Ordovician and Silurian Graptolite Succession in the Trail Creek Area, Central Idaho — A Graptolite Zone Reference Section

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By **CLAIRE CARTER** *and* **MICHAEL CHURKIN, JR.**

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By CLAIRE CARTER and MICHAEL CHURKIN, JR.

ABSTRACT

The graptolite-bearing sequence in the vicinity of Trail Creek, Idaho, consists of an unusually large number of zones virtually continuously exposed in a homoclinal section of siliceous shale. Eight Ordovician zones have been distinguished in the Phi Kappa Formation. These include the Early Ordovician Zones of *Didymograptus protobifidus* and *Isograptus*, the Middle Ordovician zones of *Glossograptus hincksii, Nemagraptus, Climacograptus bicornis,* and *Climacograptus tubuliferus,* and the Late Ordovician Zones of *Pleurograptus linearis* and *Dicellograptus ornatus*. The Early and Middle Silurian Zones of *Monograptus convolutus* and *Cyrtograptus* overlie this Ordovician succession. The relative completeness of the graptolite succession from late Early Ordovician through Late Ordovician becomes apparent when it is compared to other known graptolitic sequences of western North America. Thus it is a potentially useful reference section for at least the southern part of the North American Cordillera. The species *Leptograptus demissus* and the subspecies *Phyllograptus anna prolatus* are new. The species *Cyrtograptus kirki* Ruedemann is revised.

INTRODUCTION

Graptolites from western North America have been collected for over a century. Most of these collections have been from isolated outcrops of argillaceous rocks and chert within the Cordilleran geosyncline, particularly in the Basin and Range province, where the graptolitic rocks are assigned to the "western" or eugeosynclinal facies (Ross, 1961; Churkin, 1974). Until 30 years ago only graptolite lists accompanied reconnaissance geologic reports of the region. In his monograph of graptolites of North America, Ruedemann (1947) first illustrated many of these Cordilleran faunas and described some new species from the Phi Kappa Formation of Idaho. A summary of the older collections, together with systematic descriptions and illustrations of Ordovician graptolites in the Basin and Range province, was published by Ross and Berry (1963). This report provides useful documentation of what had been identified over the years and also provides, in many cases for the first time, systematic descriptions of Cordilleran graptolites. From a biostratigraphic viewpoint, however, most of the graptolite faunas described prior to 1963 were not fitted into a local stratigraphic succession of graptolite faunas. Ross and Berry (1963) had to use the graptolite succession of the Marathon region, Texas (Berry, 1960), as a standard to compare and correlate the isolated graptolite faunas of the Basin and Range province "because *** no readily zonable succession has yet been found in the Great Basin" (Ross and Berry, 1963, p. 68).

Later, in the vicinity of Trail Creek, Custer and Blaine Counties, central Idaho (fig. 1), an unusually continuous stratigraphic section of graptolitic shale was discovered (Churkin, 1963), and a preliminary correlation of the Idaho graptolite succession was made with the British graptolite zones of Elles and Wood (1901-18). At about the same time, a number of incomplete graptolite successions were discovered in Nevada (Kay and Crawford, 1964; Roberts, 1964; Gilluly and Gates, 1965; Churkin and Kay, 1967; Riva, 1970; Carter, 1972). These incomplete faunal successions from widely separated localities, when pieced together, form a composite succession of graptolite zones that closely resembles the continuously exposed Trail Creek, Idaho, succession, and individual faunas can be readily correlated with it (Churkin, 1974).

In the Cordillera to the north of Idaho, graptolite successions similar to that at Trail Creek have been described from British Columbia (Larson and Jackson, 1966; Jackson and others, 1965), the Yukon Territory (Jackson and Lenz, 1962; Lenz and Perry, 1972), and Alaska (Churkin and Brabb, 1965; Churkin and others, 1971). The graptolite succession of the Road River Formation in Yukon Territory and Alaska is more nearly complete than that at Trail Creek because it extends with only a few paleontological breaks from the Early Ordovician through the Silurian and into the Early Devonian. However, the succession of graptolite zones in the Road River Formation has been established on the basis of

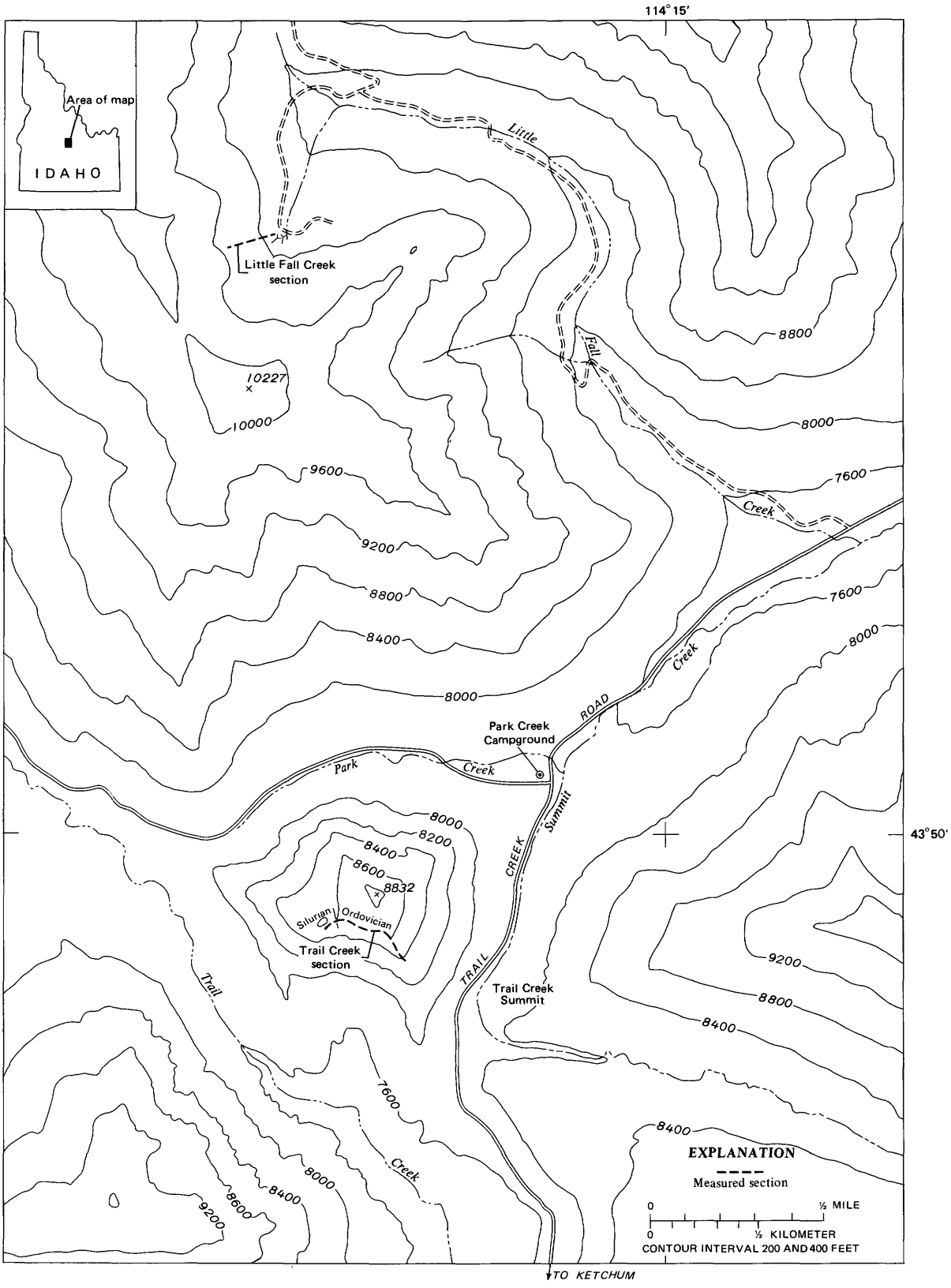

FIGURE 1.—Location of measured sections in the vicinity of Trail Creek, central Idaho. Base from U. S. Geological Survey, Rock Roll Canyon and Phi Kappa Mountain 7½′ quadrangles.

several separate sections rather than from one continuously exposed homoclinal section as in the Phi Kappa Formation.

When the stratigraphic continuity of the Idaho graptolitic succession is compared to the best known Ordovician graptolitic successions not only in the Cordillera but elsewhere in North America—for example, the Marathon region, Texas (Berry, 1960); Appalachian Mountains (Ruedemann, 1947; Riva, 1972); and the Canadian Arctic Islands (Trettin, 1971)—the relative incompleteness of individual stratigraphic sections in these other areas becomes apparent. The Marathon succession, which has been repeatedly cited as the standard for correlation of North American Ordovician graptolite zones, is, in fact, a composite section of several structurally complicated sections separated by large covered areas (King, 1937; Berry, 1960). Furthermore, the Marathon section has at least two important stratigraphic breaks within the Ordovician, each marked by coarse conglomerate (King, 1937, p. 30, 32, 36; P. B. King, 1974, oral commun.), which may help explain missing graptolite zones and some of the controversy regarding the correlation of its faunas (Kay, 1962, p. 1426; Riva, 1972, 1974b). Graptolite provincialism, particularly in the Ordovician, has now become well known, and it is necessary to establish a set of graptolite zones that typify each major geologic province.

A search of the world literature and discussions with graptolite specialists working in other regions (A. M. Obut, T. N. Koren, and R. F. Sobolevskaya in the U.S.S.R.; Peter Toghill in the British Isles; G. H. Packham in Australia; R. A. Cooper in New Zealand; Bedrich Bouček in Czechoslovakia; Hermann Jaeger in Germany and elsewhere) have corroborated the fact that the Trail Creek section has an unusually continuous sequence of Ordovician graptolite faunas. Another important feature is that it appears to have only a small covered interval on top of the *Dicellograptus ornatus* Zone that may conceal the Ordovician-Silurian boundary. This boundary is visible in only a few places in western North America (Churkin and others, 1971). When these facts are considered, together with its accessibility, the upper Lower through Upper Ordovician part of the Phi Kappa Formation appears to be a potentially useful reference section for at least the southern part of the North American Cordillera.

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GEOLOGIC SETTING

The graptolite succession in the vicinity of Trail Creek, Idaho, described in this paper occurs in the Phi Kappa and Trail Creek Formations (Umpleby and others, 1930), a part of the shale and chert belt extending along the axis of the Cordilleran fold belt from southern California and Nevada to Alaska (Churkin, 1974, fig. 1). The shale and chert belt, which in places contains pillow basalts, originally separated the carbonate and quartzite belt (miogeosyncline) from the volcanic and graywacke belt (outer part of eugeosyncline). At many localities, however, the predominantly argillaceous rocks of this central belt have been thrust eastward onto the carbonate and quartzite belt.

At Trail Creek the shale and chert belt attains a width of 3–8 km (2–5 mi) along the crest of the Pioneer Mountains, which separate the Wood River and Big Lost River drainages northeast of Ketchum, Idaho (Umpleby and others, 1930; Dover, 1969, pl. 1, fig. 32).

LITHOLOGY AND STRUCTURE

The area of the Phi Kappa Formation is complicated by thrust faults and some granitic intrusions, as shown by Umpleby, Westgate, and Ross (1930, p. 64–66, pl. 1) and by Dover (1969, fig. 32, pl. 1). The stratigraphic succession within some of the thrust plates is relatively undeformed.

East of Trail Creek gorge the Phi Kappa Formation forms much of the upper plate of the Park Creek thrust and consists of about 200 m (650 ft) of black shale that in its lower half has thin interbeds of gray quartzite (fig. 2). The base of the Phi Kappa lying above the Park Creek thrust is marked by a massive quartzite that has several thin interbeds of shale very rich in graptolites. The Phi Kappa appears to be thicker in the lower plate of the Park Creek thrust than in the upper plate and has conspicuous quartzite that is characterized by distinctive banding.

The argillaceous parts of the Phi Kappa consist of dark-gray to black shale, slate, and argillite. Many of these beds have yielded Ordovician graptolites. Much of the shale is silty, and some thin discrete beds of cherty shale alternate rhythmically with partings of more fissile shale, particularly in the upper part of the section. The Phi Kappa contains almost no limestone, except for several thin and slabby beds of dark-gray fine-grained limestone.

Small folds in about a 6-m (20-ft) interval in the upper part of the section that includes localities 69ICt 42 and 69ICt 41 (fig. 2) suggest minor displace-

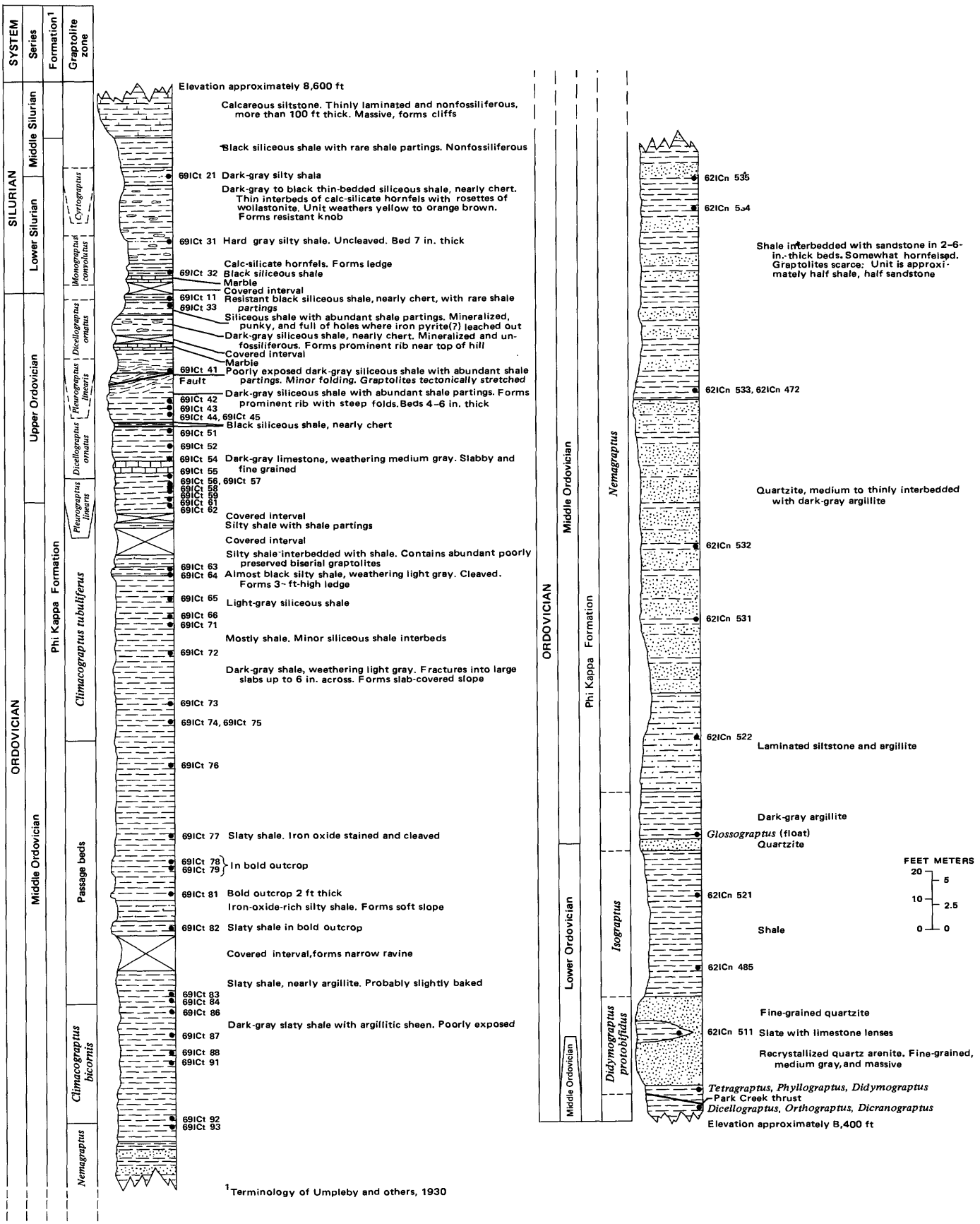

FIGURE 2.—Stratigraphic column of the upper plate of the Park Creek thrust in the Trail Creek section, showing zonal sequence and location of graptolite collections. See figure 1 for location.

ment along a bedding plane fault. The marble lying approximately 3 m (10 ft) above 69ICt 41 may thus be a structural repetition of the same limestone lying directly above locality 69ICt 55. This fault would also help explain the presence of *Pleurograptus linearis* Zone graptolites in locality 69ICt 41, structurally above the Zone of *Dicellograptus ornatus*.

Overlying the Ordovician part of the Phi Kappa Formation is a section about 16 m (50 ft) thick of dark-gray shale that includes several thin beds of calc-silicate marble. These beds have yielded Silurian graptolites and were elsewhere assigned to the Trail Creek Formation (Umpleby and others, 1930). This 16-m thick shale is included in the Phi Kappa Formation (J. H. Dover and R. J. Ross, Jr., oral commun.). The contact between Ordovician and Silurian parts of the Phi Kappa Formation is concealed in a small saddle on the west side of the peak (elevation 8832 ft) separating Summit Creek from Park Creek (fig. 1). Discontinuous outcrops in the saddle (fig. 2, locality 69ICt 32) have yielded early but not earliest Silurian graptolites. There is no evidence of a stratigraphic break, but folding in the uppermost Ordovician beds suggests faulting along the contact with the Silurian part of the Phi Kappa. Also, the presence of wollastonite-bearing calc-silicate hornfels and marble in the lower part of the Silurian beds indicates that thermal metamorphism may have locally obscured any earliest Silurian graptolite faunas. This metamorphism is probably related to emplacement of a quartz monzonite pluton or associated dikes centered along Summit Creek. At the contact with these intrusive rocks, the Phi Kappa is a flinty argillite commonly spotted with incipient growth of porphyroblasts.

The uppermost unit within the measured section is marked by a massive cliff-forming unit of medium-gray thinly laminated nonfossiliferous siltstone. This siltstone, unlike the quartzitic rocks lower in the section, is readily distinguished in the field by its calcareous cement and in thin section by its high proportion (15–20 percent) of angular feldspar grains. The base of this siltstone, at least within our measured section, is a logical place to draw the upper contact of the Phi Kappa Formation.

Locally, especially in the Upper Ordovician part of the Phi Kappa Formation, the beds are fairly strongly cleaved and folded. A microscopic lineation in these beds has developed where bedding is intersected by cleavage. Graptolites in these beds are tectonically deformed, and thus rhabdosomes lying parallel to the lineation on the average are thinner than those lying at right angles to the lineation. Thecal counts are lowest for specimens of a particular species lying parallel to the lineation and greatest for those lying at right angles to the lineation. Rhabdosomes making angles between 0° and 90° with the lineation have intermediate thecal counts. Tectonic deformation of the graptolites, where recognized, has been taken into account in their descriptions.

The Phi Kappa Formation in a section only 200-m (650 ft) thick appears to represent an unbroken succession of sedimentation ranging from late Early Ordovician through latest Ordovician. Similarly thin graptolite shale successions occur in other parts of the Cordillera as well as in other mobile belts. The condensed nature of the graptolitic shales and their lithologic similarity to modern deep-sea siliceous sediments suggest that they are pelagic sediments deposited mainly below the carbonate-compensation depth (Churkin, 1974).

GRAPTOLITE ZONES AND THEIR CORRELATION

Ten named graptolite zones have been recognized in the Trail Creek section (figs. 1, 2). These zones have been established on the basis of diagnostic assemblages of graptolite species as they occur in the Trail Creek section; we have not merely applied the zonal schemes worked out elsewhere. The reader probably will recognize the names of some of our zones (*Climacograptus bicornis, Dicellograptus ornatus*) as being the same as those of nearly equivalent zones in other sections and provinces. This was done where the zones were nearly equivalent and the appropriate name-giver was present at Trail Creek. The Trail Creek zones with unfamiliar names did not contain the name-giver of any corresponding "equivalent" zone.

A description of each zone and its correlation with some of the better known graptolite successions of the Pacific faunal province, as well as with the British sequence, follows in ascending order (see also fig. 3). The correlations in figure 3 were made by directly comparing the faunal assemblages from Trail Creek with the faunal assemblages listed by other authors. There was no consideration of how each author correlated his own section with the others. Therefore there are differences in correlation between the scheme in figure 3 and the correlation schemes of other authors.

LOWER ORDOVICIAN SERIES

Zone of Didymograptus protobifidus.—This zone contains the oldest fauna in the Trial Creek section (figs. 1, 2). It is characterized by several species of *Tetragraptus,* abundant *Phyllograptus anna, P. ilic-*

SYSTEM	Series	European stage	Great Britain Elles and Wood, 1901–18; Bulman, 1970; Toghill, 1970	Trail Creek, Idaho	Western Canada Jackson and Lenz, 1962 Jackson, 1964	Marathon region, Texas Berry, 1960	Australia Thomas, 1960	Northeastern U.S.S.R. Obut and Sobolevskaya, 1973	Australian stege
SILURIAN	Middle	Wenlockian	*Cyrtograptus ellesae*	?					Eildonian
			Cyrtograptus linnarsoni						
			Cyrtograptus rigidus						
			Monograptus riccartonensis	*Cyrtograptus*					
			Cyrtograptus murchisoni		*Cyrtograptus* cf. *C. murchisoni*				
			Cyrtograptus centrifugus						
	Lower	Llandoverian	*Monoclimacis crenulata*		*Monograptus spiralis*				?
			Monoclimacis griestoniensis	?					
			Monograptus crispus						
			Monograptus turriculatus		? *Monograptus turriculatus*				Keilorian
			Rastrites maximus		*Monograptus sedgwickii* and *Monograptus convolutus*				
			Monograptus sedgwickii						
			Monograptus convolutus	*Monograptus convolutus*					
			Monograptus gregarius		*Monograptus millepeda*				
			Monograptus cyphus to *Glyptograptus persculptus*		*Monograptus cyphus* and *Diplograptus modestus*				

FIGURE 3.—Correlation of graptolite sequences in western North America, Great Britain, Australia, and the U.S.S.R. The correlations on this chart were made by directly comparing individual faunal assemblages from Trail Creek with the faunal assemblages listed by the respective authors.

ifolius, P. ilicifolius major, Didymograptus protobifidus, and *D. extensus. Isograptus* is rare, as are the multibranched *Goniograptus* and *Loganograptus* (table 1).

This zone is only represented by one collection from a 7-ft (2.1-m) thick bed that was not searched so meticulously as the rest of the section. Thus, it is possible that two or more distinguishable horizons are lumped together in this collection.

The association of *Tetragraptus amii, T. quadri-*

SYSTEM	Series	European stage	Great Britain (Elles and Wood, 1901–18; Bulman, 1970; Toghill, 1970)	Trail Creek, Idaho	Western Canada (Jackson and Lenz, 1962; Jackson, 1964)	Marathon region, Texas (Berry, 1960)	Australia (Thomas, 1960)	Northeastern U.S.S.R. (Obut and Sobolevskaya, 1973)	Australian stage
ORDOVICIAN	Upper	Ashgillian	*Dicellograptus anceps*	*Dicellograptus ornatus*	*Dicellograptus ornatus*	*Dicellograptus ornatus*		*Dicellograptus ornatus* and *Climacograptus supernus*	Bolindian
			Dicellograptus complanatus						
	Middle	Caradocian	*Pleurograptus linearis*	*Pleurograptus linearis*	*Orthograptus quadrimucronatus*	*Orthograptus quadrimucronatus*		*Orthograptus quadrimucronatus*	
			Dicranograptus clingani	*Climacograptus tubuliferus*	*Dicranograptus clingani*			*Diplograptus ingens wellingtonensis* and *Dicranograptus clingani*	Eastonian
						Orthograptus amplexicaulis			
				Passage beds					
			Diplograptus multidens	*Climacograptus bicornis*				*Climacograptus peltifer*	Gisbornian
			Nemagraptus gracilis	*Nemagraptus*	*Nemagraptus gracilis*	*Climacograptus bicornis* and *Nemagraptus gracilis*		*Nemagraptus gracilis*	
		Llandeilian	*Glyptograptus teretiusculus*	*Glossograptus hincksii*	*Glyptograptus euglyphus*	*Glyptograptus* cf. *G. teretiusculus*	D4	*Glyptograptus teretiusculus*	Darriwilian
		Llanvirnian	*Didymograptus murchisoni*		*Cardiograptus crawfordi* *Cryptograptus schaferi* *Tylograptus geniculiformis flexilis*	*Paraglossograptus tentaculatus*	D3	*Paraglossograptus tentaculatus* and *Cardiograptus crawfordi*	
			Didymograptus bifidus				D2		
	Lower	Arenigian	*Didymograptus hirundo*		*Isograptus caduceus*		D1	*Cardiograptus morsus*	
					Pseudotrigonograptus ensiformis	*Isograptus caduceus*	Ya 2		Yapeenian
				Isograptus			Ya 1		
			Didymograptus extensus / *Isograptus gibberulus*		*Skiagraptus gnomonicus* *Isograptus caduceus* var.		Ca 3		Castlemanian
							Ca 2		
			Didymograptus nitidus	*Didymograptus protobifidus*	*Didymograptus protobifidus*	*Didymograptus bifidus*	Ca 1		
							Ch 2		Chewtonian
						Didymograptus protobifidus	Ch 1		
			Didymograptus deflexus		*Didymograptus extensus*	*Tetragraptus fruticosus* 3 to 4 branched	Be 4		Bendigonian
							Be 3		
						Tetragraptus fruticosus 4 branched	Be 2		
							Be 1		

FIGURE 3.—Continued.

TABLE 1.—*Distribution and zonal ranges of Ordovician graptolite genera and species in the lower part of the Phi Kappa Formation, Trail Creek section*

[×, present, in unknown abundance; r, rare; f, frequent; c, common; a, abundant]

Series	Lower Ordovician			Middle Ordovician												
Zone	*Didymograptus protobifidus*	*Isograptus*		*Nemagraptus*								*Climacograptus bicornis*				
Collection No.	62ICn 511	62ICn 485	62ICn 521	62ICn 522	62ICn 531	62ICn 532	62ICn 533	62ICn 472	62ICn 534	62ICn 535	69ICt 93	69ICt 92	69ICt 91	69ICt 88	69ICt 87	69ICt 86, 85
Goniograptus geometricus Ruedemann	r															
Loganograptus logani pertenuis Ruedemann	r															
Tetragraptus amii Elles and Wood	r															
T. pseudobigsbyi Skevington	f															
T. quadribrachiatus (Hall)	f															
Phyllograptus anna Hall	a															
P. anna ? Hall		r														
P. anna prolatus n. subsp	f															
P. ilicifolius Hall	f															
P. ilicifolius major Ruedemann	c															
Didymograptus extensus (Hall)	f	a														
D. gracilis Törnquist	r															
D. cf. *D. gemminus* (Hisinger)	r															
D. protobifidus Elles	a															
D. sp (pendent)	f	f														
D. sp (horizontal)			×													
Isograptus aff. *I. caduceus caduceus* (Salter)			×													
I. cf. *I. caduceus imitatus* Harris	r															
I. aff. *I. victoriae* Harris	r															
I. cf. *I. victoriae lunatus* (Harris)	r	r														
I. aff. *I. victoriae lunatus* (Harris)		c														
I victoriae maximodivergens (Harris)		r														
I. sp			×													
Corynoides calicularis Nicholson														f		
Nemagraptus cf *N. gracilis remotus* Elles and Wood				×												
N. sp						×		r		×	r					
Dicranograptus cf. *D. brevicaulis* Elles and Wood				×												
D. contortus Ruedemann											f	r	a	r		
D. cf. *D. kirki* Ruedemann																r
D nicholsoni nicholsoni Hopkinson												f	c	a	r	
D cf *D nicholsoni nicholsoni* Hopkinson																r
D. cf *D spinifer* Elles and Wood											f					
Dicellograptus divaricatus bicurvatus Ruedemann											c	c		r		
D sextans exilis Elles and Wood				×							a					
D sp						×	×									
Glossograptus hincksii hincksii (Hopkinson)												r	r	r		
Cryptograptus tricornis (Carruthers)											f	r	f	c	a	r
C sp						×										
Diplograptus sp																r
Amplexograptus perexcavatus (Lapworth)														r		
A sp												r				
Climacograptus bicornis bicornis (J. Hall)											r	r	f	r		f
C bicornis tridentatus Lapworth														r		
C brevis Elles and Wood											r					
C cf *riddellensis* Harris																f
C sp				×		×	×	r								
Glyptograptus cf *G. euglyphus euglyphus* (Lapworth)												f				f
G cf *G euglyphus pygmaeus* (Ruedemann)								r			r					
G tamariscinus (Hisinger)								c	×							
G sp																c
G sp				×												
Orthograptus amplexicaulis (Hall)														r		r
O aff. *O calcaratus calcaratus* (Lapworth)											r					r
O calcaratus acutus Elles and Wood								r								
O calcaratus cf. subsp *acutus* Elles and Wood												c	f	c	c	
O pageanus pageanus Elles and Wood																f
O cf. *O whitfieldi* (Hall)																r
Pseudoclimacograptus cf *P. modestus* (Ruedemann)				×	a											
P scharenbergi scharenbergi (Lapworth)													r		c	
P. sp																
Pasiograptus harknessi (Nicholson)											f			r		
P. ? sp						×										
Retiograptus geinitzianus Hall				×												
R sp							×									

brachiatus, Didymograptus extensus, D. gracilis, D. protobifidus and *Phyllograptus anna* suggests correlation with the Arenigian Zone of *Didymograptus extensus* in Great Britain (Elles and Wood, 1901–18).

The presence of *T. amii, T. quadribrachiatus, Phyllograptus ilicifolius, P. anna, D. extensus, D. protobifidus* and *Isograptus* cf. *I. victoriae lunatus* also indicates correlation with the Early Ordovician

Zones of *Didymograptus protobifidus* and *Didymograptus bifidus* of Texas (Berry, 1960).

Zone of Isograptus.—This interval is poorly represented in the Trail Creek and Little Fall Creek sections (tables 1, 2). It is distinguished mainly by the presence of isograptids that occur at higher horizons than the *D. protobifidus* Zone in other areas (Australia, Texas). The fauna of this zone is sparse and includes abundant *Didymograptus extensus* and rare, small phyllograptids.

About 50 ft (15.2 m) of shale in the Trail Creek section is assigned to this zone (collections 62ICn 485 and 62ICn 521 in table 1; fig. 2). Two collections (69ICn 491 and 62ICn 492) from a 125-ft (38.1-m) shale interval in the Little Fall Creek section (table 2; fig. 4) are also believed to belong to this zone.

This interval is difficult to correlate with sequences elsewhere because of the unusual association of *D. extensus*, *T. amii*, *Isograptus victoriae maximodivergens*, *Isograptus caduceus imitatus*, *Pseudisograptus dumosus*, and *Maeandrograptus tau*. If only the isograptid species are considered, the zone can be correlated with the upper Castlemanian to lower Yapeenian horizons of Australia (Thomas, 1960).

TABLE 2.—*Distribution and zonal ranges of Ordovician graptolite genera and species in the Phi Kappa Formation, Little Fall Creek section*

[×, present in unknown abundance; r, rare; f, frequent; c, common; a, abundant; questioned where identification uncertain]

Series	Lower Ordovician		Middle Ordovician			
Zone	*Isograptus*		*Glossograptus hincksii*			*Nemagraptus*
Collection No.	62ICn 491	62ICn 492	62ICn 493	62ICn 494	62ICn 495	62ICn 496
Tetragraptus amii Elles and Wood	r					
T. aff. *T. quadribrachiatus* (Hall)	r					
T. sp (reclined)	r					
Phyllograptus anna prolatus n. subsp	r	×				
Didymograptus extensus (Hall)	c					
D. sp	f		r ?			
Cardiograptus (?) sp		×				
Isograptus caduceus imitatus Harris	f					
I. victoriae maximodivergens (Harris)	r					
I. sp						r
Pseudisograptus dumosus (Harris)	f					
P. sp aff. *P. dumosus* (Harris)		×				
Maeandrograptus tau Harris	r					
Nemagraptus sp					×	f
Leptograptus (?) sp						r
Dicranograptus cf. *D. brevicaulis* Elles and Wood						r
Dicellograptus sextans sextans (Hall)						r
D. sextans exilis Elles and Wood						c
Glossograptus hincksii hincksii (Hopkinson)			c	f	×	r
G. hincksii fimbriatus (Hopkinson)						r
Cryptograptus tricornis (Carruthers)			r	f	×	f
Diplograptus sp						r
Climacograptus sp			f		×	a
Glyptograptus euglyphus (Lapworth)						f
G. sp			r ?	r		
Reteograptus geinitzianus Hall						r

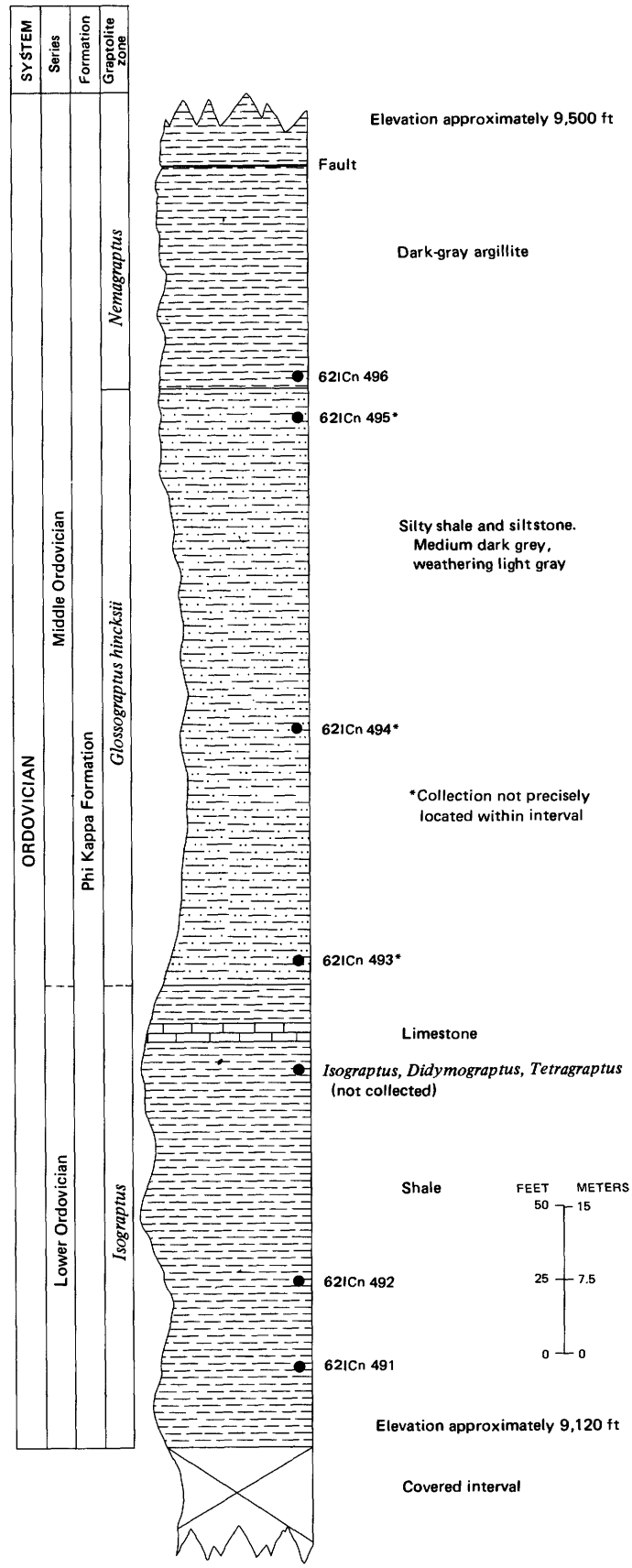

FIGURE 4.—Stratigraphic column of the Little Fall Creek section, showing zonal sequence and location of graptolite collections. See figure 1 for location.

MIDDLE ORDOVICIAN SERIES

Zone of Glossograptus hincksii.—This zone is characterized by a very sparse fauna of biserial scandent genera and marks the first appearance of the long-ranging species *Glossograptus hincksii* and *Cryptograptus tricornis*. It also marks the first appearance of *Climacograptus* and *Glyptograptus* (table 2).

The zone is represented by three collections (62ICn 493, 62ICn 494, and 62ICn 495) from 200 ft (61 m) of siltstone in the Little Fall Creek section (fig. 4). The *Isograptus* Zone occurs stratigraphically below this interval, and the *Nemagraptus* Zone above it.

The Trail Creek section (fig. 2) contains about 50 ft (15.2 m) of nearly barren siltstone and silty shale between the Zones of *Isograptus* and *Nemagraptus*.

Because the sparse fauna of this zone consists only of *Glossograptus hincksii, Cryptograptus tricornis, Climacograptus* sp., and *Glyptograptus* sp., correlation with other sequences is difficult. It seems to be about the same age as the *Glyptograptus teretiusculus* Zone of Great Britain and the upper part of the Darriwilian of Australia.

Zone of Nemagraptus.—The fauna of this zone is more varied and abundant than that of the preceding zone. It is characterized by *Nemagraptus* and the first appearance of *Dicranograptus* and *Dicellograptus* in association with biserial scandent genera (tables 1, 2).

At least 220 ft (67 m) of interbedded quartzite and argillite in the Trail Creek section is assigned to this zone (collections 62ICn 552, 62ICn 531-535, 62ICn 472, and 69ICt 93 (table 1; fig. 2)). One collection (62ICn 496) from the Little Fall Creek section is also assigned to this zone (fig. 4).

The association of *Nemagraptus, Dicellograptus sextans exilis, Cryptograptus tricornis, Climacograptus bicornis, Glyptograptus teretiusculus, Orthograptus calcaratus acutus,* and *Reteograptus geinitzianus* (table 1, 2) indicates correlation with the Zone of *Nemagraptus gracilis* in Great Britain (Elles and Wood, 1901-18), the Zone of *N. gracilis* in the northern Yukon, Canada (Jackson and Lenz, 1962), and the Zone of *N. gracilis* in Texas (Berry, 1960).

Zone of Climacograptus bicornis.—This zone marks the last appearance of *Cryptograptus tricornis* and *Glossograptus hincksii* in the Trail Creek section (fig. 1). *Dicranograptus contortus* and *Dicranograptus nicholsoni* are common, as is *Orthograptus calcaratus* cf. subsp. *acutus*. *C. bicornis bicornis* and *C. bicornis tridentatus* are present in small numbers, and there are scattered occurrences of *Dicellograptus* throughout the zone (table 1). About 40 ft (12.2 m) of slaty shale with six collections in the Trail Creek section is included in this zone.

TABLE 3.—*Distribution and zonal ranges of Ordovician graptolite genera and species in the upper part of the Phi Kappa Formation, Trail Creek section*

[×, present in unknown abundance; r, rare; f, frequent; c, common; a, abundant; queries indicate uncertain identification]

Series	Middle Ordovician																		Upper Ordovician														
Zone	Passage beds								Climacograptus tubuliferus										Pleurograptus linearis					Dicellograptus ornatus								Pleurograptus linearis	
Collection No.	69ICt 84	69ICt 83	69ICt 82	69ICt 81	69ICt 79	69ICt 78	69ICt 77	69ICt 76	69ICt 75	69ICt 74	69ICt 73	69ICt 72	69ICt 71	69ICt 66	69ICt 65	69ICt 64	69ICt 63	69ICt 62	69ICt 61	69ICt 59	69ICt 58	69ICt 57	69ICt 56	69ICt 55	69ICt 54	69ICt 52	69ICt 51	69ICt 45	69ICt 44	69ICt 43	69ICt 42	69ICt 41	69ICt 33
Leptograptus demissus n. sp																			c	c	a	r	r?									r	
L. cf. *L. flaccidus arcuatus* Elles and Wood																					r												
L. n. sp ?													f																				
L. sp			c																														
Pleurograptus linearis linearis (Carruthers)																				c													
Dicranograptus cf. *D. kirki* Ruedemann		r																															
Dicellograptus alector Carter									c	c	a		c						r														
D. cf. *D. alector* Carter														×																			
D. cf. *D. angulatus* Elles and Wood															r?	f?	f																
D. cf. *D. elegans elegans* (Carruthers)					r																												
D. cf. *D. elegans rigens* Elles and Wood										r																							
D. cf. *D. elegans* or *D. moffatensis*																								r			r						
D. ornatus ornatus Elles and Wood																															f		f
D. ornatus (without spines)																														c	f		
D. cf. *D. ornatus minor* Toghill																				r	r			f	c			c	f	r			
D. n. sp ?							c	f																									

D. sp	?											f																					
Climacograptus bicornis bicornis (J. Hall)	c	f																															
C. cf. *bicornis tridentatus* Lapworth	r	...	...	...																													
C. caudatus Lapworth									c	c	f	r																					
C. hastatus T. S. Hall																								r?	f			r	r		c		f
C. innotatus subsp indet									r	r																							
C. longispinus hvalross Ross and Berry																								c				a	c	c	r		f?
C. aff. *C. manitoulinensis* Caley																				r	r	c	f										
C. cf. *C. mohawkensis* (Ruedemann)											c							r		r	c	r	c										
C. pacificus pacificus Ruedemann																														r	a		a
C. pacificus pilosus Riva																															r		
C. cf. *C. raricaudatus* Ross and Berry			f																														
C. tubuliferus Lapworth										r	c	c	c	?	f	c	f	r	f	r	r	c	f										
C. cf. *tubuliferus* Lapworth							r																										
C. uncinatus Keble and Harris																			r	c	f	r	r									c	
C. n. sp ? (very tapered)	r	f																															
C. sp A																									f?	f	r	c	c	f?	f		f
C. n. sp ? (aff. *C. latus*)																															f		
C. sp			f	×	a			c	c	c		c	f	×	r	r				r				f	r					f			
Glyptograptus altus Ross and Berry																											r						
G. cf. *G. euglyphus* (Lapworth)				×	f	c																											
G. tamariscus (Nicholson)																															f		r
G. cf. *G. teretiusculus occidentalis* Ruedemann																								r									
G. sp							r																		r				r				
Orthograptus amplexicaulis abbreviatus (Elles and Wood)																								a		c	c						
O. amplexicaulis cf. subsp *abbreviatus*																		c	f			r	a							r	c	r	r
O. amplexicaulis (Hall)		c	c			a			r				a		r		a	f	a	f													
O. cf. *O. amplexicaulis* (Hall)							r							×																			
O. amplexicaulis pauperatus (Elles and Wood)															a																		
O. amplexicaulis rarithecatus (Ross and Berry)																												c					
O. amplexicaulis cf. subsp *socialis* (Lapworth)																			a		r												
O. amplexicaulis strigosus (Ross and Berry)					f																												
O. aff. *O. amplexicaulis* (Hall)																																	r
O. calcaratus acutus Elles and Wood		c					r											f															
O. cf. *O. calcaratus acutus* Elles and Wood												r					f																
O. calcaratus basilicus Elles and Wood																			a														
O. calcaratus?																												r					
O. calcaratus grandis Ross and Berry																													r				
O. calcaratus cf. subsp *tenuicornis* Elles and Wood																				f													
O. quadrimucronatus quadrimucronatus (J. Hall)		f	c												r																		
O. cf. *O. quadrimucronatus quadrimucronatus* (J. Hall)	r													×										r									
O. quadrimucronatus inequispinosus (Ruedemann)						r		r																									
O. sp (spined)					r	r																											
O. sp	r				r		r	r		r																							
Pseudoclimacograptus cf. *P. scharenbergi scharenbergi* (Lapworth)									c																								
Hallograptus (?) sp				×																													
Neurograptus margaritatus (Lapworth)	r																																
Arachniograptus laqueus Ross and Berry																								r					r		r		
A. (?) sp																		r	r														
Orthoretiolites hami hami Whittington												c	r																				
O. hami robustus Skevington											r	c																					
O. (?) sp														×	r																		
Reteograptus cf. *R. pulcherrimus* Keble and Harris											r				f		r																

The presence of *Corynoides calicularis, Cryptograptus tricornis, Glossograptus hincksii, Dicranograptus nicholsoni nicholsoni, Climacograptus bicornis bicornis, C. bicornis tridentatus, Pseudoclimacograptus scharenbergi scharenbergi, Glyptograptus* cf. *G. euglyphus euglyphus,* and *Lasiograptus harknessi* suggests a correlation with the British Caradocian Zone of *Diplograptus multidens.* The *D. multidens* Zone differs from the underlying *N. gracilis* Zone in having *D. nicholsoni* and abundant *Corynoides,* as well as *D. multidens* (Riva, 1972). The association of *Corynoides, Cryptograptus tricornis, G. hincksii, D. nicholsoni, C. bicornis, Amplexograptus perexcavatus,* and *G.* cf. *G. euglyphus euglyphus* indicates a correlation with the Gisbornian stage of Australia (Thomas, 1960).

Passage beds.—This interval has yielded eight collections from 90 ft (27.4 m) of shale (fig. 2) but with only scattered occurrences of any one species (table 3). The fauna consists mainly of a few dicellograptids, the last of the dicranograptids, and a few new species of *Orthograptus* (particularly the spined species). *Orthograptus amplexicaulis* is present in some horizons, but it does not occur throughout the interval and is not restricted to this interval.

Zone of Climacograptus tubuliferus.—This zone is characterized by the presence of *Dicellograptus alector, Climacograptus caudatus,* and *C. tubuliferus. Orthograptus amplexicaulis* is abundant in certain horizons, and *Orthoretiolites* is restricted to this zone (table 3). It is represented by ten collections from 82 ft (25 m) of shale in the Trail Creek section (fig. 2).

The association of *Climacograptus caudatus, C. tubuliferus, Orthograptus amplexicaulis,* and *O. amplexicaulis pauperatus* allows only a tentative correlation with the British Zone of *Dicranograptus clingani* (Elles and Wood, 1901–18) because the *C. tubuliferus* Zone lacks dicranograptids. Both the *Orthograptus quadrimucronatus* Zone and the *O. amplexicaulis* Zone of the Marathon, Tex., succession (Berry, 1960) contain species found in the *C. tubuliferus* Zone at Trail Creek. Common species include *C. caudatus, C. tubuliferus, O. quadrimucronatus quadrimucronatus,* and *Reteograptus pulcherrimus* for the *O. quadrimucronatus* Zone, and *C. caudatus, P. scharenbergi, O. amplexicaulis,* and *R. pulcherrimus* for the *O. amplexicaulis* Zone. The presence of *C. caudatus, C. tubuliferus, O. amplexicaulis, O. amplexicaulis pauperatus, O. calcaratus acutus,* and *O. quadrimucronatus* suggests a correlation with the upper Eastonian of Australia (Thomas, 1960).

UPPER ORDOVICIAN SERIES

Zone of Pleurograptus linearis.—Only 8 ft (2.4 m) of siliceous shale is included in this very distinctive zone (fig. 2). Its characteristic species include *Leptograptus demissus* n.sp., *Climacograptus* cf. *C. mohawkensis, Climacograptus tubuliferus,* and *Climacograptus uncinatus. C. uncinatus* is an excellent indicator of this zone. *P. linearis* occurs in only one horizon in the middle of the zone (table 3).

The association of *P. linearis, Climacograptus tubuliferus, Leptograptus* cf. *L. flaccidus arcuatus,* and *Orthograptus amplexicaulis* cf. subsp. *socialis* suggests correlation with the *P. linearis* Zone of the Hartfell Shales in Great Britain (Elles and Wood, 1901–18; Toghill, 1970). In the Marathon, Tex., succession, the *Orthograptus quadrimucronatus* Zone contains the following species in common with the Trail Creek *P. linearis* Zone: *C. minimus, C. tubuliferus, Orthograptus* cf. *O. calcaratus basilicus,* and *Leptograptus* (Berry, 1960). The Trail Creek zone can be correlated with the lower and middle Bolindian Stage of Australia (Thomas, 1960) on the basis of the presence of *P. linearis, C. uncinatus, Orthograptus amplexicaulis, O. amplexicaulis abbreviatus,* and *O. calcaratus basilicus. O. quadrimucronatus,* a species common to this interval in Great Britain, Texas, Australia, and the northern Yukon, is not present in the *P. linearis* Zone at Trail Creek. Here it is restricted to the underlying *C. tubuliferus* Zone and the passage beds.

Zone of Dicellograptus ornatus.—The characteristic species of this zone are *Dicellograptus* cf. *D. ornatus minor, Climacograptus longispinus hvalross, C. hastatus,* and in the upper part of the zone, *C. pacificus pacificus* and *D. ornatus ornatus. Orthograptus amplexicaulis abbreviatus* and *O. a.* cf. subsp. *abbreviatus* occur in the lower part and the upper part of the zone, respectively (table 3). It is difficult to determine the true thickness of this zone because a *P. linearis* Zone fauna was either infolded or faulted into the middle of it (table 3; fig. 2).

This zone can be correlated with the *Dicellograptus anceps* Zone of the Hartfell Shales in Great Britain (Toghill, 1970) because of the presence in both of *D. ornatus, O. amplexicaulis abbreviatus,* and local subspecies of *Climacograptus longispinus.* The presence of *D. ornatus* and *O. amplexicaulis abbreviatus* indicates correlation with the *D. ornatus* Zone in the northern Yukon, Canada (Jackson and Lenz, 1962), the *D. ornatus* Zone in Texas (Berry, 1960), and the Bolindian of Australia (Thomas, 1960).

SILURIAN SYSTEM

Zone of Monograptus convolutus.—Most of the lower Llandoverian is missing in the Trail Creek section, and the middle Llandoverian monograptids occur directly above the Upper Ordovician *D. ornatus* Zone. These include *Monograptus convolutus, Monograptus lobiferus, Monograptus sedgwickii,* and *M.* cf. *Monograptus decipiens decipiens. Climacograptus* cf. *C. scalaris* is also present (table 4). This zone is represented by two collections (69ICt 32 and 69ICt 31) from a 12-ft (3.7-m) interval of siliceous shale (fig. 2).

The association of *M. convolutus, M. lobiferus, M. sedgwickii, M.* cf. *M. decipiens, Monograptus* cf. *M. argutus argutus, Monograptus* cf. *M. leptotheca,* and *Petalograptus minor* suggests a correlation with the British Llandoverian Zone of *M. convolutus* (Elles and Wood, 1901–18) and the Zone of *M. sedgwickii* and *M. convolutus* in the northern Yukon (Jackson and Lenz, 1962).

Zone of Cyrtograptus.—This zone, containing the youngest fauna in the section (collection 69ICt 21), includes such upper Llandoverian and lower Wenlockian species as *Cyrtograptus laqueus* and *Cyrtograptus* cf. *C. grayae,* and the middle Wenlockian species *Cyrtograptus rigidus rigidus* and *Monograptus* cf. *M. flemingii flemingii* (table 4). In the northern Yukon, cyrtograptids occur mainly in the *Cyrtograptus* cf. *C. murchisoni* zone, (Jackson and Lenz, 1962) although the range of *C. laqueus* extends down into the *M. spiralis* Zone (Jackson and Etherington, 1969). In Australia, *Cyrtograptus* indicates an Eildonian age, as does *M. flemingii.*

TABLE 4.—*Distribution and zonal ranges of Silurian graptolite genera and species in the Phi Kappa Formation, Trail Creek section*

[r, rare; f, frequent; a, abundant]

Series	Lower Silurian		Middle Silurian
Zone	*Monograptus convolutus*		*Cyrtograptus*
Collection No.	69ICt 32	69ICt 31	69ICt 21
Climacograptus cf. *C. scalaris* (Hisinger)	f	f	
C. sp	f		
Glyptograptus cf. *G. tamariscus* (Nicholson)	r		
Petalograptus minor Elles		f	
Monograptus cf. *M. argutus argutus* Lapworth		r	
M. convolutus (Hisinger)		a	
M. cf. *M. decipiens decipiens* Törnquist	f	f	
M. cf. *M. flemingii flemingii* (Salter)			a
M. cf. *M. leptotheca* Lapworth		f	
M. lobiferus (McCoy)		f	
M. sedgwickii (Portlock)	f		
M. sp	f		
Monoclimacis aff. *M. griestoniensis* (Nicol)			f
Cyrtograptus cf. *C. grayae* Lapworth			f
C. kirki Ruedemann			r
C. laqueus Jackson and Etherington			r
C. rigidus rigidus Tullberg			f

SYSTEMATIC DESCRIPTIONS[1]

Class GRAPTOLITHINA
Order GRAPTOLOIDEA
Suborder DIDYMOGRAPTINA
Family DICHOGRAPTIDAE
Genus Loganograptus Hall, 1868
Loganograptus logani pertenuis Ruedemann
Plate 1, figure 1

Loganograptus logani mut. *pertenuis* Ruedemann, 1904, New York State Mus. Mem. 7, p. 633, pl. 9, fig. 5.

Loganograptus logani mut. *pertenuis* Ruedemann, 1947, Geol. Soc. America Mem. 19, p. 287, pl. 45, fig. 14 (not figs. 15, 16).

Loganograptus logani mut. *pertenuis* Ruedemann. Berry, 1960, Texas Univ. Pub. 6005, p. 50, pl. 12, fig. 5.

Loganograptus logani (Hall). Churkin, 1963, Am. Assoc. Petroleum Geologists Bull., v. 47, p. 1617, pl. 1, fig. 18.

Diagnosis: According to Berry (1960, p. 50) this subspecies is like the typical form of *L. logani* except that it is much thinner (0.2–0.3 mm wide) and has thecae that are more closely spaced (10–12 thecae per centimeter).

Discussion: This subspecies greatly resembles *Brachiograptus etaformis* Harris and Keble but can be distinguished from it by the presence of fourth order branches, which do not occur in *Brachiograptus.*

Figured specimen: USNM 189095.

Occurrence: Zone of *Didymograptus protobifidus* (Phi Kappa Formation, collection 62ICn 511), Trail Creek, Idaho. Zone of *Paraglossograptus tentaculatus (Hallograptus etheridgei)* (Fort Peña Formation) in the Marathon region, west Texas (Berry, 1960). Deepkill Shale in New York (Ruedemann, 1947). Lower member of Valder Formation, HD Range, Nevada (Riva, 1970).

Genus Goniograptus M'Coy, 1876
Goniograptus geometricus Ruedemann
Plate 6, figure 5

Goniograptus geometricus Ruedemann, 1904, N.Y.

[1] Bulman's (1970) terminology and classification have been used in the following descriptions.

State Mus. Mem. 7, p. 627-630, text-figs. 43-45, pl. 7, figs. 5, 10-20.

Goniograptus geometricus Ruedemann, 1947, Geol. Soc. America Mem. 19, p. 296-297, pl. 48, figs. 16-21.

Diagnosis: According to Ruedemann (1947, p. 297), the sicula is long and narrow, averaging 3.5 mm in length, and the first two thecae grow from it near its apex. These two thecae are about 2 mm long, as are the next four thecae, which form the four second-order branches diverging at angles of 120°-150°. The four zigzagging main stipes bear branches at nearly right angles to their general direction of growth. The thecae are tubular and narrow, three times as long as wide, and number eight per centimeter.

Discussion: This species resembles *Goniograptus perflexilis* Ruedemann but differs from it by the shorter length of its sicula and thecae and the more compact arrangement of its branches. *G. perflexilis* has a sicula 4 mm long and six to seven thecae per centimeter.

Figured specimen: USNM 189114.

Occurrence: Zone of *Didymograptus protobifidus* (Phi Kappa Formation, collection 62ICn 511), Trail Creek, Idaho. *Didymograptus bifidus* Zone, Deepkill Shale, New York (Ruedemann, 1947).

Genus Tetragraptus Salter, 1863

Tetragraptus pseudobigsbyi Skevington

Plate 1, figure 7

Graptolithus bigsbyi J. Hall, 1865, Canada Geol. Survey, Canadian Organic Remains, Dec. 2, pl. 16, figs. 22-24, 27, 28.

Tetragraptus pseudobigsbyi Skevington, 1965, Bull. Geol. Instn. Univ. Uppsala, v. 43, p. 8-9, fig. 2.

Diagnosis: According to Skevington (1965, p. 9), the second order stipes are highly reclined and straight or slightly flexed. They have a mature dorso-ventral width of 2.9-3.2 mm (including the apertural denticles) and 12-13 thecae per centimeter.

T. pseudobigsbyi differs from *Tetragraptus bigsbyi* (Hall) in having a less scandent rhabdosome, less strongly overlapping thecae with more prominent denticles, and generally straight, parallel-sided stipes.

Discussion: Most of the Idaho specimens have somewhat narrower stipes (2.5 mm wide) and slightly more thecae per centimeter (12-14) than Skevington's type specimen. The figured specimen (pl. 1, fig. 7) is more reclined than the others; it has wider stipes (2.7 mm) and fewer thecae (11 per centimeter).

Figured specimen: USNM 189134.

Occurrence: Zone of *Didymograptus protobifidus* (Phi Kappa Formation, collection 62ICn 511), Trail Creek, Idaho. Levis Shale in Quebec (Hall, 1865). Zone of *Didymograptus hirundo* (Ontikan limestone) in Öland, Sweden (Skevington, 1965).

Genus Phyllograptus Hall, 1858

Phyllograptus anna prolatus n. subsp.

Plate 1, figures 2, 3

Description: The rhabdosome is small, relatively long, and measures 4.5-5.4 mm wide at its widest point near the level of th 10^1, gradually decreasing in width thereafter. The maximum observed length is 16.5 mm. The thecae are curved and number 12-14 per centimeter. The thecal apertures are concave and mucronate.

Discussion: This subspecies closely resembles *P. anna* Hall except for the length of the rhabdosome. Hall (1865, p. 124) stated that the rhabdosome of *P. anna* is up to 7/16 inch (11 mm) long, whereas this subspecies is as much as 16.5 mm long. *P. anna longus* Ruedemann is about 10-14 mm long but much narrower (3.5 mm wide) than this subspecies. *P. anna ultimus* Ruedemann is only 3.6 mm long and has 22 thecae per centimeter. *P. anna prolatus* can be distinguished from all other phyllograptids by its small size and closely spaced thecae.

Holotype: USNM 189143.

Figured specimens: USNM 189143, USNM 189144.

Occurrence: Zones of *Didymograptus protobifidus* and *Isograptus* (Phi Kappa Formation; collections 62ICn 511, 62ICn 491, 62ICn 492), Trail Creek, Idaho.

Phyllograptus ilicifolius major Ruedemann

Plate 1, figure 4

Phyllograptus ilicifolius var. *major* Ruedemann, 1947, Geol. Soc. America Mem. 19, p. 318-319, pl. 53, fig. 21.

Phyllograptus ilicifolius Hall. Churkin, 1963, Am. Assoc. Petroleum Geologists Bull., v. 47, p. 1617, pl. 1, fig. 14.

Phyllograptus ilicifolius var. *major* Ruedemann. Ross and Berry, 1963, U.S. Geol. Survey Bull. 1134, p. 83, pl. 3, fig. 17.

Diagnosis: According to the original description, this form resembles *P. ilicifolius ilicifolius* Hall in general outline and the characters of its thecae but is larger in size and has more closely spaced thecae. The rhabdosome is 18.5 mm long and 8.5 mm wide, with 14-12 thecae per centimeter. Ross and Berry (1963) described specimens of *P. ilicifolius major* from the Phi Kappa Formation as being about 25 mm long and 10 mm wide, with 18-10 thecae per centimeter and narrowly pointed proximal portions. Our specimens are as much as 32 mm long, 12-14 mm wide, and have 18-12 thecae per centimeter.

Discussion: P. ilicifolius grandis Elles is similar to our specimens in size but has much more widely spaced thecae (11-13 per cm). *P. typus* Hall is narrower and has only 9-10 thecae per centimeter. *P. griggsi* Ross and Berry is only 9-6 mm wide and has 13-11 thecae per centimeter.

Figured specimen: USNM 189145.

Occurrence: Zone of *Didymograptus protobifidus* (Phi Kappa Formation, collection 62ICn 511), Trail Creek, Idaho. Sarbach Formation, western Canada (Ruedemann, 1947).

Genus Didymograptus M'Coy 1851

Didymograptus cf. D. geminus (Hisinger)

Plate 1, figure 9

Prionotus geminus Hisinger, 1840, Lethaea Suecica, Supplementus Secundum.

Didymograptus murchisoni var. *geminus* (Hisinger). Elles and Wood, 1901-18, Palaeontographical Soc., Mon. British Graptolites, p. 40-41, text-figs. 25a-d, pl. 3, figs. 2a-j.

Diagnosis: According to Elles and Wood (1901-18, p. 40-41), this species has stipes which widen more rapidly than those of *D. murchisoni* (Beck) and has a more slender and more rounded proximal region. The stipes are generally divergent throughout most of their length, diverging initially at angles of about 90° and then curving so as to form an angle of 20°-30°. They widen abruptly from about 0.9 mm to 2.5 mm. The sicula is about 2.6 mm long. Thecae number 12 per centimeter, and they curve so that their angle of inclination increases from 45° initially to 55° at the aperture.

Discussion: The Idaho specimens are only about 0.6 mm wide proximally and have shorter siculae (about 1.0 mm long) than those described above. They resemble *D. bifidus* (Hall) in general appearance, but *bifidus* has 15-13 thecae per centimeter and stipes with straight dorsal margins. Ruedemann's (1947, pl. 54, figs. 33-35) figured specimens of *D. murchisoni geminus* are considerably wider than those from Trail Creek.

Figured specimen: USNM 189146.

Occurrence: Zone of *Didymograptus protobifidus* (Phi Kappa Formation, collection 62ICn 511), Trail Creek, Idaho. Zone of *Didymograptus murchisoni* in Great Britain (Elles and Wood, 1901-18).

Didymograptus protobifidus Elles

Plate 1, figures 5, 8

Didymograptus protobifidus Elles, 1933, Great Britain Geol. Survey Summary of Progress for 1932, p. 98, figs. 1-4.

Didymograptus protobifidus Elles. Ripper, 1937, Proc. Royal Soc. Victoria, v. 49 (N.S.), pt. 2, p. 154-156, figs. 1A-C, 2A,B, 3.

Didymograptus protobifidus Elles. Berry, 1960, Texas Univ. Pub. 6005, p. 63-64, pl. 8, figs. 5-9.

Didymograptus protobifidus Elles. Churkin, 1963, Am. Assoc. Petroleum Geologists Bull., v. 47, p. 1617, pl. 1, fig. 12.

Didymograptus protobifidus Elles. Ross and Berry, 1963, U.S. Geol. Survey Bull. 1134, p. 90, pl. 4, figs. 6, 12.

Diagnosis: According to the original description, the pendant stipes of this species are 10-20 mm long, narrow proximally, and widen to 1.3 mm distally. The stipes diverge at angles of about 20°-25° or are subparallel. Thecae number 13 per centimeter and they overlap one-half and are inclined at a low but variable angle to the stipe axis.

Discussion: The Idaho specimens closely resemble Elles' holotype (1933, fig. 1) but appear to be slightly narrower (0.5-1.2 mm wide) than specimens figured by Berry (1960, pl. 8, figs. 5-9) and Ross and Berry (1963, pl. 4, figs. 6, 12), and they have 14 thecae per centimeter. *D. protobifidus* strongly resembles *Didymograptus artus* Elles and Wood, which has 18-19 thecae per centimeter.

Figured specimens: USNM 189147, USNM 189148.

Occurrence: Zone of *D. protobifidus* (Phi Kappa Formation, collection 62ICn 511), Trail Creek, Idaho. Zone of *D. protobifidus* (Marathon Limestone) in the Marathon region of west Texas and the Deepkill Shale in New York (Berry, 1960). Bendigonian and Chewtonian Stages (Lower Ordovician) in Australia (Thomas, 1960). Zones of *Didymograptus extensus* and *Didymograptus hirundo* (Skiddaw Slates) in Great Britain (Elles, 1933).

Genus Isograptus Moberg, 1892

Isograptus aff. I. victoriae Harris

Plate 2, figure 9

Isograptus victoriae Harris. Cooper, 1973, Palaeontology, v. 16, pt. 1, p. 59.

Diagnosis: The rhabdosome is V-shaped, with nearly straight stipes about 10 mm long and a conspicuous nema 10 mm long. The sicula is 3.7 mm long, 0.7 mm wide at its aperture, and its supradorsal length is 1.9 mm. There are 14 thecae per centimeter, with slightly concave, denticulate apertural margins, and 5 pendent thecae in the proximal region. The stipes are 2.0 mm wide proximally and attain a maximum width of 2.5 mm at about theca 7.

Discussion: There is only one mature specimen of this form in our collections, and it is not completely preserved. It has the general characters of *I. victoriae* but does not match any of its subspecies

(Cooper, 1973) in details. It appears to be about the same size as *I. victoriae victoriae* Harris, which differs in being U-shaped and having only 11 thecae per centimeter.

Figured specimen: USNM 189111.

Occurrence: Zone of *Didymograptus protobifidus* (Phi Kappa Formation, collection 62ICn 511), Trail Creek, Idaho. *I. victoriae* ranges from Castlemanian to Darriwilian in Australasia (Cooper, 1973).

Isograptus sp.

Plate 1, figure 6

Discussion: The illustrated specimen (pl. 1, fig. 6) is the only one of its kind in the collection and is probably an immature form. Its sicula is 5.0 mm long and 0.8 mm wide at the aperture and extends 2.0 mm above the dorsal edge of the stipes. The stipes are 2.0 mm wide proximally, narrowing to 1.5 mm distally, and are about 3.5 mm long.

Figured specimen: USNM 219001.

Occurrence: Zone of *Isograptus* (Phi Kappa Formation, collection 62ICn 521), Trail Creek, Idaho.

Genus Maeandrograptus Moberg, 1892

Maeandrograptus tau Harris

Plate 7, figure 1

Maeandrograptus tau Harris, 1933, Proc. Royal Soc. Victoria, v. 46, pt. I, p. 107, pl. 6, figs. 5A-D, text-figs. 47-49.

Maeandrograptus tau Harris. Cooper, 1973, Palaeontology, v. 16, pt. 1, p. 89-90, text-figs. 24a, b, d.

Maeandrograptus tau Harris. Beavis and Beavis, 1974, Proc. Royal Soc. Victoria, v. 86, pt. 2, p. 212, figs. 20a-b.

Diagnosis: According to the original description, the rhabdosome is usually small (less than 1 cm long) and consists of two short stipes diverging at an angle of 180° or slightly more. The long sicula measures 5-6 mm in length. The thecae overlap one-half to one-third and have sigmoidally curved ventral margins and concave apertures.

Figured specimen: USNM 164425.

Occurrence: Zone of *Isograptus* (Phi Kappa Formation; collection 62ICn 491), Trail Creek, Idaho. Castlemanian Ca 3 to Yapeenian Ya 1 in Victoria, Australia (Beavis and Beavis, 1974).

Family CORYNOIDIDAE

Genus Corynoides Nicholson, 1867

Corynoides calicularis Nicholson

Plate 2, figure 12

Corynoides calicularis Nicholson, 1867a, Geol. Mag., v. 4., p. 108, pl. 7, figs. 9-11.

Corynoides gracilis Ruedemann, 1947, Geol. Soc. America Mem. 19, p. 361, pl. 58, figs. 34-37a.

Corynoides gracilis mut. *perungulatus* Ruedemann, 1947, Geol. Soc. America Mem. 19, p. 361, pl. 58, figs. 38-46.

Corynoides calicularis Nicholson. Strachan, 1949, Geol. Mag., v. 86, p. 156-157, text fig. 1.

Corynoides calicularis Nicholson. Berry, 1960, Texas Univ. Pub. 6005, p. 68-69, pl. 15, fig. 5

Corynoides calicularis Nicholson. Ross and Berry, 1963, U.S. Geol. Survey Bull. 1134, p. 95-96, pl. 5, figs. 32-33.

Discussion: The figured specimen from collection 69ICt 88 fits the description of *Cornyoides calicularis* given by Strachan (1949, p. 156). Several other specimens from the same collection, though morphologically identical, are smaller than the figured specimen, measuring only 6.0-7.5 mm long and 0.4-0.5 mm wide. Riva (1974b, p. 36) has suggested that such smaller forms should be included in the species *C. calicularis.*

Figured specimen: USNM 189084.

Occurrence: Zone of *Climacograptus bicornis* (Phi Kappa Formation, collection 69ICt 88), Trail Creek, Idaho. *C. bicornis* Zone (Vinini Formation), Simpson Park Range, Nevada (Ross and Berry, 1963). Zones of *Nemagraptus gracilis* and *C. bicornis* (Woods Hollow Shale), Marathon region, west Texas (Berry, 1960). Normanskill Shale in New York,Glenogle Shale in British Columbia (Ruedemann, 1947). Zones of *Climacograptus wilsoni* and *Dicranograptus clingani* (Moffat Shales), Great Britain (Strachan, 1949). The Beauceville (Magog) Slates and the Quebec City Formation of Quebec and the lower Snake Hill Formation of New York (Riva, 1974b).

Family NEMAGRAPTIDAE

Genus Leptograptus Lapworth, 1873

Leptograptus demissus n. sp.

Plate 2, figure 1; plate 7, figures 2, 3

Description: The stipes are long, narrow, and broadly curved, diverging from the sicula at angles of less than 180° (slightly declined) initially. The stipes are as much as 11 cm long but commonly are much shorter (about 2 cm or less). The width of the stipes at the first thecal aperture is 0.2 mm, at the fifth thecal aperture 0.3 mm, increasing gradually to a maximum of 0.8 mm. The thecae are of characteristic leptograptid type, numbering 8½-10 per centimeter initially and 10-11 per centimeter distally. The sicula is prominent, 1.2-1.7 mm long.

Discussion: The most distinguishing feature of this species is the angle of divergence of the stipes. The curvature of the stipes gives the rhabdosome the gross appearance of 180° of divergence, but actually

the initial mode of growth is slightly declined. The stipes of the figured specimen (pl. 2, fig. 1) diverge at an angle of 135°. Although Bulman (1970, p. V121) listed one of the generic characters of *Leptograptus* as "slightly reclined" stipes, this species is certainly a *Leptograptus*. It differs from *L. flaccidus flaccidus* (Hall) in having thinner stipes and a different angle of divergence. *L. flaccidus macer* Elles and Wood has more widely spaced thecae (8–6 per centimeter). *L. capillaris* (Carruthers) is similar in appearance to this species but differs in having a maximum width of only 0.5 mm and more strongly curved stipes.

Holotype: USNM 189085.

Figured specimens: USNM 189085, USNM 164427.

Occurrence: Zone of *Pleurograptus linearis* (Phi Kappa Formation, collections 69ICt 61, 69ICt 59, 69ICt 58, 69ICt 57, 69ICt 56), Trail Creek Idaho.

Leptograptus n. sp.?

Plate 2, figure 3

Description: The stipes are straight after their initial flexure near the sicula. They are 0.5 mm wide and bear about 12 thecae per centimeter. The sicula is 2.5 mm long.

Discussion: The Idaho specimens have more thecae per centimeter, a longer sicula, and straighter stipes than *Leptograptus flaccidus flaccidus* (Hall). They have narrower stipes, a longer sicula, and more thecae per centimeter than *Leptograptus validus validus* Elles and Wood. However, only a few specimens were collected and they are not well enough preserved to merit a new name.

Figured specimen: USNM 189086.

Occurrence: Zone of *Climacograptus tubuliferus* (Phi Kappa Formation, collection 69ICt 71), Trail Creek, Idaho.

Genus Pleurograptus Nicholson, 1867

Pleurograptus linearis linearis (Carruthers)

Plate 2, figure 4

Cladograpsus linearis Carruthers, 1858, Proc. Royal Phys. Soc. Edinburgh, v. 1, p. 467, fig. 1.

Pleurograpsus linearis (Carruthers). Nicholson, 1867b, Geol. Mag., v. 4, p. 258, pl. XI, figs. 1-5.

Pleurograptus linearis (Carruthers). Elles and Wood, 1901-18, Palaeontographical Soc., Mon. British Graptolites, p. 119-121, pl. 16, fig. 7, pl. 17, fig. 1.

Pleurograptus linearis (Carruthers). Ruedemann, 1947, Geol. Soc. America Mem. 19, p. 375, pl. 61, figs. 29-30.

Pleurograptus linearis (Carruthers). Strachan, 1969, Bull. British Mus. (Nat. Hist.) Geology, v. 17, no. 4, p. 186-187, text figs la-c, pl. 2.

Pleurograptus linearis (Carruthers). Toghill, 1970, Bull. British Mus. (Nat. Hist.) Geology, p. 20, pl. 10, figs. 2, 4.

Discussion: The Idaho specimens are fragmentary but still exhibit the characteristic branching pattern of *P. linearis*. The stipes are 0.5-0.7 mm wide and have 9-10 thecae per centimeter. Elles and Wood (1901-18, p. 120) gave the count as 7-8 thecae per centimeter.

Figured specimen: USNM 189087.

Occurrence: Zone of *Pleurograptus linearis* (Phi Kappa Formation, collection 69ICt 59), Trail Creek, Idaho. Upper part of Utica Shale, New York State (Ruedemann, 1908). The Exploits Group of Newfoundland (Bergstrom and others, 1974). Zone of *P. linearis* (Hartfell Shales), Scotland (Toghill, 1970).

Family DICRANOGRAPTIDAE

Genus Dicranograptus Hall, 1865

Dicranograptus contortus Ruedemann

Plate 2, figure 6; plate 7, figure 4

Dicranograptus contortus Ruedemann, 1908, N.Y. State Mus. Mem. 11, p. 337-338, pl. 23, fig. 9, text-figs. 275-278.

Dicranograptus contortus Ruedemann, 1947, Geol. Soc. America Mem. 19, p. 389, pl. 65, figs. 14-36.

Dicranograptus contortus Ruedemann. Churkin, 1963, Am. Assoc. Petroleum Geologists Bull., v. 47, p. 1617, pl. 1, fig. 4.

Dicranograptus contortus Ruedemann. Ross and Berry, 1963, U.S. Geol. Survey Bull. 1134, p. 109, pl. 7, figs. 9, 14.

Diagnosis: According to Ruedemann (1908), the rhabdosome is very small and consists of a short biserial portion, which is 3 mm long and 0.8 mm wide, and two relatively thick uniserial, uniformly wide (0.7 mm) branches which in compressed specimens are intricately contorted. The biserial portion contains 5 thecae on either side, and the uniserial branches have 18-20 thecae per centimeter. The proximal end has a long virgella and conspicuous lateral spines.

Discussion: The Idaho specimens have biserial portions measuring 2.0-2.8 mm long and 0.7-1.2 mm wide. The stipes are commonly 0.6 mm wide. Ruedemann (1947, pl. 65, figs. 19-25) illustrates several specimens from Fall Creek, Hailey quadrangle, Idaho, which appear to be closely similar to those illustrated here.

Figured specimens: USNM 189088a, b, USNM 219006.

Occurrence: Zones of *Nemagraptus* and *Climacograptus bicornis* (Phi Kappa Formation, collections 69ICt 93, 69ICt 92, 69ICt 91, and 69ICt 88), Trail Creek, Idaho. Normanskill Shale in New York and

correlative units in Quebec and Newfoundland (Ruedemann, 1947). Zone of *Nemagraptus gracilis* (Woods Hollow Shale), Marathon region, Texas (Berry, 1960). Upper member of Valder Formation, HD Range, Nevada (Riva, 1970).

Dicranograptus cf. D. kirki Ruedemann

Plate 2, figure 7

Dicranograptus kirki Ruedemann, 1947, Geol. Soc. America Mem. 19, p. 391, pl. 66, figs. 1-4.

Dicranograptus kirki Ruedemann. Ross and Berry, 1963, U.S. Geol. Survey Bull. 1134, p. 109-110, pl. 7, figs. 1-4, 6, 21.

Diagnosis: According to Ross and Berry (1963, p. 109), who re-examined Ruedemann's type material, the biserial part of the rhabdosome is approximately 3.5 mm long and 0.8-1.0 mm wide and is composed of three to five thecae on each side. The uniserial stipes diverge initially and then bend distally with the convex side ventral, so that they become subparallel or approach each other slightly. Thecae number eight to nine per centimeter.

Discussion: Our specimens are difficult to identify positively because they do not have a sufficient length of uniserial stipe preserved. The biserial portions are 3.0 mm long and about 0.8 mm wide.

Figured specimen: USNM 189089.

Occurrence: Zone of *Climacograptus bicornis* and passage beds (Phi Kappa Formation, collections 69ICt 86, 69ICt 83), Trail Creek, Idaho. Zone of *Orthograptus amplexicaulis* (Saturday Mountain Formation), Bruno Creek, Bayhorse quadrangle, Idaho (Ross and Berry, 1963). Tiser Limestone and Agort Chert, HD Range, Nevada (Riva, 1970).

Dicranograptus nicholsoni nicholsoni Hopkinson

Plate 2, figures 10, 11

Dicranograptus nicholsoni Hopkinson, 1870, Geol. Mag., v. 7, p. 357, pl. 16, fig. 3.

Dicranograptus nicholsoni Hopkinson. Elles and Wood, 1901-18, Palaeontographical Soc., Mon. British Graptolites, p. 171-173, pl. 25, figs. 1a-h, text-figs. 108a-e.

Dicranograptus nicholsoni Hopkinson. Bulman, 1944-47, Palaeontographical Soc. Mon., Caradoc Graptolites in Laggan Burn, p. 36-40, text-figs. 18-20, pl. 3, figs. 1-11.

Dicranograptus nicholsoni Hopkinson, Harris and Thomas, 1955, Mining Geol. Jour. (Victoria), v. 5, no. 6, p. 43, figs. 22, 23.

Dicranograptus nicholsoni Hopkinson. Berry, 1960, Texas Univ. Pub. 6005, p. 78, pl. 17, fig. 6.

Dicranograptus nicholsoni Hopkinson. Churkin, 1963, Am. Assoc. Petroleum Geologists Bull., v. 47, p. 1617, pl. 1, fig. 3 (in part).

Dicranograptus nicholsoni Hopkinson. Ross and Berry, 1963, U.S. Geol. Survey Bull. 1134, p. 110-111, pl. 7, fig. 5.

Discussion: There is much variation in the dimensions of this species from one locality to another (see Ross and Berry, 1963, p. 110, for summary). The Idaho specimens agree most closely with the description given by Bulman (1944-47, p. 36-37). They have biserial portions 6.2-9.5 mm long and widening from 0.8-1.0 mm wide proximally to 2.0-3.0 mm wide near the point of bifurcation. The uniserial stipes are about 1.0-1.5 mm wide and have 9-10 thecae per centimeter.

Figures specimens: USNM 189090, USNM 189091.

Occurrence: Zone of *Climacograptus bicornis* (Phi Kappa Formation, collections 69ICt 92, 69ICt 91, 69ICt 88, 69ICt 87, and 69ICt 86), Trail Creek, Idaho. Zone of *Orthograptus amplexicaulis* (Maravillas Chert), Marathon region, Texas (Berry, 1960). Sams Spring Formation (Caradocian), Toquima Range, Nevada (Kay, 1962). Zones of *Nemagraptus gracilis* to *Dicranograptus clingani* (Glenkiln Shales, Hartfell Shales) in Great Britain (Elles and Wood, 1901-18). Upper Ordovician from near the Wellington River, Victoria, Australia (Harris and Thomas, 1955).

Genus Dicellograptus Hopkinson, 1871

Dicellograptus alector Carter

Plate 3, figures 8, 12, 13, 17

Dicellograptus morrisi Hopkinson. Churkin, 1963, Am. Assoc. Petroleum Geologists Bull., v. 47, p. 1619, pl. 2, fig. 24.

Dicellograptus alector Carter, 1972, Jour. Paleontology, v. 46, no. 1, p. 46-47, text-figs. 2A,G, Pl. 1, figs. 9, 11, 12, 15.

Diagnosis: According to the original description, the stipes are as long as 2.5 cm, somewhat flexed, increasing gradually from a width of 0.3-0.4 mm at their origin to a maximum width of 1.5 mm, and they form an axial angle of 70°-90°. The sicula is 2.0 mm long, and short, slender lateral spines and virgella are present. The thecae have introverted apertural margins opening within excavations and number 8-11 per centimeter. The axil is square.

Discussion: The Idaho specimens generally have an axial angle of around 45°, but this may be due to tectonic distortion. *D. alector* is distinguished from other species of *Dicellograptus* by the squareness of its axil and its well-defined thecae.

Figured specimens: USNM 189092, USNM 189093 a, b, USNM 189094.

Occurrence: Zones of *Climacograptus tubuliferus* and *Pleurograptus linearis* (Phi Kapa Formation, collections 69ICt 75, 69ICt 74, 69ICt 73, 69ICt 71,

69ICt 66, 69ICt 61), Trail Creek, Idaho, Zone of *Dicranograptus clingani* (Jacks Peak Formation of Churkin and Kay, 1967), Independence Range, Nevada (Carter, 1972).

Dicellograptus cf. D. angulatus Elles and Wood

Plate 3, figure 1

Dicellograptus angulatus Elles and Wood, 1901-18, Palaeontographical Soc., Mon. British Graptolites, p. 149-150, text-fig. 93a-c, pl. 21, fig. 4.

Diagnosis: According to the original description, the stipes of *D. angulatus* are 1-2 cm long, very slender (0.4 mm wide, maximum), and straight, diverging at about 270°-300° from a conspicuous sicula (1.5 mm long). The virgella and lateral spines are slender but conspicuous, and the axil is square. The thecae number 10-8 per centimeter and have slightly introverted apertures and gently curving free ventral walls.

Discussion: The figured specimen (pl. 3, fig. 1) is the only whole rhabdosome of this species in the Idaho collections. The remainder are proximal fragments consisting of a sicula and the first four to six thecae. The poor state of preservation of the specimens does not allow determination of the thecal characteristics and, therefore, more precise identification. However, they do closely resemble *D. angulatus* in the extreme narrowness and straightness of the stipes, the angle of divergence, the square axil, and the length of the sicula.

Figured specimen: USNM 189105.

Occurrence: Zone of *Climacograptus tubuliferus* (Phi Kappa Formation, collections 69ICt 63-65), Trail Creek, Idaho. Zones of *Climacograptus peltifer* and *Climacograptus wilsoni* (Glenkiln and Hartfell shales) Scotland (Elles and Wood, 1901-18). Zone of *Orthograptus quadrimucronatus* (Road River Formation) in Yukon Territory, Canada (Jackson and Lenz, 1962).

Dicellograptus divaricatus bicurvatus Ruedemann

Plate 2, figure 5

Dicellograptus divaricatus var. *bicurvatus* Ruedemann, 1908, N.Y. State Mus. Mem. 11, p. 300, text-fig. 216, pl. 18, fig. 8.

Dicellograptus divaricatus var. *bicurvatus* Ruedemann, 1947, Geol. Soc. America Mem. 19, p. 379, pl. 62, figs. 31-35, pl. 63, fig. 4.

Dicellograptus divaricatus var. *bicurvatus* Ruedemann. Ross and Berry, 1963, U.S. Geol. Survey Bull. 1134, p. 104, pl. 6, figs. 5, 9.

Diagnosis: According to Ross and Berry (1963), the stipes are 0.75 mm wide proximally, widening to 1 mm distally, and have 12-10 thecae per centimeter. The stipes diverge at an angle greater than 270°, and 2-5 mm from the sicula they bend abruptly, so that their subsequent divergence is lessened.

Discussion: The distinguishing feature of this subspecies is the shape of its rhabdosome—the acutely rounded axil and the abrupt bend in the stipes. It differs from *Dicellograptus elegans elegans* (Carruthers) in having straight free ventral walls, whereas those of *D. e. elegans* are strongly curved. The Idaho specimens agree with the above description in all respects except for being slightly narrower proximally (0.5 mm).

Figured specimen: USNM 189096.

Occurrence: Zone of *Climacograptus bicornis* (Phi Kappa Formation, collections 69ICt 92, 69ICt 88), Trail Creek, Idaho. Normanskill Shale, New York, and Womble Shale, Arkansas (Ruedemann, 1947).

Dicellograptus cf. D. elegans elegans (Carruthers)

Plate 2, figure 2

Didymograpsus elegans Carruthers, 1868, Geol. Mag., v. 5, p. 129, pl. 5, figs. 8a,d.

Dicellograpsus elegans (Carruthers). Hopkinson, 1871, Geol Mag., v. 8, p. 24-25, pl. 1, fig. 3a-e.

Dicellograptus elegans (Carruthers). Elles and Wood, 1901-18, Palaeontographical Soc., Mon. British Graptolites, p. 159-160, text-figs. 100a-d, pl. 23, figs. 2a-e.

Dicellograptus elegans (Carruthers). Ruedemann, 1947, Geol. Soc. America Mem. 19, p. 380-381, pl. 63, fig. 1.

Dicellograptus elegans (Carruthers). Strachan, 1969, Bull. British Mus. (Nat. Hist.) Geology, v. 17, no. 4, p. 187-188, text-figs. 2a,b, pl. 3, fig. 1.

Diagnosis: According to Elles and Wood (1901-18, p. 159), the stipes are 7-10 cm or more in length, with pronounced curvature and an approximately uniform width of 0.8-1.0 mm. The sicula is long (2-3 mm), and the virgella and lateral spines are always well developed. The thecae number 10-8 per centimeter and have strongly curved free ventral walls. Thecal apertures are strongly introverted, opening in a deep excavation which occupies about one-half the width of the stipe. In the proximal region, the stipes grow nearly parallel to each other, forming a square axil, then make an abrupt bend, lessening their subsequent divergence.

Discussion: Dicellograptus elegans elegans resembles *Dicellograptus divaricatus bicurvatus* Ruedemann in its curving stipes but differs by having a square axil and more abrupt curvature of the stipes. *D. divaricatus bicurvatus* has a more V-shaped axil and more gently curved stipes. The Idaho specimen (pl. 2, fig. 2) has even more contorted stipes (possibly due to tectonic deformation) than a normal *D. e. elegans*. It also does not have the

characteristic prominent virgella and lateral spines; this could be due to an accident of preservation.

Figured specimen: USNM 189097.

Occurrence: Passage beds (Phi Kappa Formation, collection 69ICt 79), Trail Creek, Idaho. Sams Spring Formation (Caradocian) of Kay (1962), Toquima Range, Nevada (Kay, 1962). Zones of *Dicranograptus clingani* and *Pleurograptus linearis* (Hartfell Shales), Great Britain (Elles and Wood, 1901-18).

Dicellograptus cf. D. elegans rigens Elles and Wood

Plate 2, figure 8

Dicellograptus elegans var. *rigens* (Lapworth MS) Elles and Wood, 1901-18, Palaeontographical Soc., Mon. British Graptolites, p. 161, text-fig. 101a,b, pl. 23, fig. 3.

Diagnosis: According to Elles and Wood (1901-18, p. 161), this subspecies has the same characteristics as *D. elegans elegans* but differs in having almost no curvature in the stipes. They are characteristically straight and rigid.

Discussion: The Idaho specimen has straight stipes measuring 0.5 mm wide proximally and widening to 1.0 mm distally. The thecae are typical for *D. e. elegans*—strongly introverted, with very curved free ventral walls—and they number six in 5 mm (12 per cm). The lateral spines are 0.8 mm long. What appears to be a membrane is present within the axil extending up to the level of the second thecal apertures. Elles and Wood (1901-18, p. 160) mentioned a similar membrane occurring in *D. e. elegans*.

Figured specimen: USNM 189098.

Occurrence: Zone of *Climacograptus tubuliferus* (Phi Kappa Formation, collection 69ICt 74), Trail Creek, Idaho. Zone of *Pleurograptus linearis* in Great Britain (Elles and Wood, 1901-18).

Dicellograptus cf. D. ornatus minor Toghill

Plate 3, figures 11, 14, 15, 16

Dicellograptus complanatus ornatus Elles and Wood, 1901-18, Palaeontographical Soc., Mon. British Graptolites, p. 140-141, pl. 20, fig. 2c.

Dicellograptus ornatus minor Toghill, 1970, Bull. British Mus. (Nat. Hist.) Geology, p. 16-17, text-figs. 3c-g, pl. 6, figs. 5-7.

Diagnosis: According to Toghill (1970, p. 16), this very slender dicellograptid has introverted thecae numbering 11-12 per centimeter. The stipes are straight, 0.2 mm wide proximally widening to a maximum of 0.5 mm, and enclosing a square axial region with an axial angle of 100°-120°. The sicula and virgella are conspicuous, and the first two thecae bear very short apertural spines.

Discussion: The Idaho specimens are similar in size and appearance to *D. ornatus minor* but differ in having a smaller axial angle (45°-70°) and a less prominent sicula. There is a certain amount of tectonic distortion involved in these measurements, but it is doubtful that undistorted specimens would have axial angles of 100°-120°.

Figured specimens: USNM 189099, USNM 189100, USNM 189101, and USNM 189102.

Occurrence: Zones of *Pleurograptus linearis* and *Dicellograptus ornatus* (Phi Kappa Formation, collections 69ICt 59, 69ICt 58, 69ICt 55, 69ICt 54, 69ICt 45, 69ICt 44, 69ICt 43), Trail Creek, Idaho. Zone of *Dicellograptus anceps* (Hartfell Shales), Scotland (Toghill, 1970).

Dicellograptus n.sp.(?)

Plate 3, figures 2, 3; plate 6, figure 2

Description: The sicula, though not commonly preserved, has been measured as 2.2 mm long. The stipes are long, curving, and cross each other once and possibly twice. They diverge initially and then curve inward, so that they cross each other approximately 1 cm above the level of the first thecae. They are 0.5 mm wide proximally, increasing to a maximum width of 1.0 mm, and have 11-12 thecae per centimeter. The thecal apertures are extremely introverted and probably introtorted. The free ventral walls of the thecae are curved and the proximal thecae often bear small mesial spines. The axil is square and the axial angle is approximately 70°-80°.

Discussion: Dicellograptus n.sp.(?) resembles *Dicellograptus intortus* Lapworth in the crossing habit of its stipes (as illustrated by Elles and Wood, 1901-18, pl. 20, fig. 4b) but differs in the characters of its thecae and axial region. *D. intortus* has thecae with straight free ventral walls and only slightly introverted apertures; its axial angle is very small, and the axil is V-shaped. *D. affinis* T. S. Hall, *D. gurleyi* Lapworth, and *D. caduceus* Lapworth are similar to *Dicellograptus* n.sp.(?) in having crossing branches. *D. affinis* differs from *Dicellograptus* n.sp.(?) in having long and stout lateral spines similar to those of *D. ornatus ornatus* Elles and Wood (in fact, Ross and Berry (1963, p. 104) included one of T. S. Hall's original illustrated specimens in their synonomy of *D. ornatus*); *D. gurleyi* differs in having a greater maximum width (1.25 mm), a rounded axil, and a prominent, thickened virgella (see Lapworth's original manuscript figure in Ruedemann, 1908, text-fig. 223); and *D. caduceus* differs in having a much more acute axial angle (20° or more), thecae that are more closely spaced (14-12), and the first crossing of

the stipes less than 5 mm above the level of the first thecae.

According to J. Riva (personal commun., 1975), dicellograptid stipes are not rigid and can twist in many different directions. Therefore, because crossing stipes may not be a diagnostic feature, and because the specimens are few in number and not especially well preserved, they have not been named.

Holotype: USNM 189106.

Figured specimens: USNM 189103, USNM 189104, USNM 189106.

Occurrence: Passage beds (Phi Kappa Formation, collections 69ICt 76-77), Trail Creek, Idaho.

Suborder GLOSSOGRAPTINA

Family GLOSSOGRAPTIDAE

Genus Glossograptus Emmons, 1855

Glossograptus hincksii hincksii (Hopkinson)

Plate 3, figure 4

Diplograptus hincksii Hopkinson, 1872, Geol. Mag., vol. 9, p. 507-508, pl. 12, fig. 9.

Glossograptus hincksii (Hopkinson). Elles and Wood, 1901-18, Palaeontographical Soc., Mon. British Graptolites, p. 309-312, text-figs. 205 a-f, pl. 33, figs. 2a-j.

Glossograptus hincksii (Hopkinson). Berry, 1960, Texas Univ. Pub. 6005, p. 71, pl. 12, fig. 9a.

Glossograptus hincksii (Hopkinson). Ross and Berry, 1963, U.S. Geol. Survey Bull. 1134, p. 99, pl. 5, figs. 25, 26.

Discussion: The Idaho specimens closely fit the description given by Elles and Wood (1901-18, p. 309-10). *G. h. hincksii* is distinguished from other glossograptids by the spacing of its thecae (16-10 per cm), the shape and size of its rhabdosome (2-4 cm long with rounded proximal end, 3 mm wide), and the appearance of its spines.

Figured specimen: USNM 189107.

Occurrence: Zones of *Glossograptus hincksii* and *Climacograptus bicornis* (Phi Kappa Formation, collections 62ICn 493-496, 69ICt 92, 69ICt 91, and 69ICt 88), Trail Creek, Idaho. Zones of *Paraglossograptus tentaculatus* (*P. etheridgei*) to *C. bicornis* (Vinini Formation, Valmy Formation, Palmetto Formation), Nevada (Ross and Berry, 1963). Zones of *Paraglossograptus tentaculatus* (*P. etheridgei*) (Fort Peña Formation) and *Nemagraptus gracilis* (Woods Hollow Shale), in the Marathon region, Texas (Berry, 1960). Petes Summit Formation and Sams Spring Formation, Toquima Range, Nevada (Kay, 1962). Valder Formation and Agort Chert, HD Range, Nevada (Riva, 1970). Zones of *N. gracilis* to *Climacograptus wilsoni* (Glenkiln and Hartfell Shales) Great Britain (Elles and Wood, 1901-18). Zone of *N. gracilis* (Road River Formation) in Yukon Territory, Canada (Jackson and Lenz, 1962). Road River Formation in east-central Alaska (Churkin and Brabb, 1965).

Family CRYPTOGRAPTIDAE

Genus Cryptograptus Lapworth, 1880

Cryptograptus tricornis (Carruthers)

Plate 3, figure 5

Diplograpsus tricornis Carruthers, 1858, Proc. Royal Phys. Soc. Edinburgh, v. 1, p. 468, fig. 2.

Cryptograptus tricornis (Carruthers). Elles and Wood, 1901-18, Palaeontographical Soc., Mon. British Graptolites, p. 296-298, text-figs. 200a-j, pl. 32, figs. 12a-d.

Cryptograptus tricornis (Carruthers). Ruedemann, 1908, N.Y. State Mus., Mem. 11, p. 443-448, pl. 28, figs. 1-3.

Cryptograptus tricornis (Carruthers). Bulman, 1944-47, Palaeontographical Soc. Mon., Caradoc Graptolites in Laggan Burn, p. 29-36, pl. II, figs. 1-8, text-figs. 14-17.

Cryptograptus tricornis (Carruthers). Ruedemann, 1947, Geol. Soc. America Mem. 19, p. 446, pl. 76, figs. 23-33.

Cryptograptus tricornis (Carruthers). Berry, 1960, Texas Univ. Pub. 6005, p. 70, pl. 15, fig. 9.

Cryptograptus tricornis (Carruthers). Churkin, 1963, Am. Assoc. Petroleum Geologists Bull., v. 47, p. 1617, pl. 1, fig. 9.

Cryptograptus tricornis (Carruthers). Ross and Berry, 1963, U.S. Geol. Surv. Bull. 1134, p. 97-98, pl. 5, fig. 27.

Cryptograptus tricornis (Carruthers). Strachan, 1969, Bull. British Mus. (Nat. Hist.) Geology, p. 194-195, text-fig. 3c, pl. 4, figs. 4-6.

Discussion: This well known and easily recognized graptolite is distinguished by the three proximal spines present in scalariform view.

Figured specimen: USNM 189108.

Occurrence: Zones of *Nemagraptus* and *Climacograptus bicornis* (Phi Kappa Formation, collections 69ICt 86-88, and 69ICt 91-93), Trail Creek, Idaho. Zones of *Glyptograptus teretiusculus* to *C. bicornis* (Vinini Formation, Valmy Formation, Toquima Formation), Nevada (Ross and Berry, 1963). McAfee Quartzite (Middle Ordovician), northern Independence Range, Nevada (Churkin and Kay, 1967). Petes Summit Formation and Sams Spring Formation of Kay (1962), Toquima Range, Nevada. Upper member, Valder Formation of Riva (1970), HD Range. Zones of *Nemagraptus gracilis* and *C. bicornis* (Woods Hollow Shale), Marathon region, Texas

(Berry, 1960). Normanskill Shale in New York, Womble Shale in Arkansas, Womble Shale in Oklahoma, and Glenogle Shale in British Columbia (Ruedemann, 1947). Lower Caradoc Zones 9-10 (Road River Formation) in east-central Alaska (Churkin and Brabb, 1965). Zone of *Didymograptus extensus* and zones of *Didymograptus bifidus* through *Dicranograptus clingani* in Great Britain (Elles and Wood, 1901-18).

Suborder DIPLOGRAPTINA

Family DIPLOGRAPTIDAE

Genus Diplograptus M'Coy, 1850

Diplograptus sp.

Plate 3, figure 7

Description: The rhabdosome is about 15 mm long and widens gradually from a width of 1 mm proximally through 1.7 mm at the fifth thecal pair to a maximum width of 3.0 mm, which is attained about 12 mm from the proximal end and thereafter maintained. The virgella is short (about 0.5 mm long) and two equally short, straight lateral spines are present on the proximal end. There are 6 thecae in 5 mm proximally and 10 thecae per centimeter distally. *Climacograptus*-like thecae are present for about the first 3 mm, followed by *Orthograptus*-like thecae.

Discussion: Only one good specimen of this form is present in the collection.

Figured specimen: USNM 189109.

Occurrence: Zone of *Climacograptus bicornis* (Phi Kappa Formation, collection 69ICt 86), Trail Creek, Idaho.

Genus Climacograptus Hall, 1865

Climacograptus bicornis tridentatus Lapworth

Plate 4, figure 14

Climacograptus bicornis var. *tridentatus* Lapworth, 1876, Cat. Western Scottish Fossils, p. 6, pl. 2, fig. 52.

Climacograptus bicornis var. *tridentatus* Lapworth. Elles and Wood, 1901-18, Palaeontographical Soc., Mon. British Graptolites, p. 195-196, pl. 26, figs. 9a-c.

Climacograptus bicornis var. *tridentatus* Lapworth. Ruedemann, 1908, N.Y. State Mus. Mem. 11, p. 83, pl. A, figs. 32-38.

Climacograptus bicornis (Hall) var. *tridentatus* Lapworth. Ruedemann, 1947, Geol. Soc. America Mem. 19, p. 426, pl. 72, fig. 56.

Discussion: The figured specimen (pl. 4, fig. 14) shows the three proximal spines characteristic of this subspecies and a triangular membrane developed between the spines and the rhabdosome. In addition, one of the Idaho specimens has wide spines covered by membrane and another has very slender spines.

Figured specimen: USNM 189110.

Occurrence: Zone of *Climacograptus bicornis* and passage beds(?) (Phi Kappa Formation, collections 69ICt 88 and 69ICt 84), Trail Creek, Idaho. Zone of *C. bicornis,* Cresent Valley quadrangle, Nevada (Ross and Berry, 1963). Sams Spring Formation, Toquima Range, Nevada (Kay, 1962). Valder Formation, HD Range, Nevada (Riva, 1970). Normanskill Shale in New York and Womble Shale (Stringtown Shale of Ruedemann, 1947) in Oklahoma. Zones of *Climacograptus peltifer* and *Climacograptus wilsoni* (Glenkiln Shales and Hartfell Shales) in Great Britain (Elles and Wood, 1901-18).

Climacograptus hastatus T. S. Hall

Plate 4, figure 7

Climacograptus hastata T. S. Hall, 1902, New South Wales Geol. Survey Rec., v. 7, pt. 2, p. 54-55, pl. 14, figs. 1-3.

Climacograptus hastatus T. S. Hall. Harris and Thomas, 1955, Victoria Dept. Mines, Mining and Geology Jour., vol. 5, no. 6, p. 39, figs. 8, 9.

Climacograptus hastatus T. S. Hall. Ross and Berry, 1963, U.S. Geol. Survey Bull. 1134, p. 121, pl. 8, figs. 8, 10.

Climacograptus hastatus var. *angustus* Ross and Berry, 1963, U.S. Geol. Survey Bull. 1134, p. 122-123, pl. 9, fig. 22.

Climacograptus hastatus var. *martini* Ross and Berry, 1963, U.S. Geol. Survey Bull. 1134, p. 123-124, pl. 9, figs. 4, 6, 7, 10, 11, 16.

Climacograptus n. sp. (not described) Ross and Berry, 1963, U.S. Geol. Survey Bull. 1134, pl. 9, fig. 19.

Discussion: The figured specimen (pl. 4, fig. 7) resembles *Climacograptus* n. sp. Ross and Berry (1963, pl. 9, fig. 19) with its rounded proximal end and slender lateral spines. Most probably it is an immature specimen of *Climacograptus hastatus,* as it is always associated with well developed examples of *C. hastatus* in the Idaho collections.

Figured specimen: USNM 189118.

Occurrence: Zone of *Dicellograptus ornatus* (Phi Kappa Formation, collections 69ICt 33, 69ICt 42, 69ICt 44, 69ICt 45, 69ICt 54, 69ICt 55), Trail Creek, Idaho. Also reported from Phi Kappa Formation, Idaho, by Ross and Berry (1963). Eastonian series (Upper Ordovician) in Victoria, Australia (Harris and Thomas, 1955).

Climacograptus longispinus hvalross Ross and Berry

Plate 4, figures 12, 13

Climacograptus hvalross Ross and Berry. 1963, U.S.

Geol. Survey Bull. 1134, p. 124-125, pl. 8, figs. 19, 26, 27.

Climacograptus supernus Elles and Wood. Churkin, 1963, Am. Assoc. Petroleum Geologists Bull., v. 47, p. 1621, pl. 3, fig. 38.

Climacograptus hvalross Ross and Berry. Toghill, 1970, Bull. British Mus. (Nat. Hist.) Geology, p. 22, pl. 2, figs. 1-4, 7.

Climacograptus longispinus hvalross Ross and Berry. Riva, 1974a, Spec. Paper Palaeont., no. 13, p. 114-119, text-figs. 5, 6, 7.

Description: The rhabdosome widens from 0.5-0.7 mm proximally to about 2.0 mm (and as much as 2.6 mm in specimens compressed perpendicularly to their length) in a distance of approximately 9 mm and is parallel sided thereafter. Thecae number 12-8 per centimeter in specimens compressed perpendicular to the rhabdosome length and 15-12 per centimeter in specimens compressed parallel to their length. Thecal excavations occupy about one-third the width of the rhabdosome. The proximal end bears conspicuous stout spines that are as much as 1.1 cm long and are thickened by membranes on their undersides for about one-fourth to one-half or more of their length.

Discussion: Climacograptus longispinus hvalross resembles *Climacograptus longispinus longispinus* T. S. Hall, from which it differs by having shorter and usually thinner spines with only one set of membranes on their undersides. *C. l. longispinus* has one or more sets of membranes along the upper sides of the spines. (See Riva, 1974c.) There are numerous specimens present in our collections (69ICt 44; 69ICt 43; 69ICt 42), however, that have much shorter basal spines and membranes (see pl. 4, fig. 13). These specimens may represent a new subspecies evolving from *C. l. hvalross,* as they are found in association with *C. l. hvalross* in collections 69ICt 44 and 69ICt 43 but without it in collection 69ICt 42.

Figured specimens: USNM 164466, USNM 189112.

Occurrence: Zone of *Dicellograptus ornatus* (Phi Kappa Formation, collections 69ICt 55, 69ICt 45, 69ICt 44, 69ICt 43, 69ICt42, 69ICt33), Trail Creek, Idaho. Top of the Agort Chert in the HD Range and the Perkins Canyon Formation in the Toquima Range in Nevada (Riva, 1974c).

Climacograptus pacificus pacificus Ruedemann

Plate 4, figures 8, 9

Climacograptus innotatus Nicholson var. *pacificus* Ruedemann, 1947, Geol. Soc. America Mem. 19, p. 429, pl. 73, fig. 29.

Climacograptus innotatus var. *pacificus* Ruedemann. Ross and Berry, 1963, U.S. Geol. Survey Bull. 1134, p. 125, pl. 8, fig. 21.

Climacograptus pacificus Ruedemann. Riva, 1974a, Canadian Jour. Earth Sci., vol. 11, p. 1457-1459, figs. 2a-h.

Diagnosis: According to Riva (1974a, p. 1457-59), the rhabdosome is small, with an average length of 7-8 mm, exclusive of virgella and nema, and a width that gradually increases from 1.1-1.2 mm at the first thecal pair to a maximum of 1.6-2.0 mm distally. Thecae number 7 in the first 5 mm in relatively undeformed specimens in Nevada and as many as 9-10 per 5 mm in the Idaho specimens. Thecal excavations are shallow, occupying only about one-eighth to one-fifth the width of the rhabdosome. One or two spines, about 0.8-0.9 mm long, project from each geniculum.

Discussion: This species differs from *Climacograptus innotatus* and its subspecies in its stubby shape and double genicular spines.

Figured specimens: USNM 189113, USNM 189115.

Occurrence: Zone of *Dicellograptus ornatus* (Phi Kappa Formation, collections 69ICt 43, 69ICt 42, 69ICt 33), Trail Creek, Idaho. First described from Trail Creek by Ruedemann (1947) and also reported by Ross and Berry (1963). Perkins Canyon Formation (Marshall Kay collection), Toquima Range, Nevada (Riva, 1974a).

Climacograptus tubuliferus Lapworth

Plate 7, figure 5

Climacograptus tubuliferus Lapworth, 1876, Cat. Western Scottish Fossils, pl. 2, fig. 49.

Climacograptus tubuliferus Lapworth. Elles and Wood, 1901-18, Palaeontographical Soc., Mon. British Graptolites, p. 203-204, text figs. 134a-c, pl. 27, figs. 8a-d.

Climacograptus tubuliferus Lapworth. Ruedemann, 1947, Geol. Soc. America Mem. 19, p. 440, pl. 75, figs. 54-56.

Climacograptus tubuliferus Lapworth. Harris and Thomas, 1955, Mining Geol. Jour. (Victoria), v. 5, no. 6, p. 40, figs. 10-12.

Climacograptus tubuliferus Lapworth. Berry, 1960, Texas Univ. Pub. 6005, p. 85, pl. 19, fig. 5.

Climacograptus tubuliferus Lapworth. Churkin, 1963, Am. Assoc. Petroleum Geologists Bull., v. 47, p. 1619, pl. 2, fig. 29.

Climacograptus tubuliferus Lapworth. Ross and Berry, 1963, U.S. Geol. Survey Bull. 1134, p. 132, pl. 10, figs. 1, 2.

Discussion: According to Elles and Wood (1901-18, p. 203), the virgella of *Climacograptus tubuliferus* is well developed and as much as 4 mm long. Harris and Thomas (1955, p. 40) noted that the rodlike virgella of *C. tubuliferus* is "sometimes surrounded by a membranous body as in *C. caudatus*" but that

the membrane "is longer in *C. caudatus* and the virgella projects considerably beyond its extremity." There are specimens of *C. tubuliferus* in our collections with virgellas 3.0–3.3 mm long and virgellar membranes 1.3–2.8 mm long. There are also specimens (for example, pl. 7, fig. 5) with virgulas of the *C. tubuliferus* type, virgellas up to 11 mm long and virgellar membranes up to 5.3 mm long, which are within the limits cited by Elles and Wood (1901–18, p. 202) for *C. caudatus*. Whether these specimens are *C. caudatus* with abnormal virgulas or *C. tubuliferus* with abnormally elongated virgellas remains a matter of conjecture.

Figured specimen: USNM 164424.

Occurrence: Zones of *Climacograptus tubuliferus* and *Pleurograptus linearis* (Phi Kappa Formation, collections 69ICt 71–75, 69ICt61–65, and 69ICt 56–59), Trail Creek, Idaho. Zone of *Orthograptus quadrimucronatus* (Hanson Creek Formation) in Nevada (Ross and Berry, 1963). Jacks Peak Formation (upper Caradocian), northern Independence Range, Nevada (Churkin and Kay, 1967). Zone of *O. quadrimucronatus* (Maravillas Chert) in the Marathon region, Texas (Berry, 1960). Polk Creek Shale of Oklahoma (Ruedemann, 1947). Upper Ordovician from near the Wellington River, Victoria, Australia (Harris and Thomas, 1955). Zones of *Dicranograptus clingani* and *P. linearis* (Hartfell Shales) in Great Britain.

Climacograptus? uncinatus Keble and Harris

Plate 4, figures 1, 2

Climacograptus uncinatus Keble and Harris, 1934, Nat. Mus. Melborne, Mem. 8, p. 173–174, pl. 20, figs. 5a–c.

Climacograptus uncinatus Keble and Harris. Harris and Thomas, 1955, Mining Geol. Jour. (Victoria), v. 5, no. 6, p. 40, fig. 13.

Climacograptus uncinatus Keble and Harris. Churkin, 1963, Am. Assoc. Petroleum Geologists Bull., v. 47, p. 1619, pl. 2, fig. 21.

Climacograptus? uncinatus Keble and Harris. Carter, 1972, Jour. Paleontology, v. 46, no. 1, p. 48, text-figs. 2J, L–O, pl. 1, figs. 2–7, 10.

Diagnosis: According to the original description, the rhabdosome widens from a pointed proximal end to 2.5 mm in 3 mm and thereafter maintains that width. Thecae number 12–14 per centimeter. Two fairly stout curved spines, about 2 mm long, arise approximately 2.0 mm from the proximal end.

Discussion: The Idaho specimens are all considerably narrower (1.0–1.5 mm maximum) than the 2.5-mm width cited by Keble and Harris (1934, p. 173). However, measurement of their figures (1934, pl. 20, figs. 5a–c) indicates a width of 1.0 mm or less. Its small size and septal spines distinguish *C.? uncinatus* from other species of *Climacograptus*.

Figured specimens: USNM 189116, USNM 189117.

Occurrence: Zone of *Pleurograptus linearis* (Phi Kappa Formation, collections 69ICt 61, 69ICt 59, 69ICt 57, 69ICt 56, 69ICt 41), Trail Creek, Idaho. Upper Ordovician Bolindian Stage in Victoria, Australia (Keble and Harris, 1934; Harris and Thomas, 1938 and 1955).

Genus Glyptograptus Lapworth, 1873

Glyptograptus cf. G. euglyphus euglyphus (Lapworth)

Plate 5, figure 1

Diplograptus (*Glyptograptus*) *euglyphus* Lapworth, 1880, Ann. Mag. Nat. Hist. Ser. 5, no. 5, p. 166, pl. 4, figs. 14a–e.

Diplograptus (*Glyptograptus*) *teretiusculus* var. *euglyphus* Lapworth. Elles and Wood, 1901–18, Palaeontological Soc., Mon. British Graptolites, p. 252, text-fig. 172, pl. 31, figs. 2a–d.

Diplograptus (*Glyptograptus*) *euglyphus* Lapworth. Ruedemann, 1908, N.Y. State Mus. Mem. 11, p. 369–370, text-figs. 315–316, pl. 25, figs. 22, 23.

Diplograptus (*Glyptograptus*) *euglyphus* Lapworth. Ruedemann, 1947, Geol. Soc. America Mem. 19, p. 405–406, pl. 69, figs. 46–50, 55–59.

Glyptograptus teretiusculus var. *euglyphus* (Lapworth). Berry, 1960, Texas Univ. Pub. 6005, p. 88, pl. 15, fig. 8.

Glyptograptus euglyphus (Lapworth). Ross and Berry, 1963, U.S. Geol. Survey Bull. 1134, p. 140, pl. 10, figs. 27, 28; pl. 11, figs. 3, 4.

Discussion: Some of the Idaho specimens are slightly wider (up to 2.5 mm) than *G. euglyphus euglyphus* (2.1 mm wide), and some have 14–12 thecae per centimeter instead of the 7–10 thecae per centimeter of *G. e. euglyphus*. In other respects, however, they fit the description of *G. e. euglyphus,* which is distinguished by its long, slender rhabdosome and widely spaced thecae.

Figured specimen: USNM 189119.

Occurrence: Zone of *Climacograptus bicornis* and passage beds (Phi Kappa Formation, collections 69ICt 92, 69ICt 86, 69ICt 81, 69ICt 79, and 69ICt 78), Trail Creek, Idaho. Zones of *Paraglossograptus tentaculatus* (*Hallograptus etheridgei*) to *Orthograptus amplexicaulis* (Vinini Formation), Nevada and in California (Ross and Berry, 1963). Zones of *Nemagraptus gracilis* and *C. bicornis* (Woods Hollow Shale) in the Marathon region, Texas (Berry, 1960). Normanskill Shale of New York, the Womble Shale of Oklahoma (Stringtown Shale of Ruedemann, 1947), and Arkansas. Zones of *Glyptograptus tere-*

tiusculus to *Climacograptus wilsoni* in Great Britain (Elles and Wood, 1901-18). Zones of *Glyptograptus euglyphus* to *N. gracilis* (Road River Formation) in Yukon Territory, Canada (Jackson and Lenz, 1962).

Glyptograptus(?) sp.

Plate 5, figures 2, 3

Description: The rhabdosome is short (about 2 cm) and very wide, increasing throughout its length from a width of about 1.0 mm proximally to 3.4 mm distally. The thecae are of the *Glyptograptus* type and number 11-8 per centimeter, with marked sigmoid curvature and slightly convex apertural margins perpendicular to the axis of the rhabdosome. The apertural excavations are deep, giving a very serrate appearance to the rhabdosome margins similar to *Glyptograptus sinuatus sinuatus* Nicholson (see Elles and Wood, 1901-18, p. 256, text-fig. 175b).

Discussion: Only 3 specimens of this species are in the collection and none of them have the proximal end preserved. For this reason, the species has not been named. However, its great width is distinctive. *Glyptograptus serratus serratus* Elles and Wood is also very wide (as much as 3.5 mm) but is of Silurian age.

Figured specimens: USNM 189120, USNM 189121.

Occurrence: Zone of *Climacograptus bicornis* (Phi Kappa Formation, collection 69ICt 86), Trail Creek Idaho.

Genus Orthograptus Lapworth, 1873

Orthograptus aff. O. calcaratus calcaratus (Lapworth)

Plate 4, figure 10

Diplograptus foliaceus var. *calcaratus* Lapworth, 1876, Cat. Western Scottish Fossils, p. 6, pl. 1, fig. 30.

Diplograptus (*Orthograptus*) *calcaratus* Lapworth. Elles and Wood, 1901-18, Palaeontological Soc., Mon. British Graptolites, p. 239-241, text-figs. 159a-c, pl. 30, figs. 1a-c.

Diplograptus (*Orthograptus*) *calcaratus* Lapworth. Ruedemann, 1947, Geol. Soc. America Mem. 19, p. 398-399, pl. 68, figs. 21-23.

Orthograptus calcaratus (Lapworth). Ross and Berry, 1963, U.S. Geol. Survey Bull. 1134, p. 144-145, pl. 11, fig. 14.

Description: The rhabdosome is 18 mm long and widens from 1.0 mm wide initially to a maximum of 3.0 mm, which is attained 11 mm from the proximal end and maintained thereafter. The thecae are of the *O. calcaratus* type, numbering 14 per centimeter. The virgella is tiny, and two inconspicuous lateral spines are present on the initial thecae.

Discussion: This form differs from *O. calcaratus calcaratus* in two respects: it has more thecae per centimeter (*O. c. calcaratus* has 10-8 per centimeter), and it lacks the prominent lateral spines and virgella of *O. c. calcaratus*. It fits the description of *O. calcaratus vulgatus* Elles and Wood (1901-18, p. 241) except for the number of thecae per centimeter (approximately 10-8 per centimeter in *O. c. vulgatus*), and it does not appear to widen as abruptly as their illustrated specimens (1901-18, pl. 30, figs. 5a-d). It differs from the remaining subspecies of *O. calcaratus* as described by Elles and Wood (1901-18, p. 242-245) in details of rhabdosome size and thecal spacing. Perhaps it is a new subspecies of *O. calcaratus*, but it is not very distinctive in appearance and has therefore not been named.

Figured specimen: USNM 189123.

Occurrence: Zones of *Nemagraptus* and *Climacograptus bicornis* (Phi Kappa Formation, collections 69ICt 93, 69ICt 86), Trail Creek, Idaho. *O. calcaratus* has been reported from the *C. bicornis* Zone in Nevada (Ross and Berry, 1963), the Polk Creek Shale of Oklahoma (Ruedemann, 1947), and the Zones of *Climacograptus wilsoni* to *Pleurograptus linearis* in Great Britain (Elles and Wood, 1901-18).

Orthograptus calcaratus cf. subsp. tenuicornis Elles and Wood

Plate 4, figure 11

Orthograptus calcaratus var. *tenuicornis* Elles and Wood, 1901-18, Palaeontographical Soc., Mon. British Graptolites, p. 243, text-fig. 163a, b, pl. 30, figs. 4a-c.

Diplograptus (*Orthograptus*) *calcaratus* Lapworth, var. *tenuicornis* Elles and Wood. Harris and Thomas, 1955, Mining Geol. Jour. (Victoria), v. 5, no. 6, p. 36, figs. 33, 34.

Discussion: The Idaho specimens are up to 4.4 cm long, 1.0 mm wide initially, and up to 3 mm wide distally and have 13-10 thecae per centimeter. One specimen (pl. 4, fig. 11) has slender spines about 1.5 mm long on the basal thecae. This agrees with the description and figured specimens given by Elles and Wood (1901-18, p. 243) except for the number of thecae per centimeter, which was implied to be 10-8 per centimeter. Also, the lateral spines are more curved and not as long as those of *O. calcaratus tenuicornis* (7 mm). The figured specimen (pl. 4, fig. 11) also resembles Ross and Berry's (1963, pl. 11, figs. 15, 16) figures of *Orthograptus* cf. *O. calcaratus*.

Figured specimen: USNM 189122.

Occurrence: Zone of *Pleurograptus linearis* (Phi Kappa Formation, collection 69ICt 59), Trail Creek, Idaho. Base of Agort Chert, HD Range, Nevada (Riva, 1970). Zone of *Dicranograptus clingani* (Hart-

fell Shales), Scotland (Elles and Wood, 1901-18). Upper Ordovician from near the Wellington River, Victoria, Australia (Harris and Thomas, 1955).

Orthograptus calcaratus cf. subsp. acutus Elles and Wood

Plate 4, figures 15-17

Diplograptus (Orthograptus) calcaratus var. *acutus* [Lapworth Ms] Elles and Wood, 1901-18, Paleontographical Soc., Mon. British Graptolites, p. 242, pl. 30, figs. 3a-c.

Diplograptus (Orthograptus) calcaratus var. *acutus* Lapworth. Ruedemann, 1947, Geol. Soc. America Mem. 19, p. 399, pl. 68, figs. 14-19.

Orthograptus calcaratus var. *acutus* (Lapworth). Berry, 1960, Texas Univ. Pub. 6005, p. 89, pl. 16, figs. 3, 4.

Orthograptus calcaratus var. *acutus* Elles and Wood. Ross and Berry, 1963, U.S. Geol. Survey Bull. 1134, p. 145, pl. 11, fig. 18, pl. 12, figs. 1, 17.

Description: The specimens are as much as 5 cm long and increase steadily in width from 1.5 mm wide at theca 1^1 through 2.9-3.0 mm wide at theca 5^1 to a maximum width of 4.5 mm. The thecae are of the *O. calcaratus* type, numbering 14-9 per centimeter. There are two short, slender lateral spines on the apertures of the basal thecae. The virgella is stout and 1.6-3.5 mm long, sometimes partially surrounded by a membrane 1.0-1.5 mm long, similar to the sicular downgrowths observed by Bulman (1944-47, p. 69, text-fig. 36) on *Pseudoclimacograptus scharenbergi*. In some specimens, a broad tubelike structure runs through the length of the rhabdosome.

Discussion: According to the original description, this subspecies lacks the large basal spines of *O. calcaratus*. It widens rapidly from 1 mm to 4 mm within 1.5 cm of the proximal end and has 12-9 thecae per centimeter.

The Idaho specimens appear to widen more rapidly than do specimens of *O. c. acutus* illustrated by Elles and Wood (1901-18, p. 30, figs. 3a, b). The British specimens measure 1.5-1.7 mm wide at the level of theca 5^1, whereas the specimens in our collections are 2.9-3.0 mm wide at theca 5^1.

Figured specimens: USNM 189124, USNM 189125, USNM 189126.

Occurrence: Zone of *Climacograptus bicornis* (Phi Kappa Formation, collections 69ICt 92, 69ICt 91, 69ICt 88, and 69ICt 87), Trail Creek, Idaho. *Orthograptus calcaratus acutus* s.s. occurs in: Zones of *Nemagraptus* and *Climacograptus tubuliferus* and passage beds (Phi Kappa Formation, collections 62ICn 472, 69ICt 83, 69ICt 77, and 69ICt 62), Trail Creek, Idaho; Zones of *C. bicornis* and *Orthograptus amplexicaulis* (Palmetto and Toquima Formations, Nevada, and Saturday Mountain(?) Formation, Idaho) (Ross and Berry, 1963); Agort Chert, HD Range, Nevada (Riva, 1970); Zone of *C. bicornis* (Woods Hollow Shale), Marathon region, Texas (Berry, 1960); Normanskill Shale, New York (Ruedemann, 1947); Zone of *Nemagraptus gracilis* (Road River Formation) in northern Yukon Terr., Canada (Jackson and Lenz, 1962); Zones of *N. gracilis* and *Diplograptus multidens* in Great Britain (Elles and Wood, 1901-18).

Orthograptus pageanus pageanus Elles and Wood

Plate 4, figure 3

Diplograptus pageanus Lapworth, *nom. nudum*, 1873, Geol. Mag., v. 10, p. 134.

Diplograptus (Orthograptus) pageanus Lapworth. Elles and Wood, 1901-18, Palaeontographical Soc., Mon. British Graptolites, p. 225-226, text-fig. 147, pl. 28, figs. 3a-c.

Diagnosis: According to Elles and Wood (1901-18, p. 225), the rhabdosome is 2.5-4 cm long and typically somewhat fusiform in shape. It widens from 2 mm initially to a maximum width of 4.5 mm within 1 cm of the proximal end but usually diminishes distally to about 3 mm wide. The thecae number 16-12 per centimeter and are of the *Orthograptus* type, with long, horizontal, somewhat flexed spines. The spines on the basal thecae are especially long (as much as 4 mm).

Discussion: The Idaho specimens closely fit the above description. *O. p. pageanus* resembles *Orthograptus quadrimucronatus* (Hall) but differs from it in being generally shorter and wider proximally and having thecae that are more closely spaced. The long basal spines are also a distinctive feature of *O. p. pageanus*. Ruedemann (1947, p. 455) noted the similarity of this species to *Orthograptus quadrimucronatus cornutus* (Ruedemann) in the general character of the rhabdosome and the basal spines but stated that his species was narrower and had less closely spaced thecae than *O. p. pageanus*. *O. quadrimucronatus cornutus* has much longer thecal spines than *O. p. pageanus* (John Riva, written commun., 1973).

Figured specimen: USNM 189127.

Occurrence: Zone of *Climacograptus bicornis* (Phi Kappa Formation, collection 69ICt 86), Trail Creek, Idaho. Tiser Limestone, HD Range, Nevada (Riva, 1970). Zone of *Dicranograptus clingani* (Hartfell Shales), Scotland (Elles and Wood, 1901-18).

Orthograptus quadrimucronatus quadrimucronatus (J. Hall)

(not figured)

Graptolithus quadrimucronatus J. Hall, 1865, Canada Geol. Survey, Canadian Organic Remains, Decade 2, p. 144-146, pl. 13, figs. 1-10.

Diplograptus (Orthograptus) quadrimucronatus (J.

Hall). Elles and Wood, 1901-18, Palaeontological Soc., Mon. British Graptolites, p. 223-224, text-figs. 145a-f, pl. 28, figs. 1a-d.

Glossograptus (Orthograptus) quadrimucronatus (J. Hall). Ruedemann, 1908, N.Y. State Mus. Mem. 11, p. 385-392, text-fig. 336.

Glossograptus quadrimucronatus (J. Hall). Ruedemann, 1947, Geol. Soc. America Mem. 19, p. 452-454, pl. 78, figs. 1-5.

Orthograptus quadrimucronatus (J. Hall). Berry, 1960, Texas Univ. Pub. 6005, p. 91, pl. 18, fig. 1.

Orthograptus quadrimucronatus (J. Hall). Ross and Berry, 1963, U.S. Geol. Survey Bull. 1134, p. 146-147, pl. 12, figs. 4-6.

Diagnosis: According to Elles and Wood (1901-18, p. 223), the rhabdosome is 7 cm or more in length and widens gradually from an initial width of 1.5 mm to a maximum of about 3.0 mm within 2 cm from the proximal end. The thecae number 12-8 per centimeter, are rectangular in cross section, and have stiff spines projecting from both outer angles of the aperture.

Discussion: Some of the Idaho specimens fit the above description closely. Others are slightly wider (3.5 mm) and have more thecae per centimeter (16-12) and have been designated as *O.* cf. *O. quadrimucronatus quadrimucronatus* (see pl. 4, fig. 5).

Occurrence: Zone of *Climacograptus tubuliferus* and passage beds (Phi Kappa Formation, collections 69ICt 65, 69ICt 82, and 69ICt 83), Trail Creek, Idaho. *O.* cf. *O. q. quadrimucronatus* ranges from the passage beds to the lower *Dicellograptus ornatus* Zone in Idaho (collections 69ICt 55, 69ICt 66, and 69ICt 84). *O. quadrimucronatus quadrimucronatus* is also reported from the Zone of *O. quadrimucronatus* in Nevada (Ross and Berry, 1963); the zone of *O. quadrimucronatus* (Maravillas Chert) in the Marathon region, Texas (Berry, 1960); Sams Spring Formation, Toquima Range, Nevada (Kay, 1962); top of the Agort Chert, HD Range, Nevada (Riva, 1970); the Atwater Creek Shale in New York and the Glouster Shale in Quebec (Ruedemann, 1947); the Zone of *Pleurograptus linearis* (Hartfell Shales) in Scotland (Elles and Wood, 1901-18); the Zone of *O. quadrimucronatus* (Road River Formation) in northern Yukon Terr., Canada (Jackson and Lenz, 1962); upper Caradocian (Road River Formation) in east-central Alaska (Churkin and Brabb, 1965).

Orthograptus quadrimucronatus inequispinosus (Ruedemann)

Plate 4, figure 4

Glossograptus quadrimucronatus mut. *inequispinosus* Ruedemann, 1925, N.Y. State Mus. Bull. 262, p. 66-67, pl. 7 figs. 7-10.

Glossograptus quadrimucronatus var. *inequispinosus* Ruedemann, 1947, Geol. Soc. America Mem. 19, p. 455-456, pl. 79, figs. 16-19.

Diagnosis: According to the original description, this subspecies is similar to *O. quadrimucronatus quadrimucronatus* except for the presence of double length spines (2 mm or more) on the sixth or seventh and sometimes the fifth pair of thecae. The rhabdosome is as much as 40 mm long, is 2.5 mm wide, and has 14-10 thecae per centimeter.

Discussion: The Idaho specimens closely fit the above description. *Orthograptus quadrimucronatus spinigerus* Lapworth is similar to this subspecies but has longer spines (5 mm or more), and they are on the tenth thecal pair.

Figured specimen: USNM 189130.

Occurrence: Passage beds (Phi Kappa Formation, collections 69ICt 78, 69ICt 76), Trail Creek, Idaho. The Utica Shale of New York (Ruedemann, 1925).

Genus Petalograptus Suess, 1851

Petalograptus minor Elles

Plate 3, figure 10

Petalograptus minor Elles, 1897, Quart. Jour. Geol. Soc. London, v. 53, p. 201, pl. 14, figs. 17-21.

Petalograptus minor Elles. Elles and Wood, 1901-18, Palaeontographical Soc., Mon. British Graptolites, p. 279-281, text-figs. 193a, b, pl. 32, figs. 5a-e.

Petalograptus minor Elles. Churkin and Carter, 1970, U.S. Geol. Survey Prof. Paper 653, p. 32, text-figs. 13E, F, pl. 3, fig. 5.

Petalograptus minor Elles. Rickards, 1970, Palaeontographical Soc. Mon., Llandovery graptolites of Howgill Fells, p. 48, pl. 3, figs. 3, ?6, ?7.

Discussion: The Idaho specimens are 6.5-10 mm long, 2.7-3.5 mm wide, and have 14-12 thecae per centimeter, which is in agreement with published descriptions of *P. minor.* The shape and size of its rhabdosome and proximal end serve to distinguish P. minor from immature specimens of *Petalograptus palmeus* (Barrande).

Figured specimen: USNM 189131.

Occurrence: Zone of *Monograptus convolutus* (Phi Kappa Formation, collection 69ICt 31), Trail Creek, Idaho. Zone of *Monograptus gregarius* (Descon Formation), Noyes Island, southeast Alaska (Churkin and Carter, 1970). Zones of *M. gregarius* and *M. convolutus* (Birkhill Shales) in Great Britain (Elles and Wood, 1901-18).

Genus Pseudoclimacograptus Pribyl, 1947

Pseudoclimacograptus scharenbergi scharenbergi (Lapworth)

Plate 3, figure 6

Climacograptus scharenbergi Lapworth, 1876, Cat. Western Scottish Fossils, pl. 2, fig. 55.

Climacograptus scharenbergi Lapworth. Elles and Wood, 1901-18, Palaeontographical Soc., Mon. British Graptolites, p. 206-208, text-figs. 139a-c, pl. 27, figs. 14a-e.

Climacograptus scharenbergi Lapworth. Ruedemann, 1908, N.Y. State Mus. Mem. 11, p. 428-431, text-figs. 394-399, pl. 28, fig. 31.

Climacograptus scharenbergi Lapworth. Bulman, 1944-47, Palaeontographical Soc. Mon., Caradoc Graptolites in Laggan Burn, p. 65-70, pl. 7, figs. 1-10, pl. 8, figs. 1, 5-7, text-figs. 34-38.

Climacograptus scharenbergi Lapworth. Ruedemann, 1947, Geol. Soc. America Mem. 19, p. 438-439, pl. 74, fig. 41-54.

Climacograptus scharenbergi Lapworth. Ross and Berry, 1963, U.S. Geol. Survey Bull. 1134, p. 129-130, pl. 9, figs. 14, 17.

Climacograptus scharenbergi Lapworth. Berry 1964, Norsk Geol. Tidssk., B. 44, H. 1, p. 137-139, pl. 13, fig. 8.

Pseudoclimacograptus scharenbergi (Lapworth). Riva, 1974b, Palaeont., v. 17, pt. 1, p. 27-29, text-figs. 8c-h, pl. 2, figs. 4, 5.

Discussion: Because the Idaho specimens are compressed, the zigzag septal groove characteristic of *P. s. scharenbergi* is not preserved, but the introversion of their thecal apertures, the alternate arrangement of their thecae, and the dimensions of their rhabdosomes identify them as *P. s. scharenbergi.*

Figured specimen: USNM 189132.

Occurrence: Zone of *Climacograptus bicornis* (Phi Kappa Formation, collection 69ICt 91), Trail Creek, Idaho. Zone of *C. bicornis* in Nevada (Ross and Berry, 1963). Middle Ordovician McAfee Quartzite, Independence Range, Nevada (Churkin and Kay, 1967). Sams Spring Formation, Toquima Range, Nevada (Kay, 1962). Zone of *Orthograptus amplexicaulis* (Maravillas Chert) in the Marathon region, Texas (Berry, 1960). Lower Caradocian (Road River Formation) in east-central Alaska (Churkin and Brabb, 1965). The Normanskill Shale in New York (Ruedemann, 1947). Zone of *Diplograptus multidens* (Quebec City Formation) in Quebec (Riva, 1974b). Zones of *Didymograptus bifidus*(?) to *Climacograptus wilsoni* in Great Britain (Elles and Wood, 1901-18). Zones of *Didymograptus murchisoni* and *Glyptograptus teretiusculus* (*Ogygiocaris* series) in the Oslo region, Norway (Berry, 1964).

Family LASIOGRAPTIDAE

Genus Neurograptus Elles and Wood, 1908

Neurograptus margaritatus (Lapworth)

Plate 3, figure 9

Lasiograptus margaritatus Lapworth, 1876, Cat. Western Scottish Fossils, pl. 2, fig. 60.

Lasiograptus (*Neurograptus*) *margaritatus* (Lapworth). Elles and Wood, 1901-18, Palaeontographical Soc., Mon. British Graptolites, p. 332-333, text-figs. 219a, b, pl. 34, figs. 6a-e.

Diagnosis: According to Elles and Wood (1901-18, p. 332-333), the rhabdosome is about 1.5 cm long, with an average uniform width of 1.5 mm (exclusive of the lacinia). The thecae are of the *Hallograptus* type, alternate, and number 14-12 per centimeter. The lacinia is delicate and continuous.

Discussion: This species is represented in our collections by only one specimen. It is somewhat wider (about 2.5 mm) than the width reported by Elles and Wood (1901-18), but measurement of their figures (pl. 34, figs. 6a-e) reveals a width of 2.5-3.0 mm. *Neurograptus fibratus* (Lapworth) resembles *N. margaritatus* but is a much larger form and has a thinner periderm; consequently, its clathria is much more pronounced than that of *N. margaritatus.*

Figured specimen: USNM 189133.

Occurrence: Passage beds (Phi Kappa Formation, collection 69ICt 84), Trail Creek, Idaho. Zone of *Dicranograptus clingani* (Point Leamington Greywacke) in Newfoundland (Bergstrom and others, 1974). Zone of *D. clingani* (Hartfell Shales) in Scotland (Elles and Wood, 1901-18).

Family RETIOLITIDAE

Genus Orthoretiolites Whittington, 1954

Orthoretiolites hami robustus Skevington

Plate 4, figure 6

Orthoretiolites hami var. *robustus* Skevington, 1960, Palaeontology, v. 2, p. 226-235, text-figs. 1-4, pl. 34,35.

Orthoretiolites hami robustus Skevington. Carter, 1972, Jour. Paleontology, v. 46, p. 49, text-figs. 2 P, Q, pl. 1, figs, 13,14.

Discussion: The figured specimen (pl. 4, fig. 6) is much longer (2.5 cm) than any previously described specimen of this form. It is 1.0 mm wide proximally and 2.5 mm wide distally, exclusive of spines. There are 9 thecae in 5 mm proximally and 12 thecae per centimeter distally. The apertural spines measure 1-1.5 mm long.

Figured specimen: USNM 189129.

Occurrence: Zone of *Climacograptus tubuliferus* (Phi Kappa Formation, collections 69ICt 73 and 69ICt 72), Trail Creek, Idaho. Jacks Peak Formation, northern Independence Range, Nevada (Churkin and Kay, 1967; Carter, 1972). Ordovician Viola Limestone in the Criner Hills, Oklahoma (Skevington, 1960).

Suborder MONOGRAPTINA

Family MONOGRAPTIDAE

Genus Monograptus Geinitz, 1852

Monograptus convolutus (Hisinger)

Plate 5, figure 11

Prionotus convolutus Hisinger, 1837, Lethaea Suecica Supp., p. 114, pl. 35, fig. 7.

Graptolithus convolutus (Hisinger). Carruthers, 1868, Geol. Mag., v. 5, p. 127, pl. 5, fig. 1.
Monograptus convolutus (Hisinger). Törnquist, 1899, Lunds Univ. Arsskr., v. 35, no. 1. p. 21-22, pl. 4, figs. 15-22.
Monograptus convolutus (Hisinger). Elles and Wood, 1901-18, Palaeontographical Soc., Mon. British Graptolites, p. 467-469, text-figs. 324a, b, pl. 47, figs. 1a-d.
Dimirastrites convolutus (Hisinger). Přibyl and Münch, 1941, Rozpr. České Akad., v. 51, no. 31, p. 15-17, pl. 1, figs. 9-10, pl. 3, figs. 7-9.
Monograptus convolutus (Hisinger). Sudbury, 1958, Philos. Trans. Royal Soc. London, Ser. B, no. 685, v. 241, p. 511-513, text-fig. 13, pl. 21, figs. 76-78.
Monograptus convolutus (Hisinger). Churkin, 1963, Am. Assoc. Petroleum Geologists Bull., v. 47, p. 1621, pl. 3, fig. 36.
Monograptus convolutus (Hisinger). Rickards, 1970, Palaeontographical Soc. Mon., Llandovery Graptolites of Howgill Fells, p. 82-83, text-fig. 13, fig. 15.

Discussion: M. convolutus is distinguished from most monograptids by its spirally coiled rhabdosome. *Monograptus spiralis* (Geinitz) has a spiral rhabdosome but differs from *M. convolutus* in having triangular-shaped thecae throughout its length. The thecae of *M. convolutus* are *Rastrites*-like in the proximal part of the rhabdosome, changing to triangular-shaped distally.

Figured specimens: USNM 189135.

Occurrence: Zone of *Monograptus convolutus* (Phi Kappa Formation, collection 69ICt 31), Trail Creek, Idaho. Zones of *Monograptus gregarius* and *M. convolutus* (Gatecliff Formation), Toiyabe Range, Nevada (Kay and Crawford, 1964). Zone of *M. convolutus* to *Monograptus sedgwickii* (Road River Formation), northern Yukon Territory, Canada (Jackson and Lenz, 1962). Zones of *M. convolutus* and *M. sedgwickii* in Great Britain (Sudbury, 1958). Zones of *M. convolutus* to *Rastrites maximus* (Birkhill Shales) in Scotland (Toghill, 1968). Zone of *M. convolutus* (Stockdale Shales), Howgill Fells, northern England (Rickards, 1970). Zones of *Diplograptus folium* and *Diplograptus cometa* at Tomarp, Sweden (Törnquist, 1899).

Monograptus cf. M. decipiens decipiens Törnquist

Plate 5, figures 9, 10

Monograptus decipiens Törnquist, 1899, Lunds Univ. Arsskr., v. 35, no. 1, p. 20-21, pl. 4, figs. 9-14.
Monograptus decipiens Törnquist. Elles and Wood, 1901-18, Palaeontographical Soc., Mon. British Graptolites, p. 469-470, text-fig. 325a (not b-d), pl. 47, figs. 3a?, b, e (not 3c, d).
Demirastrites decipiens decipiens (Törnquist). Přibyl and Münch, 1941, Rozpr. České Akad., v. 51, no. 31, p. 13-14, text-fig. 1, fig. 6
Monograptus decipiens Törnquist. Sudbury, 1958, Philos. Trans. Royal Soc. London, Ser. B, no. 685, v. 241, p. 510-511, pl. 21, figs. 74, 75.
Monograptus decipiens Törnquist. Rickards, 1970, Palaeontographical Soc. Mon., Lland. Graptolites of Howgill Fells, p. 83, text-fig. 13, fig. 16, text-fig. 17, fig. 8, text-fig. 18, fig. 3.

Diagnosis: According to the original description, the rhabdosome initially forms a spiral of at most two involutions and continues in an arcuate manner tending to become straight. It increases in width from 1 mm to 1.5 mm. The thecae are located on the convex margin of the rhabdosome and number 10 per centimeter. Proximally they are tubular and isolate as in *Rastrites,* gradually becoming subtriangular distally. All the thecae terminate in a reflexed lobe.

Discussion: Rickards (1970, p. 83) cited a maximum width of 1.4 mm and a thecal spacing of 8-11 per centimeter for this species. Sudbury (1958, p. 511) stated that the early thecae are about 0.45-1.0 mm high and rastritiform until about the eighth or tenth theca, after which they become more triangular. She also stated that the maximum rhabdosome width observed was 1.7 mm and that the thecae number 10 per centimeter. The proximal thecae of the Idaho specimens are 0.6-1.0 mm high and number 10 per centimeter. They increase to 1.5 mm high distally and exhibit the characteristics of *M. decipiens*. However, the Idaho specimens are all fragmentary, and it is difficult to identify the various spiral monograptids from fragmentary material. They differ from *Monograptus urceolus* Richter sensu Elles and Wood, which has 11-12 thecae per centimeter and an irregularly coiled rhabdosome. *M. convolutus* is much wider and has as many as five whorls in its spiral rhabdosome.

Figured specimens: USNM 189140, USNM 189141.

Occurrence: Zone of *M. convolutus* (Phi Kappa Formation, collections 69ICt 32, 69ICt 31), Trail Creek, Idaho. Zones of *Monograptus gregarius* to *M. sedgwickii* in Great Britain (Elles and Wood, 1901-18). Zone of *M. convolutus* (Stockdale Shales), Howgill Fells, northern England (Rickards, 1970). Zones of *M. gregarius* and *M. convolutus* in Great Britain (Sudbury, 1958). Zone of *Diplograptus cometa* (Scanian *Rastrites* beds) at Tomarp, Sweden (Tornquist, 1899).

Monograptus cf. M. flemingii flemingii (Salter)

Plate 5, figures 6-8

Graptolithus flemingii Salter, 1852, Quart. Jour. Geol. Soc. London, v. 8, p. 390, pl. 21, figs. 5a, b, 6, 7a, b.
Monograptus flemingii (Salter). Elles and Wood, 1901-18, Palaeontographical Soc., Mon. British Graptolites, p. 425-426, text-figs. 287a-d, pl. 42, figs. 5a-d.

Diagnosis: According to Elles and Wood (1901-18, p. 425), the rhabdosome is straight or slightly flexed,

reaches a length of 17 cm or more, has a recurved proximal portion, and widens gradually to a maximum width of 2.5 mm. The sicula is about 1.6 mm long. The thecae number 14-9 per centimeter and have abruptly narrowing apertural regions which commonly bear a short spine, giving the appearance of a beak. The whole beak occupies from one-fifth (proximally) to one-third (distally) of the total width of the rhabdosome.

Discussion: The Idaho specimens are as much as 7 cm long, 0.8 mm wide proximally, and 2.2-3.2 mm wide distally. They have 12-8 thecae per centimeter and siculae measuring 1.2-2.0 mm long. In comparison to Elles and Wood's figured specimens (1901-18, pl. 42, figs. 5a-d), they have more slender, slightly more recurved proximal ends. They resemble *Monograptus priodon* (Bronn), but *M. priodon* has a straight, rigid rhabdosome and widens much more slowly.

Figured specimens: USNM 189136, USNM 189137, USNM 189138.

Occurrence: Upper Llandoverian and Wenlockian (Phi Kappa Formation, collection 69ICt 21), Trail Creek, Idaho. Wenlock Zones of *Monograptus flexilis belophorus* (=*Cyrtograptus rigidus)* through *Cyrtograptus lundgreni* in northern England (Rickards, 1967). Also reported from the Trail Creek area by Bassler (1915). Jackson and Lenz (1962) identified *M.* cf. *M. flemingii* from a horizon between the Zones of *Cyrtograptus lundgreni* and *Monograptus riccartonensis* (Road River Formation) in Yukon Territory, Canada.

Monograptus sedgwickii (Portlock)

Plate 5, figure 4

Graptolithus (*Prionotus*) *Sedgwickii* Portlock, 1843, Rept. Geology of Londonderry, p. 318, pl. 19, fig. 1.

Monograptus Sedgwickii (Portlock). Elles and Wood, 1901-18, Palaeontographical Soc., Mon. British Graptolites, p. 441-443, text-figs. 304a-e, pl. 44, figs. 10a-f.

Monograptus sedgwickii (Portlock). Rickards, 1970, Palaeontographical Soc. Mon., Llandovery Graptolites of Howgill Fells, p. 73-74, text-fig. 14, fig. 34.

Diagnosis: According to Elles and Wood (1901-18, p. 441), the rhabdosome is straight or slightly flexed, reaches 20 cm or more in length, and widens gradually to a maximum width of 3 mm exclusive of spines. The thecae number 10-6 per centimeter and have isolate, retroverted apertural regions that occupy about one-half the width of the rhabdosome. The apertural margin is spined, with the spine becoming more conspicuous distally.

Discussion: M. sedgwickii may be distinguished from *Monograptus halli* (Barrande) by its less rapidly increasing width, its more flexuous rhabdosome, and its more strongly retroverted thecal apertures.

Figured specimen: USNM 189139.

Occurrence: Zone of *Monograptus convolutus* (Phi Kappa Formation, collection 69ICt 32), Trail Creek, Idaho. Zones of *Monograptus sedgwickii* and *Rastrites maximus* (Birkhill Shales), Dobbs Linn, Scotland (Toghill, 1968). Zone of *M. sedgwickii* (Stockdale Shales), Howgill Fells, northern England (Rickards, 1970).

Family CYRTOGRAPTIDAE

Genus Cyrtograptus Carruthers, 1867

Cyrtograptus kirki Ruedemann

Plate 6, figure 1

Cyrtograptus kirki Ruedemann, 1947, Geol. Soc. America Mem. 19, p. 495, pl. 89, figs. 4, 12 (not figs. 1-3, 5-11, 13, 14).

Ruedemann (1947, pl. 89, figs. 1-14) included two separate species in his orginal description and illustrations of *C. kirki* from Trail Creek. Since he did not designate a holotype, the problem arises as to which of the two species should be designated as *C. kirki.* As one of the species (*Cyrtograptus laqueus* Jackson and Etherington) has subsequently been described elsewhere, it has been decided to restrict the name *C. kirki* to the species most nearly represented by Ruedemann's reconstructions[2] (1947, pl. 89, figs. 13, 14).

Revised description: The rhabdosome measures about 10 cm across and has numerous cladia, of one or two generations, separated by two to nine thecae. The main stipe is coiled in an irregular spiral through 2½ volutions, being more tightly coiled proximally and becoming nearly straight distally. The first volution is a loop formed when the stipe crosses itself near the sicula. The diameter of the last volution is 1.0-1.5 cm. The main stipe is more than 9 cm long and widens from about 0.5 mm proximally to 1.0-1.5 mm wide near the point of origin of the first cladium, between th^{23} and th^{32}. The cladia are strongly dorsally curved and measure 1.3-1.5 mm wide; they are as much as 8 cm long and have 8-10 thecae per centimeter. The first thecal segment of each cladium is 2.3-3.0 mm long. The thecae on the main stipe are triangular, with hooked apertural regions and apertural spines. Cladial thecae are less strongly hooked and more beaklike but generally are seen in profile only near the origin of the cladium.

The maximum number of primary cladia observed on a single rhabdosome is eight. One specimen (pl. 6,

[2]Those reconstructions do, however, misrepresent the nature of the proximal portion of *C. kirki.*

fig. 1) has three secondary cladia on the third primary cladium. The proximal part of the main stipe is narrow, and the proximal thecae are smaller and more widely spaced than the distal thecae. Initially, the main stipe is nearly straight, then curves to cross itself near the sicular end, forming a loop. It continues to coil for another 1½ volutions, becoming nearly straight distally.

Discussion: C. kirki resembles *Cyrtograptus canadensis* Jackson and Etherington but differs in having more irregular spacing between cladia, shorter initial thecal segments in its cladia, narrower stipes, and an irregularly coiled main stipe with a smaller diameter of the last volution.

Bouček and Přibyl (1952, p. 183-185) described *C. kirki* as a subspecies of *Cyrtograptus multiramis* Törnquist and designated as lectotype the specimen figured by Ruedemann (1947) in pl. 89, fig. 12. However, this was done largely on the basis of the long, thin, loop-shaped proximal parts of specimens figured by Ruedemann in pl. 89, figs. 3, 4, 9-11 (1947), and further examination has convinced this writer that one of those specimens (pl. 89, fig. 11) is actually *Cyrtograptus laqueus*. Bouček and Přibyl's figures of *C. multiramis multiramis* (1952, pl. I, fig. 1, text fig. 1b) show that that species has fewer volutions in its spiral main stipe than does *C. kirki* and its cladia are not bent back as far. Otherwise, the two species are quite similar. However, the form described and illustrated by Bouček and Přibyl as *C. multiramis kirki* (1952, p. 183-185, pl. I, fig. 2, text-figs. 1c-d) has many more secondary cladia than the Idaho species. Only one of Ruedemann's original specimens has any secondary cladia, and it has only three, located on the third primary cladium. Therefore, *C. kirki* may indeed be a subspecies of *C. multiramis,* but it is not the same form as *C. multiramis kirki* of Bouček and Přibyl.

Figured specimen: USNM 219002.

Occurrence: Upper Llandoverian and Wenlockian (Phi Kappa Formation, collection 69ICt 21), Trail Creek, Idaho.

Cyrtograptus laqueus Jackson and Etherington

Plate 6, figure 3

Cyrtograptus kirki Ruedemann, 1947, Geol. Soc. America Mem. 19, pl. 89, fig. 11.

Cyrtograptus laqueus Jackson and Etherington, 1969, Jour. Paleontology, v. 43, no. 5, pt. I, p. 1119-1121, pl. 130, figs. 1-3, text-figs. 4A, B.

Diagnosis: According to the original description, the rhabdosome is up to 9 cm across, with usually two, but occasionally with as many as five, simple cladia. The coiled main stipe is up to 5 cm long, with the proximal 10 mm almost straight; therefore, the stipe crosses itself, forming a loop. The cladia are dorsally curved, and the first cladium is given off the main stipe between th^{12} and th^{15}. Subsequent cladia are separated by 3-5 thecae. The first thecal segment of each cladium is 2.0-2.5 mm long and 1.1 mm wide across the aperture. Cladia attain a maximum width of 1.3 mm. Proximal thecae on the main stipe are subtriangular with hooked apertural portions. Distal thecae on the main stipe and all cladial thecae are straight walled, with slightly reflexed distal margins. Width of thecae at the aperture level increases from 0.4 mm proximally to a maximum of 1.5 mm. Thecae number seven to eight per centimeter.

Discussion: The specimens from Idaho closely fit the above description with only minor differences. The first cladium is given off the main stipe between approximately th^{21} and th^{23} in the Idaho specimens. Also, the first cladial thecae are somewhat longer (2.5-3.3 mm) and wider (1.2-1.4 mm).

C. laqueus can be distinguished from other cyrtograptids by its loop-shaped main stipe and small number of cladia.

Figured specimen: USNM 219003.

Occurrence: Upper Llandoverian and Wenlockian (Phi Kappa Formation, collection 69ICt 21), Trail Creek, Idaho. Zone of *Monograptus spiralis* into basal Wenlockian at Clearwater Creek, Northwest Territories, Canada (Jackson and Etherington, 1969).

Cyrtograptus rigidus rigidus Tullberg

Plate 5, figure 5; plate 6, figure 4; plate 7, figure 6

Cyrtograptus rigidus Tullberg, 1883, Skånes Graptoliter II, p. 38, pl. 4, figs. 12-14.

Cyrtograptus symmetricus Elles. Elles and Wood, 1901-18, Palaeont. Soc., Mon. British Graptolites, p. 509 [parts], pl. 51, figs. 5a, b, text-fig. 355 (not pl. 51, fig. 5c).

Cyrtograptus rigidus Tullberg. Gortani, 1922, Palaeont. italica, vol. 28, p. 59-61, pl. 11 [4], figs. 5-11, pl. 13 [6], figs. 4D, D', 6A, A'.

Description: The rhabdosome is small, rarely more than 3 cm across, with a single simple cladium. The main stipe is coiled proximally into a spiral of one-half or one volution, becoming nearly straight distally. The thecae occur on the convex side of the stipe proximally; usually beyond the cladium the stipe twists 90°-180° in such a way that the thecae are obscured or lie on the concave side.

The single cladium is straight or gently curved dorsally (toward the distal end of the main stipe) and is as much as 4.5 cm long. It is given off the main stipe between th^{7} and th^{9} and measures 1.2-1.5 mm

wide. The first thecal segment of the cladium is 2.1-2.8 mm long and 1.2-1.5 mm wide at the level of the aperture. There are 8½-10 thecae per centimeter on the cladium.

Proximally, the thecae on the main stipe are triangular, with hooked apertural portions and short apertural spines. Distally, the amount of apertural hooking decreases, so that the thecae become beak-like to nearly tubular. The thecae on the cladium are similar to those on the distal part of the main stipe.

Discussion: The proximal spiral of the main stipe must have been somewhat helical (not in a single plane) because the compressed specimens from Idaho always have broken or twisted proximal portions, and so the sicula and first few thecae are lying at an acute angle to the main direction of the stipe.

Figured specimens: USNM 189142, USNM 219004, USNM 219005.

Occurrence: Upper Llandoverian and Wenlockian (Phi Kappa Formation, collection 69ICt 21), Trail Creek, Idaho. Middle Wenlock Zone of *C. rigidus* (=*C. symmetricus*) in Great Britain (Elles and Wood, 1901-18).

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[Italic page numbers indicate both major references and descriptions]

PLATES 1-7

Contact photographs of the plates in this report are available, at cost, from U.S. Geological Survey Library, Federal Center, Denver, Colorado 80225

PLATE 1

FIGURE 1. *Loganograptus logani pertenuis* Ruedemann (p. 13) USNM 189095, x 5.1, collection 62ICn 511.

2,3. *Phyllograptus anna prolatus* n. subsp. (p. 14)
2. USNM 189143, x 5.0, holotype, collection 62ICn 511.
3. USNM 189144, x 5.1, collection 62ICn 511.

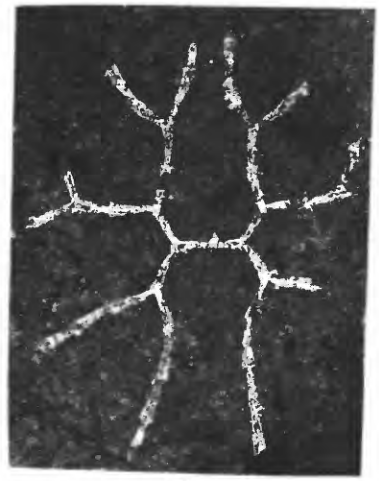
4. *Phyllograptus ilicifolius major* Ruedemann (p. 14)
USNM 189145, x 2.5, collection 62ICn 511.

5,8. *Didymograptus protobifidus* Elles (p. 15)
5. USNM 189147, x 4.9, collection 62ICn 511.
8. USNM 189148, x 5.0, collection 62ICn 511.

6. *Isograptus* sp. (p. 16)
USNM 219001, x 5.1, collection 62ICn 521.

7. *Tetragraptus pseudobigsbyi* Skevington (p. 14)
USNM 189134, x 5.1, collection 62ICn 511.

9. *Didymograptus* cf. *D. gemminus* (Hisinger) (p. 15)
USNM 189146, x 2.8, collection 62ICn 511.



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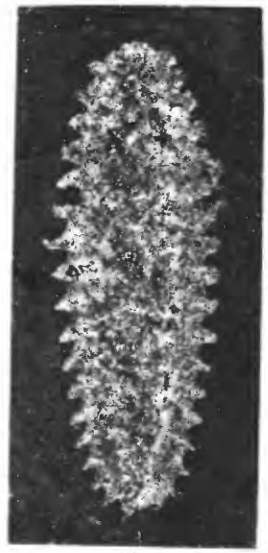

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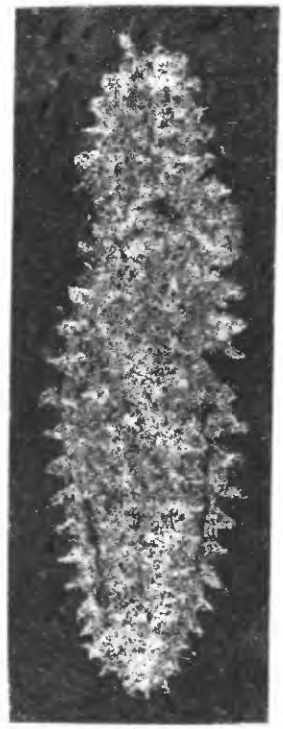

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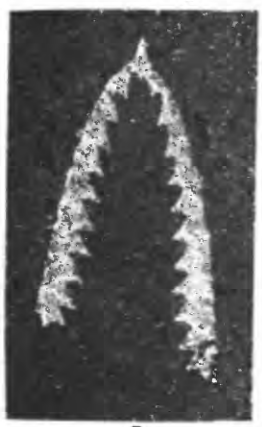

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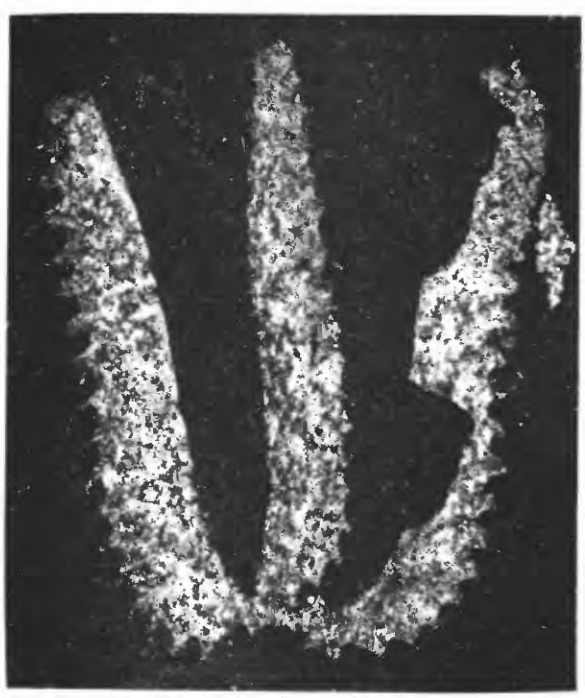

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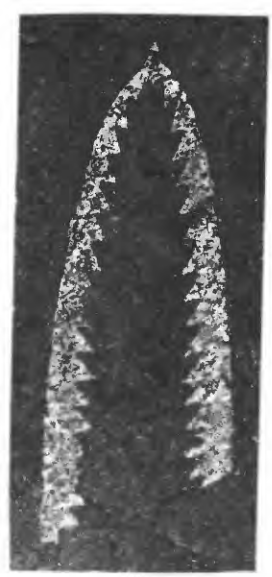

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LOGANOGRAPTUS, PHYLLOGRAPTUS, DIDYMOGRAPTUS, ISOGRAPTUS, AND *TETRAGRAPTUS*

PLATE 2

FIGURE 1. *Leptograptus demissus* n.sp. (p. 16)
USNM 189085, x 4.7, holotype, collection 69ICt 59.

2. *Dicellograptus* cf. *D. elegans elegans* (Carruthers) (p. 19)
USNM 189097, x 5.1, collection 69ICt 79.

3. *Leptograptus* n.sp.? (p. 17)
USNM 189086, x 4.9, collection 69ICt 71.

4. *Pleurograptus linearis linearis* (Carruthers)(p. 17)
USNM 189087, x 1.0, collection 69ICt 59.

5. *Dicellograptus divaricatus bicurvatus* Ruedemann (p. 19)
USNM 189096, x 4.8, collection 69ICt 92.

6. *Dicranograptus contortus* Ruedemann (p. 17)
USNM 189088a (left), USNM 189088b (right), x 4.6, collection 69ICt 88.

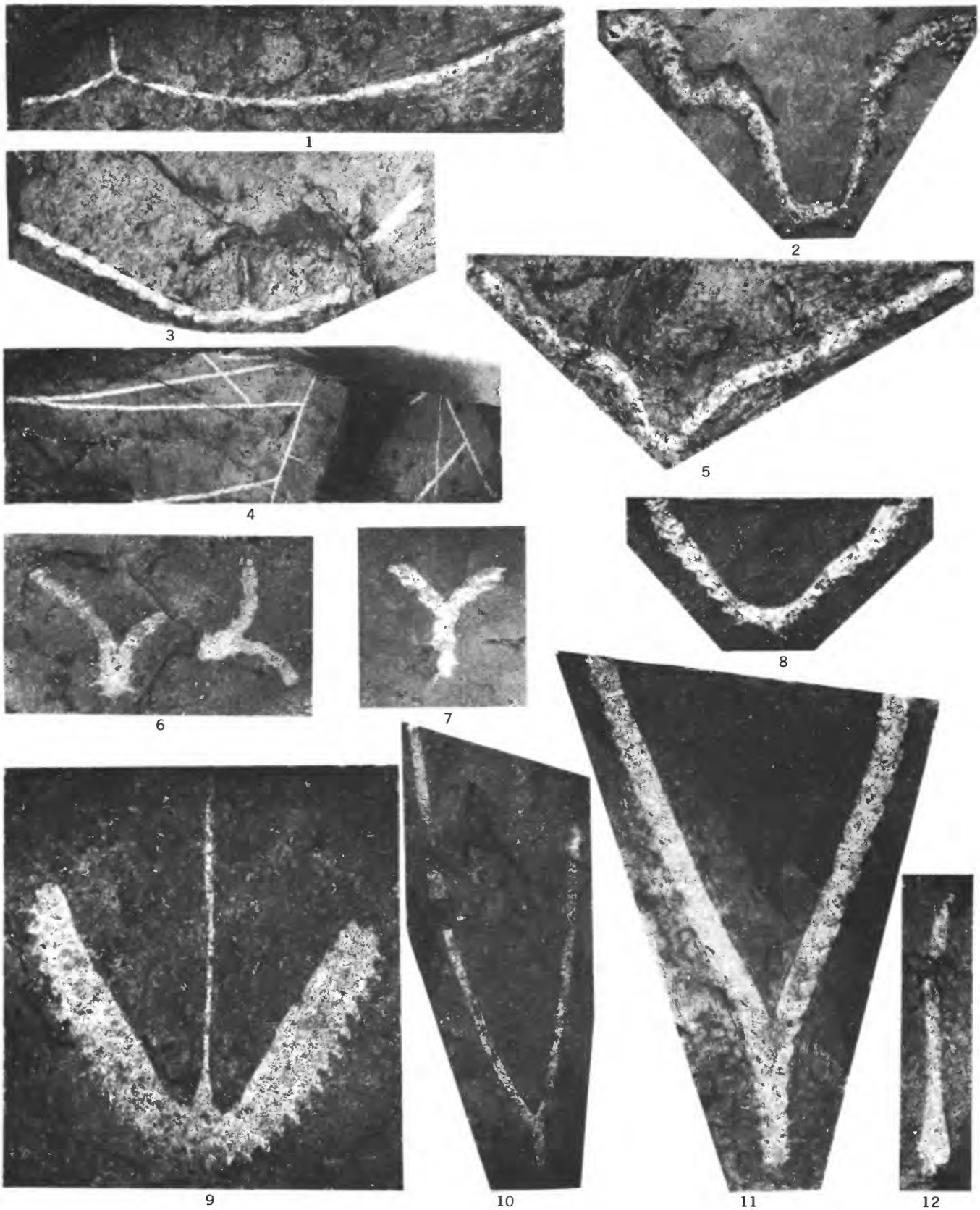
7. *Dicranograptus* cf. *D. kirki* Ruedemann (p. 18)
USNM 189089, x 4.8, collection 69ICt 86.

8. *Dicellograptus* cf. *D. elegans rigens* Elles and Wood (p. 20)
USNM 189098, x 4.5, collection 69ICt 74.

9. *Isograptus* aff. *I. victoriae* Harris (p. 15)
USNM 189111, x 5.1, collection 62ICn 511.

10,11. *Dicranograptus nicholsoni nicholsoni* Hopkinson (p. 18)
10. USNM 189091, x 1.3, collection 69ICt 88.
11. USNM 189090, x 4.7, collection 69ICt 91.

12. *Corynoides calicularis* Nicholson (p. 16)
USNM 189084, x 5.0, collection 69ICt 88.



LEPTOGRAPTUS, DICELLOGRAPTUS, PLEUROGRAPTUS, DICRANOGRAPTUS, ISOGRAPTUS, AND *CORYNOIDES*

PLATE 3

FIGURE 1. *Dicellograptus* cf. *D. angulatus* Elles and Wood (p. 19)
USNM 189105, x 4.8, collection 69ICt 63.

2,3. *Dicellograptus* n.sp.(?) (p. 20).
2. USNM 189104, x 5, collection 69ICt 77.
3. USNM 189103, x 4.7, collection 69ICt 77.

4. *Glossograptus hincksii hincksii* (Hopkinson) (p. 21)
USNM 189107, x 4.6, collection 69ICt 91.

5. *Cryptograptus tricornis* Carruthers (p. 21)
USNM 189108, x 4.8, collection 69ICt 91.

6. *Pseudoclimacograptus scharenbergi scharenbergi* (Lapworth) (p. 27) USNM 189132, x 4.9, collection 69ICt 91.

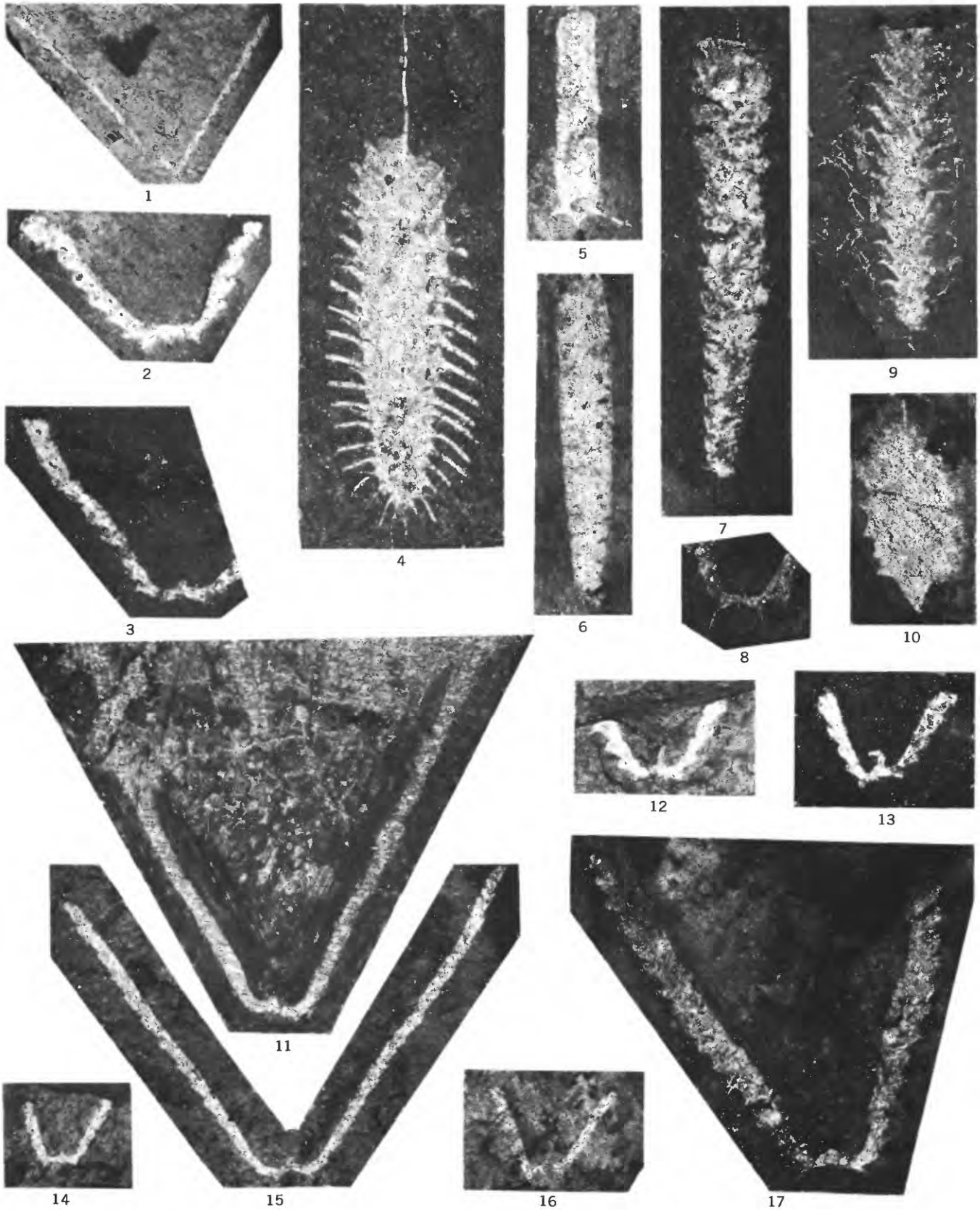
7. *Diplograptus* sp. (p. 22)
USNM 189109, x 5.1, collection 69ICt 86.

8,12,13,17. *Dicellograptus alector* Carter (p. 18).
8. USNM 189093b, x 5.1, collection 69ICt 73.
12. USNM 189094, x 4.8, collection 69ICt 61.
13. USNM 189092, x 4.8, collection 69ICt 73.
17. USNM 189093a, x 5.1, collection 69ICt 73.

9. *Neurograptus margaritatus* (Lapworth) (p. 28)
USNM 189133, x 4.6, collection 69ICt 84.

10. *Petalograptus minor* Elles (p. 27)
USNM 189131, x 5.2, collection 69ICt 31.

11,14,15,16. *Dicellograptus* cf. *D. ornatus minor* Toghill (p. 20)
11. USNM 189101, x 5.2, collection 69ICt 44.
14. USNM 189100, x 4.2, collection 69ICt 55.
15. USNM 189102, x 5.1, collection 69ICt 59.
16. USNM 189099, x 4.7, collection 69ICt 55.



DICELLOGRAPTUS, GLOSSOGRAPTUS, CRYPTOGRAPTUS, PSEUDOCLIMACOGRAPTUS, DIPLOGRAPTUS, NEUROGRAPTUS, AND *PETALOGRAPTUS*

PLATE 4

FIGURE 1,2. *Climacograptus? uncinatus* Keble and Harris (p. 24)
1. USNM 189117, x 4.7 (tectonically stretched lengthwise), collection 69ICt 41.
2. USNM 189116, x 4.7, collection 69ICt 59.

3. *Orthograptus pageanus pageanus* Elles and Wood (p. 26) USNM 189127, x 5.0, collection 69ICt 86.
4. *Orthograptus quadrimucronatus inequispinosus* (Ruedemann)(p. 27) USNM 189130, x 4.9, collection 69ICt 78.
5. *Orthograptus* cf. *O. quadrimucronatus quadrimucronatus* (J. Hall) (p. 26) USNM 189128, x 4.7, collection 69ICt 55.
6. *Orthoretiolites hami robustus* Skevington (p. 28) USNM 189129, x 4.5, collection 69ICt 72.
7. *Climacograptus hastatus* T. S. Hall (p. 22) USNM 189118, x 4.7, collection 69ICt 42, immature specimen.

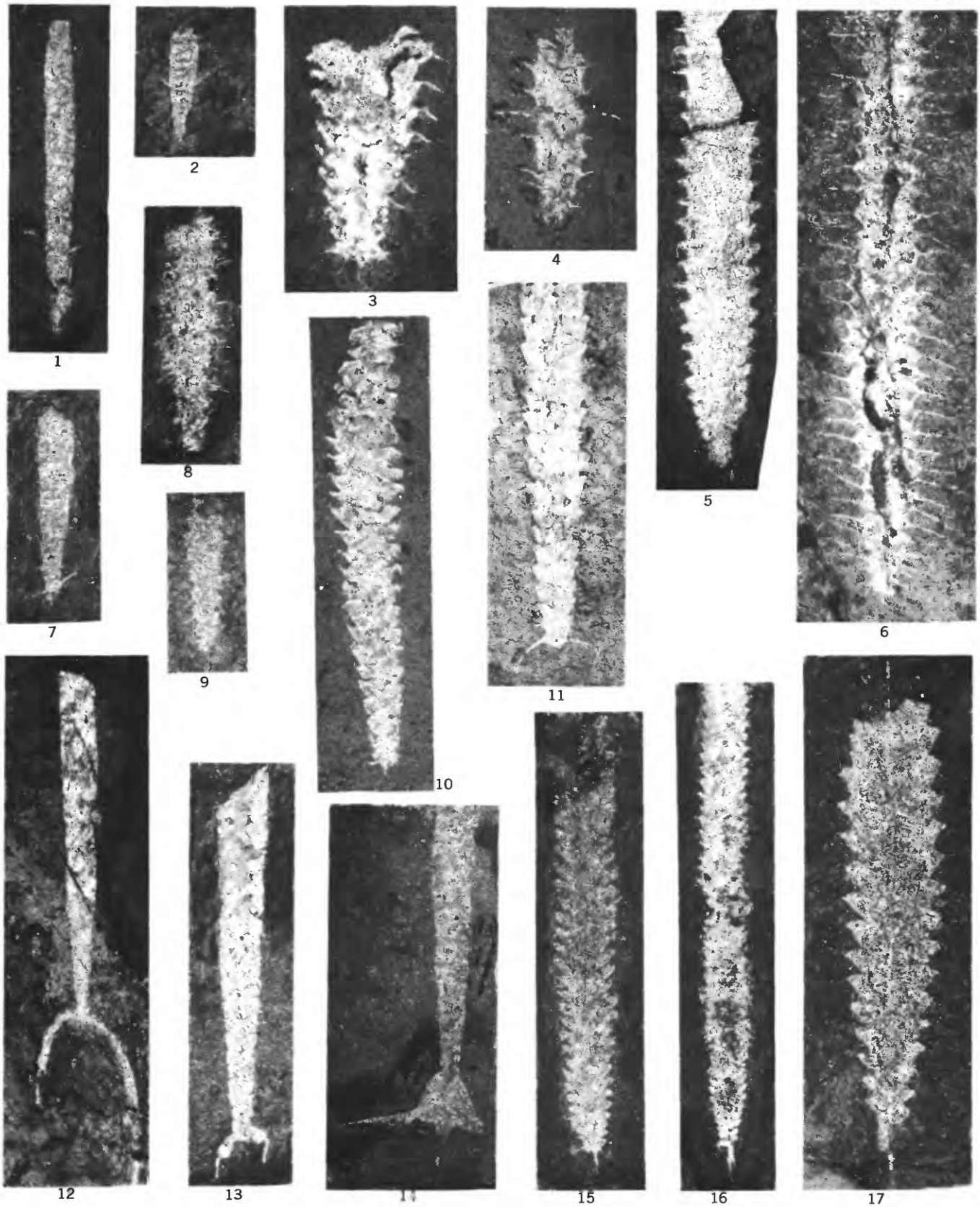
8,9. *Climacograptus pacificus* Ruedemann (p. 23).
8. USNM 189115, x 4.7, collection 69ICt 33.
9. USNM 189113, x 4.7, collection 69ICt 33.

10. *Orthoraptus* aff. *O. calcaratus calcaratus* (Lapworth) (p. 25) USNM 189123, x 4.6, collection 69ICt 86.
11. *Orthograptus* cf. *O. calcaratus tenuicornis* Elles and Wood (p. 25) USNM 189122, x 4.8, collection 69ICt 59.

12,13. *Climacograptus longispinus hvalross* Ross and Berry (p. 22)
12. USNM 164466, x 4.0, also figured by Riva (1974c, text-fig. 7e), collection 69ICt 55.
13. USNM 189112, x 5.1, showing reduction of basal spines, collection 69ICt 42.

14. *Climacograptus bicornis tridentatus* Lapworth (p. 22). USNM 189110, x 2.2, collection 69ICt 88.

15–17. *Orthograptus calcaratus* cf. subsp. *acutus* Elles and Wood (p. 26).
15. USNM 189124, x 2.7, collection 69ICt 88.
16. USNM 189126, x 2.1, collection 69ICt 92.
17. USNM 189125, x 5.1, collection 69ICt 88.



CLIMACOGRAPTUS, ORTHOGRAPTUS, AND *ORTHORETIOLITES*

PLATE 5

FIGURE 1. *Glyptograptus* cf. *G. euglyphus* (Lapworth) (p. 24)
USNM 189119, x 5.2, collection 69ICt 79.

2,3. *Glyptograptus*(?) sp. (p. 25).
2. USNM 189121, x 4.9, collection 69ICt 86.
3. USNM 189120, x 5.1, collection 69ICt 86.

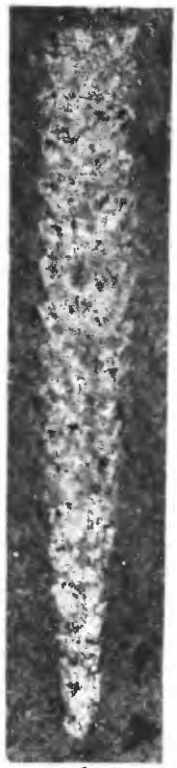
4. *Monograptus sedgwickii* (Portlock) (p. 30)
USNM 189139, x 2.7, collection 69ICt 32.

5. *Cyrtograptus rigidus rigidus* Tullberg (p. 31)
USNM 189142, x 4.8, collection 69ICt 21.

6-8. *Monograptus* cf. *M. flemingii flemingii* (Salter)(p. 29)
6. USNM 189138, x 2.8, collection 69ICt 21.
7. USNM 189136, x 4.2, collection 69ICt 21.
8. USNM 189137, x 2.7, collection 69ICt 21.

9,10. *Monograptus* cf. *M. decipiens decipiens* Törnquist (p. 29).
9. USNM 189141, x 4.8, collection, 69ICt 31.
10. USNM 189140, x 4.8, collection 69ICt 31.

11. *Monograptus convolutus* (Hisinger) (p. 28)
USNM 189135, x 5.0, collection 69ICt 31.



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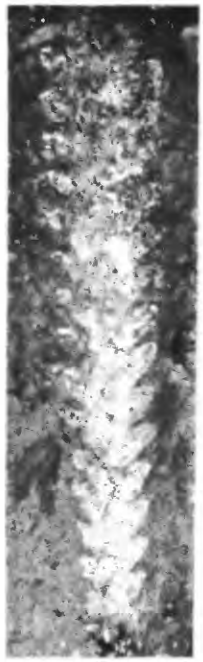

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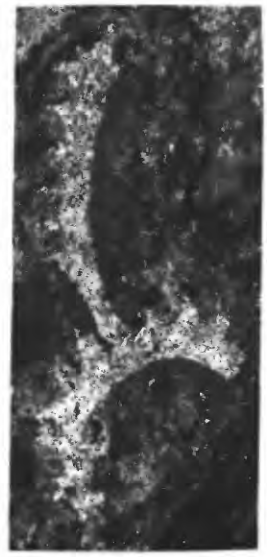

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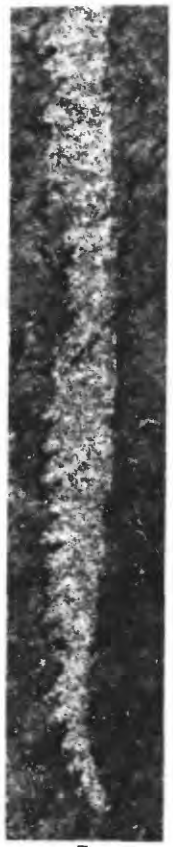

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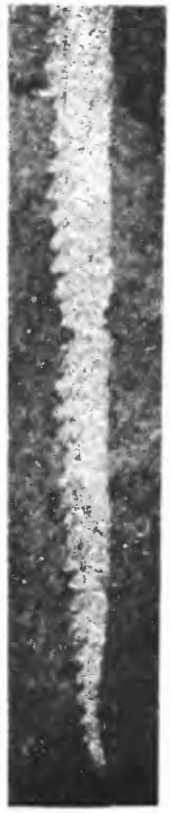

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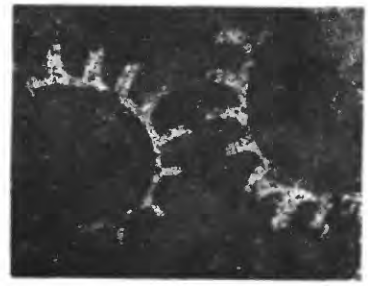

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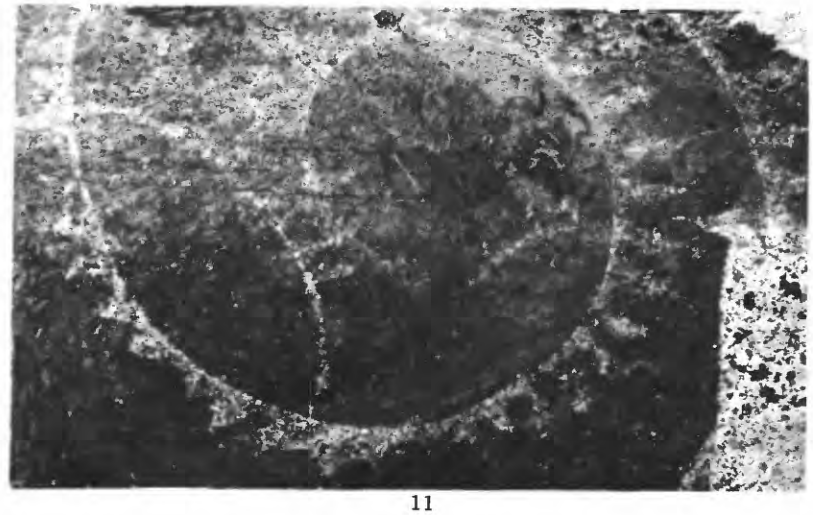

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GLYPTOGRAPTUS, MONOGRAPTUS, AND *CYRTOGRAPTUS*

PLATE 6

FIGURE 1. *Cyrtograptus kirki* Ruedemann (p. 30).
USNM 219002, x 2, collection 69ICt 21; from U.S. Geological Survey loc. 1371.

2. *Dicellograptus* n.sp.? (p. 20)
USNM 189106, x 5, collection 69ICt 76.

3. *Cyrtograptus laqueus* Jackson and Etherington (p. 31) USNM 219003, x 2, collection 69ICt 21; also figured by Ruedemann (1947, pl. 89, fig. 11), from U.S. Geological Survey loc. 1371.

4. *Cyrtograptus rigidus rigidus* Tullberg (p. 31)
USNM 219004, x 5, collection 69ICt 21.

5. *Goniograptus geometricus* Ruedemann (p. 13)
USNM 189114, x 5, collection 62ICn 511.

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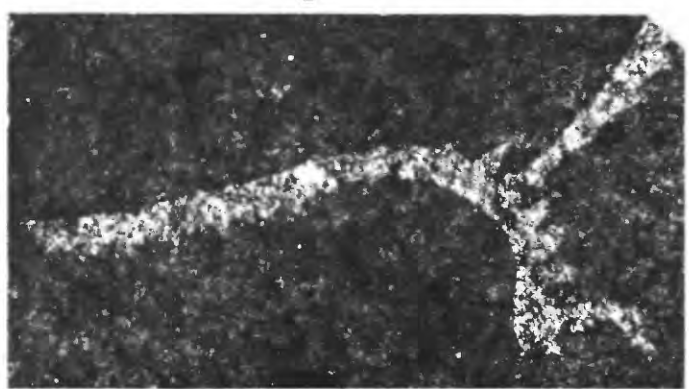

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CYRTOGRAPTUS, DICELLOGRAPTUS, AND *GONIOGRAPTUS*

PLATE 7

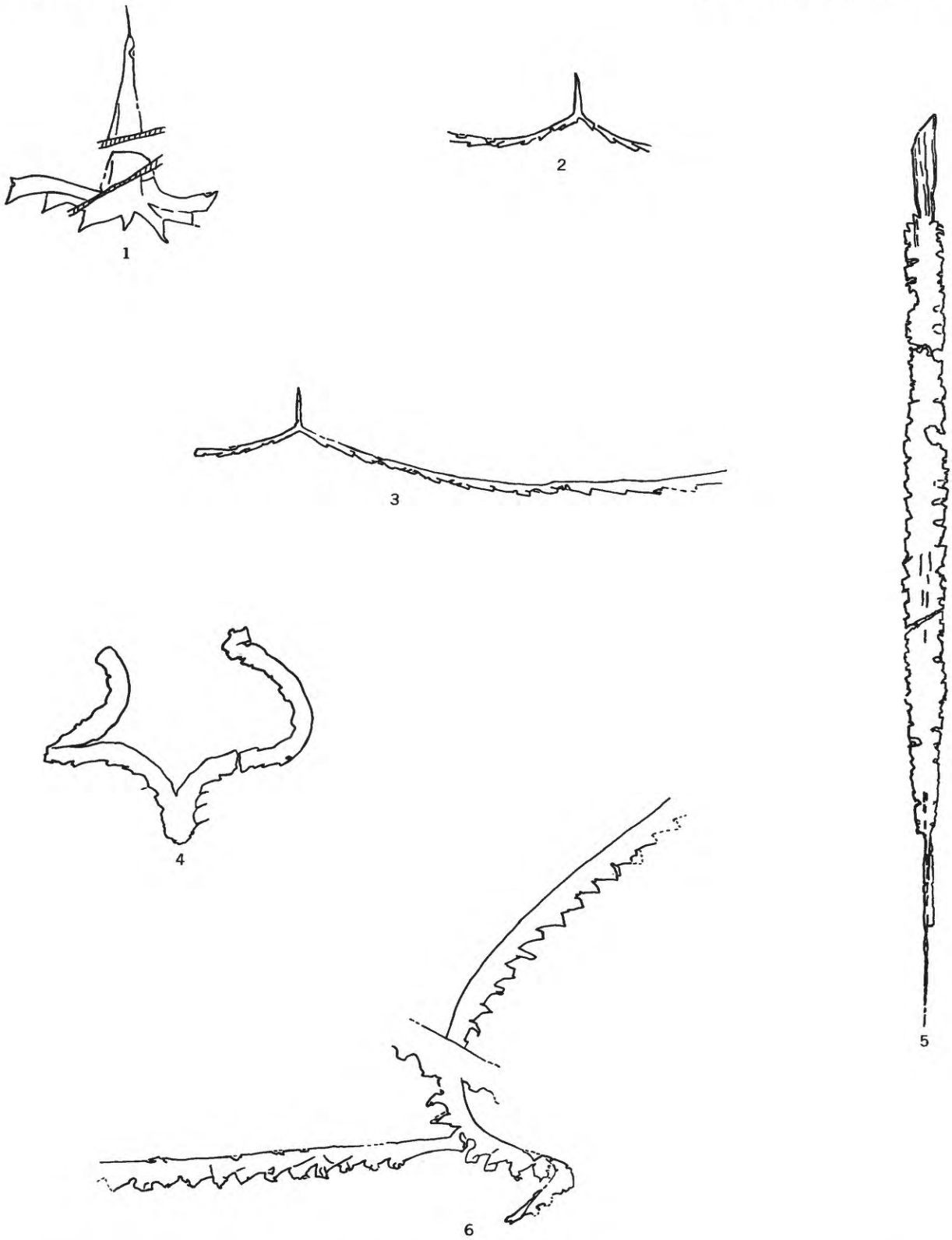
FIGURE 1. *Maeandrograptus tau* Harris (p. 16)
USNM 164425, x 5, collection 62ICn 491.

2,3. *Leptograptus demissus*, n.sp. (p. 16)
2. USNM 164427, x 5, collection 69ICt 59.
3. USNM 189085, holotype, x 5, collection 69ICt 59.

4. *Dicranograptus contortus* Ruedemann (p. 17)
USNM 219006, x 5, collection 69ICt 91.

5. *Climacograptus tubuliferus* Lapworth (p. 23)
USNM 164424, x 3, collection 69ICt 61.

6. *Cyrtograptus rigidus rigidus* Tullberg (p. 31)
USNM 219005, x 4, collection 69ICt 21.



SKETCH OF *MAEANDROGRAPTUS, LEPTOGRAPTUS, DICRANOGRAPTUS, CLIMACOGRAPTUS,* AND *CYRTOGRAPTUS*