Ordovician Graptolites of North-west Nelson.

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PLATES 104-107.

CONTENTS.

INTRODUCTION.

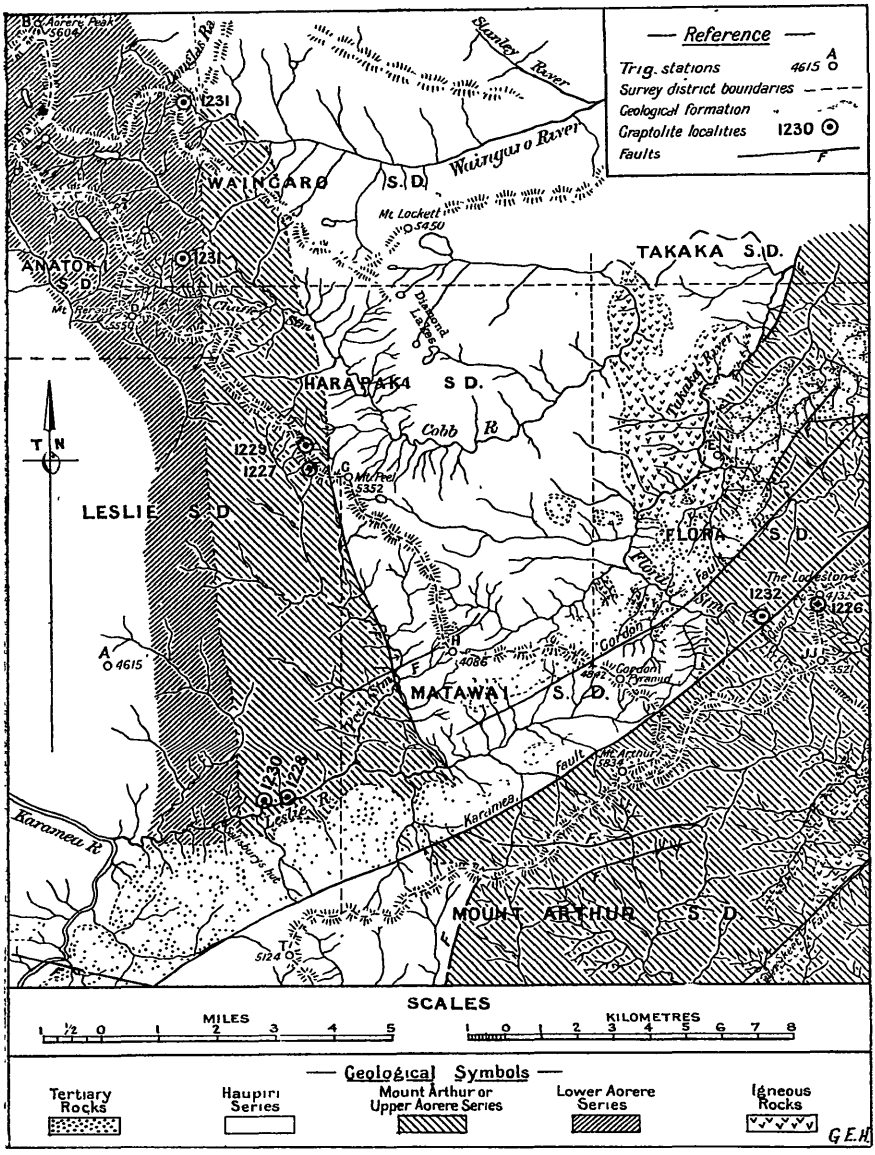
THIS paper enters into a detailed examination of several graptolite collections from the Motueka and Collingwood subdivisions of the South Island, in regard both to their palaeontological classification and to their sequence, and is, more particularly, an attempt to elucidate the stratigraphical position of the Haupiri Series in regard to the adjoining series.

The collections were made by Messrs. L. I. Grange and E. O. Macpherson of the New Zealand Geological Survey, and Mr. S. J. H. Sylvester of Canterbury College. The Cobb collection (1231) is a very fine one from a bed that is highly important, both palaeontologically and stratigraphically: some of the others, however, are in extremely unyielding matrices, and attest the assiduity and purpose of the collectors.

On account of the difficulty in obtaining additional collections we have figured some imperfect material. It all, however, shows sufficient detail for generic classification.

A representative selection from this material was submitted to one of us (W. N. Benson) by the late Director of the Geological Survey, Mr. P. G. Morgan. Its study indicated the presence of a number of species occurring also in Victoria, but belonging to a higher zone than had yet been recognised in New Zealand. The whole collection was therefore sent for examination to Mr. Keble, who confirmed the earlier work and recognised a number of additional forms. Though the authors collaborated for a time in Melbourne, it should be understood that most of the work recorded herein has been done by Mr. Keble, with whom rests the responsibility for the bulk of the determination and illustration of the species, and all comments on their phylogenetic significance.

We would gratefully express our indebtedness to the late Mr. Morgan for the opportunity of examining these very interesting forms, and to Dr. Henderson, his successor, for the suggestion of appropriate names for the various stratigraphical subdivisions pro-



GEOLOGICAL SKETCH MAP OF THE MOUNT ARTHUR DISTRICT SHOWING GRAPTOLITE LOCALITIES.

posed in the Ordovician system in New Zealand, and for the geological map herewith. To Mr. L. I. Grange we are indebted for notes descriptive of the geological occurrence of the fossiliferous beds.

Problem Stated

Three sets of Palaeozoic beds, which may be distinguished by lithology, form broad meridional belts through the western part of the Motueka Subdivision. The strike of the rocks is north and south, and most of the dips are steeply eastward; there are, however, many exceptions. What has always been regarded as the Aorere Series, the most westerly belt, consists of green and grey argillites and greywackes overlain by dark argillites and shales with thin greywacke bands and lenses of marble. The Cobb graptolites (Coll. No. 1231) are from the dark shale containing thin greywacke bands. They were collected from both sides of the Cobb Valley, and lie about 15 chains above a strong band of quartzite (Sketch Map). The Mount Peel graptolites (Coll. No. 1227 and 1229), which come from shales a little west of Mount Peel, have been regarded on stratigraphical evidence to be a little higher than the Cobb graptolites. The Haupiri rocks, which lie east of the Aorere beds, consist of thick conglomerates, greenstones (metamorphosed igneous rocks), greywacke, and argillite. The eastern belt forming the typical Mount Arthur Series is made up chiefly of marble, phyllites, and dark shales, which in some places are interbedded with greywacke bands similar to those of the western band. These beds contain the Lodestone Peak (Coll. No. 1226) and Flora Track (Coll. No. 1232) graptolites. From the marble farther north a few corals and crinoid stems* have been collected. About 18 miles or so southwestwards of the Lodestone, trilobites were obtained from what are thought to be the Mount Arthur beds. These trilobites have been identified by Dr. Cowper Reed† as Ordovician (perhaps Upper Ordovician).

In the field the evidence is not clear as to the stratigraphical succession of these beds. Two classifications may be drawn up, the youngest formation being on top.

(1)	(2)
Mount Arthur Series	Haupiri Series
Haupiri Series	Mount Arthur Series
Aorere Series	Aorere Series

By the old Survey the Haupiri Series was placed above the Mount Arthur Series. In some places the Haupiri Series rests on what are considered to be portions of the Mount Arthur Series, while in others it appears to underlie them. The investigation of the palaeontological evidence that may throw light on the stratigraphical relationship is the main problem of this paper.

*Dr. Cowper Reed compares the corals with *Palaeopora inordinata* Lonsd., an Ordovician species. The encrinites are indeterminable.

†F. R. Cowper Reed, "New Trilobites from the Ordovician Beds of New Zealand," *Trans. N.Z. Inst.*, vol. 57, pp. 310-14; 1927.

COLLECTIONS AND LOCALITIES.

The following list enumerates the exact localities which have yielded fossils:

Reference in this Paper.	Collection No. Geol. Survey	Locality.
Lodestone Peak Bed	1226	Five chains south of Lodestone Peak, head of Graham Stream, Mount Arthur Survey District, Motueka Subdivision. Collectors L. I. Grange and E. O. Macpherson.
Mount Peel, Band A.	1227	Eastern band on ridge, dip west, about 50 chains west-north-west of Mount Peel, on ridge between Peel and Cobb rivers, Harapaki Survey District, Motueka Subdivision. Collector E. O. Macpherson.
Leslie River, Band A.	1228	1¼ mile below Peel Junction, Leslie Survey District, Motueka Subdivision. Collector E. O. Macpherson.
Mount Peel, Band B.	1229	Western band on ridge, dip east, about 70 chains north-west of Mount Peel, ridge between Peel and Cobb rivers, Harapaki Survey District, Motueka Subdivision. Collector E. O. Macpherson.
Leslie River, Band B.	1230	1¾ mile below Peel Junction, Leslie Survey District, Motueka Subdivision. Collector E. O. Macpherson.
Cobb Bed	1231	Ridge between Cobb and Waingaro rivers, 1½ miles N.E. of Lake Cobb, Waingaro Survey District, Motueka Subdivision. Collectors L. I. Grange and S. J. H Sylvester.
Flora Track Bed	1232	Flora track, ½ mile north of Quartz Creek, Flora Survey District, Motueka Subdivision. Collector L. I. Grange.
Aorangi Mine Bed	1273	Graphitic slate on tramway between Aorangi Mine and Battery, Golden Ridge, Collingwood Subdivision. Collector E. O. Macpherson.

The positions of all these collections except that of the Aorangi Mine Bed are shown on the Geological Sketch Map herein.

List of Determinations.

The following list enumerates the fossils which have been recognised in the collections from the several localities:—

1226. Lodestone Peak Bed.
Dicellograptus cf. *affinis* T. S. Hall. (2 specimens).
Dicellograptus spp. (10).
Climacograptus missilis Keble & Harris. (2).
Climacograptus cf. *missilis* K. & H. (1).
Climacograptus sp. (1).
Diplograptus euglyphus Lapworth var. *sepositus* K. & H. (3).
Diplograptus cf. *spiculatus* sp. nov. (2).
Diplograptus sp. (7).
Cryptograptus tricornis Carr. (1).
Rest indeterminable.

1227. Mt. Peel, Band A.
Dicellograptus cf. *divaricatus* J. Hall. (3 specimens, 2 figured).
Dicellograptus cf. *elegans* Carr. (2).
Dicellograptus cf. *moffatensis* Carr. (1).
Dicellograptus spp. (8).
Cryptograptus tricornis Carr. (1).
Glossograptus sp. (2).
Climacograptus sp. (3).
Diplograptus cf. *quadrimucronatus* Hall. (1).
Diplograptus cf. *truncatus* Lapw. (2).
Diplograptus spiculatus sp. nov. (2).
Diplograptus cf. *spiculatus*. (1).
Diplograptus euglyphus Lapw. var *distans* K. & H. (3).
Diplograptus cf. *euglyphus* var. *distans*. (1).
Diplograptus semotus sp. nov. (2, Type Fig.).
Diplograptus spp. (19).
Rest indeterminable.

1228. Leslie River, Band A.
Tetragraptus similis ? J. Hall. (1).
Didymograptus sp. (1).
Dichograptid fragments. (5).
Rest indeterminable.

The identification of *T. similis* is somewhat doubtful. Fragments of the Dichograptidae are, however, very common, occurring almost on every slab. The *Didymograptus* is suggestive of the *D. euodus* group. All that may be said is that the horizon is most probably Lower Ordovician.

1229. Mount Peel, Band B.
Dicellograptus sp. (5).
Indeterminable. (1).

1230. Leslie River, Band B.
? *Lasiograptus* sp. (1).
Dicellograptus sp. (1).
Dicranograptus cf. *rectus* Hopk. (1, Fig.).
Climacograptus sp. (1).
Diplograptus sp. (1).
Biserial forms. (2).
Rest indeterminable.

1231. Cobb Bed.
Didymograptus euodus Lapw. (1, Fig.).
Didymograptus cf. *euodus*. (1).
Didymograptus cf. *superstes* Lapw. (1, Fig.).
Didymograptus cf. *sagitticaulis* Gurley. (1, Fig.).
Didymograptus sagitticaulis Gurley var. *cobbensis* nov. (5, Type Fig.).
Didymograptus caduceus Salter. (1, Fig.).
Didymograptus caduceus Salter var. *spinifer* nov. (1, Type Fig.).
Didymograptus ovatus T. S. Hall. (3, Fig.).
Didymograptus sp. (4).
Tetragraptus tabidus sp. nov. (1, Type Fig.).
Tetragraptus cf. *tabidus*. (2).
Tetragraptus (?) *insuetus* sp. nov. (6, Type Fig. and two others).
Azygograptus prolixus sp. nov. (1, Fig.).
Cryptograptus tricornis Carr. (8, Two Fig.).
Cryptograptus sp. (2).
Glossograptus hincksii Hopk. (12, Eight Fig.).
Glossograptus cf. *hincksii*. (2).
Glossograptus cf. *hermani* T. S. Hall. (1).
Glossograptus acanthus Elles & Wood. (1, Fig.).
Glossograptus villosus sp. nov. (3, Three Fig.).
Glossograptus sp. (13).
Lasiograptus sp.
Retiograptus speciosus Harris. (10, Three Fig.).
Retiograptus cf. *speciosus*. (1).
Retiograptus latus sp. nov. (1, Type Fig.).
Retiograptus cf. *geinitzianus* J. Hall. (1).
Retiograptus sp. (7).
Syndyograptus artus sp. nov. (2, Fig.).
Syndyograptus cf. *pecten* Ruedemann. (1, Fig.).
Leptograptus flaccidus J. Hall var. *angustus*, K. & H. (1, Fig.).
Leptograptus sp. (3).
Climacograptus missilis K. & H. (10).
Climacograptus cf. *missilis*. (1).
Climacograptus cf. *antiquus* J. Hall. (3, Fig.).
Climacograptus sp. (9).
Diplograptus cf. *quadrimucrmonatus* J. Hall. (1).
Diplograptus spiculatus sp. nov. (29, Four Fig.).
Diplograptus cf. *spiculatus*. (3).

Diplograptus euglyphus Lapw. var. *sepositus* K. & H. (24, Four Fig.).
Diplograptus cf. *euglyphus*. (2).
Diplograptus euglyphus Lapw. var. *coitus* nov. (1, Type Fig.).
Diplograptus cf. *teretiusculus* His. (1).
Diplograptus cf. *perexcavatus* Lapw. (1, Fig.).
Diplograptus spp. (11).
Sponge spicules. (1).
Trilobite fragment (?). (1).
Rest indeterminable.

1232. Flora Track Bed.
Didymograptus cf. *sagittícaulis* Gurley. (1).
Cryptograptus tricornis Carr. (1).
Cryptograptus sp. (1).
Glossograptus sp. (1).
Dicellograptus spp. (3).
Dicranograptus sp. (1).
Climacograptus bicornis J. Hall. (1).
Diplograptus cf. *euglyphus* Lapw. var. *sepositus* K. & H. (4).
Diplograptus cf. *spiculatus* sp. nov. (1).
Diplograptus spp. (5).

1273. Aorangi Mine Bed.
Didymograptus nitidus J. Hall var. *aorangiensis* nov. (1, Fig. Fig.).
Didymograptus mundus T. S. Hall. (2, Fig.).
Didymograptus caduceus Salter mut. (3).
Didymograptus caduceus Salter var. *manubriatus* T. S. Hall. (2, Fig.).
Didymograptus sp. (2).
Dichograptus octobrachiatus J. Hall. (2, Fig.).
Dichograptus cf. *octobrachiatus*. (1).

SYNOPTIC TABLE.

	Ladystone Peak Beds	Mt. Peel, Band A	Leslie River, Band A	Mt. Peel, Band B	Leslie River, Band B	Cobb Beds	Flora Track Beds	Aorangi Mine Beds
	1226	1227	1228	1229	1230	1231	1232	1273
Didimograptus nitidus J. Hall								x
Didymograptus mundus T. S. Hall								x
Didymograptus caduceus, Salter						x		x
Didymograptus caduceus var. *manubriatus* T. S. Hall								x
Didymograptus caduceus var. *spinifer* n. var.						x		
Didymograptus ovatus T. S. Hall						x		
Didymograptus euodus Lapw.						x		
Didymograptus cf. *superstes* Lapw.						x		
Didymograptus cf. *sagitticaulis* Gurley						x	x	
Didymograptus sagitticaulis var. *cobbensis* n. var.						x		
Didymograptus spp.			x					
Tetragraptus similis (?) J. Hall			x (?)					
Tetragraptus tabidus n. sp.						x		
Tetragraptus (?) *insuetus* n. sp.						x		
Dichograptus octobrachiatus J. Hall								x
Azygograptus prolixus n. sp.						x		
Cryptograptus tricornis Carr	x	x				x	x	
Leptograptus flaccidus J. Hall var. *angustus* K. & H.						x		
Syndyograptus artus n. sp.						x		
Syndyograptus cf. *pecten* Ruedemann						x		
Dicellograptus cf. *divaricatus* J. Hall		x						
Dicellograptus cf. *elegans* Carr		x						
Dicellograptus cf. *affinis* T. S. Hall	x							
Dicellograptus cf. *moffatensis* Carr		x						
Dicellograptus spp.				x	x		x	
Dicranograptus cf. *rectus* Hopk.					x			
Glossograptus hincksii Hopk.						x		
Glossograptus cf. *hermani* T. S. Hall						x		
Glossograptus acanthus E. & W.						x		
Glossograptus villosus n. sp.						x		
Glossograptus sp.		x				x	x	
Lasiograptus sp.					x (?)	x		
Retiograptus speciosus Harris						x		
Retiograptus latus n. sp.						x		
Retiograptus cf. *geinitzianus* J. Hall						x		
Climacograptus missilis K. & H.	x					x		
Climacograptus cf. *antiquus* J. Hall						x		
Climacograptus bicornis J. Hall							x	
Climacograptus sp.		x			x			
Diplograptus euglyphus Lapw. var. *sepositus* K. & H.	x	x				x	?	
Diplograptus euglyphus var. *coitus* n. var.						x		
Diplograptus spiculatus n. sp.	x ?	x				x	?	
Diplograptus cf. *quadrimucronatus* J. Hall		x				x		
Diplograptus cf. *truncatus* Lapw.		x						
Diplograptus semotus n. sp.		x						
Diplograptus cf. *teretiusculus* His.						x		
Diplograptus cf. *perexcavatus* Lapw.						x		
Diplograptus sp.					x		x	

Palaeontological Sequence.

The Aorangi Mine Bed (Coll. No. 1273) is considerably older than any bed represented in the other collections. It is the equivalent of Subzone C.1. of the Castlemaine zone of Victoria, there at least 8000 feet below the Turner's quarry beds, the Victorian equivalent of the Cobb Bed (Coll. No. 1231).

The Leslie River Band A (Coll. No. 1228) is certainly lower than the Cobb bed (Coll. No. 1231), but precisely how far below is not clear from the imperfect preservation of the collection. If, as we think, the *Didymograptus eudus* group occurs in this bed, then it would be relatively close to the Cobb bed and considerably higher than the Aorangi Mine Bed. It probably indicates the presence of an anticlinal or faulted inlier of Lower Ordovician beds among the Upper Ordovician rocks.

The Cobb Bed association (Coll. No. 1231) is near the top of the Lower Ordovician. This highly fossiliferous bed should afford a very definite bench-mark in separating the Lower from the Upper Ordovician, particularly if the quartzite band a little to the west is a persistent feature. The line of demarcation between the Lower and Upper Ordovician lies to the east of the Cobb Bed.

The Upper Ordovician is made up of three known beds. Undoubtedly resting conformably on the Cobb Bed (No. 1231) and with several common forms, is the Mount Peel Band B (Coll. No. 1229). About the same horizon as the Mount Peel Band B is the Mount Peel Band A (Coll. No. 1227), and the Lodestone Peak Bed (Coll. No. 1226).

The Flora Track or *Climacograptus bicornis* bed (Coll. No. 1232) is higher than, but conformable to, the Mount Peel Bands. The only fairly definite species in the Leslie River Band B. (Coll. No. 1230) is *Dicranograptus* cf. *rectus,* but the genus is indubitable. The collection is small and this is the only bed from which *Dicranograptus* gen. has been recorded. In Victoria* the Dicranograptidae characterize subzones above the *C. bicornis* subzone, and occur sparingly with *C. bicornis* towards the close of the latter's range. There is little doubt that the Leslie River *Dicranograptus* Bed rests conformably on the Flora Track Bed.

Proposed Subdivision of Lower and Upper Ordovician Rocks.

The following table showing a tentative subdivision of the broad belts of strata flanking the Haupiri Series on the east and west, that is, of the Aorere Series, is based on a comparison with the sequence of Ordovician graptolitic beds in Victoria, and is submitted as a working hypothesis. In order to increase its usefulness, the opportunity is taken to include also the graptolite-bearing beds of Western Southland, so that the table summarizes all the available data concerning the graptolitic rocks of New Zealand, and indicates what additional zones may eventually be found.

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*Harris, W. J. and Crawford, W., The Relationships of the Sedimentary Rocks of the Gisborne District, Victoria. *Proc. Roy. Soc. Vict.*, vol. 33 (N.S.), 1921. On p. 53 a broad subdivision of the Upper Ordovician is given.

TENTATIVE SUBDIVISION AND CORRELATION OF NEW ZEALAND AND AUSTRALIAN GRAPTOLITE STRATA.

NEW ZEALAND.						AUSTRALIA.		
Series.	Zone.	Index Forms.	Sub Zone		Index Forms.	Zone	Sub Zone.	Remarks.
Early Lower Ordovician No. Series name suggested at present.	PRESERVATION.	Appearance of *Staurograptus* gen. to extinction *T. decipiens* and *T. approximatus* which range into the next zone to appearance of *T. fruticosus.*	d	Not yet known in N.Z. (1)	*Clonograptus* spp. *Bryograptus* spp. *Staurograptus* gen. to extinction	LANCEFIELD	L. 4.	See Notes A and B below.
			c	Preservation Inlet Beds.	*C. tenellus* *C. tenellus* var. *callavei* *C.* spp. *B.* spp. *Tetragraptus decipiens* to appearance of *T. approximatus*		L. 3.	
			b	Not yet known in N.Z.	(*T. Approximatus* *T. decipens* *C. tenellus*			
			a	Not yet known in N.Z.	*C.* spp. *B.* spp. *Didymograptus* spp.)		L. 2. L. 1.	
	Not yet known in N.Z.	*T. fruticosus.* Appearance to extinction.	e	Not yet known in N.Z.	(*T. fruticosus* *T. approximatus* *T. decipens*	BENDIGO	B. 5.	
			d	Not yet known in N.Z.	*C.* spp. *B.* spp.		B. 4.	
			c		*T. fruticosus*		B. 3.	
			b		*D. bifidus*		B. 2.	
			a		*C.* spp.)		B. 1.	
Lower Aorere	GOLDEN RIDGE.	The dependent *Didymograpti* (*D. bifidus, D. nanus,* etc.) without *Tetragraptus fruticosus* become extinct above this zone.		Band B. Slaty Ck. (2) Cape Providence. (3)	*D. bifidus* and *D. nanus.* The above with *D. caduceus* et mut.	CASTLEMAINE.	WATTLE GULLY.	
		The reclined *Didymograpti* (*D. caduceus* et mut.) appear before the dependent *Didymograpti* become extinct, and range beyond this zone.		Band A. Slaty Ck. (4)	Reclined *Didymograpti*		VICTORIA GULLY.	
				Aorangi Mine (5)	Reclined *Didymograpti,* *D. caduceus* var. *manubriatus,* but no *Oncograptus*		McKENZIE HILL. (Upper Part.)	
	DOUGLAS	*Oncograptus* gen. which outruns *D. caduceus* var. *manubriatus* appears rarely and overlaps the lower range of *Cryptograptus tricornis* which extends into the Mount Arthur Series.		Not yet found in N.Z.		DARRIWIL (6)	WOODBROOK ROAD CASTLEMAINE McIVOR RD. BENDIGO E. BENDIGO E.	See Note C below.
		The reclined *Didymograpti,* of which the last is *D. ovatus* range throughout this zone. The extinction of *Tetragraptus* gen. marks the close of the Lower Orodvician.		Cobb (7)	*D. caduceus* *D. ovatus* *Diplograptus spiculatus* *Cryptograptus tricornis*		TURNER'S QUARRY. BITTERN	
Mount Arthur or Upper Aorere	LODESTONE	*C. tricornis* and *D. spiculatus.* The *Dicellograpti* appear above the base, and continue with *D. spiculatus* and after it becomes extinct, *C. tricornis* still continues. The extinction of *Climacograptus bicornis,* which appear about the time *D. spiculatus* becomes extinct, marks the close of the Lodestone Zone.			(*D. spiculatus* and *D. ovatus*) (*D. spiculatus* no *D. ovatus* no *Dicellograpti*)		SANDY'S CK. (8)	
				Mt. Peel (9)	*D. spiculatus* and *Dicellograpti*		DARK RIVER (10)	
				Flora Track (11)	*C. bicornis* no *Dicellograpti*		YARRA TRACK (12)	
	LESLIE	From the appearance of the Dicranograptidae to the appearance of the Monograptidae.		Leslie River (13)	*Dicranograptus*		MT. (14) EASTON (*Dicranograptus* beds) JERICHO	

NOTE A.—In this table the terms "Aorere," "Preservation," and "Preservation Inlet" have been employed as series, zonal, and subzonal names respectively in a manner which seems to accord with their original usage, and the distribution of the rocks they denote. They have, however, been confused since their first application. Thus Park (18) in 1910 extended the term "Kakanui (Aorere)" to cover all the Ordovician rocks in New Zealand, and Marshall (19) and later writers have employed "Aorere" in a similar manner. Subsequently Park (20) used the term "Preservation Inlet Series" to denote all the slaty argillites and schistose greywackes of his Kakanui (Aorere) Series in Western Southland, specifically including in these the rocks of Chalky Inlet (Cape Providence) and Preservation Inlet. The discovery (3) that the Cape Providence beds belong to a horizon which, in Victoria is about 15,000 feet stratigraphically above the horizon represented by the graptolitic beds at Preservation Inlet, makes desirable their nomenclatural separation.

NOTE B.—Provision is made for the addition, when discovered, of a basal sub-zone (e) equivalent to the *Dictyonema flabelliforme* subzone of Europe and America. This subzone is regarded by British geologists as marking the close of the Cambrian, but by others in Europe and America as ushering in the Ordovician transgression (15, 16). It is known that *Staurograptus* gen. is in its lower range, associated with *Dictyonema,* and in its higher range, with a fauna similar to that of Preservation Inlet. There is reason for suspecting that the form from Preservation Inlet figured by T. S. Hall as *Bryograptus* (17) may actually belong to the genus *Staurograptus.* It is confidently assumed that the *T. approximatus* beds when found will be capable of subdivision.

NOTE C.—Victorian subzonal associations probable in the Douglas Zone are *O. upsilon* and *D. caduceus* var. *manubriatus* (Woodbrook Road, Castlemaine); *Oncograpti, C. tricornis,* and *D. caduceus* (McIvor Road, Bendigo East); *C. tricornis* without *Oncograpti* (Bendigo East); and *D. ovatus, C. tricornis,* and *D. caduceus* (Turner's quarry).

REFERENCES CITED IN ABOVE TABLE AND NOTES.

1. HALL, T. S. The Occurrence of Lower Ordovician Graptolites in Western Otago. *Trans. N.Z. Inst.* vol. 47, 1914, pp. 410-1.
2. SHAKESPEAR, Ethel M. R. On Some New Zealand Graptolites, *Geol. Mag.* (N.S.) Dec. 5, vol. 5, pp. 145-48, 1908.
3. KEBLE, R. A. Graptolites from Cape Providence, Chalky Inlet, Southland, *Trans. N.Z. Inst.*, vol. 58, pp. 157-59, 1927.
4. SHAKESPEAR, Ethel M. R. *Supra cit.* Also HALL, T. S., The Golden Ridge Graptolites *Trans. N.Z. Inst.*, vol. 47, 1914, pp. 411-3.
5. COLL. No. 1273.
6. HARRIS, W. J. The Palaeontological Sequence of the Lower Ordovician Rocks in the Castlemaine District, *Proc. Roy. Soc. Vict.*, vol. 29, (N.S.) p. 55, 1916.
7. COLL. No. 1231.
8. HALL, T. S. Reports on Graptolites, *Rec. Geol. Surv. Vict.*, vol. 1, pt. 1, pp. 33-34, 1902. Further collecting has shown that the fauna is larger than listed in this report.
9. COLL. Nos. 1226, 1227, and 1229.
10. *D. spiculatus* is recorded in MS. report on Dark River.
11. COLL. No. 1232.
12. KEBLE, R. A. and HARRIS, W. J. *Graptolites* from Mt. Easton, *Rec. Geol. Surv. Vict.*, vol. 4, pt. 4, locs. 10 and 18, pp. 510-11, 1925.
13. COLL. No. 1230.
14. KEBLE, R. A. and HARRIS, W. J. *Supra cit.* loc. C., p. 511.
15. RUEDEMANN, R. Palaeontological Contributions from the New York State Museum, 16th Report of the State Mus. and Science Dept. Bull. 227, 228 (1919) pp. 118-9. Ruedemann concludes his remarks on the *O. flabelliforme* zone with the following: " . . . . it has been recognised in Europe especially through Moberg's work, from the accompanying biota, that the *Dictyonema* shale introduces an extensive Ordovician transgression and therefore is properly considered the base of that series."
16. HARRIS, W. J. and KEBLE, R. A. The *Staurograptus* Bed of Victoria. *Proc. Roy. Soc. Vict.*, vol. 40, pt. 2 (N.S.) 1928, p. 94.
17. cf. Fig. 5, Plate VIII, *Trans. N.Z. Inst.*, vol. 47.
18. PARK, J. *The Geology of New Zealand,* Whitcomb and Tombs, Christchurch, 1910, pp. 29-38.
19. MARSHALL, P. New Zealand and adjacent Islands. *Handbuch der regionalen Geologie,* Carl Winter, Heidelberg, 1912, pp. 12-14.
20. PARK, J. The Geology and Mineral Resources of Western Southland, *Geol. Survey, New Zealand Bull.* 23, 1921, pp. 33-38.

Owing to the fact that Victorian palaeontologists have some difficulty in specifically separating the dependent group of *Didymograptus* in the Australian region, we have, in this tentative subdivision, used them as a group. Similarly we have used the reclined group as a group, knowing that a revision of *Didymograptus caduceus* with its many mutations is urgently required. In fixing *D. caduceus* var. *manubriatus* as the concluding subzonal form of the Golden Ridge zone, we are guided by the facts, (a) that it is readily recognized by its abnormal sicula; (b) that it comes into the succession at a time that divides the upper portion of the Lower Ordovician into two approximately equal periods; and (c) that, if the beds can be found, the next highest subzone should contain *Oncograptus* making the Douglas zone start at approximately the same horizon as the Victorian Darriwil zone, an eminently satisfactory basis for comparison.

The extinction of *Tetragraptus* gen. is generally regarded as marking the close of the Lower Ordovician and, incidentally, the close of the Douglas zone. Its extinction is not always easy to prove on account of its rarity and gerontic attenuation, which makes for fragmentary and poor preservation. With such an associate as *D. ovatus* which has a slightly higher range, and other characteristic associates in the uppermost bed, the task is somewhat simplified.

The succession from the Cobb to the Mount Peel subzone is apparently quite conformable. All the species that will enter into a subdivision of the intervening beds are recorded in the Cobb (Coll. 1231) and the Mount Peel collections (1231, 1227, 1229). The subzonal forms will probably be found to be *Didymograptus ovatus, Azygograptus prolixus,* and the several species of *Leptograptus, Retiograptus, Syndyograptus,* and *Glossograptus.* We have, in the tentative subdivision, suggested subzones known to have Victorian equivalents.

Climacograptus bicornis, the index form of the Flora Track subzone is readily recognized, as are also the *Dicranograptidae.*

CONCLUSION.

From what has been said above it is obvious that the rocks occurring east and west of the broad belt of Haupiri Series belong to the same group of strata. The sequence of faunas shows that the beds were deposited, if not continuously, at least without any considerable stratigraphical break. Clearly the Haupiri rocks, which are of vast thickness, cannot be included as part of the sequence from which the graptolites considered in this paper were obtained. Probably they owe to folding or faulting their position between belts of Ordovician strata differing little in age.

DESCRIPTION OF SPECIES.

Family—DICHOGRAPTIDAE.

Genus—DIDYMOGRAPTUS.

Didymograptus nitidus J. Hall var. **aorangiensis** n. var. (Fig. 1).

In the Aorangi Mine specimens the branches arise at an angle slightly less than 180° but about Th 7 assume a greater angle. Sicula

slightly more than 1.0 mm. long. Thecae number 12 in 10 mm., overlap one-half their length proximally, and distally two-thirds; they are inclined at an angle of from 25° to 35°. Apertural margin straight or slightly concave and normal to thecal axis; ventral margin straight.

Proximal width of branch, 0.3 mm., less than that given by Elles & Wood,* viz. 0.87 mm. for British forms of *D. nitidus;* maximum width observed, 1.1 mm., is relatively near sicula. Angle of inclination of thecae is, too, less than in British forms. There appears to be little doubt, however, that the Aorangi Mine form has close affinities to *D. nitidus* and agrees well except where indicated; to mark these differences, therefore, we have made a varietal distinction.

Associates—*D. nitidus* var. *aorangiensis* has as associates *D. mundus, D. caduceus, D. caduceus* var. *manubriatus, Dichograptus separatus, D.* cf. *octobrachiatus.*

Horizon—Lower Aorere Series, Zone-Golden Ridge, Subzone-Aorangi Mine.

Didymograptus mundus T. S. Hall. (Fig. 2).

Hall, T. S., Vic. Grap., *Proc. Roy. Soc. Vict.,* vol. 27, p. 107, Fig. 9.

Branches diverge from sciula at angle of 102° and curve to Th 6 when they become approximately horizontal. Maximum length observed is slightly more than 40 mm. and width near sicula is between 0.3 and 0.5 mm. Sicula 1.5 mm. long.

Proximal thecae number 8 in 10 mm., overlap one-half their length and are more than twice as long as wide; they are slowly expanding and inclined at an angle of from 40° to 50°. Outer extremity forms an acute denticle.

The Aorangi Mine specimens agree in all particulars with T. S. Hall's description.

Horizon—Lower Aorere Series, Zone—Golden Ridge, Subzone—Aorangi Mine.

Didymograptus cf. **sagitticaulis** Gurley. (Fig. 3).

Ruedemann, R. Graptolites of New York, *New York State Mus.,* Mem. No. 11, pt. 2, pp. 247-251, Fig. 151-155 emend.

In the polypary of the New Zealand specimen the branches diverge from the sicula at 45° or more (sicula not visible) but attain approximate horizontality within 10 mm., a width of 0.7 mm. within 2.0 cm. and 1.0 mm. within about 5.0 cm. from the sicula.

Thecae in proximal portion of specimen 7 or 8 in 10 mm., inclined at an angle of from 15° to 20°, overlapping one-quarter their length, 6 or 7 times as long as wide; in distal portion 6 or 7 in 10 mm., inclined at an angle from 20° to 25°, overlapping one-half their length, 6 or 7 times as long as wide, ventral margin straight or slightly concave, apertural margin straight, normal to axis of theca.

*Elles, Gertrude L., and Wood, Ethel M. R., British Graptolites pt. 1, p. 10, *Palaeon. Soc.,* vol. 55.

This differs from Ruedemann's description in (a) a dorso-concave as compared with a dorso-convex curvature of branches near sicula, (b) ventral margins of thecae straight as compared with straight or slightly convex margins in American forms. How far these differences are attributable to the direction of compression is difficult to judge, but there is a close agreement between the two forms, and if the sicula were not missing in the New Zealand specimen we would have no hesitation in relegating it to *D. sagitticaulis* without reservation.

Horizon—Lower Aorere Series, Zone—Douglas, Subzone—Cobb.

Didymograptus sagitticaulis Gurley var. **cobbensis** n. var. (Figs. 4a-c).

Polypary declined, but branches passing from gentle dorso-concave curvature into relative straightness, 0.3 mm. wide near sicula, gradually widening to 0.5 mm. at about Th. 16, but maximum width not known. Sicula small, about 0.5 mm. long and 0.3 mm. broad. Thecae number 12 or 13 in 10 mm. in proximal portion, and 11 in distal portion. Proximal thecae about 1.2 mm. long and 0.5 mm. wide with straight apertural margins normal to axis of branch, ventral margins concave, twice as long as broad, overlapping one-fourth their length or less and inclined at angle of 25°. Ventral margin straightens as polypary develops and with the oblique apertural margin forms a distinct denticle. The most distal thecae observed are 1.8 mm. long and 0.6 mm. wide, more than twice as long as broad, overlap one-half their length, and are inclined at an angle of 20°.

The first thecae originate near the apex of the sicula and diverge below the parture. The species differs from *D. sagitticaulis* in the proximal curvature of the branches, closer set of thecae in the more distal portions, the point of divergence of the branches, and in other minor respects, but there is little doubt regarding its affinity; these differences are, perhaps, regional but we think they merit a varietal distinction.

Horizon—Lower Aorere Series, Zone—Douglas, Subzone—Cobb.

Didymograptus cf. **superstes** Lapw. (Fig. 5)

Elles, Gertrude L., and Wood, Ethel M. R., British Graptolites pt. 1, *Palaeon. Soc.*, vol. 55, p. 19-21, plate 1, figs. 9 a. b., text figs. 11 a. b. c.

In the Cobb River collection there occurs a sicula and proximal portion of a *Didymograptus* which we think may be correlated with this species. Branches 0.3 mm. wide near sicula from which they diverge at wide angle but subsequently become straight; at Th 6 they attain a width of approximately 1 mm. Thecae number 5 or 6 in 10 mm., are twice as long as broad, overlap slightly in the proximal portion and about one-fourth their length at Th 6. Ventral margin irregularly concave, inclined at angle of 30°, apertural margin straight or slightly concave, lying at angle of from 140° to 150° to axis of branch. Sicula small and inconspicuous probably with nema. Unfortunately the sicula is somewhat indistinct and the distal portions of the branches are missing.

Horizon—Lower Aorere Series, Zone—Douglas, Subzone—Cobb.

Didymograptus euodus Lapw. (Figs. 6a-c).

Lapworth, C., *Quart. Journ. Geol. Soc.*, vol. 31, p. 645, Pl. 35, Fig. 1a-c.

In the New Zealand form the sicula is 1.1 mm. long and 0.5 mm. wide. Thecae number 8 or 9 in 10 mm., are four or five times as long as broad, overlap one-half their length proximally, and from one-half to two-thirds distally, inclined at angle of from 20° to 30° (distally). Ventral margin with shallow double curvature, apertural margin straight or slightly concave. Minimum width near sicula 0.5 mm., maximum width 1.5 mm.

Owing to distortion the appearance of the sicula in the only specimen (Fig. 6b), where it is visible is unusual. It has the appearance of having two openings, an aperture corresponding to the normal one and a subangular one near the apex. The normal aperture is circular and has the appearance of opening from the side of the sicula. The whole sicula has been reversed and were it not for the traces of a nema one would have difficulty in distinguishing its apical from its apertural region. The points of origin of the first thecae are obscure.

Horizon—Lower Aorere Series, Zone—Douglas, Subzone—Cobb.

Didymograptus caduceus Salter. (Fig. 7).

Salter, J. W. (pars), *Quart. Journ. Geol. Soc.*, vol. 9, p. 87, Fig. 1a.

Branches about 5 mm. long, decreasing from a width of 1.5 mm. at sicula to 1.0 mm. at distal end. Sicula 2.0 mm. or more in length. Thecae 16 in 10 mm., curved, inclined to axis of branch at about 45°, two to three times as long as wide, in contact two-thirds their length. Apertural margins concave.

The variability of this species is clearly shown by tabulating the several dimensions from Elles & Wood's, Ruedemann's and the New Zealand forms—

		New Zealand sp.	America*	Britain†
Branches	Width at sicula	1.5	2.2	2.1
	Width at end	1.0	1.1	—
Sicula		long, very slender	long and slender	long and slender
Thecae	Angle of ventral margin	45°	45°	45°
	Length to breadth	3 : 1	3 : 1	4 : 1
	Overlap	⅔	none	none
	Apertural margin	concave, conspicuously mucronate or spinous	concave, mucronate	concave
	Number in 10 mm.	12-13	11-14	16

Horizon—Lower Aorere Series, Zones—Golden Ridge and Douglas, Subzones—Cape Providence to Cobb (incl.).

*Ruedemann, R. *Grap. of New York, New State Mus.*, Mem. 7, pp. 693-8.

†Elles, Gertrude L. and Wood, Ethel M. R. Brit. Grap., pt. 1, p. 52-4. *Palaeon. Soc.*, vol 55.

Didymograptus caduceus Salter var. **manubriatus** T. S. Hall. (Fig. 8).

Hall, T. S. *Proc. Roy. Soc. Vict.*, vol. 27 (N.S.), pt. 1, pp. 108-9, Pl. 17, Fig. 12 and 13.

T. S. Hall states that *D. caduceus* var. *manubriatus* "differs from the typical form by the immense size of the sicula, which at the point of separation of the branches is as wide as the branch itself. Thecae 10 in 1 cm. Branches diverging at 130° to 140° and varying from 2 to 3 mm. in width."

The dimensions tabulated with those of the New Zealand form are as follows:—

	Victorian Species.	New Zealand Species.
Sicula	as wide as branch at divergence, conical	not quite as wide as branch, tapering
Thecae in 10 mm.	?	13-14
Branches		
Divergence	130°-140°	100°
Width	2-3 mm.	1-2 mm.

Before accepting these differences it would be advisable to compare a number of more mature New Zealand forms, particularly as T. S. Hall* says that "there is a considerable range in width of the branches and the angle of divergence, but the great size of the sicula is remarkable."

Horizon—Lower Aorere, Zone—Golden Ridge and probably Douglas, Subzone—Aorangi Mine and next subzone above.

Didymograptus caduceus Salter mut. **spinifer** n. mut. (Fig. 9.)

Branches long, over 40 mm., decreasing in width and forming a polypary, the contained angle of which falls within 25°. Sicula about 1.5 mm. long.

Thecae 12 to 13 in 10 mm., curved, inclined to axis of branch at angle of from 25° to 35° (distally), from three to four times as long as wide, in contact for more than three-fourths their length, ventral margins, concave, apertural margins, concave in proximal thecae, each produced into a more or less conspicuous spine or mucro.

This is one of the many mutations of *D. caduceus* that call for a revision of the species. It differs from the typical species in (*inter alia*) (a) the smaller inclination of the thecae, and, (b) the smaller contained angle of the polypary, and (c) the spinous nature of the proximal thecae. Differences (a) and (b) are concomitant and may be of some phylogenetic value as they foreshadow the concrescence of the branches in such a genus as *Cardiograptus*.†

Horizon—Lower Aorere Series, Zone—Douglas, Subzone—Cobb.

**Supra cit.*

†Harris, W. J., The Palaeontological Succession of the Lower Ordovician Rocks in the Castlemaine District, *Proc. Roy. Soc. Vict.*, vol. 29 (N.S.), pt. 1 (1916), Pl. 1, Fig. 1-3.

Didymograptus ovatus T. S. Hall. (Fig. 10).

Hall, T. S., *Rec. Geol. Surv. Vict.*, vol. 1, pt. 1, p. 33, Fig. 1.

T. S. Hall's description was as follows:—"Hydrosome [Polypary] stout, branches abruptly recurved and gradually approaching one another . . . . . Branches of a uniform width of 1.0 mm. or to the top of the mucronate extensions of the thecae about 2.0 mm. Sicula long and slender with a delicate virgula. Thecae curved, expanding, about 0.5 mm., overlapping by one-half their length, and at a distance of about 10 mm. from the sicula inclined at an angle of 40°; outer margin curved; apertural margin deeply concave, and produced so as to make, with the outer margin, a stout, spinose, mucronate extension of about 1.0 mm. in length. Thecae numbering 12 in 10 mm."

The New Zealand form is much more robust than the Victorian but is, at the same time, not so long and does not show the recurvature. Sicula short (2.7 mm.) and broad (2.0 mm.); there is no nema (virgula). Thecae wider, overlap two-thirds their length, are inclined distally about 45°, and have spines up to 2.0 mm. in length. Thecae number 9 in 10 mm. Most of these differences are merely relative and there is little doubt that the form from Cobb River is the regional equivalent of the Victorian form. Further collections from Sandy's Creek made by the Victorian Geological Survey since Hall described *D. ovatus* in 1901, contain forms of *D. ovatus* markedly similar to the New Zealand form in an association that is almost identical.

Horizon—Lower Aorere Series, Zone—Douglas, Subzone—Cobb; also probably ranging up into the Mount Arthur Series.

Associates—In the Cobb subzone *D. ovatus* is the index species with *Tetragraptus* gen. In the Mount Arthur Series it occurs without *T.* gen.

Genus—Tetragraptus.

Tetragraptus (?) **insuetus** n. sp. (Figs. 11 a-c.)

Shape of polypary unknown, but almost certainly one in which dichotomy up to the second order has taken place. Branches usually exhibit a dorsal curvature. Sicula not seen. Thecae suggestive of the *Monograptus* type, 12 or 13 in 10 mm., aperture normal to axis of branch or slightly everted and prolonged into a broad spine; ventral margin with a slight sigmoidal curvature. Overlap slight.

Like *Monograptus T. insuetus* sometimes shows torsion of thecal axis (Fig. 11c). Apertures seen on left hand branch (Fig. 11c) while on the other branch apertural termination is blunted in more proximal thecae and almost entirely concealed in distal thecae. On the other hand, all thecae of one branch (Fig. 11b) are more or less spinous while on other branch of same polypary ventral walls are absent only, the thickened apertural margin with its spinous termination being preserved and suggestive of some forms of Rastrites.

The generic position of *T. insuetus* is doubtful. As yet we have only seen portions of the polypary which show, however, with tolerable certainty that the form branches by simple dichotomy. The unique features of the form are too important phylogenetically to pass over, particularly as a complete polypary of such a compara-

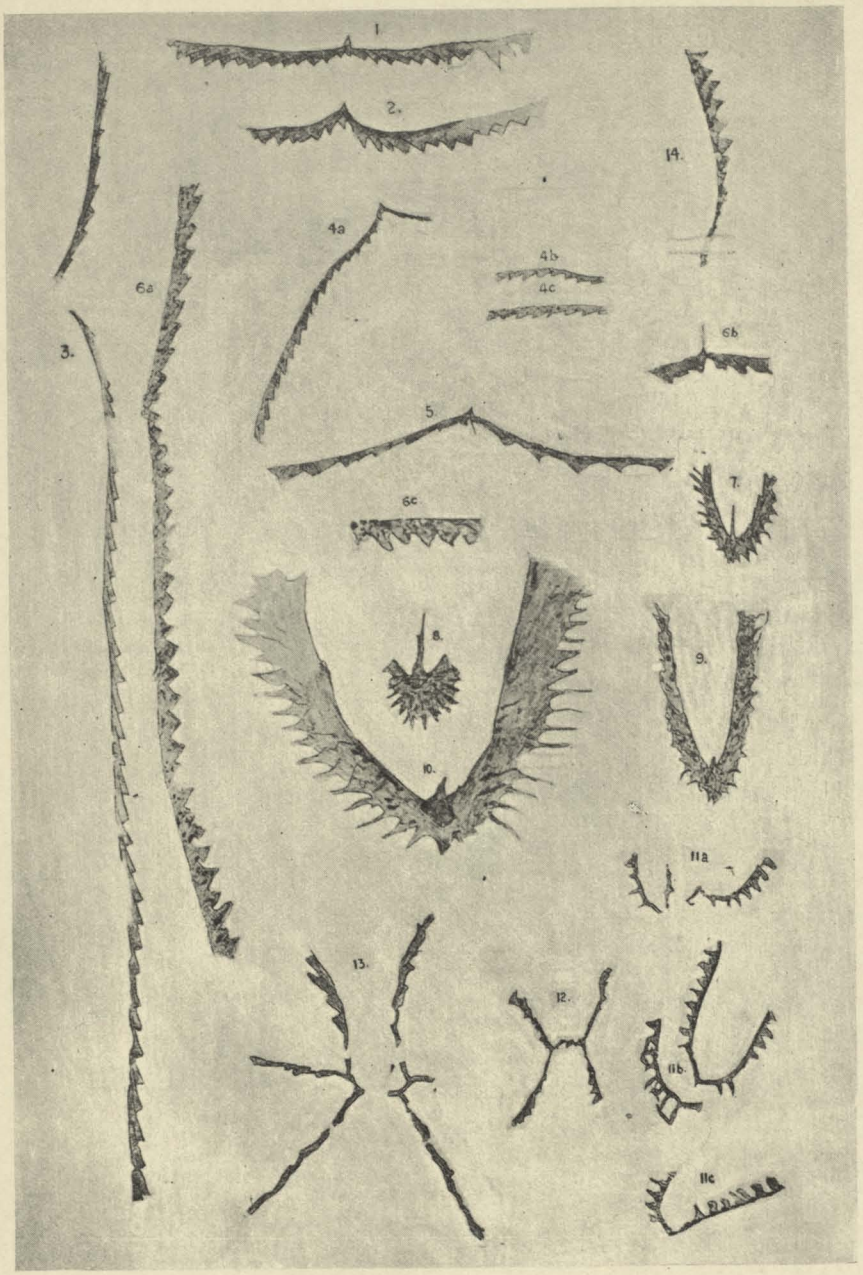

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Fig. 1. *Didymograptus nitidus* J. Hall var. *aorangiensis* var. nov. Loc. No. 1273. Polypary.

Fig. 2. *D. mundus* T. S. Hall, Loc. No. 1273. Polypary.

Fig. 3. *D.* cf. *sagitticaulis* Gurley, Loc. No. 1231 Branches, sicula missing.

Fig. 4. *D. sagitticaulis* Gurley var. *cobbensis* var. nov. Loc. No. 1231.
a. Polypary. c. Distal thecae.
b. Proximal thecae.

Fig. 5. *D.* cf. *superstes* Lapw., Loc. No. 1231. Proximal portion.

Fig. 6. *D. euodus* Lapw., Loc. No. 1231.
a. Polypary. b. Thecae of proximal portion.
c. Distal thecae.

Fig. 7. *D. caduceus* Salter, Loc. No. 1231. Polypary.

Fig. 8. *D. caduceus* Salter var. *manubriatus* T. S. Hall, Loc. No. 1273. Young Polypary.

Fig. 9. *D. caduceus* Salter var. *spinifer* var. nov. Loc. No. 1231. Polypary.

Fig. 10. *D. ovatus* T.S. Hall, Loc. No. 1231. Polypary.

Fig. 11. *Tetragraptus insuetus* sp. nov., Loc. No. 1231.
a. Imperfect branches.
b. and c. Showing aspects due to compression from different angles.

Fig. 12. *Tetragraptus tabidus* sp. nov., Loc. No. 1231. Polypary.

Fig. 13. *Dichograptus octobrachiatus* J. Hall, Loc. No. 1273. Imperfectly preserved polypary.

Fig. 14. *Azygograptus prolixus* sp. nov., Loc. No. 1231. Polypary.

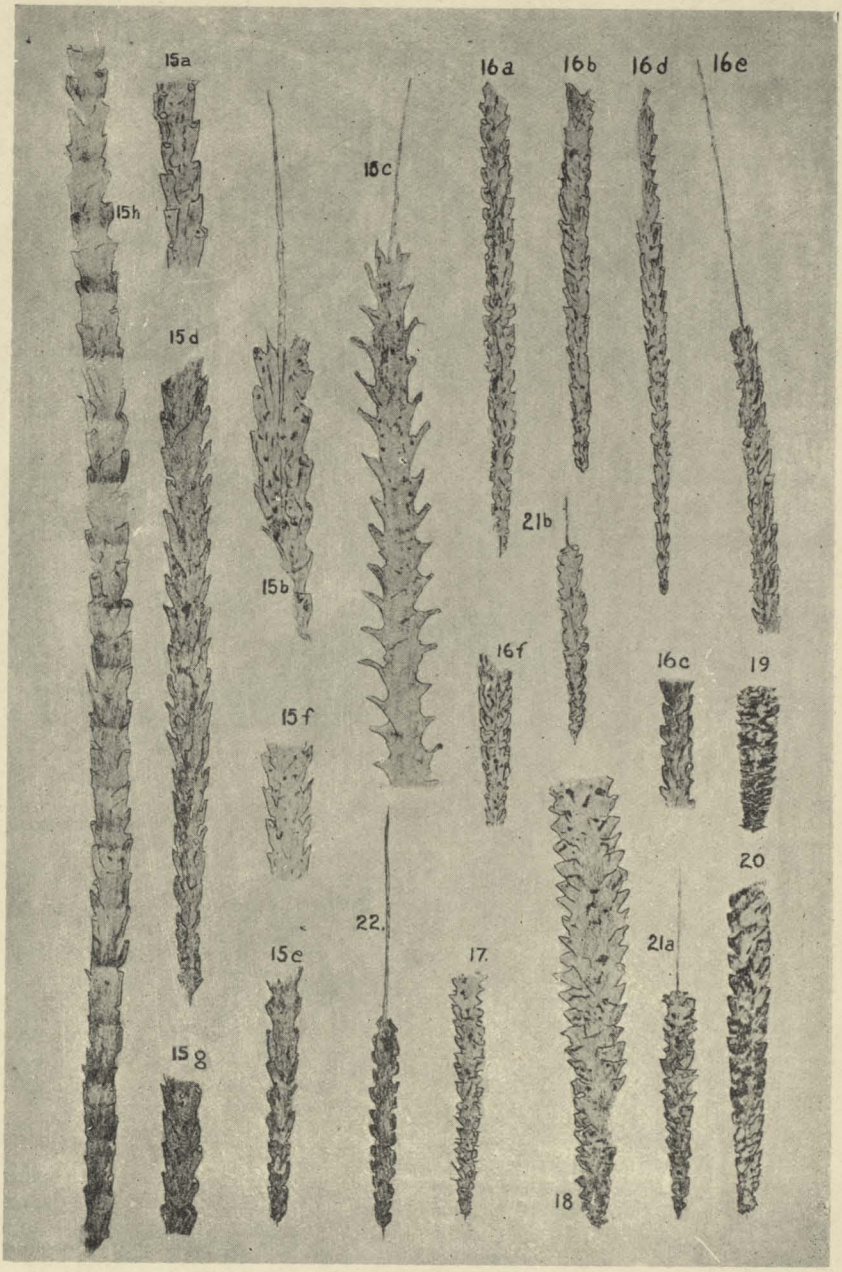

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Fig. 15. *Diplograptus spiculatus* sp. nov. Loc. No. 1231.
- a. Middle portion of polypary.
- b. Distal portion of polypary showing virgula. Paratype.
- c. Distal portion showing preservation in which thecal tubes are isolated.
- d. Proximal and middle portions of sicula showing typical aspect. Holotype.
- e. Proximal portion of polypary.
- f. Proximal portion of subscalariform polypary showing different appearance of thecae.
- g. Proximal thecae showing apertures.
- h. Incomplete polypary showing length attained.

Fig. 16. *D. euglyphus* Lapw. var. *sepositus* Keble and Harris, Loc. No. 1231.
- a. Incomplete polypary.
- b. Typical proximal portion of polypary.
- c. Distal thecae.
- d. Proximal end of polypary narrower form proximally.
- e. Distal end of polypary and virgula, subscalariform aspect.
- f. Portion of polypary.

Fig. 17. *D. euglyphus* Lapw. var. *coitus* var. nov., Loc. No. 1231. Polypary.

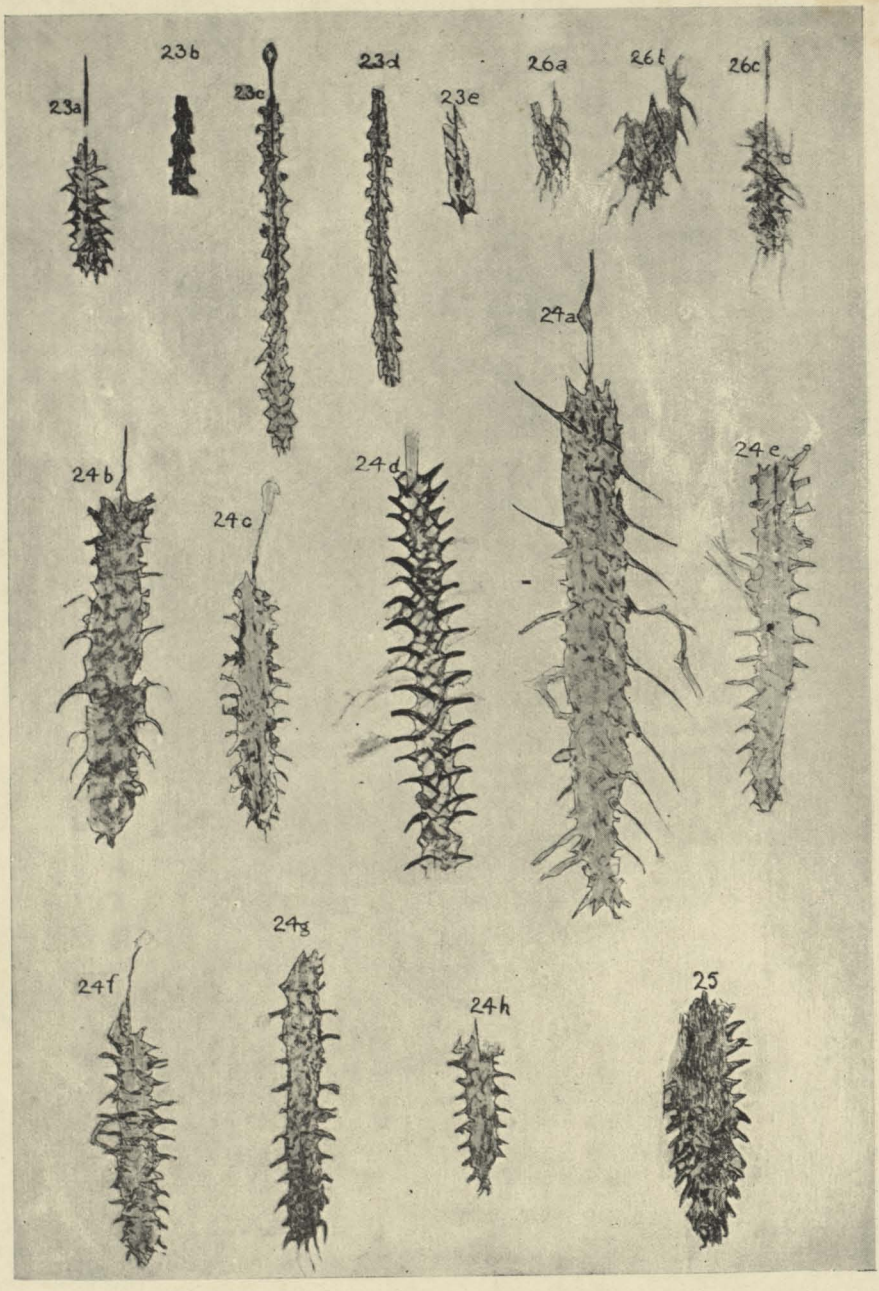
Fig. 18. *D. semotus* sp. nov., Loc. No. 1227. Polypary.

Fig. 19. *D.* cf. *perexcavatus* Lapw., Loc. No. 1231. Polypary.

Fig. 20. *Climacograptus* cf. *antiquus* Lapw., Loc. No. 1231. Polypary.

Fig. 21. *C. missilis* Keble and Harris, Loc. No. 1231.
a. Polypary b. Polypary.

Fig. 22. *C.* cf. *missilis*. Polypary distorted.



(All figures twice natural size).

Fig. 23. *Cryptograptus tricornis* Carr., Loc. No. 1231.
a. Typical polypary.
b. Distal thecae.
c. Club-shaped compression of polypary.
d. Club-shaped compression of polypary.
e. Proximal portion showing basal spines.

Fig. 24. *Glossograptus hincksii* Hopk., Loc. No. 1231.
a. Polypary.
b. Polypary.
c. Small polypary.
d. Distal portion of polypary.
e. Proximal portion of polypary.
f. Small polypary.
g. Polypary.
h. Small polypary.

Fig. 25. *G. acanthus* Elles and Wood, Loc. No. 1231.
Polypary.

Fig. 26. *G. villosus* sp. nov., Loc. No. 1231.
a. Young polypary.
b. Young polypary, somewhat larger.
c. Complete polypary.

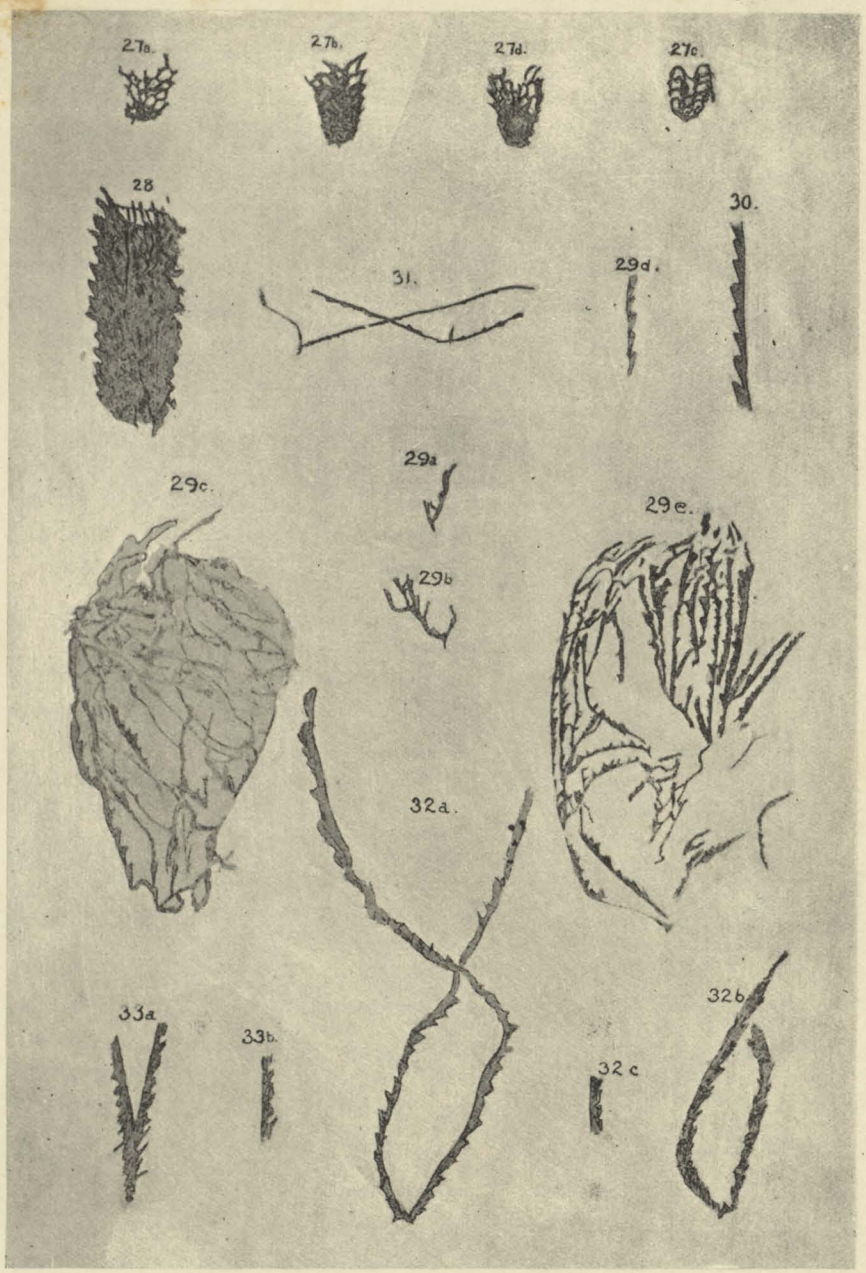


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Fig. 27. *Retiograptus speciosus* Harris, Loc. No. 1231.
- a. Polypary, somewhat broken but showing inclination to parietal lists.
- b. Polypary, with proximal half showing attentuated test and lists in distal portion.
- c. Distorted polypary.
- d. Polypary, with proximal half showing test but ventral lists showing in distal portion.

Fig. 28. *R. latus* sp. nov., Loc. No. 1231.
Polypary.

Fig. 29. *Syndyograptus artus* sp. nov., Loc. No. 1231.
- a. Sicula and proximal thecae.
- b. Sicula and proximal thecae.
- c. Broken polypary.
- d. Typical thecae.
- e. Large broken polypary showing characteristic symmetry.

Fig. 30. *S.* cf. *pecten* Ruedemann, Loc. No. 1231.
Portion of a branch.

Fig. 31. *Leptograptus flaccidus* J. Hall var. *angustus* Keble and Harris, Loc. No. 1231.
Polypary.

Fig. 32. *Dicellograptus* cf. *divaricatus* J. Hall, Loc. No. 1227.
- a. Distorted polypary.
- b. Distorted polypary.
- c. Thecae.

Fig. 33. *Dicranograptus* cf. *rectus* Hopk., Loc. No. 1230.
- a. Polypary.
- b. Thecae.

tively lax form will be difficult to procure. *T. insuetus* adds to the number of forms in New Zealand and Australia in which the Monograptus elaboration is foreshadowed; it is instructive to compare in this regard such forms as *Retrograptus circinus* Keble and Harris,* a biserial form with retroverted thecae and isolated apertures, and *Atopograptus*,† one of the Dichograptidae with similar thecae.

Horizon—Lower Aorere Series, Zone—Douglas, Subzone—Cobb.

Tetragraptus tabidus n. sp. (Fig. 12).

Polypary attenuate, consisting of (a) two branches of first order (funicle) arising from a minute sicula at a low irregular angle, each branch consisting of two thecae less than 0.1 mm. in minimum width and 0.2 mm. in maximum width, the second pair of which give rise to (b) four branches of the second order usually curved or flexuous and attaining a width of 0.5 mm. about Th 6.

Thecae, 10 to 16 in 10 mm., proximal ones with inapproachable overlap which increases to two-thirds distally, about three times as long as wide, apertural margins straight or slightly concave, abnormal to axis of theca, outer margins straight or slightly concave at an angle of 40° to axis of branch.

T. tabidus suggests the gerontic phase of the genus *Tetragraptus;* its laxity and attenuation both point to this. The other Tetragraptid associate *T. insuetus,* if it is correctly placed generically, is not typical and appears to have sought survival by thecal elaboration; in these Cobb River beds, and in the beds immediately above and below them taking the Australasian region as a whole, thecal elaboration appears to be supplanting dichotomy. We have hereabouts the balance in favour of biserial and uniserial forms to the exclusion of the Dichograptidae. The few Dichograptidae remaining have either specialized thecae as in *Tetragraptus insuetus, Didymograptus nodosus, Atopograptus woodwardi,* etc., or suggest old age as in *T. tabidus.*

Horizon—Lower Aorere Series, Zone—Douglas, Subzone—Cobb.

Genus—AZYGOGRAPTUS.

Azygograptus prolixus n. sp. (Fig. 14).

Branch nearly 3 cm. long, curved, slender (–0.2 mm.) at origin, of fairly uniform breadth to Th 5, and then rapidly increasing to a maximum width of slightly under 1.3 mm., originating from a small inconspicuous sicula apparently in centre. In proximal portion of branch thecae long and narrow, four or five times as long as wide, outer walls straight up to Th 5, in contact for small portion of length, in distal portion 9 or 10 in 10 mm., inclined at angle of from 30° to 35°, twice as long as wide, outer walls slightly concave, in contact for one-half to two-thirds of their length, apertural margins normal to axis of theca.

A. prolixus differs from *A. lapworthi*—the nearest form to it in its greater maximum width, its relatively inconspicuous sicula, and the closer set of the thecae. The thecae are typical of the Dichograptidae.

Horizon—Lower Aorere Series, Zone—Dougles, Subzone—Cobb.

*Keble, R. A. and Harris, W. J., *Rec. Geol. Surv. Vict.*, vol. 5, pt. 1, (*In litt).*
†Harris, W. J., *Proc. Roy. Soc. Vict.*, vol. 38 (N.S.), pp. 59-60, Pl. 2, Fig. 12-15.

Family—DIPLOGRAPTIDAE.

Genus—DIPLOGRAPTUS.

Diplograptus spiculatus n. sp. (Figs. 15a-h).

Polypary 10 cm. or more in length, widening gradually from a width of 1.1 mm. near sicula to a width of 2.5 to 2.8 mm., then slightly decreasing to distal extermity. Sicula minute, about 0.2 mm. long with an extremely fine inconspicuous virgella. Virgula 15 mm. or more in length, visible in polypary, moderately stout but tapering to a fine thread. Thecae alternate, long (3.5 mm.) tubes with slight double curvature, about 1.1 mm. wide near apertures, 6 to 8 in 10 mm. in proximal portion of polypary, 4 to 5 in distal portion, inclined at an angle of about 20°, in contact for about one half their length in proximal portion, and from one half to two-thirds in distal portion, aperture opening proximally into a shallow excavation which becomes obliquely elliptical distally and occupies about one-fourth the width of polypary. Aperture normal to axis of theca in proximal portion, introverted in distal region.

Sicula minute and seldom visible. First theca appears to originate near middle of sicula and grows obliquely downward towards aperture before turning outwards and obliquely upwards; it, too, is small. There is considerable variation in width, that given in the description being the mean of a number of measurements of average specimens; some over 3.0 mm. wide are known. The mature polypary must be of considerable length as fragments up to 10 cm. with both proximal and distal extremities missing are not uncommon. In the obverse aspect the proximal excavations are shallow but the distal excavations gradually become more oblique and incised and ultimately almost disappear (Figs. 15b, 15h); in the reverse aspect the apertural regions of the thecae become isolated (Fig. 15c) in the distal portion, suggesting a polypary of concavo-convex cross-section. In the subscalariform view the excavations are merely represented by the overhanging free margins of the theca above.

Of the Diplograptidae in the Australasian region *D. spiculatus* perhaps most resembles *D. coelatus* particularly in the scalariform aspect. It differs however in the more remote set of thecae, less width, absence of the characteristic sheathed virgella of *D. coelatus* and growth of first thecae, and in dimensions and form of interthecal excavations.

D. spiculatus is a striking and characteristic species and should be of zonal value. Since its first recognition in the New Zealand fauna, it has been observed in the Dark River beds in Victoria.

Horizons—Lower Aorere and Mount Arthur Series, Zones—Douglas and Lodestone, Subzones—Cobb to Mt. Peel (incl.).

Diplograptus (Glyptograptus) euglyphus, Lapw. var. **sepositus** Keble & Harris. (Figs. 16d-f.).

Keble & Harris's* description is as follows:—"Polypary 21 mm. or more in length widening from about 0.7 mm. near the sicula to a

*Keble, R. A. and Harris, W. J., New and Little Known Graptolites from the Lower Ordovician of Victoria. *Rec. Geol. Surv. Vict.*, vol. 5, pt. 1.

maximum width of from 1.5 to 1.8 mm. in 6 mm. and then of uniform width to distal extremity. Sicula small with a fine short virgella and usually curved apertural spine. Thecae alternate from 8 to 10 in 10 mm., similar to those of *D. euglyphus.*"

The New Zealand form reaches its maximum width in 20 mm., but in all other particulars agrees well with the Victorian form. Sicula about 0.5 mm. long and relatively broad. Th. 1^1 apparently originates near apex of sicula and grows downwards, outwards and obliquely upwards. Ruedemann's* description of the thecae of *D. euglyphus* is as follows:—"Thecae numbering 7 to 9 in 10 mm., overlapping less than one-third of length, inclined at an angle of about 40°; proximal part of outer wall excavated, distal part of outer edge very convex, aperture vertical to axis of theca, apertural margin concave. Interthecal excavation deep (nearly two-fifths of width) and as long as free part of theca."

Horizons—Lower Aorere and Mount Arthur Series, Zones—Douglas and Lodestone, Subzones—Cobb to Mt. Peel (incl.).

Diplograptus euglyphus var. **coitus** n. var. (Fig. 17).

This is a variety of *D. euglyphus* that differs from the parent form in the closer set of the thecae. It has 14 thecae in 10 mm. in the proximal portion and 12 in 10 mm. in the distal portion of the polypary. In other respects it agrees well with *D. euglyphus.* As the wider set of the thecae is consistent in *D. euglyphus* and its variety *distans,* we have ventured to make a varietal distinction on this difference.

Horizon—Lower Aorere Series, Zone—Douglas, Subzone—Cobb.

Diplograptus semotus n. sp. (Fig. 18).

Polypary widening consistently from relatively broad proximal extremity where the minimum width is 1.5 mm. to maximum width of about 4.3 mm., 13 mm. from sicula. Thecae number 9 or 10 in 10 mm. and are rapidly expanding tubes, twice as long as wide, overlapping two-thirds of their length. Outer margins usually show double curvature; apertural margins concave and normal to axis of theca. Length of type-specimen is 27 mm.

Sicula and place of origin of first theca obscure.

D. semotus outwardly resembles *D. calcaratus* var. *priscus* but differences become apparent immediately one enters into a detailed comparison.

Associates—*D. spiculatus, D. euglyphus* var. *distans, Dicellograptus* cf. *gurleyi, D.* cf. *elegans, D.* cf. *moffatensis, Glossograptus* sp.

Horizon—Mount Arthur Series, Zone—Lodestone, Subzone—Mt. Peel.

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* Ruedemann, R. Graptolites of New York, *N.Y. State Museum, Mem.* 11, pt. 2, p. 369-70, Fig. 315-6, Pl. 25, Fig. 21-23.

Diplograptus cf. **perexcavatus** Lapw. (Fig. 19).

Elles, Gertrude L., and Wood, Ethel M. R., British Graptolites pt. 6, *Palaeon Soc.*, vol. 61, p. 267-9, plate 31, figs. 15 a-d.

The polypary of this New Zealand form is 9 mm. or more in length and widens from about 1.1 mm. in sicula region to 2.7 at distal extremity. Virgella absent. Thecae 15 or 16 in 10 mm., basal thecae furnished with spines, all with pronounced sigmoid curvature and wide and deep excavations occupying one-half to one-third width of polypary and more than half ventral margin.

The British specimens of *D. perexcavatus* generally appear to be somewhat wider in proximal region and sigmoid curvature of thecae less pronounced than in the New Zealand form. There is only one specimen in the collection.

Horizon—Lower Aorere Series, Zone—Douglas, Subzone—Cobb.

Genus CLIMACOGRAPTUS.

Climacograptus cf. **antiquus** Lapw. (Fig. 20).

Elles, Gertrude L., and Wood, Ethel M. R., British Graptolites pt. 5, *Palaeon. Soc.*, vol. 60, p. 199-200, plate 27, figs. 4 a-e.

A single specimen of *Climacograptus,* indifferently preserved, widens from a breadth of 1.2 mm. near sicula to maximum breadth of 2.5 mm. in a little over 1 cm. Excavations about one-fourth the width of polypary, and from one-fourth to one-third the ventral margin; thecae number from 7 to 10 in 10 mm. We have tentatively compared it with *C. antiquus,* but while there is a general agreement collectively between *C. antiquus* and its varietal form *lineatus,* poor preservation, particularly in proximal portion, leaves the criteria doubtful.

Horizon—Lower Aorere Series, Zone—Douglas, Subzone—Cobb.

This species probably ranges into the Mount Arthur Series.

Climacograptus missilis Keble & Harris. (Figs. 21a-b).

Keble, R. A. and Harris, W. J. Graptolites from Mt. Easton, *Rec. Geol. Surv. Vict.,* vol. 4, pt. 4, p. 513, Figs. 144a-d.

The original description was as follows:—

" Rhabdosome short, not exceeding 1.5 cm. in observed specimens, narrow at origin and increasing constantly in width throughout to 2.0 mm. Virgella short. Virgula visible in the body of the rhabdosome, free at the distal end for 6.0 mm. or more, and in some cases expanded into a short irregularly shaped vesicle at its apical extremity. Sicula visible for 0.6 mm. of its length. Thecae 10 to 14 in 10 mm., proximally sigmoidal, distally slightly curved, overlapping one-third to one-half; apertural margin undulate, lying within excavations which occupy one-quarter the width of the rhabdosome."

The length of the New Zealand polypary (rhabdosome) is 1.3 cm. and it increases to a width of 2.0 mm. Virgella short; virgula partly visible in polypary, free for 14 mm., but without vesicle at extremity. Thecae number 10 to 12 in 10 mm. Excavations occupy about one-quarter width of polypary. The other dimensions are somewhat uncertain.

Horizon—Lower Aorere and Mount Arthur Series, Zones—Douglas and Lodestone, Subzones—Cobb to Mt. Peel (incl.)

Genus CRYPTOGRAPTUS.

Cryptograptus tricornis Carr. (Figs. 23a-e).

Carruthers, W., *Ann. & Mag. Nat. Hist.*, 1859, vol. 3, pt. 25.

Several specimens of *Cryptograptus* occur in the Cobb River Collection and illustrate the variable appearance of this species, due to the direction of compression.

The polypary of specimen figured (No. 1231 (11) (Figs. 23c, d) is 19 mm. long and is adorned with four straight or slightly curved spines. It widens rapidly to 1.7 mm., maintains that width for about 3.0 mm., then diminishes in width until at distal end it is only 1.0 mm. wide. Fig. 23e shows the obverse aspect and basal spines. Fig. 23a is a typical aspect.

Horizon—Lower Aorere and Mount Arthur Series, Zones—Douglas Lodestone and probably Leslie, Subzones—Cobb, Mt. Peel, Flora Track and Leslie River.

Genus GLOSSOGRAPTUS.

Glossograptus hincksii Hopk. sp. (Figs. 24a-h).

Hopkinson, J. *Geol. Mag.*, vol. 9, p. 507, Pl. 12, Fig. 9.

In the Cobb River material (1231) there are specimens of this species up to 2.7 cm. in length. Breadth varies from 1.7 to 3.2 mm. From 10 to 12 thecae in 10 mm. in proximal portion of polypary and 8 to 10 in distal portion. Apertural spines strong, arcuate, and at maximum length longer than width of polypary; septal spines straight and ascending. Some specimens with consistently shorter spines (Figs. 24g, h) have some characters in common with *G. hincksii* var. *fimbriatus* Hopk. but in the Cobb River material we find some difficulty in separating them from the parent species. In one specimen (Fig. 24d) there is a suggestion of scopulae as in *Lasiograptus*.

Horizon—Lower Aorere and Mount Arthur Series, Zone—Douglas, Lodestone and probably Leslie, Subzones—Ranging up through Cobb to Flora Track and probably beyond.

Glossograptus acanthus Elles & Wood. (Fig. 25).

Elles, Gertrude L., and Wood, Ethel M. R., *Brit. Grap.*, pt. 7, p. 314, Pl. 33, Fig. 4a-c., Text Fig. 208a-b.

The polypary of the New Zealand form is 13 mm. or more in length and widens rapidly to a width of about 4 mm., diminishing distally, suggesting a sub-fusiform outline as in the British forms. Sicula obscure. Thecae 10 or 11 in 10 mm. Apertural margins apparently everted with relatively short, robust spines. Spines in proximal portion of polypary directed downwards, but towards middle become horizontal and at distal end trend upwards. Sicula extends beyond end of polypary and is provided with at least one blunt spine.

Apertural spines not as long as in British forms and there appears to be some evidence of apertural lists.

Horizon—Lower Aorere Series, Zone—Douglas, Subzone—Cobb.

Glossograptus villosus n. sp. (Figs. 26a-c).

Sicula 1.5 mm. long, tapering. Thecae of *Cryptograptus* type, i.e., strongly everted, and showing marked curvature in apertural region, about 2.0 mm. long and 0.7 mm. broad. Basal thecae furnished with long spines, trending directly downwards, but in more distal thecae obliquely downwards. Distal thecae in contact for about one-third their length, 12 to 13 in 10 mm. Virgula gradually widening, visible throughout polypary and prolonged 4.0 mm. or more beyond. Test attenuate.

The long and tapering sicula is directed downwards as in *Cryptograptus tricornis.* Th 1^1 arises near middle of sicula growing first outwards then downwards. Points of origin of subsequent thecae are obscured by the superposition of sicula and first theca, but they are similarly curved, i.e., with a dorso-convex curvature, and are so oriented about sicula as to give polypary a sub-rounded base. The filamentous apertural margins, particularly those belonging to more distal thecae, similar to those of *Glossograptus pilosus,** in fact, the general appearance of immature polypary suggests a *Cardiograptus*†-shaped *Glossograptus pilosus.* Both *G. villosus* and *G. pilosus* develop two abnormal distal thecae in immature polyparies, but as polypary grows, it takes on more the appearance of *Glossograptus* or *Lasiograptus.* The distal V-shaped space formed by dorsal curvature of thecae in young polypary, and giving it the appearance of a reclined *Didymograptus,* is closed by inward growth and appression to virgula which projects beyond polypary as in a normal *Glossograptus.* Spines on basal thecae long but so tenuous that it is difficult to follow them for their full length. The test must have been very thin.

This remarkable species combining, as it does, the characteristics of several genera, may call for a new genus; it is only tentatively placed in *Glossograptus* because of its suggestive affinities to *G. pilosus* which, too, is abnormal in many respects.

Horizon—Lower Aorere Series, Zone—Douglas, Subzone—Cobb.

Genus—RETIOGRAPTUS.

Retiograptus speciosus Harris. (Figs. 27a-d).

Harris, W. J., *Proc. Roy. Soc. Vict.,* vol. 36 (N.S.) pt. 2, pp. 99-100, Pl. 8, Fig. 8-10.

The New Zealand specimens are usually small, less than 5.0 mm. in length and widen rapidly to 3.0 mm.; in no specimen is there a mature polypary and in every instance the polypary is broken. The test is partly preserved usually in proximal part. Medial zigzag not clearly shown. Thecae in 10 mm., 14 to 16.

Harris's remarks‡ on his species are as follows:—" This form is quite unlike any other with which we are acquainted, though, when preserved so that the two ascending zigzags coincide, the outline agrees with that sometimes shown by *R. geinitzianus,* J. Hall. Its characteristic outline, however, is quite different, and so is the

*Keble, R. A. and Harris, W. J., *Rec. Geol. Surv., Vict.*, vol. 5, pt. 1.
†Harris, W. J., *Proc. Roy. Soc., Vict.*, vol. 29, pt. 1, Pl. 1, Fig. 1-3.
‡*Supra cit.*, p. 100.

arrangement of parietal lists. These arise from the zigzag medial of each surface at the apices of the zigzags. Their direction, especially near the proximal end of the rhabdosome, is at first almost horizontal, but they gradually ascend and form part of what may be called the ventral strands. The thecae appear to have been sub-rectangular in section in the body of the rhabdosome and the same shape is maintained throughout, though the axis of each theca is curved upwards and the theca gradually narrows towards its aperture." We are unable to verify the upward curvature of the thecal axis and the sub-rectangular section, in fact in the New Zealand specimens the former appears to be straight and the latter round, but distortion has obviously modified them. The specimens show the characteristic outline of *R. speciosus* as compared with that of *R. geinitzianus* and the typical ascending parietal lists.

Horizon—Lower Aorere and probably Mount Arthur Series, Zones—Douglas and probably Lodestone, Subzones—Cobb but not as far as Mt. Peel.

Retiograptus latus n. sp. (Fig. 28).

Polypary with broadly rounded base and sub-parallel margins, 1.5 cm. in length and 5.5 mm. broad. Test almost continuous, attenuated, but usually thick enough to mask lists and clathria. Sicula long. Theca 11 or 12 in 10 mm. with convex or slightly-sigmoidal outer margins and concave apertural margins in contact for about one-third their length.

The test seems to have been thicker in this species than either *R. speciosus* or *R. geinitzianus* for all; the polyparies in the collection show it as almost continuous. Parts of the lists and clathria are sometimes seen either at proximal or distal ends but disclose no arrangement of them. Thecae seem to have been triangular in shape. Part of sicula lies outside polypary.

This form may easily be distinguished from *R. speciosus* and *R. geinitzianus* by (*inter alia*) its relative width.

Horizon—Lower Aorere Series, Zone—Douglas, Subzone—Cobb.

Family—LEPTOGRAPTIDAE.

Genus—SYNDYOGRAPTUS.

Syndyograptus artus n. sp. (Figs. 29a-e).

Polypary consisting of branches (a) of the first order, two branches widening from 0.2 mm. near sicula to 0.7 mm. in distal portion. The first 4.0 mm. of proximal portion forms a broadly rounded base to polypary, the branches then gently curving upwards and apparently inwards towards axis of polypary, the whole of which is contained within angle of 25°, (b) of the second order, up to twenty branches of like dimensions arising from successive thecae in pairs (apparently sometimes singly) forming with their dorsal walls at points of origin acute angles with the branches of the first order. Sicula 0.7 mm. long, tapering. Thecae narrow simple tubes, in proximal portion 8 or 9 in 10 mm., about three times as long as wide, overlapping one-fourth their length, inclined at an angle of from 15° to 20°, apertural margins straight, normal to axis of branch, in

distal portion in contact for about one-third their length, apertural margins normal to axis of thecae.

Both specimens showing a complete polypary are distorted; they occur on the surface of a sheared slate. The following is a tabulation of the characters of the New Zealand, Victorian and American forms:—

	S. artus	*S. gracilis**	*S. pecten*†
Angle containing polypary	25°	65°	90°
Thecae in first order giving rise to secondary branches	succeeding thecae	every second theca	every third theca
Width of branches at origin	0.2	0.2	0.3
distally	0.7	0.5	0.5
Sicula—length	0.7	?	1.2
Thecae—Number in 10 mm.			
proximally	8-9	10-11	12
distally	?	8	10
Width to length, proximally	3 : 1	4 : 1	6 : 1
Overlap, proximally	¼	⅓ – ⅔	¼
Angle of inclination	15°-20°	25°	?

Associates—List of species for Loc. 1231. *S. gracilis* occurs in Victoria with *Didymograptus ovatus, D. caduceus, D. nodosus, Glossograptus hincksii, Loganograptus logani* (mut.), *T.* cf. *quadribrachiatus, Diplograptus euglyphus* var. *sepositus, Lasiograptus* sp., *Cryptograptus tricornis* and others at the top of the Lower Ordovician. In America *S. pecten* occurs rarely with *Didymograptus sagitticaulis, Azygograptus walcotti, Leptograptus flaccidus* et. var., *Nemagraptus* ssp., *Dicellograptus gurleyi, D. moffatensis, Diplograptus euglyphus* (common), *Cryptograptus tricornis* (common) and other forms.

Horizon—Lower Aorere and probably Mount Arthur Series, Zones—Douglas and Lodestone, Subzones—Cobb and next subzone above.

Genus—Leptograptus.

Leptograptus flaccidus J. Hall var. **angustus** Keble & Harris. (Fig. 31).

The description* of this form is as follows:—Branches narrow, slightly flexed, 5 cm. or more in length widening gradually from 0.2 mm. near sicula to 0.6 mm. distally. Sicula slightly under 1.0 mm. in length. Thecae long tubes, 7 or 8 in 10 mm., inclined at 15°, about three times as long as wide in proximal portion and from three to four times in distal portion, overlapping one-fourth their length. Apertural margins normal to axis of thecae, introverted when compressed, ventral margins slightly concave.

*Keble, R. A. and Harris, W. J., *Rec. Geol. Surv. Vict.*, vol. 5, pt. 1 (*In litt*).

†Ruedemann, R., Graptolites of New York, *N.Y. State Mus.* Mem. 11, pt. 2, p. 267-8, Pl. 15, Fig. 5 and 6.

The branches of the New Zealand specimen are slightly narrower in proximal portion but otherwise the dimensions would seem to agree fairly well.

Horizon—Lower Aorere Series, Zone—Douglas, Subzone—Cobb.

Family—DICRANOGRAPTIDAE.

Genus—DICELLOGRAPTUS.

Dicellograptus cf. **divaricatus** J. Hall. (Fig. 32).

Hall, J. *Palaeontology of New York*, vol. 3, p. 513-4.

There is in the collection No. 12 a distorted and imperfectly preserved form of *Dicellograptus* showing the branches crossing. Both branches are twisted and the thecae in places face inwards; restoring the branches to their right positions the shape of the polypary would be divergent approximately at an angle of 235° in the proximal portion. The apical point of the sicula has been partly obscured and the short spines are visible on Th 1^1 and Th 1^2.

Thecae 8 to 10 in 10 mm., overlapping about one-third their length, free outer wall straight or slightly curved, apertural portion introverted. Apertural excavation one-half width of branch.

The few thecae that are well enough preserved for comparison suggest affinities to *D. divaricatus*.

Horizon—Mount Arthur Series, Zone—Lodestone, Subzone—Mt. Peel.

Genus—DICRANOGRAPTUS.

Dicranograptus cf. **rectus** Hopk. (Figs. 33a, b).

Hopkinson, J. *Geol. Mag.*, vol. 9, p. 508, Pl. 12. Fig. 9.

A species of *Dicranograptus* occurs at Leslie River Band comparable to *D. rectus* Hopk.

The biserial portion of polypary is 4.5 mm. long; uniserial branches are 6.5 mm. long, dorsal walls subtending an angle of 25° and ventral margins being in the same straight line as ventral margins of biserial portion.

Thecae 10 or 11 in 10 mm. with free outer walls straight and inclined at angle of 25°, apertural portion introtorted and introverted with stout spines opening into pouch-like excavations.

Biserial portion made up of 6 thecae on each side, is 0.4 mm. wide at its origin and 1.3 mm. wide at point of divergence of uniserial branches.

The width of the uniserial portion is 0.7. Hopkinson's species differs from the Leslie River form in that

(a) the biserial portion is longer
(b) the free outer walls are gently curved
(c) the apertural portion is not introtorted
(d) the spines are not conspicuous
(e) it is larger in all dimensions.

We have only one example, which is not well preserved, and hesitate at present to emphasize these differences by allotting specific or varietal distinction to the New Zealand form.

Horizon—Mount Arthur Series, Zone—Leslie, Subzone—Leslie River.