls of thecae 1^1 and 1^2 are slightly less in the Yukon specimens. Spjeldnaes considered that his *Adelograptus*? *bulmani* was descended from the Late Tremadoc genus *Kiaerograptus*, but it seems more probable that it evolved from *Adelograptus tenellus* in view of their stratigraphical relationships.

Genus *Psigraptus* Jackson, 1967

1981 *Yukonograptus* Lin, p. 24.
1985 *Muenzigraptus* Zhao & Zhang, p. 18.
1985 *Diphygraptus* Zhao & Zhang, pp. 19–20.

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1985 *Hunjiangoraptus* (sic) Zhao & Zhang, p. 20.
1985 *Holopsigraptus* Zhao & Zhang, pp. 20–1.
1985 *Clonograptus (Neoclonograptus)* Zhao & Zhang, p. 21.

Type species. *Psigraptus arcticus* Jackson, GSC 21248 from the Road River Group on Rock River, field no. U-16 at ?1060 ft where it occurs in the *Adelograptus* cf. *A. tenellus* Biozone.

Diagnosis. (Emended by Rickards & Stait, 1984, and by Rickards, Partridge & Banks, 1991) Nematophorous rhabdosome, biradiate with two primary stipes and one or two pseudoprimary stipes, branching to seventh-order. Sicula long, vertically erect, symmetrical relative to first-order branches. Autothecae and bithecae present, and sclerotized stolon is seen in one species. Proximally, autothecae are isolate and strongly down-curved, less so distally.

Remarks. The genus was first recognized in the Yukon and is now recorded from Stauro Gully in Victoria, Florentine Valley in Tasmania and Jilin Province in China. In addition to the two species described herein, a third species *P. jacksoni* has been described from Tasmania by Rickards & Stait (1984). They were able to show using an extensive collection of that species that the various genera of Lin (1981), and Zhao & Zhang (1985) are all growth stages of *P. jacksoni*. All three species occur within a narrow range of strata and have been embraced by Cooper & Stewart (1979), Rickards & Stait (1984), Zhao & Zhang (1986) and Wang & Erdtmann (1987) as constituting a zone of world-wide extent, namely, the *Psigraptus* Zone in the mid-Tremadoc. Earlier, we gave our reason for modifying this usage.

Psigraptus arcticus Jackson, 1967
Figure 8a, b

1967 *Psigraptus arcticus* n. sp. Jackson, pp. 318–19, text-fig. 1A, B.
1985 *Psigraptus arcticus* Jackson; Zhao & Zhang, pl. IV, figs 10?, 11.
1986 *Psigraptus arcticus* Jackson; Zhao & Zhang, pl. I, figs 1, 2, 3?, 11.
1988 *Psigraptus arcticus* Jackson; Zhao, Lin & Zhang, pl. III, fig. 18.

Type specimen. Holotype GSC 21248 from the *Adelograptus* cf. *A. tenellus* Biozone on Rock River, field no. U-16 at ?1060 ft collected by Union Oil of Canada, 1960.

Material and occurrences. Apart from the holotype and paratype GSC 21249, field no. U-16 at ?323 m both from Rock River, we have three specimens from a measured section ZB-19–130F on Rock River and one poorly preserved specimen from the Upper Canyon section at PR1-21 m. All are from the *Adelograptus* cf. *A. tenellus* Biozone.

Description. Rhabdosome small consisting of two short, reclined first-order branches up to 5.5 mm long. The sicula, which is 1.5–1.8 mm long and 0.25–0.4 mm across the aperture of the metasicula, is erect and symmetrical relative to stipes. A delicate nema and rutellum are seen. The reclined stipes have a maximum profile width of about 1.5 mm across the third pair of autothecae. Proximally, the thecae are tubular, strongly down curved, isolate and free for 0.6–0.7 mm. Distal thecae are less isolate and tend to be inclined at an acute angle to the stipe. The thecal apertures are concave and there are 4.75 thecae in 5.0 mm. Bithecae have not been observed but are presumed to be present.

Remarks. The age of *Psigraptus arcticus* and *P. lenzi* in Yukon is confidently placed in the lower part of the *Adelograptus* cf. *A. tenellus* Biozone. Records of *P.* cf. *P. arcticus* from the Australian La 1.5 by Stait & Laurie (1980), Banks & Burrett (1980), and Laurie (1980) have since been referred to *P. jacksoni* by Rickards & Stait (1984). Zhao & Zhang (1985, 1986) recorded *Psigraptus arcticus* from Jilin Province, in China where it is associated with *P. lenzi*.

Psigraptus lenzi Jackson, 1967
Figure 8c, d

1967 *Psigraptus lenzi* n. sp. Jackson, pp. 319–21, text-fig. 1C, D.
1985 *Yukonograptus lenzi* (Jackson); Zhao & Zhang, pl. IV, fig. 8.
1985 *Yukonograptus quadribrachiatus* Zhao & Zhang, pl. IV, fig. 9.
1986 *Yukonograptus lenzi* (Jackson); Zhao & Zhang, pl. 1, figs 6, ?7–10.
1986 *Yukonograptus quadribrachiatus* Zhao & Zhang, pl. I, figs 8–10.
1988 *Yukonograptus lenzi* (Jackson); Zhao, Lin & Zhang, pl. III, fig. 11.

Type specimen. Holotype GSC 21253 (Jackson, 1967, text-fig. 1D) from the *Adelograptus* cf. *A. tenellus* Biozone on Rock River, Yukon.

Material and occurrence. Three flattened specimens and one in partial relief including the holotype and the paratype GSC 21254, field no. ZB-19 at 130F; all from the *Adelograptus* cf. *A. tenellus* Biozone.

Description. The reclined rhabdosome is up to 6.0 mm long and 4.0–4.5 mm across at its widest point. The development of first-order branches is obscured; three or four second-order reclined branches appear to immediately grow upwards from the obscure funicle. The tubular autothecae are isolate throughout the second-order branches, strongly down-curved proximally and subparallel with the sicula. The apertures of the third autothecae on each stipe are directed horizontally, and thereafter they become inclined at progressively more acute angles to the stipe axis. The profile width

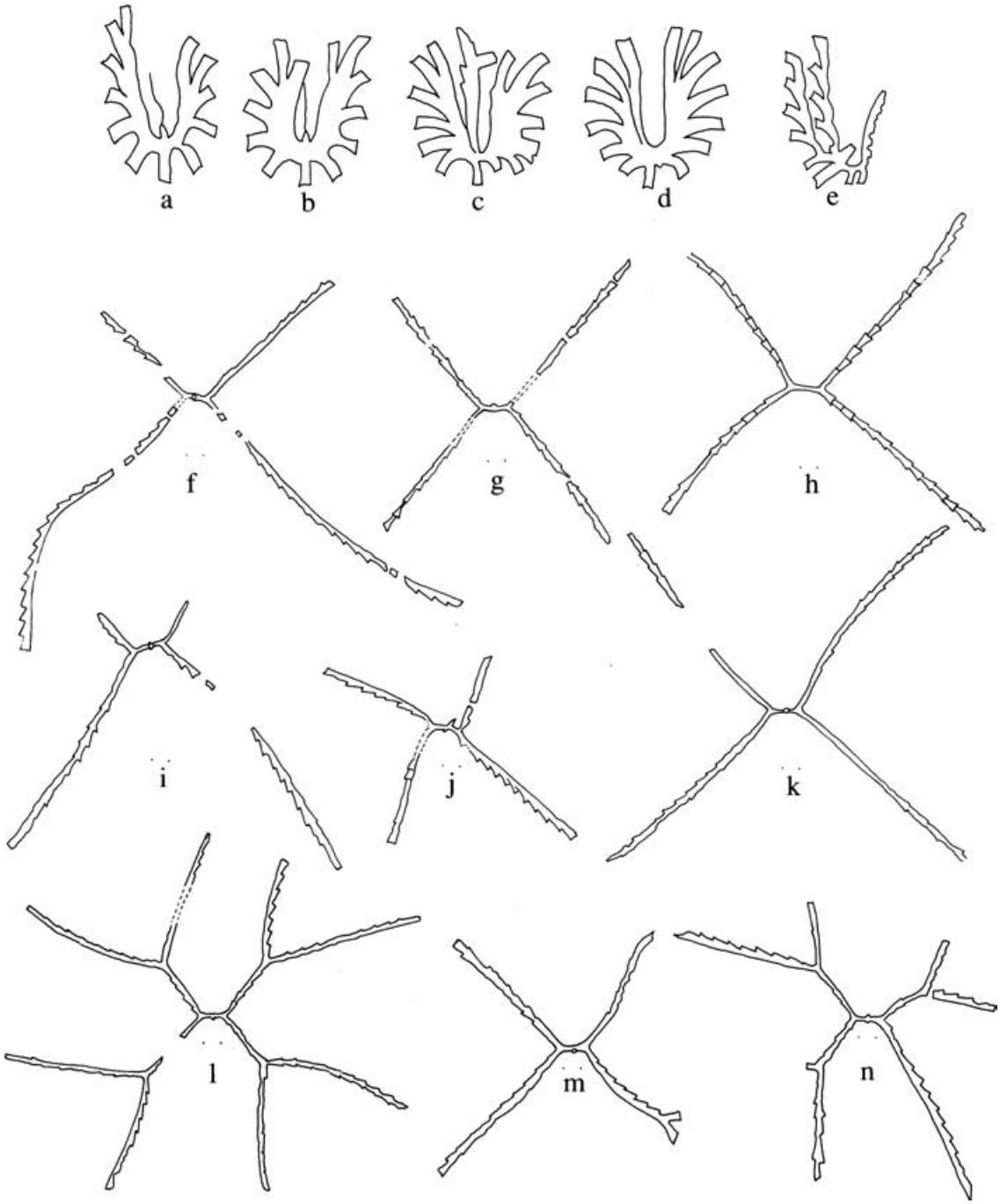

Figure 8. (a, b) *Psigraptus arcticus* Jackson. (a) GSC 21248 holotype; (b) GSC 21249 paratype from U-16 at ?1060 ft, Rock River, × 5. (c, d) *Psigraptus lenzi* Jackson. (c) GSC 21253 holotype, (d) GSC 21254 paratype from ZB-19,130F, Rock River, × 5; (e) *P.* cf. *P. lenzi* GSC 123194 from PR1-21 m, × 5. (f–k) *Kiaerograptus*? *bulmani* (Thomas), (f) GSC 123195, (g) GSC 123196, (h) GSC 123197 all from PR2-20 m, × 2.5. (i) GSC 123198, PR2-17 m, × 2.5; (j) GSC 123199, PR2-20 m, × 2.5; (k) GSC 123200, PR2-20 m, × 2.5. (l–n) *Kiaerograptus*? *kutchini* sp. nov. (l) GSC 123201 (holotype) from PR2-20 m; (m) GSC 123202; (n) GSC 123203, from PR2-17 m, × 2.5.

of the stipes is about 1.4 mm and interthecal widths vary from 0.4–0.8 mm. There are about 5 autothecae in 5 mm.

Remarks. Zhao & Zhang (1985) report this species from Unit 10 of the Yehli Formation in Hunjiang, Southern Jilin Province, China. In both Yukon and China it is associated with *P. arcticus.* At Jilin, these two species are underlain by *P. jacksoni* lending support to Rickards & Stait (1984) idea that some multiramose, dichotomously branching dendroid gave rise to *P. jacksoni* with 30 stipes or more and from it evolved *P. lenzi* with three or four stipes ending in *P. arcticus* with only two. This view is supported by the stratigraphical sequence in China.

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Psigraptus cf. *P. lenzi* Jackson
Figures 6q, 8e

cf. 1967 *Psigraptus lenzi* Jackson, pp. 319–21, text-fig. 1C, D.

Material and occurrence. Two flattened specimen GSC 117669 and GSC 123194 from the *Adelograptus* cf. *A. tenellus* Biozone at PR1-21 m, Upper Canyon, Peel River.

Description. Rhabdosome small, reclined, 10 mm wide, consisting of three terminal stipes that are 4–6 mm long. Sicula 1.5 mm long, erect with metasicula free for 0.4 mm. The funicle is hidden from view. Second-order branches have a profile width of 0.8 mm proximally and 0.4 mm distally and dorsal edges of stipes are concave. The first two autothecae on each stipe are isolate and strongly down-curved, distal thecae less so. Thecal apertures are concave and there are 5 in 5 mm.

Remarks. This form is compared to *P. lenzi* on account of it having three terminal branches but it differs from that species in having a narrower stipe width and being less reclined.

Genus *Araneograptus* Erdtmann & Vandenberg, 1985
Araneograptus cf. *A. macgillivrayi* (T. S. Hall, 1897)
Figure 9e, f

cf. 1897 *Dictyonema macgillivrayi* T. S. Hall, p. 15.
1974 *Dictyonema* cf. *macgillivrayi* T. S. Hall; Jackson, pp. 38–9, text-fig. 1K, L.

Material and occurrence. Four flattened specimens are available, all from the *K. pritchardi* Biozone in the Upper Canyon, Peel River, namely, three specimens from PR2-7 m, 9 m and 20 m; UA 1210 field no. PR1-61-7 at 280F; and one specimen from the same level on Rock River, field no. ZB-19 at 137F.

Description. Rhabdosome robust, conical proximally to horizontal distally, the largest fragment being 50 mm across with branching to the fifth-order. Branches are coated with cortical tissue that hides thecal details; dissepiments are also thickened proximally but are lacking cortical tissue distally. Branches are widely spaced at the rate of 2–3.5 in 10 mm whereas the dissepiments are spaced 6–7 mm apart proximally, increasing to 13–15 mm distally. These spacings produce a markedly rectangular fenestration.

Remarks. The fragmented nature of the Yukon material precludes a definite identification. In Yukon, this species has a similar stratigraphical range to *A. pulchellus*.

Araneograptus pulchellus (T. S. Hall, 1899)
Figure 9a–d

1899 *Dictyonema pulchellum* T. S. Hall, p. 174, pl. 18, figs 28–30.
1974 *Dictyonema* cf. *pulchellum* T. S. Hall; Jackson, p. 39, pl. 5, fig. 9.

Type specimen. Lectotype MUGD 1656 from Lancefield Quarry in the La 2 zone in Victoria, Australia.

Material and occurrence. Six flattened, mostly fragmented specimens from the Upper Canyon section on Peel River in the *K. pritchardi* Biozone at PR2-7 m, 14 m, 22 m and 30 m and the *P. kinnegraptoides* Biozone at PR2-52 m and PR3–3 m; UA 1230 (Jackson 1974, pl. 5, fig. 9) from the *K. pritchardi* Biozone in the Upper Canyon, field no. 68-PLR-1 at 56F; one specimen from the *P. kinnegraptoides* Biozone in the Lower Canyon, Peel River field no. 68-LPC-3 at F13; and one specimen from Rock River, field no. ZB-19 at 137F in the *K. pritchardi* Biozone.

Description. Rhabdosome conical, declined, the largest fragment being 105 mm long and 130 mm wide with regular branching to the eighth-order. A 2.5 mm long sicula gives rise to two declined first-order branches and subsequent dichotomies occur at regular intervals. Stipe spacing is 4–5 in 10 mm and dissepiments are about the same, resulting in square-shaped fenestration. Distal stipes have a profile width of 1.5 mm and thecae are spaced at 8–10 per cm. One juvenile specimen (Fig. 9b) from PR2-7 m shows that the proximal part of the colony is biradial and that the earliest dissepiments formed connections to fourth-order branches.

Remarks. Erdtmann & Vandenberg (1985) recognized that *Dictyonema macgillivrayi* and *D. pulchellus* have biradiate proximal ends and lack bithecae and thus removed them from that genus to their new genus *Araneograptus* which they regarded as a dissepiment-bearing clonograptid. To show this affinity, they include the genus in the Subfamily Clonograptinae (Erdtmann, 1982). Lindholm (1991) cast doubt on the biradiate nature of the colony but we have one specimen (Fig. 9b) that appears to confirm Erdtmann & Vandenberg's (1985) interpretation.

As in Victoria, the statigraphical ranges of *A. macgillivrayi* and *A. pulchellus* are about the same and both species appear alongside *K. pritchardi*. In the Yukon, the genus ranges at least as high as the *T. approximatus* Biozone.

Genus *Kiaerograptus* Spjeldnaes, 1963
Kiaerograptus? *bulmani* (Thomas, 1973)
Figures 8f–k; 9g, h, k

1971 *Tetragraptus otagoensis* (Benson & Keble); Erdtmann, pp. 259–60, pl. 33, figs 1–3.
1973 *Tetragraptus bulmani* sp. nov.; Thomas, pp. 530–1, pl. 2, figs b, c.
1979 *Tetragraptus bulmani* Thomas; Cooper & Stewart, p. 795, text-fig. 8.
1988 *Paradelograptus bulmani* (Thomas); Morris (G. W. Morris, unpub. Ph.D. thesis, Univ. Cambridge), pp. 72–5, pls 47–51.

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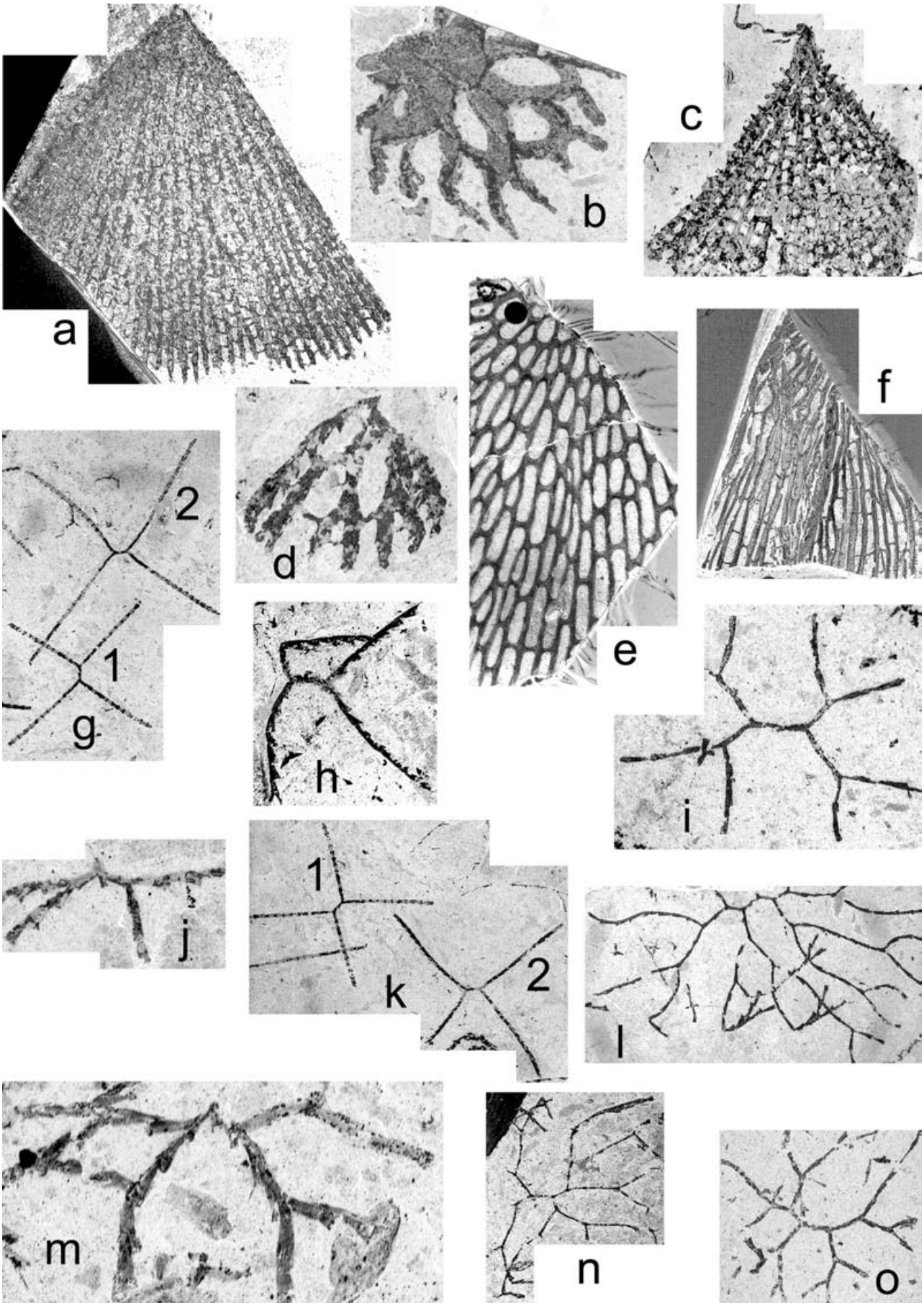

Figure 9. For legend see facing page.

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1991 *Tetragraptus longus* sp. nov.; Lindholm, pp. 308–10, text-figs 11A–D, 12.
1991 *Kiaerograptus bulmani* (Thomas); Williams & Stevens, pp. 17–19, pl.1, figs 8, 9; pl. 3, figs 5, 6, 8–14; text-fig. 9A–H.
1999*a* *Kiaerograptus*? *bulmani* (Thomas); Williams *et al.*, fig. 5a–d.

Type specimen. Holotype no. 64419 MDM from Lancefieldian (La 2) in Stauro Gully, Parish of Springfield, Victoria.

Material and occurrence. Twenty flattened specimens from the *antiquus* Biozone at PR1-68 m, ?72 m, and ?74 m and the middle part of the *K. pritchardi* Biozone at PR2-17 m, 20 m and 22 m and last appearing at PR2-74 m in the Upper Canyon, Peel River.

Description. Rhabdosome small, horizontal, consisting of four second-order terminal stipes. The funicle is 1.3–1.95 mm long, probably consisting of one theca on either side of the sicula. The longest unbranched second-order stipe is 19 mm so that the diameter of the colony may have been 40 mm. Terminal stipes widen from 0.3–0.4 mm to 0.5–0.7 mm in profile but more commonly the stipes are preserved dorso-ventrally and have a width of 0.5–0.7 mm. Thecae are simple straight tubes inclined at 20°, the free ventral wall can be slightly concave and the dorsal margin of one stipe has dorsal folds. Overlap is approximatly one-half and the thecal rate is 10–12 in 10 mm. No bithecae seen.

Remarks. Williams & Stevens (1991) removed the species from *Tetragraptus* to *Kiaerograptus* on account of their discovery of bithecae in isolated specimens from western Newfoundland. The Yukon material agrees well with the type material from Victoria except for the closer thecal spacing. However, the latter difference is diminished when one examines the illustrated specimens of *K. bulmani* from Stauro Gully in Cooper & Stewart (1979). They give a thecal rate of 8 in 10 mm but their figure 8k has a rate of 11 in 10 mm which agrees with our form. Williams *et al*. (1999*a*) repeated the view first expressed in 1996 that Lindholm's *Tetragraptus longus* is synonymous with *K*.? *bulmani*.

The species ranges from the *antiquus* Biozone upwards to the *kinnegraptoides* Biozone in Yukon Territory and occurs at about the same stratigraphical level in Newfoundland,Victoria and Bolivia.

Kiaerograptus? *kutchini* sp. nov.
Figures 8l–n; 10b, e–h

1969 *Clonograptus* sp.; Bulman & Cooper, fig. 5a, b.

Type specimen. GSC 123236 from PR2-20 m in the *pritchardi* Biozone, Upper Canyon section.

Name. Named for the native Indian tribe known as Gwich'in or Kutchin living in northern Yukon and northwest Northwest Territories.

Material and occurrence. Twelve flattened specimens from PR2-17 m, 20 m and 25 m in the *K. pritchardi* Biozone, Upper Canyon, Peel River.

Description. Rhabdosome horizontal, biradiate usually with three-orders of branching though one specimen has five orders of branching and attains a diameter of about 65 mm. The funicle is 1.5–1.8 mm long, second-order branches are 1.4–7.0 mm (commonly 4 mm), third-order stipes are up to 10 mm long and fourth-order are 6.5–12.5 mm long. Stipes have a profile width of 0.45–0.7 mm (commonly 0.6 mm) across thecal apertures and the free ventral walls are inclined at 15–20°. There are 10.5 to 13 thecae in 10 mm.

Remarks. *Kiaerograptus*? *kutchini* is associated with *K*? *bulmani* at PR2-17 m and differs from that species in the possession of third-order branching and slightly more closely spaced thecae. It should not be confused with *Paratemnograptus isolatus* Williams & Stevens (1991) having a 2.5–3.0 mm long funicle and stipes that are 1.4 mm wide. The species has a superficial resemblance to a form illustrated by Cooper (1979, fig. 24) that he called *Temnograptus* aff. *irregularis* which occurs in the *Adelograptus* Zone in New Zealand. Our species differs from that form in having stipes that are only half the width of that form. Another La 2 species that is similar is *Clonograptus kingi* (Benson & Keble, 1935) from Preservation Inlet, New Zealand. As far as we can tell from the inadequate figures of the holotype, it has much shorter third-order branches and much more closely spaced thecae. Our new species is considered conspecific with *Clonograptus* sp. Bulman & Cooper (1969, fig. 5a, b), also from Preservation Inlet.

Kiaerograptus? *peelensis* Jackson, 1974
Figure 11b, c

1974 *Kiaerograptus*? *peelensis* n. sp. Jackson, p. 50, pl. 5, fig. 6; text-fig. 1c, d.

Type specimen. UA 1214 is possibly from the *K. pritchardi* Biozone in the Upper Canyon, Peel River, field no. 68-PLR-1 at 1125 ft.

Figure 9. (a–d) *Araneograptus pulchellus* (T. S. Hall, 1899). (a) GSC 123214, PR2-30 m, × 1; (b) GSC 123215, PR2-30 m, × 5. Note biradial proximal end; (c) GSC 123216, PR2-30 m, × 1; (d) GSC 123217, PR2-30 m, × 5. (e, f) *Araneograptus* cf. *A. macgillivrayi* (T. S. Hall, 1897). (e) GSC 123218, ZB-19, 137F, × 0.5; (f) GSC 123219, PR2-52 m, × 0.5. (g, h, k) *Kiaerograptus*? *bulmani* (Thomas, 1973). (g1) GSC 123220, (g2) GSC 123221, PR2-20 m, × 1.5; (h) GSC 123222, PR2-12 m, × 2.5; (k1) GSC 123223, (k2) GSC 123224, PR2-20 m, all × 1.5. (i, j, l–o) *Adelograptus* cf. *A. tenellus* (Linnarsson, 1871). (i) GSC 123225, PR1-24 m, × 5; (j) GSC 123226, PR1-48 m, all × 5; (l) GSC 123227, PR1-56 m, × 2.5; (m) GSC 123228, PR1-68 m, × 10, (n) GSC 123229, PR1-27 m, × 2.5; (o) GSC 123230, PR1-24 m, × 2.5.

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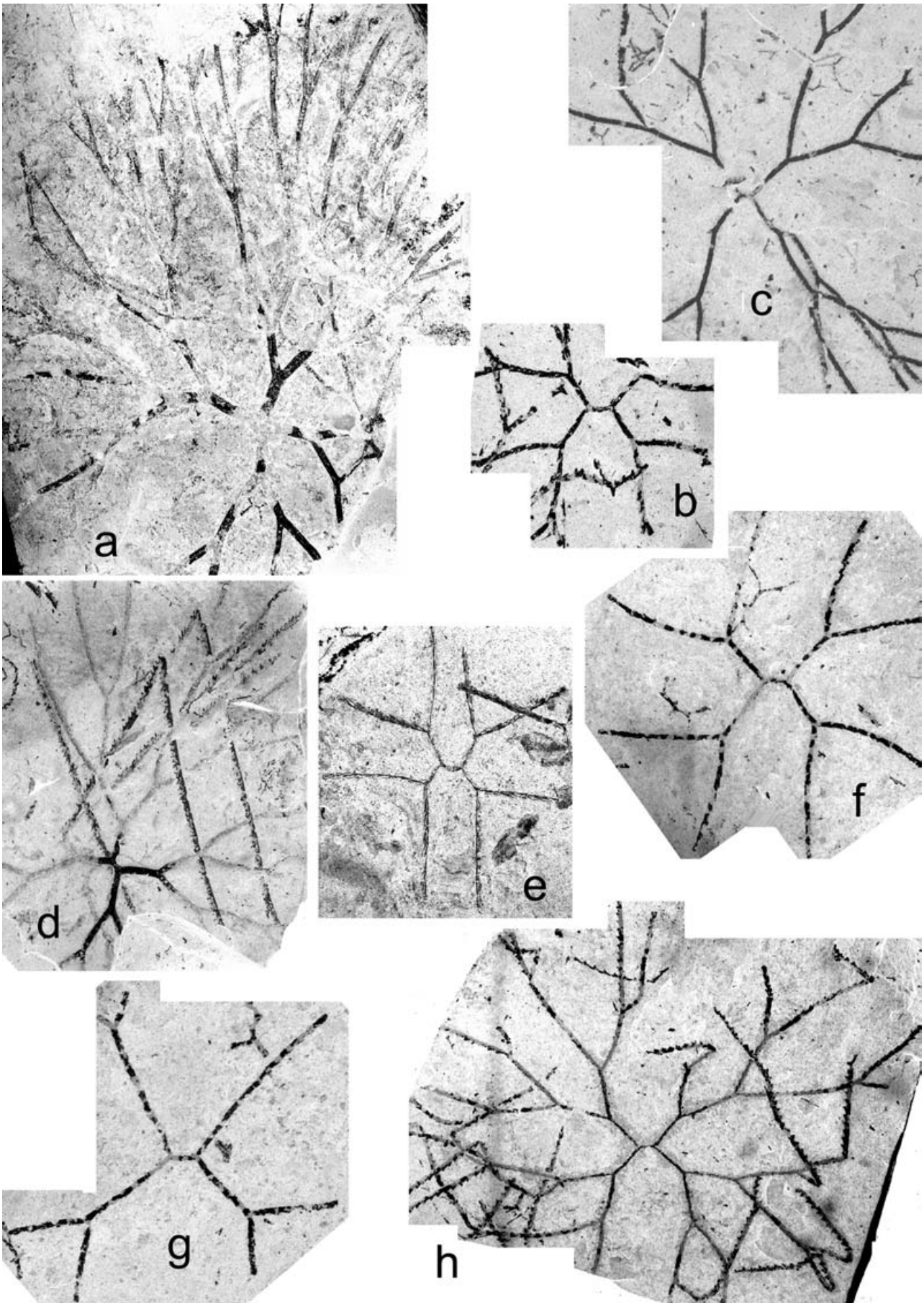

Figure 10. For legend see facing page.

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Material and occurrence. The twelve flattened specimens from the above locality is the only record of the species.

Description. Rhabdosome small, extensiform, with two unbranched primary stipes up to 7.5 mm long that diverge from the sicula at about 170°. The sicula is 2.5 mm long inclusive of rutellum, the aperture faces th1[2] and the nema in every specimen is invested with an elliptical vane or float sac up to 2.0–2.5 mm long and 0.6 mm wide. Thecae overlap about one-half; the free ventral wall is inclined initially at 30° increasing to 45° at the aperture, and spaced at the rate of 7 in 5 mm.

Remarks. This species was collected by British American Oil in 1968 and has not been found since. Jackson (1974) stated it occurred in the *Adelograptus antiquus* Subzone which we would now equate to the *K. pritchardi* Biozone. However, there is uncertainty about the source of this collection.

Kiaerograptus sp. A
Figure 11a

Material and occurrence. One pyritized specimen GSC 123206, Upper Canyon, Peel River, where it occurs in the *K. pritchardi* Biozone, field no. HS-32 at 2831 ft, that is, 9.15 m above the conglomerate that marks the top of measured section PR1 in Jackson & Lenz (2000, fig. 5).

Description. Rhabdosome probably horizontal, with five stipes produced by three orders of branching. The sicula is not visible; one first–order branch divides quickly producing two second-order stipes with five and seven autothecae respectively. The other first-order branch apparently does not divide until several thecae have formed.

The dorsal margins of the branches are undulatory. Bithecae and stolon system are believed to be present, autothecal tubes are straight, inclined at 30°, overlap two-thirds and there are 9–10 per cm. The profile width on one terminal stipe is 1.4 mm.

Remarks. This form bears some resemblance to *K. undulatus* Williams & Stevens (1991) from the *A. victoriae* Biozone in Western Newfoundland in having strong prothecal folds, bithecae and the same spacing of autothecae. The principal difference is that the Yukon form has a greater stipe width, although Williams & Stevens' species is less than half the size of the Yukon specimen and therefore may be immature.

Kiaerograptus? sp. indet.
Figure 11e

Material and occurrence. One flattened fragment GSC 123209 from Rock River, field no. ZB-19-137F from either the *pritchardi* or the *kinnegraptoides* Biozone.

Description. This 16 mm long fragment of stipe has a profile width of 1.5 mm with autothecae inclined initially at 10° near the dorsal edge of the stipe increasing to 40° at the thecal aperture. The autothecal apertures are 1.0 mm wide and slightly concave. Thecae overlap two-thirds. Conspicuous bithecae are present and apparently alternate between autothecae that are spaced at 9 in 10 mm.

Remarks. This taxon is associated with *Adelograptus antiquus* and a species of *Araneograptus* having an extremely coarse meshwork.

Family DICHOGRAPTIDAE Lapworth, 1873
Genus *Clonograptus* Nicholson, 1873
Clonograptus aureus Jackson, 1973
Figures 11d, i; 12e

1962 *Clonograptus* cf. *C. flexilis* (J. Hall); Jackson & Lenz, p. 37.
1973 *Clonograptus aureus* sp. nov. Jackson, pp. 707–11, text-figs 1A–C, 2A.
1974 *Clonograptus* sp. D; Jackson, pp. 49–50, text-fig. 3B.

Type specimen. GSC 27096 from the *K. pritchardi* Biozone in the Road River Group, Upper Canyon, Peel River.

Material and occurrence. In addition to the type series, there are ten flattened specimens available as well as numerous fragments from the *A. antiquus* Biozone to the *P. kinnegraptoides* Biozone in the Upper Canyon first occurring at PR1-68 m and last recorded at PR2-76 m.

Description. Rhabdosome horizontal, biradial, up to 66 mm diameter with branching to the sixth-order. The funicle is 1.6–2.8 mm long and is composed of thecae 1^1+ th 1^2. Second-order branches are 1.1–4.4 mm long, third-order branches 1.9–5.8 m long, fourth-order are 3.5–12.0 mm long and undivided fifth-order branches are up to 26 mm long. Terminal fifth-order stipes are commonly bent and twisted and reveal a profile width of 0.6–0.65 mm. The thecae are simple straight tubes inclined at 15–30° with slightly concave free ventral walls and spaced at 11–13 per cm. Bithecae were not seen on the branches, but specimen GSC 27098, which is considered to belong to this species, possesses a sicular bitheca (Jackson, 1973, text-fig. 2A).

Remarks. This species differs from *C. flexilis* in having stipes that are only 0.6 mm wide compared to 1.0–1.8 mm in *C. flexilis* and thecae spaced at 11–13 per cm compared to 9–9.5 in *C. flexilis*. *Clonograptus aureus* is very like some forms of

Figure 10. (a, c, d) *Clonograptus* cf. *C. multiplex* (Nicholson, 1868). (a) GSC 123231, PR2-52 m, × 0.5; (c) GSC 123232, PR2-20 m, × 1; (d) GSC 123233, PR2-74 m, × 0.5. (b, e–h) *Kiaerograptus*? *kutchini* sp. nov. (b) GSC 123234, PR2-14 m, × 2.5; (e) GSC 123235, PR2-30 m, × 2.5; (f) GSC 123201, PR2-20 m, × 2.5; (g) GSC 123236, PR2-20 m, × 2.5; (h) GSC 123237, PR2-20 m, × 1.5.

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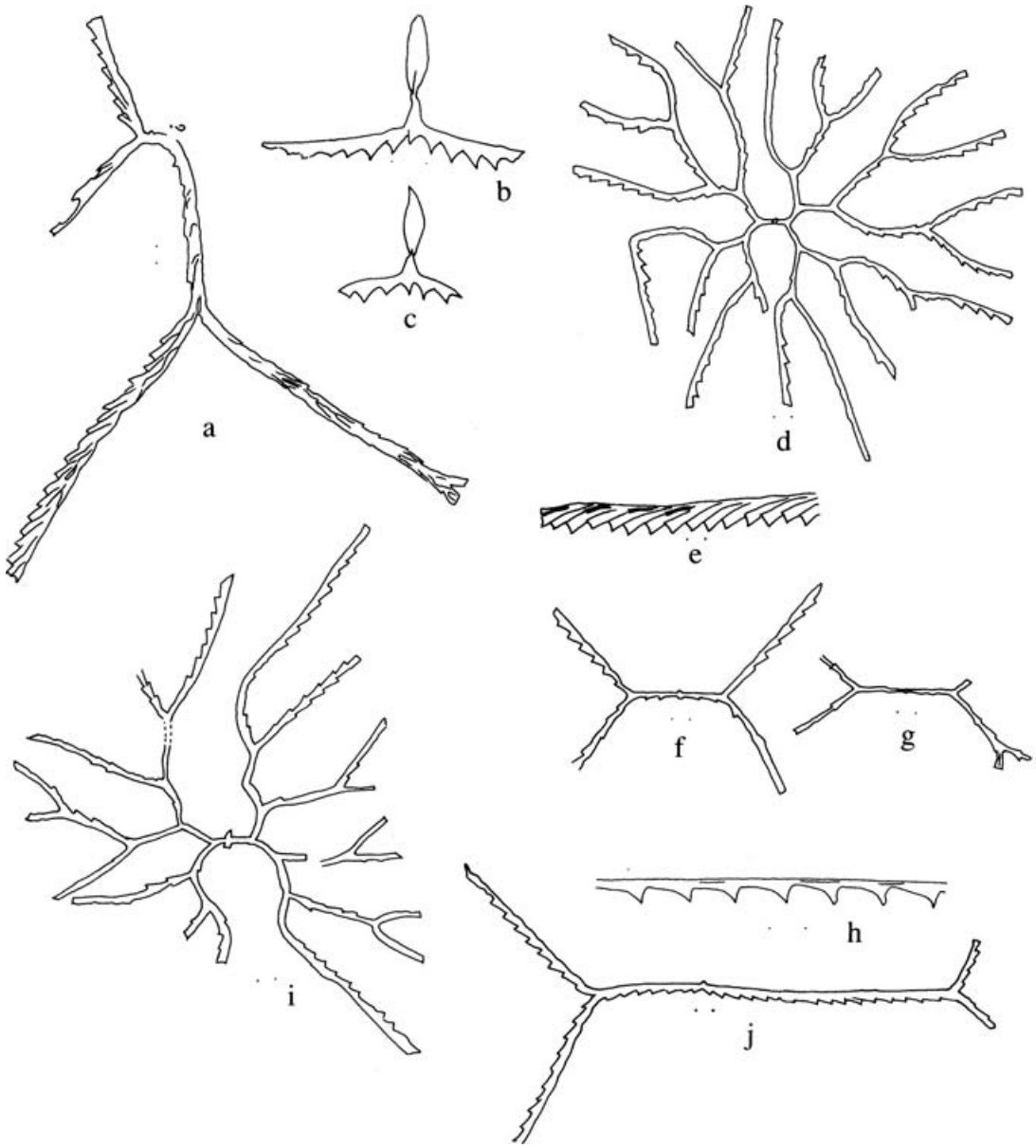

Figure 11. (a) *Kiaerograptus*? sp. A. GSC 123206, HS-32, 30 ft above Conglomerate Marker #2, × 2.5. (b, c) *Kiaerograptus*? *peelensis* Jackson. b, UA 1214; c, UA 1215 from 68-PLR-1 at F65, × 5; all from Upper Canyon, Peel River. (d, i) *Clonograptus*? *aureus* Jackson. (d) GSC 123204, PR2-14 m, × 2.5; (i) GSC 123208, HS-32 at 2910 ft, both from Upper Canyon, Peel River. × 2.5. (e) *Kiaerograptus* sp. indet. fragment, GSC 123209 from ZB-19 at 137F, Rock River; PR2-22m, × 2.5. (f, g) *Adelograptus* cf. *A. tenellus* (Linnarsson), GSC 123210, 123211 respectively, PR-1 at 68 m, × 2.5. (h) stipe of *Paradelograptus* aff. *P. kinnegraptoides* Erdtmann, Maletz & Gutiérrez-Marco, GSC 94791 from PR2-22 m, × 5. (j) *Hunnegraptus copiosus* Lindholm GSC 123213, PR-4 at 12 m, Lower Canyon, × 2.5.

C. flexilis illustrated by Morris (G. W. Morris, unpub. Ph.D. thesis, Univ. Cambridge, 1988) from the Upper Lancefieldian of Victoria, Australia. Morris believed that the material from Lancefield Quarry contained two groups on the basis of stipe width; *C. aureus* seems to belong to the group with a stipe width of 0.5–0.9 mm which comes from beds that equate with the *K. pritchardi* Biozone. A single specimen (Fig. 12j)

Figure 12. (a–c) *Clonograptus magnificus* Pritchard, 1892. (a) GSC 123238, ZB-19, 137F, × 1; (b) GSC 123239, PR2-22 m, × 0.5; (c) GSC 94790, PR3-3 m, × 1. (d, h) *Paradelograptus* aff. *P. kinnegraptoides* Erdtmann, Maletz & Gutiérrez-Marco, 1987. (d) GSC 94791, × 1; (h) GSC 94791, × 2.5, from PR2-22 m. (e) *Clonograptus aureus* Jackson, 1973, GSC 123204, PR2-14 m, × 1.5. (f) *Clonograptus* cf. *C. rigidus* (J. Hall, 1858), GSC 94792, PR2-52 m, × 1.5. (g, i, k) *Clonograptus* sp. (g) GSC 94793, PR2-76 m, × 1.5; (i) GSC 94795, PR3–27 m, × 1.5; (k) GSC 94797, PR2-33 m, × 1.5. (j) *Clonograptus* cf. *C. flexilis* (J. Hall, 1858) GSC 94796, PR2-45 m, × 1.5.

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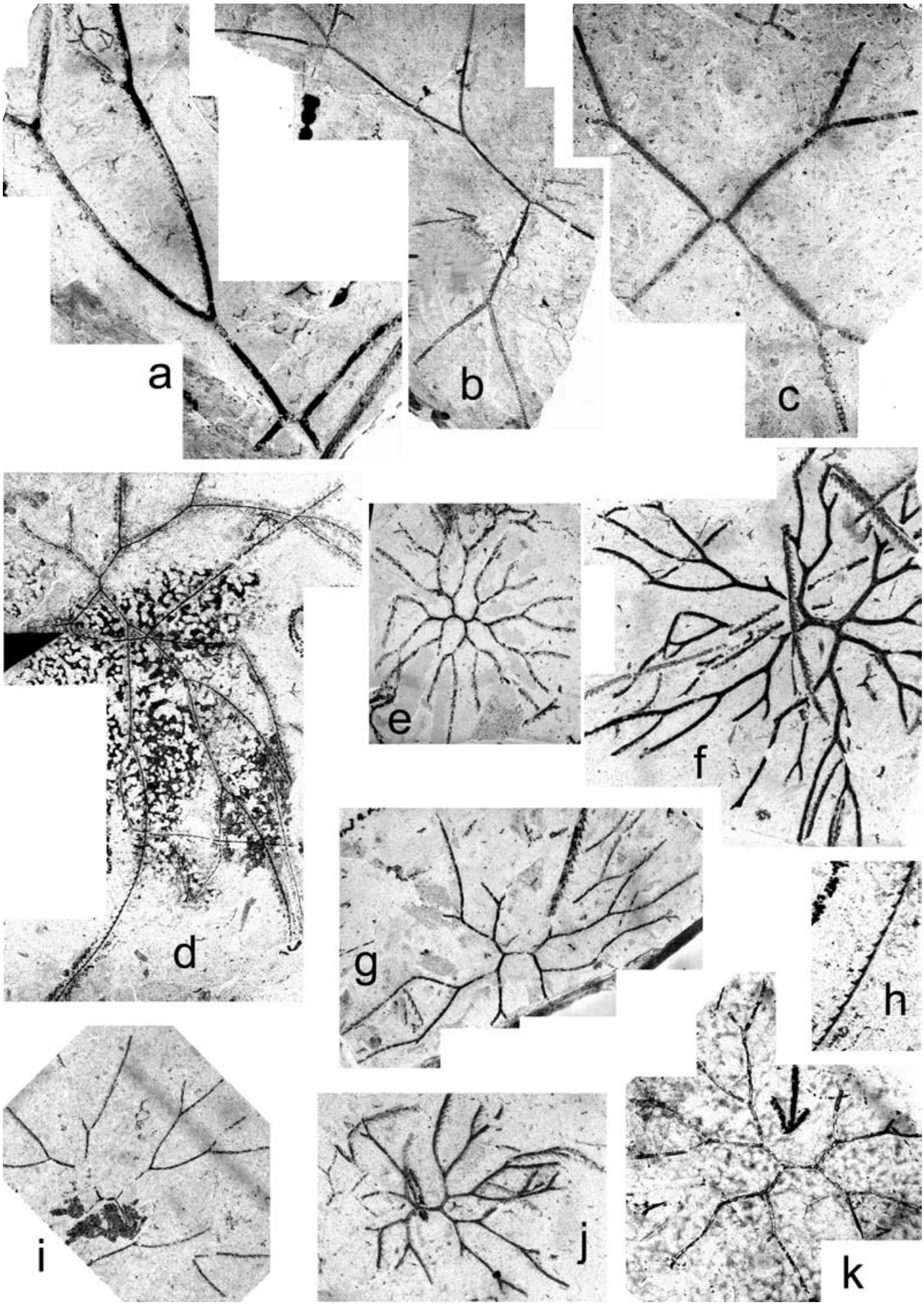

Figure 12. For legend see facing page.

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that is intermediate between *C. aureus* and *C. flexilis* occurs at PR2-45 m in the *P. kinnegraptoides* Biozone and has a stipe width of 1.0 mm with 10.5 thecae in 10 mm.

Clonograptus magnificus Pritchard, 1892
Figure 12a–c

1892 *Clonograptus magnificus* sp. nov. Pritchard, pp. 56–7, pl. 6, figs 1–3.
1974 *Clonograptus* sp. B; Jackson, p. 47, text-fig. 1M, N.
1988 *Temnograptus magnificus* (Pritchard); Morris (G. W. Morris, unpub. Ph.D. thesis, Univ. Cambridge), pp. 95–109, pls 17–42.
1991 *Clonograptus magnus* sp. nov.; Lindholm, pp. 307–8, text-fig. 10A, C, D.
1992 *Temnograptus magnificus* (Pritchard); Vandenberg & Cooper, p. 37, fig. 2B.

Type specimen. MUGD 1665 (by original designation) from Lancefield Quarry Locality PL1144 from beds of La 2 age, Lancefield, Victoria.

Material and occurrence. Several flattened specimens are available from the *antiquus* Biozone first occurring at PR1-68 m and last seen in the *P. kinnegraptoides* Biozone at PR3-3 m in the Upper Canyon; one from the *K. pritchardi* Biozone in the Lower Canyon, field no. 68-LPC-3 at F8; and two from Rock River field no. ZB-19 at 137F and probably from the *K. pritchardi* Biozone.

Description. Rhabdosome large, attaining at least a diameter of 150 mm, horizontal, rigid with branching to fourth-order. The funicle is 2.5–3.0 mm long, second-order branches are 17–40 mm long, third-order are 40–54 mm long. Stipes rarely present a profile view, but specimen GSC 123238 has a profile width of 1.9 mm. Thecal tubes have an apertural inclination of 45° and are spaced at 9–10 per cm. Sicula not seen in profile nor were bithecae seen.

Remarks. We follow Lindholm & Maletz (1989) who synonymized *Temnograptus* with *Clonograptus* on the basis that length of branches was an unsatisfactory basis for defining genera. They consider *C. magnificus* to be the largest species in *Clonograptus* (*sensu stricto*) and that it is closely related to *C. multiplex*. Although our form does not attain the diameter of the holotype, it agrees in the size of the funicle, stipe width, thecal spacing and profile shape. The lengths of second- and third-order branches tend to be shorter than the holotype but these overlap the measurements of topotypes given by Morris (G. W. Morris, unpub. Ph.D. thesis, Univ. Cambridge, 1988). The age of the Peel River specimens is the same as that in Victoria.

C. magnus Lindholm is a robust species of *Clonograptus* that Lindholm thought was distinct from *C. magnificus* on account of it having considerable cortical tissue in mature specimens. The work of Morris shows that *C. magnificus* does indeed have such tissue; it is similar in all other respects to *C. magnificus* and should be regarded as a junior synonym.

Clonograptus cf. *C. multiplex* (Nicholson, 1868)
Figure 10a, c, d

cf. 1868 *Dichograptus multiplex* n. sp.; Nicholson, pp. 129–30, pl.6, figs 1–3.

Material and occurrence. Four specimens are available, namely from the Upper Canyon, Peel River at PR-2 at 20 m in the *pritchardi* Biozone, 52 m, 56 m and 74 m in the *P. kinnegraptoides* Biozone and one from the Lower Canyon, Peel River, field no. 68-LPC-3 at 715 ft in the upper part of the *K. pritchardi* Biozone.

Description. Rhabdosome large, horizontal, rigid, biradial, probably exceeding 15 cm. diameter with branching to seventh-order. Funicle length is 2.5–3.0 mm and lengths of subsequent orders of branching are 7.5–25 mm, 10–30 mm, 16–52 mm, 20–64 mm and 30–51 mm respectively. Stipes can be seen in profile on broken or bent terminal stipes where they are 1.4–1.9 mm wide. More commonly, the preservation is a dorso-ventral view with the stipes having so much cortical tissue that they are 4–5 mm in width. Thecae are of dichograptid type, inclined at 15–20° near the common canal increasing to 35–40° at the thecal apertures and spaced at 8–9 per cm. In some specimens, the first four orders of branches are coated with thick cortical tissue.

Remarks. The holotype comes from the lowermost part of the Skiddaw Group at Peel Wyke at the north end of Bassenthwaite Lake, England. The source outcrop is believed to be the railway cutting to the east of the old railway station. These beds lie in the core of the Sale Fell Anticline and may represent the Hope Beck Slates of *D. deflexus* Zone age (Jackson, 1978).

The Yukon material agrees with the description given by Lindholm & Maletz (1989) for the thecal profile, thecal spacing and stipe width. Specimens from the same bed in the Peel River section seem to possess similar branch lengths and our few specimens fit within the variation given by Lindholm & Maletz who incidentally emphasized their great variability. Also one of our specimens shows a branching trichotomy noted by these workers. The occurrence of the Yukon material in the upper Tremadoc is older than in Sweden where it is known from the Lower Arenig *D. balticus* Zone. Maletz & Egenhoff (2001) suggest that *C. multiplex* may yet be shown to be a senior synonym of *C. magnificus*.

Clonograptus cf. *C. rigidus* (J. Hall, 1858)
Figure 12f

cf. 1858 *Graptolithus rigidus* n. sp. J. Hall, pp. 121–2.
cf. 1865 *Graptolithus rigidus*; J. Hall, pp. 105–6, pl. 11, figs 1–5

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Material and occurrences. Six flattened specimens from the *P. kinnegraptoides* Biozone at PR2-42 m, 45 m, 47 m, 52 m, 74 m and PR3-3 m in the Upper Canyon.

Description. Rhabdosome biradial, large, horizontal with seven orders of branching attaining a diameter of 500 mm. First-order branches make a funicle 3.5–4.2 mm long but the sicula is hidden. The second-order branches are 1.5–4.2 mm long and subsequent orders are 4.5–9.0 mm long. Proximally, the stipes are thickened by cortical tissue giving the stipes a width of 1.2 mm., and this thickness diminishes to about 0.5 mm in the terminal stipes. Associated with the whole colony are several broken stipes that lie in the same bedding plane. If these are part of the colony, the stipes have a profile width of 1.0 mm and a thecal rate of 12 in 10 mm.

Remarks. The type specimen of *C. rigidus* comes from the lowermost Arenig of Levis, however, Williams, Boyce & James (1987, p. 462) and Williams *et al.* (1999*a*, p. 4) recorded the species in the uppermost Tremadoc in the Cow Head Group, Newfoundland. These authors together with Lindholm & Maletz (1989) have discussed the possibility that *C. rigidus* and *C. flexilis* are conspecific but the matter remains unresolved. Comparing the Yukon specimens with the material described by Lindholm & Maletz, our form agrees in having a wide funicle, cortical thickening of proximal branches, several orders of branching of rigid appearance and a thecal rate which matches their newly collected specimens.

Genus *Hunnegraptus* Lindholm, 1991
Hunnegraptus copiosus Lindholm, 1991
Figure 11j

1991 *Hunnegraptus copiosus* sp. nov. Lindholm, pp. 299–302, text-fig. 8A–F,?18F, H, J.
?1999*a* *Hunnegraptus copiosus* Lindholm; Williams *et al.*, fig. 5e–g.

Type specimen. PMO 58.969 from the *H. copiosus* Zone at Galgeberg, Oslo.

Material and occurrence. Ten flattened specimens from PR4–12 m in the Lower Canyon where they occur in the lowermost *kinnegraptoides* Biozone; two flattened specimens from Rock River, field collection ZB-19 at 136F probably on the boundary between the *pritchardi* and the *kinnegraptoides* Biozones.

Description. Rhabdosome up to 30 mm across in largest specimen with branching to second-order and three or four terminal stipes. The sicula is approximately 1.2 mm long and inclined so that the aperture faces th1[2]. The first-order branches are horizontal to declined and have between 8 and 24 thecae. The shorter first-order branch is about 4 mm long and bears 4 thecae before it divides dichotomously giving rise to two very short second-order branches. The profile width of the first-order branches is 0.5–0.8 mm. The thecae are inclined at about 15°, overlap half and are spaced at 5–5.5 in 5 mm.

Remarks. Most of the Yukon specimens appear to be immature compared to the Norwegian material and the only difference is that the thecal rate of the Yukon specimens is marginally less. It is possible that the *Adelograptus* sp. of Jackson (1974, text-fig. 2J) belongs to this species.

Immature specimens of *Kiaerograptus pritchardi* figured by Williams & Stevens (1991) from the Cow Head Group of western Newfoundland were recently reassigned to the genus *Hunnegraptus* by Williams *et al*. (1999*a*,*b*). They also reported *H. copiosus* Lindholm in Bed 38 at Green Point, Bed 17 at Martin Point and Bed 32 at Cow Head. If these assignments are correct, these occurrences of *Hunnegraptus* sp. from the *Aorograptus victoriae* Biozone of Williams & Stevens (1991) are the oldest records known.

Family KINNEGRAPTIDAE Mu, 1974
Genus *Paradelograptus* Erdtmann, Maletz & Gutiérrez Marco, 1987
Paradelograptus aff. *P. kinnegraptoides* Erdtmann, Maletz & Gutiérrez Marco, 1987
Figure 12d, h

aff. 1987 *Paradelograptus kinnegraptoides* n. sp. Erdtmann, Maletz & Gutiérrez Marco, pp. 120–1, fig. 7A, B.
1988 *Paradelograptus* sp. B Morris (G. W. Morris, unpub. Ph.D. thesis, Univ. Cambridge), pl. 75a–h.

Material and occurrence. One whole specimen GSC 94791 from PR2-22 m and several fragmented specimens from PR2-20 m, 22 m, 28 m and 33 m, all in the *pritchardi* Biozone, and in the *kinnegraptoides* Biozone at 38 m, 42 m, 53 m and 74 m, Upper Canyon, Peel River. Another record of the species is from 68-LPC-3 (F17) at 795 ft in the Lower Canyon of Peel River.

Description. Rhabdosome horizontal, biradiate, having a radius of up to 95 mm, at least thirteen terminal stipes and branching to fifth-order. The funicle is 2.6 mm long, second-order branches 7.8–9.0 mm, third- and fourth-orders branches 16–24 mm and one unbranched fifth-order stipe is 65 mm in length. Terminal stipes are narrow and flexuous having a lateral width of 0.8–0.85 mm. The free ventral wall of each theca is inclined initially at 10° increasing to 40° at the flared thecal apertures; there are 6–7.5 thecae per cm. Bithecae were not seen.

Remarks. The species belongs to the genus *Paradelograptus*, on account of the kinnegraptid thecae, along with *'Clonograptus' smithi* Harris & Thomas, 1935, *'C.' rarus* Harris & Thomas, 1935, *'C.' ramulosus* Harris & Thomas, 1935, and *'C.' erdtmanni* Rickards & Chapman, 1991. These species range in ages from

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La 3 to Be 2. Comparisons with two of these species is not possible because the proximal end of *'C.' rarus* is unknown and the holotype of *'C.' smithi* is lost. Of the remaining, *'C.' ramulosus* has an unmistakably large funicle and *'C.' erdtmanni* seems to possess a declined funicle and more robust stipes. The form identified as *Paradelograptus smithi* by Erdtmann, Maletz & Gutiérrez Marco (1987, fig. 8) from Hunneberg bears no resemblance to the form being described. The narrow stipe width, the flared thecal apertures and the low thecal rate distinguish this species from *C*. cf. *C*. *multiplex and C*. *magnificus*. The nearest comparison is with *P*. *kinnegraptoides* that has similar slender, flexed stipes, the same thecal rate and branching to the fourth-order. The significant differences are that the first-order branches each consist of a single theca rather than three, and the thecae do not have pronounced apertural processes. The acquisition of better preserved specimens from the type area may eventually show that some of these differences can be attributed to poor preservation of the holotype.

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