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CONTENTS

UNCINULUS AUSTRALIS, A NEW RHYNCHONELLID SPECIES FROM THE LOWER DEVONIAN OF SOUTHERN NEW SOUTH WALES

by
P. G. Flood[1]

SUMMARY

Uncinulus australis sp. nov. is present in southern New South Wales in the Lick Hole Limestone of the Ravine (Upper Lobs Hole) area; it is associated with a conodont fauna of Lower Devonian (early Emsian) age. The new species shows morphological affinities to *U. subwilsoni* (d'Orbigny), the type species.

INTRODUCTION

Uncinulus australis sp. nov. is present in southern New South Wales in the Lick Hole Limestone of the Ravine (also known as Upper Lobs Hole) area, about 16 km northwest of Kiandra (see Fig. 1). The age and stratigraphic relationships of this formation have been discussed recently (Flood, 1969), and conodonts associated with the new species, at its type locality, are of early Emsian age.

Two distinct groups of sediments have been recognized in the area; the Upper Silurian Ravine Beds, and the unconformably overlying Lower Devonian Byron Range Group. The latter group contains three conformable formations; in ascending order, Milk Shanty Formation (168 m), Lick Hole Limestone (488 m), and Round Top Formation (15 m). The Lick Hole Limestone consists of richly fossiliferous interbedded bluish grey mudstone, drab olive-grey calcareous mudstone, and dark fine-grained biogenic nodules and nodular layers.

The following brachiopods are associated in the Lick Hole Limestone with *Uncinulus australis*: *Parachonetes* sp. nov., *Athyris waratahensis* (Talent, 1956), *Spinella yassensis ravinia* Flood (*in* Strusz, Chatterton, & Flood, 1970), *Howittia multiplicatus* (de Koninck), *Howellella* sp., and *Globithyris* sp. nov.

Specimens of *Uncinulus australis* are housed in the following repositories: Palaeontological Collection, Department of Geology, University of New England, Armidale (collected by Flood in 1967); Australian Museum, Sydney (collection

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[1] Present address: Dept of Geology & Mineralogy, University of Queensland, St Lucia 4067.

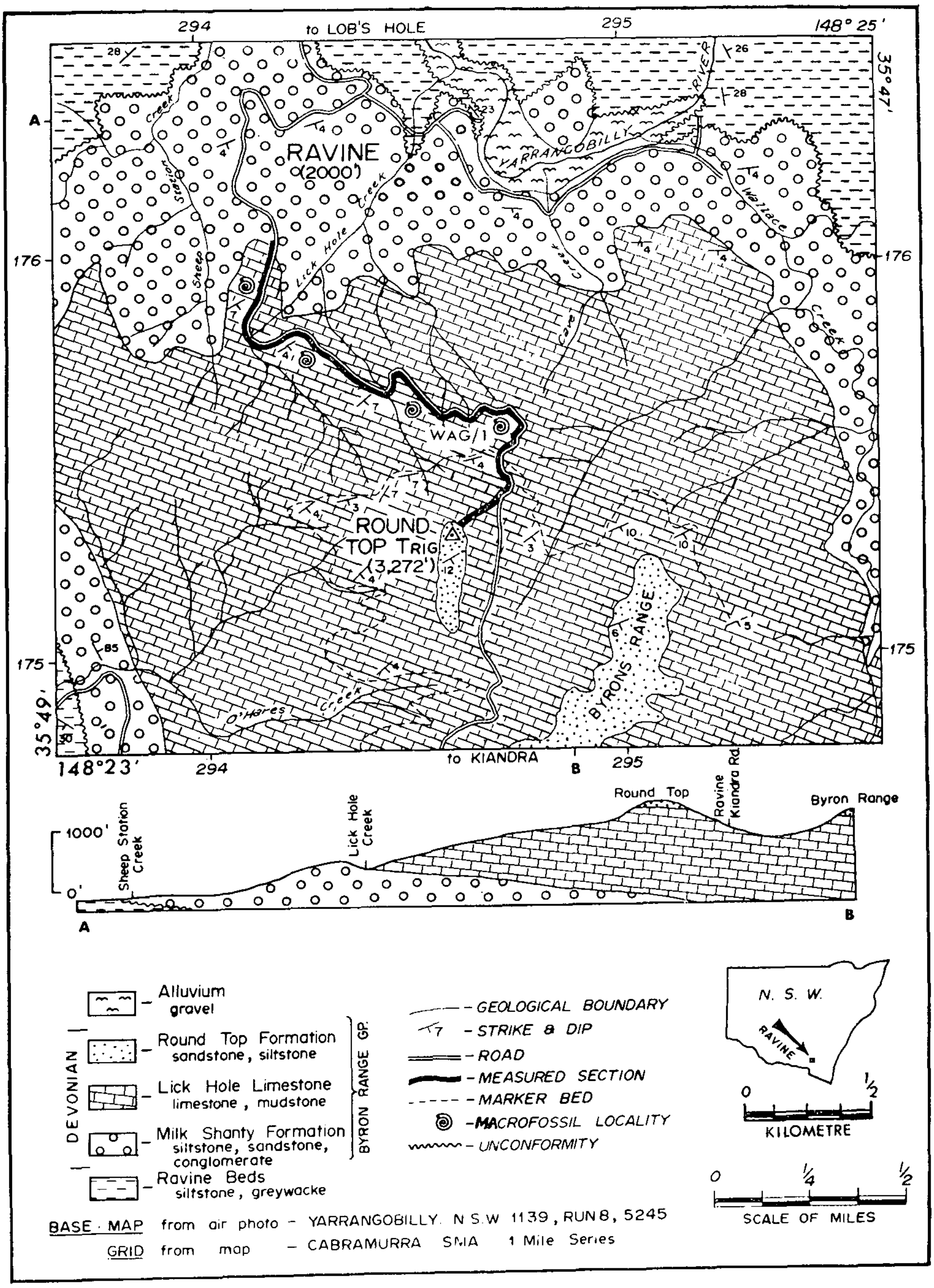

Figure 1. Geological map of the Ravine area, New South Wales.

of Andrews, 1901); Geological Survey of New South Wales (collection of Adamson, 1954); Commonwealth Palaeontological Collection, Canberra (this collection consists of the holotype, CPC 10423, and 9 figured paratypes, CPC 10424-32); and the Bureau of Mineral Resources Fossil Collection (this collection contains 21 topotypic specimens, F23577/1-21).

Genus UNCINULUS Bayle, 1878

Type species (by original designation). *Hemithyris subwilsoni* d'Orbigny, 1850, p. 92. Lower Devonian (Siegenian) Néhou Limestone, western France.

Definition. Medium-sized, roundish to pentagonal, biconvex rhynchonellid with strongly costate shell; fold and sulcus moderately or weakly developed; anterior commissure strongly uniplicate; pedicle foramen minute; marginal spines present.

Pedicle valve with short dental plates and short strong teeth; muscle field deeply impressed, semi-oval, and divided by a low thin median ridge.

Brachial valve with shallow septalium supported posteriorly by a median septum, and filled with callus forming a comb-like cardinal process; hinge-plate divided anteriorly; musculature rarely observable and divided by the septum.

Remarks. The definition is modified after Binnekamp (1965, pp. 21-3), who has discussed the lack of a connective band, or connectivium, between the anterior ends of the hinge-plate. Such a connectivium was of generic importance in Havlíček's (1961) description of the genus.

Range. The genus has been described definitely from the Siegenian Néhou Limestone of western France; the Siegenian Massif Armoricain of western France (Renaud, 1942); the middle Siegenian Lebanza Formation of Spain (Binnekamp, 1965); the Lower Devonian La Vid Formation of Spain (Comte, 1938); the early Emsian Rich Mersakhsai of Morocco (Drot, 1964); and questionably from the early Emsian (?) Kilgower Member of the Tabberabbera Formation of eastern Victoria, Australia (Talent, 1963).

Many of the species placed previously in the genus do not belong to it. Hence the significance of numerous other references to the genus will remain obscure until a revision of *Uncinulus* is attempted. Such a revision is beyond the scope of this paper.

The new species is from the early Emsian Lick Hole Limestone of southern New South Wales, Australia.

UNCINULUS AUSTRALIS sp. nov.

(Pl. 1, figs 1-4, 12; Pl. 2, figs 1-12; Fig. 2)

1901 *Rhynchonella* (*Uncinulus*) *wilsoni* Sowerby; Dun *in* Andrews, p. 16.
1902 *Rhynchonella* (*Uncinulus*) *wilsoni* Sowerby; Dun, p. 175.
1954 *Camarotoechea* cf. *cuboides* Sowerby; Fletcher *in* Adamson, p. 15.
1970 *Uncinulus* cf. *subwilsoni* (d'Orbigny); Flood *in* Philip & Jackson.

Material. 140 separate specimens.

Diagnosis. Species of medium size, globular, with 36 to 48 costae, rarely bifurcating; fold and sulcus almost imperceptible, fold with 6 to 8 costae, ventral muscle field circular, deeply impressed and divided by a low, narrow median ridge; dental plates well developed and supporting teeth; septalium supported by a median septum; cardinal process covering a large part of the anteriorly divided hinge-plate and bearing 15 to 20 subparallel longitudinal ridges; marginal spines well developed.

Description. The shells are medium-sized, biconvex, and rounded to subpentagonal in outline. The beak of the pedicle valve is slightly anterior of midlength and the fold and sulcus are almost imperceptible, but the anterior commissure is strongly uniplicate because of the prominent tongue-like projection of the pedicle valve.

The external ornament consists of 36 to 48 low, flat costae, rarely bifurcating (compare Pl. 2, fig. 2 with other figures) separated by furrows that project, as slender spines, beyond the margin of the valve, and extend under the costae of the other valve. The sulcus begins forward of midlength, and bears 6 to 8 costae. Most costae near the commissure are longitudinally grooved.

The pedicle valve interior has well developed dental plates supporting strong triangular teeth, the apices pointing ventrally and towards the beak. The muscle field is deeply impressed, circular, and divided by a delicate median ridge (Pl. 1, figs 1-3). The central oval adductor impression is surrounded by strongly developed diductors. The large pedicle cavity is commonly infilled with callus.

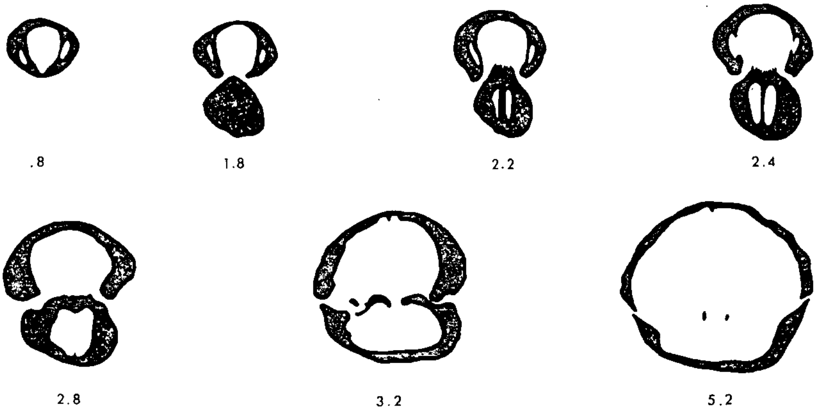

Figure 2. ***Uncinulus australis*** **sp. nov., serial sections x2 of paratype CPC 10432. Distances are mm forward of the pedicle umbo.**

The brachial valve interior has a shallow septalium, supported posteriorly by a median septum, and is filled with callus that forms the cardinal process (Pl. 1, fig. 12). The cardinal process covers a large portion of the broad but thin hinge-plate, and it bears between 15 to 20 subparallel longitudinal ridges that decrease in height anteriorly. Callus also extends on the ventral side of the anteriorly divided hinge-plate and short crura arise from the hinge-plate and diverge ventrolaterally. The outer hinge-plates bear long, narrow, widely divergent dental sockets which are bounded by the cardinal margin on the outer edge, and by the inner socket ridges. The thin median septum, which provides little or no support for the cardinal process, extends about one-third the length of the valve. Musculature is not distinguishable.

PLATE 1

All figures x 2, except 12 x 10

Figures 1-4, 12 *Uncinulus australis* sp. nov.

1-2 Latex cast of pedicle valve interior, and pedicle valve internal mould, paratype CPC 10429.

3 Pedicle valve interior impression, paratype CPC 10430.

4 Posterior view, paratype CPC 10431.

12 View of cardinal process, paratype CPC 10431.

All specimens from BMR locality WAG/1, 300 m above the base of the Lick Hole Limestone.

Figures 5-11 *Uncinulus subwilsoni* (d'Orbigny)

5-6 Latex cast of pedicle valve interior, and plaster replica of pedicle valve interior, CPC 10435 (coll. de Vibraye, Néhou).

7-11 Ventral, posterior, dorsal, lateral, and anterior views, plaster replica, CPC 10434 (St Germain Le Fouillaux, Mayenne).


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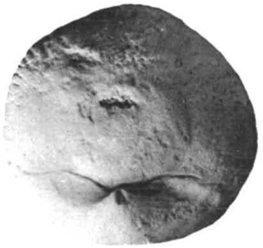
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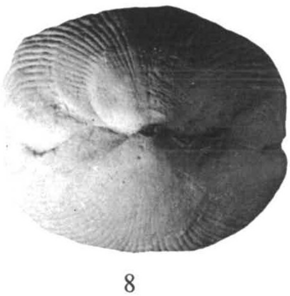
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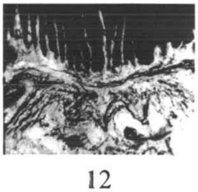
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PLATE 2

All figures x 2

Figures 1-12 *Uncinulus australis* sp. nov.
1-3 Ventral view, paratypes CPC 10427, 10425, and **holotype** 10423.
4-6 Dorsal view, paratypes CPC 10427, 10426, and **holotype** 10423.
7-9 Anterior view, paratypes CPC 10427, 10428, and **holotype** 10423.
10-12 Lateral view, paratypes CPC 10424, 10426, and **holotype** 10423.

All specimens from BMR locality WAG/1, 300 m above the base of the Lick Hole Limestone.


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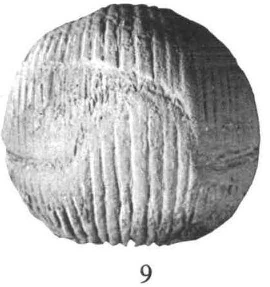
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Measurements of Holotype, 3 Paratypes, and 21 Topotypes of *U. australis* sp. nov.

	Measurements (mm)							
Specimen	Lp	Lb	Hp	Hb	Wf	Ncf	Ws	Ncs
Holotype								
CPC 10423	17.8	16.6	7.0	10.0	8.0	8	17.6	48
Paratypes								
CPC 10424	14.5	13.6	6.0	8.4	5.7	6	15.4	44
10426	17.3	16.6	7.5	9.4	7.9	8	17.5	44
10427	16.9	16.1	7.2	8.9	6.3	8	17.7	46
Max. observed	18.5	17.4	8.0	12.2	8.3	8	18.1	48
Min. observed	13.0	12.3	4.6	7.2	5.1	6	13.2	36
Mean	16.4	15.3	6.7	9.6	7.0	6.8	16.5	43.4
Standard error	0.33	0.32	0.15	0.28	0.18	0.20	0.33	0.57
Variance	2.68	2.50	0.58	1.96	0.81	1.00	2.64	8.17
Standard deviation	1.64	1.58	0.76	1.40	0.90	1.00	1.62	2.86

Lp—Length of pedicle valve
Lb—Length of brachial valve
Hp—Height of pedicle valve
Hb—Height of brachial valve
Wf—Width of fold
Ncf—No. of costae on fold
Ncs—No. of costae on shell
Ws—Width of shell

Types. Holotype, CPC 10423; figured paratypes CPC 10424-32; 21 measured topotypes collectively numbered BMR F23577. Other specimens: Australian Museum, Sydney, F43447, 43449-50; Geological Survey of New South Wales, F14700-2; University of New England, Armidale, F9802-9906.

Localities. The holotype, paratypes, and topotypes were collected 300 m above the base of the Lick Hole Limestone (BMR Locality WAG/1, Strusz et al., 1970, fig. 1; this paper, Fig. 1) from the top of the road cutting on the Ravine-Kiandra road at the position shown as microfossil locality C54 in figure 1 of Flood, 1969.

The University of New England specimens were collected throughout the stratigraphic interval 73 m to 335 m above the base of the formation.

Discussion. The stratigraphic importance of the genus *Uncinulus* Bayle has been obscured because many of the 23 species and subspecies placed by Havlíček (1961) in the genus do not belong to it, and the stratigraphic extension and precise age (Siegenian is not definite enough) of *U. subwilsoni* (d'Orbigny), the nominate type species, is still unknown (P. Sartenaer, pers. comm.). As well as examining type material from the Néhou Limestone of France, I have seen specimens, described by Binnekamp (1965) as *U. subwilsoni,* from the Lebanza Limestone of Spain, and therefore I can confidently assign the Lick Hole Limestone material to *Uncinulus.*

Of the numerous European species of *Uncinulus, U. subwilsoni* (Pl. 1, figs 5-11) is closest to *U. australis* by reason of its cubiform shape and similar arrangement of the pedicle valve musculature. *U. australis* is distinguished by its more globular outline, the accentuated curvature of the brachial valve, the possession of relatively fewer costae, which bifurcate less frequently, and the lower muscle platform in the pedicle valve.

Uncinulus australis is distinguished from *U. calathiscus* Talent (1963) by possessing a more globular outline, dental plates, and a median ridge in the pedicle valve.

ACKNOWLEDGMENTS

I am particularly indebted to Dr J. Drot, Institut de Paléontologie, Musée National D'Histoire Naturelle, Paris, who commented on the specific assignment of the Lick Hole Limestone specimens, and who kindly provided moulds of *Uncinulus subwilsoni* (d'Orbigny). I am also grateful to Dr H. Schmidt, Natur-Museum und Forschungs-Institut Senckenberg, Frankfurt, for helpful correspondence concerning *Uncinulus subwilsoni*; Dr J. G. Binnekamp, Bureau of Mineral Resources, Geology and Geophysics, Canberra, who showed me specimens of *Uncinulus subwilsoni* from the Lebanza Limestone of North Palencia, Spain; and Dr P. Sartenaer, Institut royal des Sciences naturelles, Brussells, Belgium, who read the manuscript, and offered helpful advice.

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PERMIAN FLORA FROM THE BEAVER LAKE AREA, PRINCE CHARLES MOUNTAINS, ANTARCTICA

1. PALYNOLOGICAL EXAMINATION OF SAMPLES

by

Elizabeth M. Kemp

SUMMARY

A palynological examination has been made of ten surface samples from outcrops at the southern end of the Beaver Lake area, Prince Charles Mountains, Antarctica. The samples were collected from the 'Radok Conglomerate' and the 'Baimedar Coal Measures', which form part of the unit previously referred to as the Amery Formation (Crohn, 1959). Results of the study suggest that both the 'Radok Conglomerate' and the 'Baimedar Coal Measures' are of Upper Permian age. The Upper Permian age, first determined for the upper part of the Amery Formation by Balme & Playford (1967), is reinforced by the discovery of additional species with known Upper Permian ranges.

INTRODUCTION

The samples examined were collected by A. Medvecky, Bureau of Mineral Resources, during the 1969 summer field season of the Australian National Antarctic Research Expedition. They come from the unit previously referred to as the Amery Formation (Crohn, 1959). Crohn proposed the name Amery Formation for a series of flat-lying arkosic and calcareous sandstones and grits, which contains coal seams. Samples from the Amery Formation at two sites, the 'Amery Locality' of Crohn, and the mouth of 'Pagodroma Gorge'* formed the basis of the palynological work of Balme & Playford (1967). On the evidence of assemblages recovered from these sampling sites, these authors concluded that the upper part of the Amery Formation is of Upper Permian age.

In 1969 the Beaver Lake area was mapped as part of the Prince Charles Mountains exploration programme. As a result of this recent work it is proposed that the Amery Formation be raised to group status (Mond, 1972). Three formational subdivisions have been recognized; from the base upwards these are: the 'Radok Conglomerate', which consists of conglomerate and associated sandstone and siltstone; the 'Baimedar Coal Measures', a sequence of arkosic sandstone and shale with coal seams; and the 'Flagstone Bench Formation', a light-coloured feldspathic sandstone containing iron concretions.

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* Topographic names in inverted commas have not yet been approved by the Antarctic Names Committee, Australia.

In this investigation, samples were examined from the 'Radok Conglomerate', and from the sequence of the 'Baimedar Coal Measures' in 'Pagodroma Gorge', in the hope of establishing the range of time during which deposition occurred.

Spores were too poorly preserved, however, for this end to be fulfilled in more than a general way. Spores were thinned and corroded, but did not show the darkening which is the result of carbonization. Preservation was poorest in samples low in the sequence; those from the 'Radok Conglomerate' yielded few specimens which could be identified to species level. The poor preservation may be related to the proximity of igneous intrusions—dykes have been reported from both the 'Radok Conglomerate' and the 'Baimedar Coal Measures'. In the latter case, severe baking of adjacent sediments has been noted (Mond, pers. comm.).

The position of all samples examined is shown in Figure 1. Field numbers have been abbreviated to the first two digits in the locality map.

AGE OF THE ASSEMBLAGES

There appears to be little difference in the composition of assemblages throughout the sequence examined, although preservation is too poor to allow of a definite conclusion. All assemblages, except for that from AM22.409, are characterized by a high relative frequency of striatitid, bisaccate pollens. Most contained rare monosaccates, chiefly *Parasaccites* sp., although *Densipollenites* is also present. (The composition of Sample AM22.409, which has a high relative frequency of trilete, spinose spores, is regarded as being of local significance only.)

Balme & Playford (1967) referred the upper part of the Amery Formation to the Upper Permian. The basis of this determination was the presence, in samples from the Amery Locality and Beaver Lake, of such species as *Gnetaceaepollenites sinuosus, Densipollenites indicus, Microbaculispora villosa, Bascanisporites undosus,* and *Anapiculatisporites ericianus.*

Of these species, *Gnetaceaepollenites sinuosus* and a form close to *Densipollenites indicus* were identified in the lowest productive sample studied in the present survey, i.e. AM46 in the Radok Conglomerate. *G. sinuosus* first appears in Eastern Australia probably in the late Artinskian, and characterizes the Stage 5 palynological unit of Evans (1967). *Densipollenites indicus* has an Upper Permian range in India, the Salt Range of West Pakistan (Balme, in press), and the Perth Basin of Western Australia. On this evidence it seems likely that the lower part of the sequence in the Beaver Lake area may also be referred to the Upper Permian.

Most of the forms reported by Balme & Playford have been observed in the present study (*Bascanisporites undosus* is a notable exception). Sample AM135 yielded two species not previously reported, which may have considerable stratigraphic value. These forms are *Indospora clara* Bharadwaj, and a form very close to *Guttulapollenites hannonicus* Goubin.

Evans (1967) reports the first appearance of *Indospora* in the upper part of his Stage 5 (Upper Permian); this part of the unit probably corresponds with the range of *I. clara*. Balme (1966) reports *I. clara* from the Chhidru Formation (Upper Permian) of the Salt Range and from the Wagina Sandstone in the Perth Basin.

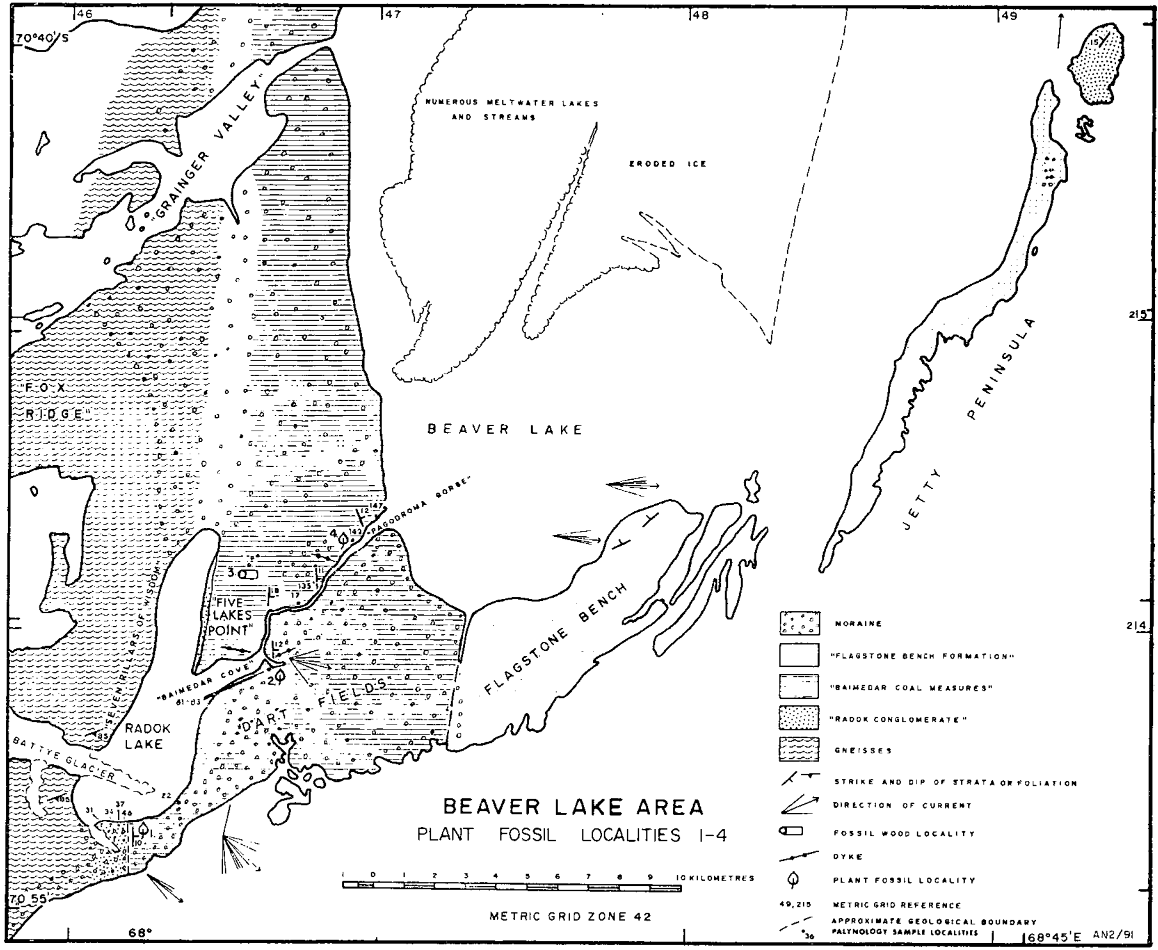

Figure 1. Locality map, Beaver Lake area, Prince Charles Mountains, Antarctica

MAP 2

Published data also indicate that the morphologically distinctive form *Guttulapollenites hannonicus* Goubin has an Upper Permian range in several localities. From Madagascar Goubin (1965) described the form from Lower Sakamena (Upper Permian) sediments, and Hart (in Goubin, 1965) recorded it from the Upper Permian of South Africa. Balme (in press) reported the species from the Salt Range, where it occurred in greatest abundance in the Wargal Limestone and lower Chhidru Formation (?Lower-Upper Permian). In the one sample from which it is reported in the present study, *G. hannonicus* was fairly common, occurring in an abundance of approximately 1 percent.

COMPOSITION OF ASSEMBLAGES

Details of samples are listed in order from the base of the sequence upwards. Both field numbers and palynology collection numbers are given.

Field No.	Palynology Coll. No.	
AM 31.412	MFP5058	'Radok Conglomerate'. Black indurated siltstone with white crystal growths. Barren of spores. Much finely divided vitrinite.
AM 36.413	MFP5059	'Radok Conglomerate'. Black siltstone with fine coaly bands and fragments of wood; very carbonized in appearance. Barren of spores; abundant woody fragments and tracheids with bordered pits.
AM 37	MFP5122	'Radok Conglomerate'. Brownish grey fissile, micaceous siltstone. Preservation of spores very poor; sample yielded abundant fine vitrinite. *Parasaccites* sp. *Striatopodocarpites* sp. *?Densipollenites* Bisaccate striatiti indet.
AM 46	MFP5123	'Radok Conglomerate'. Grey micaceous siltstone. Preservation very poor; grains thinned, extremely corroded, non-staining. Cuticle fragments are common. *Protohaploxypinus amplus* cf. *Densipollenites indicus* *Apiculatisporis* sp. *Parasaccites* sp. *Gnetaceaepollenites sinuosus* *Marsupipollenites triradiatus* *Sulcatisporites* sp. indet.
AM 22.409	MFP5057	'Baimedar Coal Measures'. Dark grey micaceous shale. Sample yielded much fine organic debris; relatively rare spores. The assemblage is characterized by an unusual concentration of small apiculate trilete spores. *Protohaploxypinus amplus* *Apiculatisporis* cf. *levis* *A*. sp. indet. *Gnetaceaepollenites sinuosus* *Leiotriletes directus* *Lophotriletes* sp. *Paravittatina* sp. cf. *Densipollenites indicus*

Field No.	Palynology Coll. No.	
AM 81/83433	MFP5060	'Baimedar Coal Measures'. Dark grey indurated micaceous shale. Much woody debris present. little with any cellular organization remaining. Spores not abundant, preservation only fair. Sexine of most specimens corroded, with loss of surface detail. *Protohaploxypinus limpidus* *P. amplus* *P.* sp. *indet.* *Striatopodocarpites* cf. *fusus* *Sulcatisporites* sp. *Gnetaceaepollenites sinuosus* *Apiculatisporis* sp. *Densipollenites indicus* *Marsupipollenites triradiatus* *Microbaculispora villosa*
AM 17.407	MFP5056	'Baimedar Coal Measures'. Very fissile dark grey micaceous shale. Sample yielded abundant tracheids and other plant tissues, all much degraded. Spores fragmentary and thinned, bisaccates predominate. *Protohaploxypinus* spp. *Protohaploxypinus amplus* *Striatopodocarpites* sp. *Parasaccites* sp. *Leiotriletes directus*
AM135.441	MFP5061	'Baimedar Coal Measures.' Dark grey carbonaceous siltstone. Spores diverse, preservation fair. *Photohaploxypinus limpidus* *P. amplus* *Striatopodocarpites* sp. *Parasaccites* sp. *Paravittatina* cf. *lucifer* *Marsupipollenites triradiatus* *Guttulapollenites hannonicus* *Indospora clara* *Leiotriletes directus* *Gnetaceaepollenites sinuosus* *Sulcatisporites* sp. *Entylissa* sp.
AM142.443	MFP5062	'Baimedar Coal Measures.' Grey micaceous siltstone. Spores rare, poorly preserved. *Protohaploxypinus limpidus* *P. amplus* *Striatopodocarpites* sp. *Marsupipollenites triradiatus* *Gnetaceaepollenites sinuosus* *Entylissa nitidus* *Granulatisporites micronodosus*
AM147.445	MFP5063	'Baimedar Coal Measures.' Carbonaceous black shale. Spores very rare, abundant fine organic debris. *Leiotriletes* sp. *Sulcatisporites* sp. *Striatites* indet.

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PERMIAN FLORA FROM THE BEAVER LAKE AREA, PRINCE CHARLES MOUNTAINS, ANTARCTICA

2. PLANT FOSSILS

by

Mary E. White

SUMMARY

Plant fossils were collected from four localities in the Beaver Lake area, Antarctica. A *Glossopteris* flora was found at three of the localities, and only petrified wood, not associated with other fossils, was found in the fourth locality. These plants are all Permian, but a more precise age cannot be determined on the present material.

INTRODUCTION

A collection of plant fossils from four localities in the Beaver Lake area, Prince Charles Mountains, Antarctica (see Fig. 1), all from 'Amery Group' sediments*, is of particular interest because of the detailed study in recent years of Antarctic *Glossopteris* floras (Plumstead, 1962; Cridland, 1963). The present collection can therefore be compared closely with these comprehensive studies.

The specimens from the Beaver Lake area were all collected by A. Mond, of the Bureau of Mineral Resources, during the 1968-9 Australian National Antarctic Research Expedition, and they have been compared with other specimens in Bureau collections, as well as with specimens illustrated by Plumstead (1962) and Cridland (1963). Plant fossil localities are shown on Figure 1 of the preceding paper.

DESCRIPTION OF THE COLLECTION

Locality 1

The grey siltstone specimens from this locality contain well preserved *Vertebraria indica* Royle (see Pl. 3, figs 1-4). Many of the impressions are of branching axes, and in some, very thin projections may be seen arising from the joints between wedges of xylem.

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* 'Amery Group', new name; see Mond, 1972.

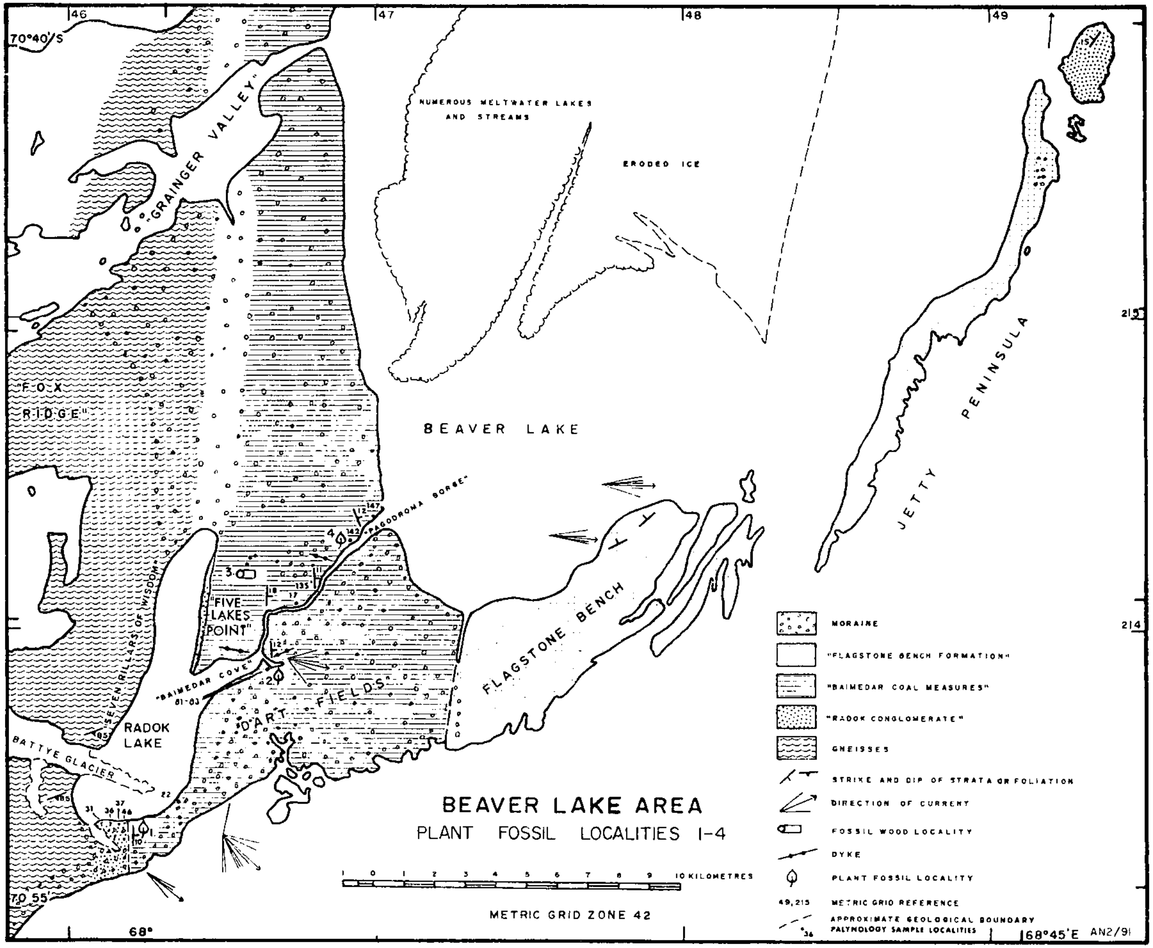


Figure 1. Locality map, Beaver Lake area, Prince Charles Mountains, Antarctica

There has long been discussion on the nature of *Vertebraria.* Plumstead (1958, p. 90, 1962, p. 57), in reporting on the *Vertebraria* axes she studied, concluded that the axes were roots, that they bore fine rootlets, and that they were most probably the root systems of glossopterids. The highly evolved and unique structure of *Vertebraria* has intrigued palaeobotanists. At first it was assumed that the axes were rhizomes which bore *Glossopteris* leaves, but as increasing study of the Glossopteridae suggested that they were arborescent, the rhizome theory for *Vertebraria* lost ground, and there was some suggestion that the internal organization of *Vertebraria* as seen in poor petrifactions showed affinity with true roots. Schopf (1965) reported on a petrifaction of *Vertebraria* found in the Ohio University collection, with sufficient preservation of tissues to show without doubt that *Vertebraria* is a true root with a specialized gymnospermous anatomy.

The assumption that *Vertebraria* is part of the glossopterid plant is still valid. It is now necessary to prove that petrified stems which occur in the Permian floras were the organs which bore *Glossopteris* leaves and that they were in continuity with *Vertebraria* root structures.

Locality 2

The plant fossils from locality 2 consist of impressions, mostly carbonized, in grey siltstone. Some are well preserved, but many of the specimens are deeply weathered and preservation is poor.

A well preserved leaf of *Glossopteris communis* Feistmantel (1881b, p. 98) is shown in Plate 5, figure 3. Following Plumstead, *communis* is separated from *indica.* Venation is of *indica* type, but whereas *indica* has a striated midrib and parallel margins over most of the length of the leaf, *communis* characteristically has the shape shown in Plate 5, figure 3, and has a smooth, hollow midrib. Cridland (1963) does not separate *communis* from *indica* and in his paper he illustrates (fig. 1) a specimen very similar to CPC 11334 as *'Glossopteris indica'.*

Many examples of *Glossopteris communis,* a species common in Australia throughout the Permian, are found in this collection from locality 2. An example was collected in Antarctica in 1961 by R. Ruker from a moraine at the foot of Mount Rymill (White, 1962), associated with *Vertebraria indica* Royle.

Four complete leaves and several fragments (Pl. 6) show the leaf form clearly; apices are bluntly rounded and there is a strong midrib which persists to the apex. The leaf margins taper abruptly to the apex over the last third of the length of the blade and curve smoothly to the leaf base. Venation in the middle of the leaf adjacent to the midrib shows meshing followed by dichotomy, and a second dichotomy halfway across the blade results in fine, close venation at the margins (Pl. 6). There are very few anastomoses between the secondary veins, which are straight and parallel to the leaf margin. There is no regular and prominent meshing of the veins, as commonly found in *Glossopteris.* The median strip of each leaf adjacent to the midrib is sparsely veined in comparison with the outer parts, which are closely veined in a taeniopteroid manner (Pl. 7, fig. 1).

The venation in these leaves resembles that shown by Walkom (1928) as *'Glossopteris angustifolia* var. *taeniopteroides* Seward'. Plumstead (1962) states that that species is unrelated to *angustifolia* and should be called *sewardii.* Leaf form does not correspond with the examples under discussion. The leaves shown in Plate 6 and Plate 7, figure 1 are similar to *G. stricta* Bunbury (1861) but the angle of the secondary veins is steeper. In *stricta,* and also in *damudica* Feistmantel (1880), they meet the margin at right angles.

The only specimens which appear to match these leaves from locality 2 are some illustrated by Plumstead (1962) as *Glossopteris fuchsii* sp. nov. Her specimens are well preserved, and show the same form and venation; these leaves are therefore identified as *Glossopteris fuchsii* Plumstead.

Dictyopteridium sporiferum Feistmantel (1881), the male fertile frond of *Glossopteris* (Pl. 5, fig. 1), and *Glossopteris ampla* Dana 1849, have also been found at this locality.

Locality 3

Several pieces of silicified wood were collected at this locality. The fossil wood is of two types which can be distinguished readily in hand specimen because of prominent resin canals in one of the types (Pl. 4, figs 1 and 2), and the absence of these canals in the other. The resin canals appear as circular spots in transverse section and as elongated lenticular patches in tangential and longitudinal sections. The wood is fine grained and has annual rings. A small block of wood was sectioned transversely and tangentially, and was seen to be composed of uniform tracheids and medullary rays. The resin canals lie in the autumn wood zones (Pl. 8, figs 1-3). There is no very dramatic variation in tracheid size at different seasons: the autumn-winter wood is composed of tracheids about half the size of those of the spring wood, but not much smaller than the average during the rest of the growth year. This pattern suggests that growth was slow throughout the year, slowing down towards winter and speeding up in spring without a very marked rest period, indicating a uniformly cool climate without much variation. Figure 3 of Plate 8 shows the medullary rays to be uniseriate, mainly 1 to 3 cells (and never more than 6 cells) deep. Multiseriate bordered pits are present on tangential walls of tracheids.

The second type of wood is extremely fine grained, lacks resin canals, and has closely spaced annual rings (Pl. 4, fig. 3). Growth was obviously slow, as there are about forty annual rings in this trunk which has a radius of only 3½ inches. Transverse, radial longitudinal, and tangential sections were cut from a small block of wood of this type (see Pl. 8, fig. 4; Pl. 9, figs 1-4). These sections show that the annual rings are clearly defined. The autumn wood has heavily lignified, narrow tracheids. There are numerous medullary rays with only two to six tracheids between each pair of rays. In tangential section (Pl. 9, fig. 1) multiseriate bordered pits are visible on parts of the tracheids. The multicellular medullary rays are in contrast to the rays of two or three cells which characterized the type of wood with resin canals. In radial longitudinal section a medullary ray four cells wide runs across the tracheids (Pl. 9, figs 2-4). The cells of the rays are in the form of filaments with cross connexions to each other, not a solid plate of cells. The tracheids of the autumn wood are heavily lignified and narrow. Multiseriate bordered pits are seen on the tangential walls of tracheids. The summer wood has less numerous multiseriate bordered pits, irregularly grouped.

Locality 4

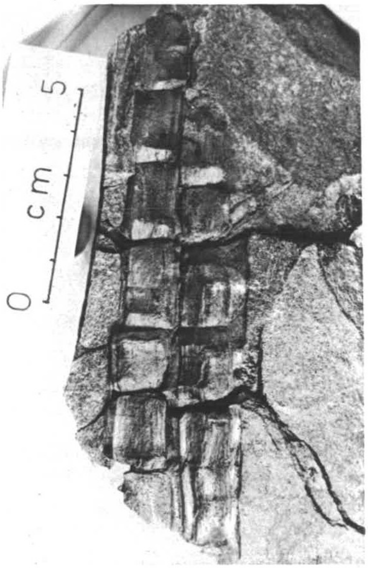
Carbonized leaf impressions in brownish grey siltstone were found at this locality. The plant assemblage included *Gangamopteris angustifolia* McCoy,

PLATE 3

Four specimens of *Vertebraria indica* Royle, all from locality 1.

Figure 1. CPC 11323.
Figure 2. CPC 11324.
Figure 3. CPC 11325.
Figure 4. CPC 11326.

1



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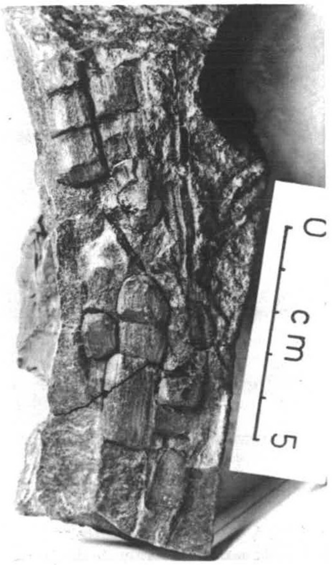

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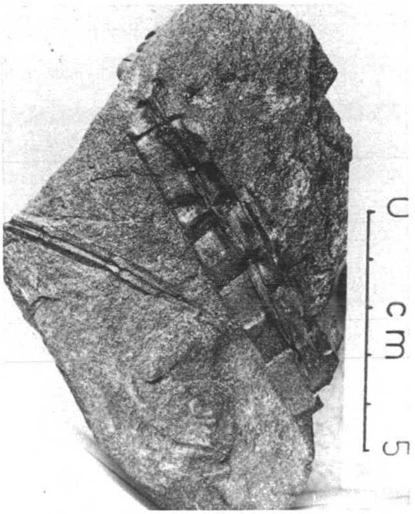

PLATE 4

Silicified Wood from locality 3.

Figure 1. A somewhat flattened cylinder of wood. The core is filled with coaly material, and there are dark lenticular patches in the wood tissue. CPC 11327.

Figure 2. Wood clearly showing annual rings and dark lenticular patches (probably resin canals) in transverse section on the annual rings and in tangential section on the side of the specimen. CPC 11328.

Figure 3. Piece of silicified tree trunk identified as *Taeniopitys scotti* Krausel, with regular annual rings. The wood is extremely fine grained, without marked seasonal changes in wood growth. Resin canals are absent. CPC 11329.

1

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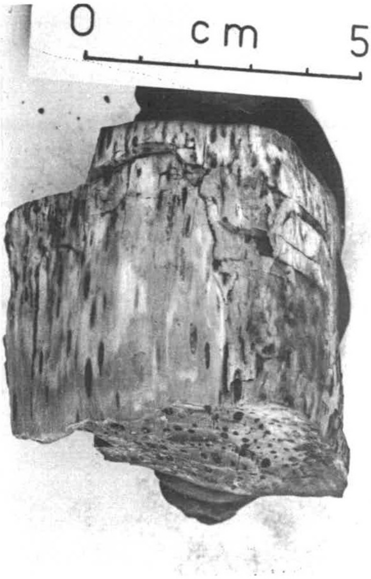

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PLATE 5

Figure 1. A plant assemblage from locality 4 including: (1 and 6), apical parts of two leaves of *Gangamopteris angustifolia*; (2), basal part of leaf, narrowing to a petiole, of *Glossopteris longicaulis*; (3), a *Glossopteris* scale leaf; (4), *Dictyopteridium sporiferum*, the male fertile frond of *Glossopteris*; and (5), *Palaeovittaria* sp. CPC 11330. Scale x1.5.

Figure 2. A plant assemblage from locality 4 composed of (1 and 2), *Gangamopteris angustifolia;* (3), *Glossopteris communis*; and (4), *Glossopteris longicaulis*. CPC 11311.

Figure 3. *Glossopteris communis*. CPC 11334. From locality 2.

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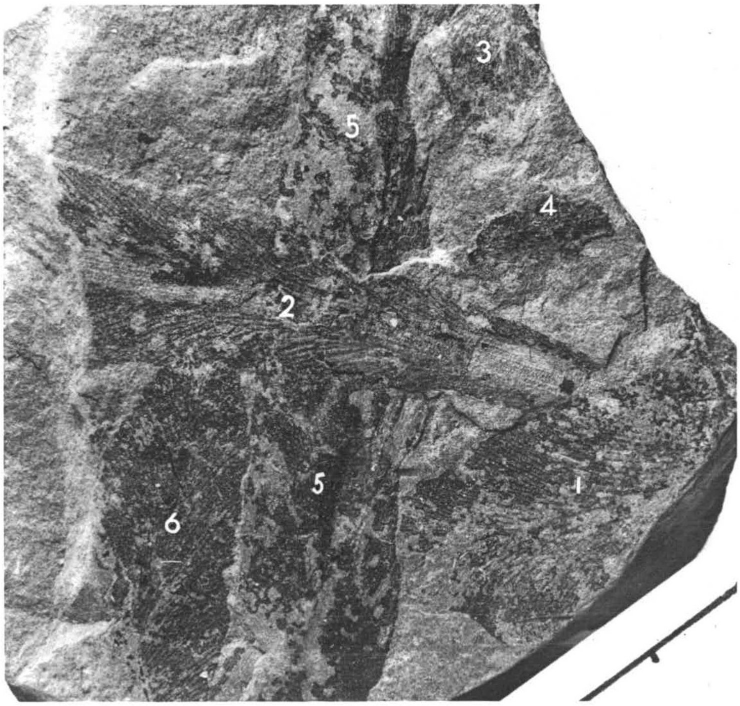

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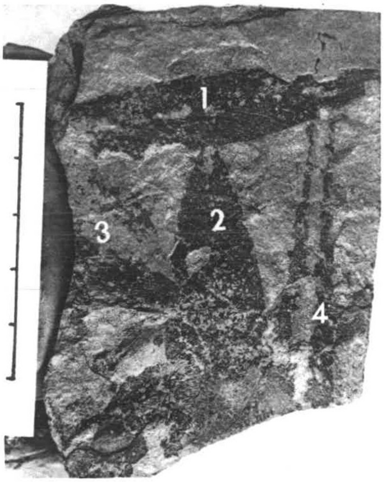

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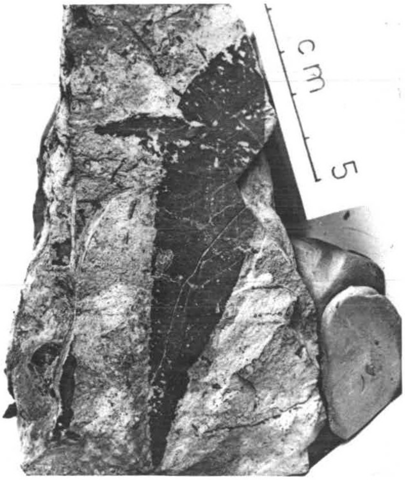


PLATE 6

Glossopteris fuchsii Plumstead, showing details of venation. CPC 11335.


1. inch

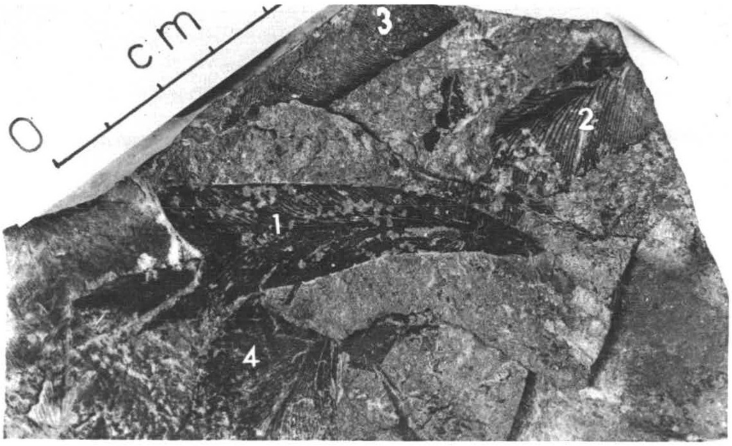
PLATE 7

Figure 1. *Glossopteris fuchsii* Plumstead, showing venation, from locality 2. CPC 11336.

Figure 2. A plant assemblage from locality 2, including (1 and 2), *Glossopteris fuchsii,* showing venation; (3), *Glossopteris communis*; and (4), *Glossopteris indica.* CPC 11337.

Figure 3. *Glossopteris indica* Schumper, showing the striated midrib and fine secondary venation. CPC 11338.

2



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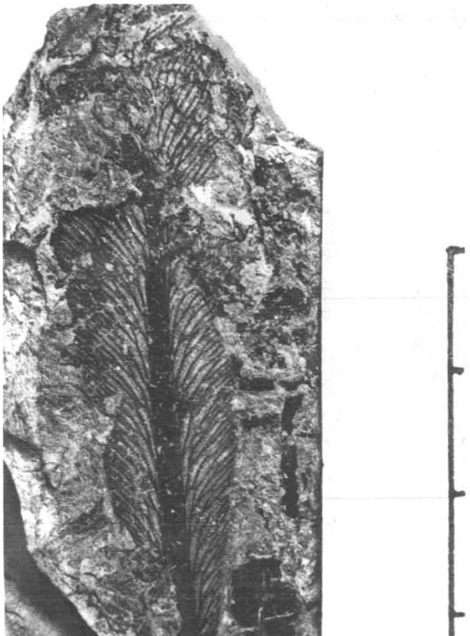

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PLATE 8

Sections of petrified wood from locality 3.

Figure 1. Transverse section, showing annual ring and resin canal in autumn wood. x20.

Figure 2. Transverse section, showing annual ring and two resin canals in autumn wood. Resin canal in longitudinal section. x20.

Figure 3. Tangential section. Note uniseriate medullary rays. x20.

Figure 4. Transverse section. Annual rings with a clear line at the end of autumn. x8.

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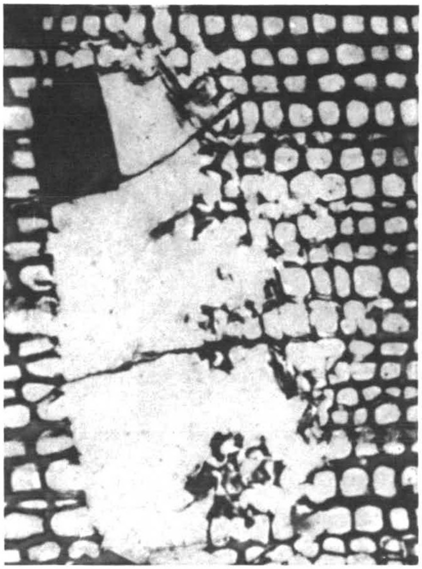

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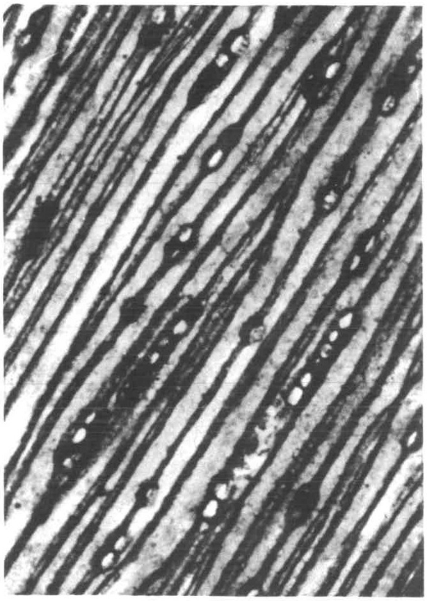

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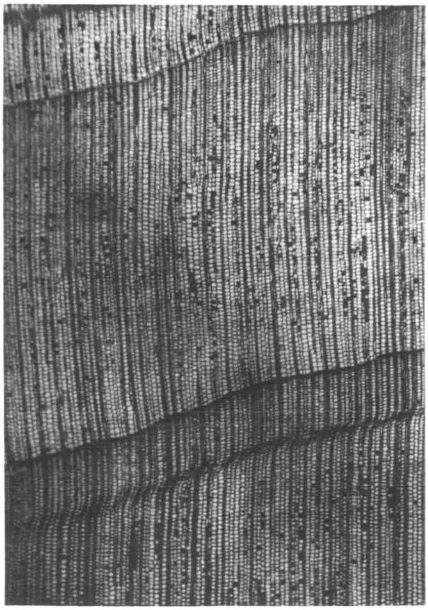

PLATE 9

Sections of petrified wood from locality 3.

Figure 1. Tangential section. Note numerous uniseriate medullary rays; each ray consists of several cells in a straight line. x20.
Figure 2. Radial longitudinal section. Short annual ring in centre. x8.
Figure 3. Radial longitudinal section. Annual rings of regular width. x8.
Figure 4. Radial longitudinal section. Annual rings of regular width. x8.

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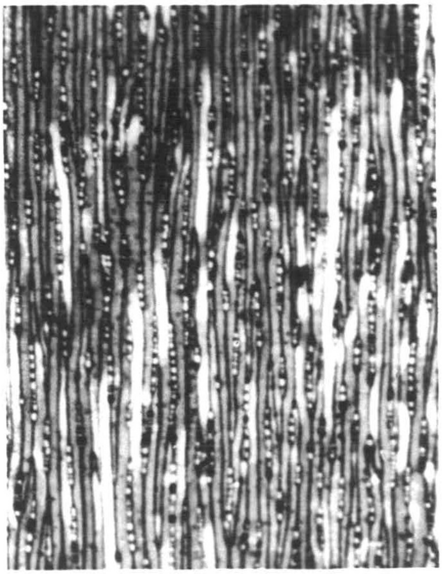

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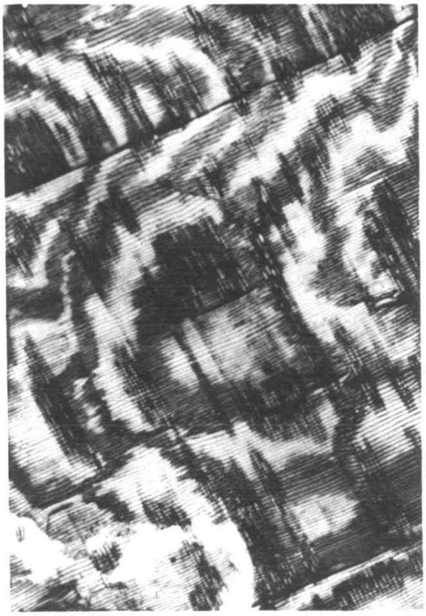

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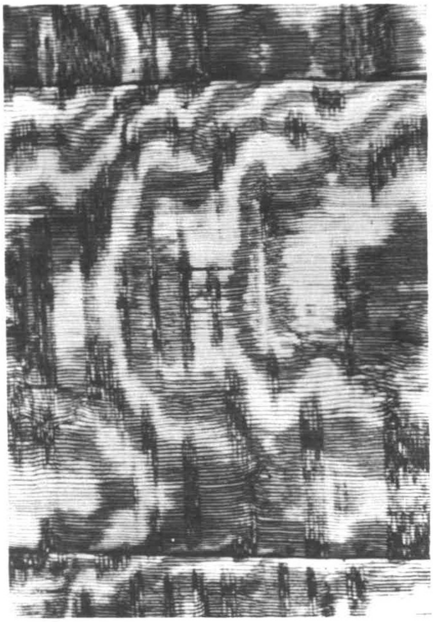

Glossopteris longicaulis Feistmantel, 1881a, *G. communis* Feistmantel, *G. indica* Schumper, *Dictyopteridium sporiferum* Feistmantel, and *Palaeovittaria* sp.

The basal part of a *Glossopteris* leaf (2 in Pl. 5, fig. 1) shows venation of *indica* type with striated midrib. The leaf margin is slightly undulating and the angle of tapering indicates that the leaf margins would probably not be parallel in the middle regions of the leaf. The leaf is referred to *Glossopteris longicaulis* Feist., and is the same as the leaf with the long petiole in Plate 5, figure 2.

A small example of *Dictyopteridium sporiferum* Feist., the male fertile frond of a species of *Glossopteris,* shows a portion of lamina 1.5 cm long and 0.5 cm wide with a blunt apex, gangamopteroid venation, and small circular spots on the surface (4 in Pl. 5, fig. 1).

One leaf (5 on Pl. 5, fig. 1) has very steeply angled venation, and in place of a midrib it appears to have a wide groove with vertical veins near the base, to be faintly grooved in the middle of the blade, and without groove near the apex. It is referred to *Palaeovittaria* sp.

Gangamopteris angustifolia McCoy (1847) was present in the collections from the Weddell and Ross Sea areas described by Plumstead (1962). Type material of the species was from Bacchus Marsh in Victoria, and the species also occurs in Greta Coal Measures and Lower Bowen. Plumstead states that *Gangamopteris* was extinct by Upper Permian. However, in Australia, although this applies to the large *Gangamopteris* leaves of *cyclopteroides* type, smaller leaves of *angustifolia* type persist into Upper Permian. An example of *Gangamopteris angustifolia* is illustrated in a collection from the Upper Permian Bandanna Formation*, Queensland (White, 1961, fig. 3). Cridland (1963) illustrated as *Gangamopteris* sp. a similar leaf from a formation regarded as younger than Lower Permian.

CONCLUSIONS

The flora is a Permian one. It does not contain any species which are limited to Lower Permian, and it lacks the large, coarse type of *Glossopteris* and *Gangamopteris* leaves which characterize the Lower Permian. On the other hand, it does not contain species which are positively diagnostic of Upper Permian.

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* Blackwater Group of Mollan, Dickins, Exon, & Kirkegaard, 1970.

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A NEW CONOCORYPHID TRILOBITE FROM THE MIDDLE CAMBRIAN OF WESTERN QUEENSLAND

by

J. H. Shergold

SUMMARY

This brief note describes the occurence of *Meneviella viatrix* sp. nov. in the Middle Cambrian Roaring Siltstone of the Selwyn Range, western Queensland. Trilobites representing the family Conocoryphidae have not previously been recorded from Australia. The age of *M. viatrix* is given by its association with *Ptychagnostus cassis* and *Pt.* ex gr. *punctuosus* at the overlap of *Pt. punctuosus* and *Pt. nathorsti* Zones.

INTRODUCTION

The trilobites described here were discovered in 1967 by C. E. Murray, then of the Geological Survey of Queensland, who was attached to a party of the Bureau of Mineral Resources engaged in remapping the Middle and Upper Cambrian outcrops of the Duchess 1:250,000 geological sheet in western Queensland. They occur at locality D476 (see Fig. 1), which is about 10 km east of the town of Duchess (Duchess air-photo 5040, run 6). The fossils occur 200 m north of the Duchess-Cloncurry road, and 100 m east of the boundary fence which divides the pastoral properties of Mayfield and Devoncourt.

The majority of the specimens were obtained from a single lamina between two white ferruginous-stained siltstone layers, but others, including the holotype, occur in the overlying inch of sediment. The fossiliferous horizon lies near the base of a silt-shale sequence referred to the Roaring Siltstone. The shales are multihued owing to tropical weathering, and in places micaceous and fissile. They dip steeply at angles of 70°-80° to the east because of their proximity to the Pilgrim Fault Belt, a series of north-trending imbricate faults. The latter have shattered, but nevertheless preserved, the western margin of the Cambrian outlier in the Duchess region, throwing it against Precambrian rocks.

The trilobites are described as *Meneviella viatrix* sp. nov., which belongs to the family Conocoryphidae, previously unknown in Australia. They are preserved as flattened ferruginized moulds, cranidia predominating, in a dissociated mass of fragments (Pl. 11, fig. 3). Their age is determined by the associated fauna, which includes: *Ptychagnostus cassis* Öpik, *Pt.* ex gr. *punctuosus* (Angelin), *Hypagnostus* cf. *brevifrons* (Angelin), *Centropleura* sp. indet. (too badly crushed for precise determination), sponge spicules, and a variety of undetermined inarticulate

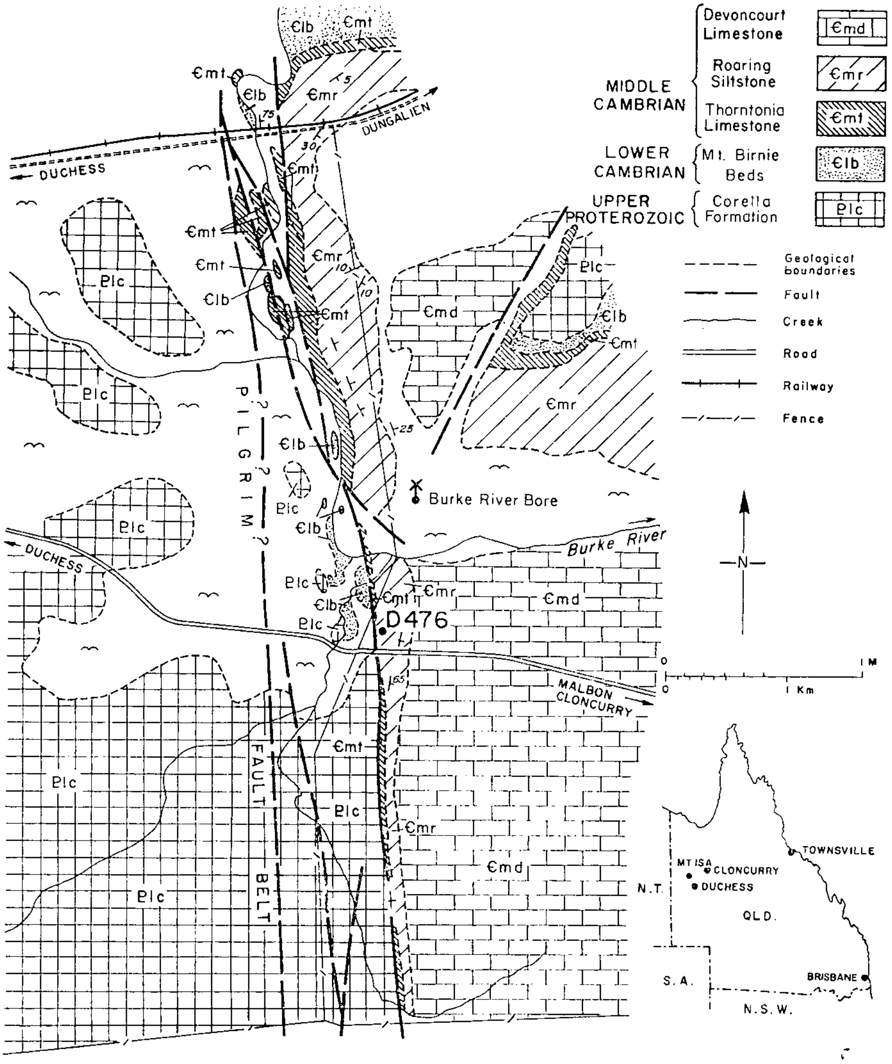


Figure 1. Map showing the position of the fossil locality, D476, at air-photo scale

brachiopods. The overlap of *Pt. cassis* and *Pt.* ex gr. *punctuosus,* together with the associated *H. brevifrons* and *Centropleura,* places *Meneviella viatrix* at the overlap of *punctuosus* and *nathorsti* Zones (A. A. Öpik, pers. comm.).

The genus *Meneviella* has hitherto been considered monotypical, based on the single wide-ranging species *M. venulosa* (Salter). This species was described originally from the Menevian of Wales (Salter *in* Hicks, 1872, p. 177; see Lake, 1940, p. 274, for full list of localities) and subsequently from the Stockingford Shales of Warwickshire (Illing, 1915, p. 426). Its geographical distribution extends westwards from the British Isles into southeastern Newfoundland, where Matthew (1899, p. 91, pl. IV, fig. 9) described the species as *Erinnys breviceps*

Angelin, and where Hutchinson (1962, p. 108, pl. XVI, figs 2-7) has more recently described further specimens from the Manuels River Formation. In southwestern Newfoundland Kindle & Whittington (1958, p. 333; 1959, p. 17, fig. 3i) have a comparable species at Broom Point in the Cow Head area; and Shaw (1966, p. 855, pl. 99, fig. 17) has described a further cranidium from the St Albans Shale in Vermont. Eastwards of the British Isles, *Meneviella venulosa* occurs in Scandinavia on Bornholm (Westergaard, 1950, p. 23).

In Russia the species has been recorded from Kazakhstan (Borukaev, 1955, pp. 223-4; Borukaev & Ivshin, 1952, p. 55; Borukaev & Ivshin *in* Tchernysheva, 1965, p. 173) and eastern Siberia (Tchernysheva, 1953, pp. 15-6, pl. 1, fig. 5; 1960, p. 117, fig. 246). Specimens of *Meneviella,* not specifically determinable, have been recorded by Repina (1960, p. 222, pl. XVII, fig. 11) from Lodochny on the Sisim River in eastern Sayan, and by Pokrovskaya (*in* Tchernysheva, 1965, p. 341) from the Maya Stage, Olenek River, North Siberian Platform.

Meneviella venulosa is commonly associated with *Centropleura* and *Paradoxides* in Europe and North America, and with *Ptychagnostus punctuosus* in North America and Britain. On the paradoxidid time scale, *M. venulosa* occurs mainly within the Zone of *Paradoxides davidis,* although in southwestern Newfoundland it is associated with *Tomagnostus fissus* in beds correlated with the *Paradoxides hicksi* Zone (Kindle & Whittington, 1958, p. 333). On the agnostid time scale the species lies within the Zone of *Ptychagnostus punctuosus.* In Australia, *M. viatrix,* occurring at the overlap of *punctuosus* and *nathorsti* Zones, is possibly slightly younger than its European relative.

Order PTYCHOPARIIDA Swinnerton, 1915

Suborder PTYCHOPARIINA Richter, 1933

Superfamily CONOCORYPHACEA Angelin, 1854

Family CONOCORYPHIDAE Angelin, 1854

Genus MENEVIELLA Stubblefield, 1951

The nomenclatorial history of *Meneviella* has been summarized by Lake (1938, pp. 270-2), Stubblefield (1951, p. 213), and Tchernysheva (1953, pp. 14-5).

MENEVIELLA VIATRIX sp. nov.

(Pl. 10; Pl. 11, figs 1-4; Pl. 12, figs 1-8; Fig. 2)

Derivation of Name. *Viator,* m., *viatrix,* f., Lat., a traveller, relating to the occurrence of the species in the Pilgrim Fault Belt, and the occurrence of the genus remote from the Atlantic realm of its original description.

Holotype. The complete internal mould of a dorsal exoskeleton, CPC 9800a, figured on Plate 10 and Plate 11, figure 1. Its counterpart is illustrated by a rubber cast as figure 2 on Plate 11 (CPC 9800b).

Material. One complete dorsal carapace is known and figured as the holotype. Several groups of thoracic segments and 35 disarticulated cranidia occur in the same sample. The most complete specimens are figured on Plates 10 and 11, and an association of cranidia is illustrated on Plate 11.

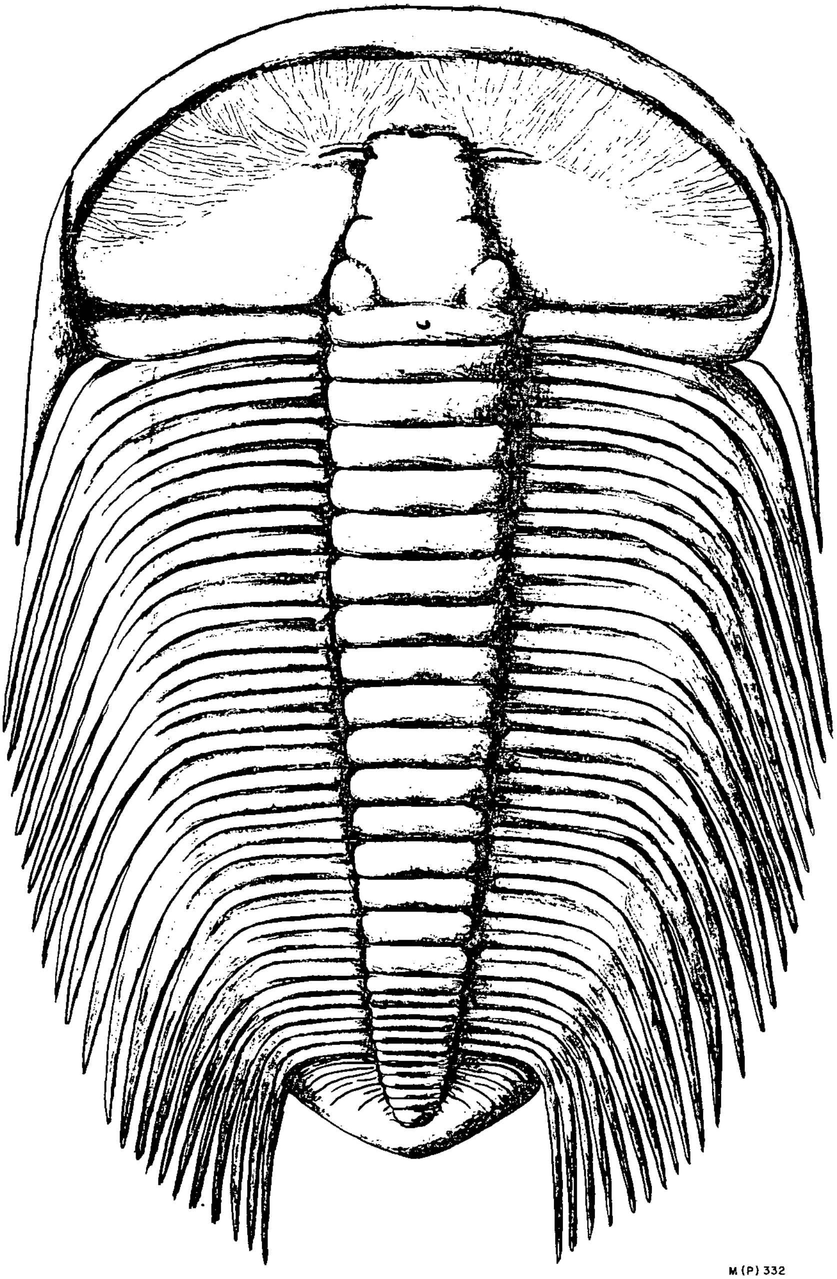


Figure 2. Reconstruction of ***Meneviella viatrix*** **sp. nov., approximately x 9.5, based on the holotype**

Size Range. The 35 cranidia vary in length (sag.) between 1.5 and 6.6 mm, but the majority of the specimens measure between 2.5 and 3.5 mm. The holotype, the largest available specimen, has a cephalic length of 7.2 mm and an overall length (head, body, tail) of about 24.3 mm. On this specimen the pygidium is very small; its length (sag.) is only one-fifteenth of the overall length.

Differential diagnosis. Meneviella viatrix sp. nov. is exceedingly similar to *M. venulosa* (Salter), the main quantitative distinction between the species as they are presently known being the number of thoracic and pygidial segments. According to Salter (1872, p. 177) *M. venulosa* has 24 thoracic segments and 4 pygidial ones. *M. viatrix,* however, has 22 thoracic and 5 pygidial metameres. Salter's most complete specimen, apparently having a full complement of thoracic segments (Salter, pl. 6, fig. 6), has a cephalic length of approximately 7.8 mm (assuming that his illustrations are of natural size), and as such is larger than the biggest specimen of *M. viatrix.* Lake's (1938, pl. XXXIX, fig. 7) most complete specimen is also larger. Even the largest available *M. viatrix* may not have achieved its full number of thoracic segments, which are possibly still in the process of liberation from the pygidium. On the other hand, the segmentation observed is very nearly equivalent to that of the related conocoryphid *Dasometopus breviceps* (Angelin) which, as illustrated by Tchernysheva (1960, p. 118, fig. 244), has 21 thoracic segments.

Segmentation apart, *Meneviella viatrix* differs from *M. venulosa* on qualitative characteristics alone: the genal spines in *viatrix* are apparently shorter, extending to the level of the fourth thoracic segment instead of the sixth, but the free thoracic pleural spines appear longer, presumably because no previously described thorax has been adequately prepared. The geniculation in the posterior cranidial margin of *viatrix* is weak, and is emphasized only on compressed material, as in British and Russian species of *venulosa,* but it differs from North American forms which have a fairly prominent geniculation, sometimes even bearing a small fulcral node (see Shaw, 1966, pl. 99, fig. 17; Kindle & Whittington, 1959, p. 14, fig. 3i).

Specific diagnosis. A species of *Meneviella* Stubblefield, 1951, with 22 thoracic and 5 pygidial segments; with weak cephalic geniculation; and faintly granulose prosopon on both thorax and pygidium.

Description. Meneviella viatrix is a multisegmented, micropygous conocoryphid with wide (tr.) headshield and an elongated body which tapers rearwards.

The cephalon is semicircular, with well defined borders thickening sagittally and posterolaterally. Its length (sag.) amounts to a little over one-third the overall length of the exoskeleton, and its width (tr.) is more than twice its length. A narrow (tr.) conical glabella occupies slightly more than half the cephalic length (sag.) and at its widest (across the preoccipital glabellar lobes) is one-quarter the total cephalic width. The glabella is anteriorly truncate with a median depression in the contour of the frontal lobe. There are three pairs of glabellar furrows: usually the preoccipital ones are sigmoidally curved to the rear and almost contact the occipital furrows, but in some cases (Pl. 12, figs 4, 5) the adaxial ends flatten transversely and form a weak connexion across the glabella to give it a decidely waisted appearance; the median lateral furrows are short, straight, and transverse, faintly impressed on the majority of specimens; and the anterior furrows are mere indentations in the margins of the glabella near the junction of the ocular 'lines' and axial furrows.

The occipital furrow is shallow and faint, bowed slightly forwards mesially. The occipital ring is narrow (sag.) and flat with transverse width equal to that of the preoccipital glabellar lobes. A small nuchal node is present mesially.

Most specimens have a convex preglabellar field broken sagittally by a slight depression which extends from the preglabellar furrow to the marginal furrow. The facial suture is marginal around the anterior periphery of the cephalon, but laterally it cuts off very narrow (tr.) librigenae which bear long slender genal spines, extending backwards to the fourth thoracic segment.

Meneviella viatrix has no eyes, in the normally accepted sense. Nevertheless, it has a well developed and magnificently displayed caecal system. The ocular 'ridges' in *Meneviella* are effectively paired diverticula, called here ocular diverticula. An anterior diverticulum is separated from a posterior counterpart by an ocular striga (Öpik, 1961, p. 436). Proximal to the glabella the diverticula are quite distinctly separated, but when traced abaxially the striga becomes effaced and the anterior and posterior diverticula come together to form an ocular caecal node (Öpik, 1961, p. 434). The anterior ocular diverticulum in *Meneviella* may be compared with the anterior ocular ridge in eyed trilobites, e.g. *Papyriaspis* (see Öpik, 1961, text-fig. 12). In both *Papyriaspis* and *Meneviella* the caecal system of the preocular parts of the cephalon arises from this diverticulum and its associated parafrontal band (the latter is not readily distinguished in *Meneviella viatrix*). Similarly, the posterior ocular diverticulum in *Meneviella* is compared with the posterior ocular ridge in *Papyriaspis*. In both cases the postocular areas are served by a reticulate caecal network arising from this diverticulum. In *Papyriaspis* the anterior diverticulum runs along the anterior ocular ridge and around the ocular groove at the base of the visual surface until it arrives at the posterior edge of the eye. There it meets the posterior diverticulum, which runs along the posterior ocular ridge and around the abaxial periphery of the palpebral area. From this conjunction (postocular caecal node of Öpik, 1961) an important system of ramified caeca crosses the posterolateral limb. In eyeless *Meneviella* the ocular caecal node forms directly at the coalescence of the anterior and posterior ocular diverticula, and from this stems the impressive duct which effectively transects the cephalon of *Meneviella viatrix*. This diverticulum runs nearly straight and somewhat obliquely from the ocular caecal node to the cranidial margin, where it contacts the marginal furrow slightly in front of the posterolateral cranidial corner. Its associated caecal system forms a plexus equivalent to that lying near the edge of the posterolateral limb in *Papyriaspis*.

The caeca of the preocular areas form a dense branching and intertwining dendritic network radiating towards the margins of the cranidium. In exceptional cases there is evidence that these caeca cross the cephalic border (Pl. 12, fig. 6). More often, however, they appear to terminate at the marginal furrow, and sometimes the spaces between them are pitted (Pl. 12, fig. 8). The caeca of the postocular areas form a reticulate network within which three further diverticula stand out: one, arcuate in orientation, curves from the axial furrows opposite the median lateral glabellar furrows, and runs subparallel with the posterior ocular diverticulum; the second, transversely oriented, arises from the axial furrow opposite the preoccipital glabellar furrows, travels abaxially a short distance, and rapidly merges with the reticulate caecal field; the third, originating near the confluence of axial and posterior marginal furrows, runs along the posterior cephalic

PLATE 10

Meneviella viatrix sp. nov.

Figure 1. CPC 9800a. Holotype, a complete internal mould of a dorsal exoskeleton, x7.

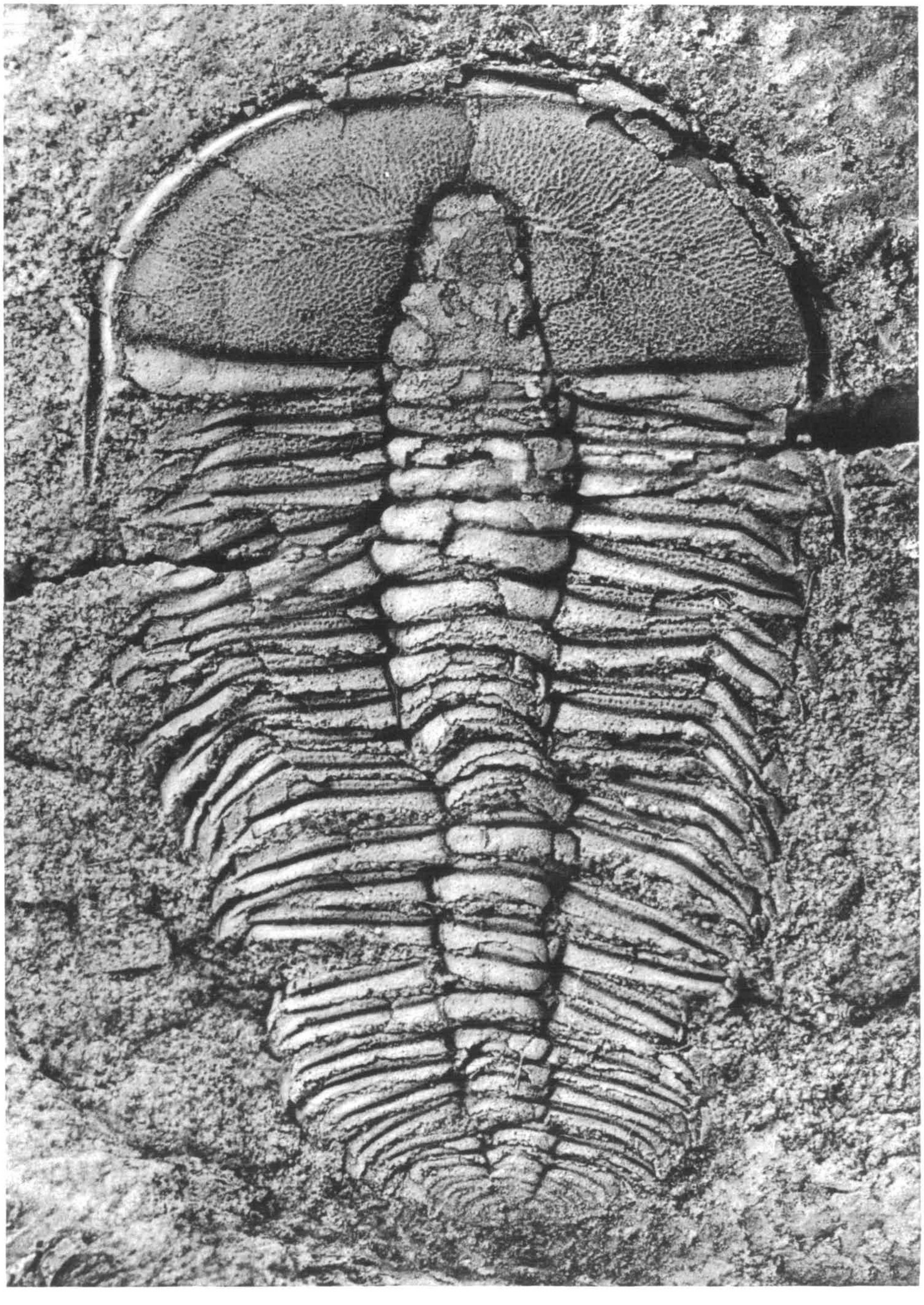


PLATE 11

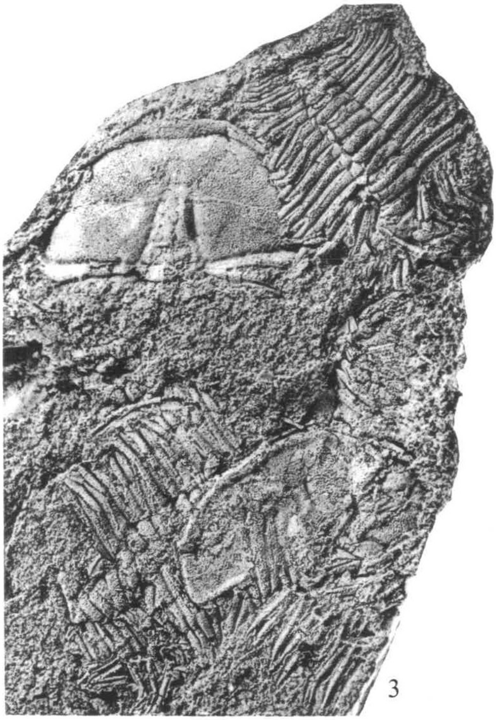
Meneviella viatrix sp. nov.

Figure 1. CPC 9800a. Holotype, complete dorsal exoskeleton, x3.

Figure 2. CPC 9800b. Latex cast from external mould of holotype, x3.

Figure 3. CPC 9801b. Latex cast of cranidium with associated thoracic fragments, on same slab as holotype, x3.

Figure 4. CPC 9803a. Internal mould of thoracic segments showing size and orientation of thoracic spines, x3.



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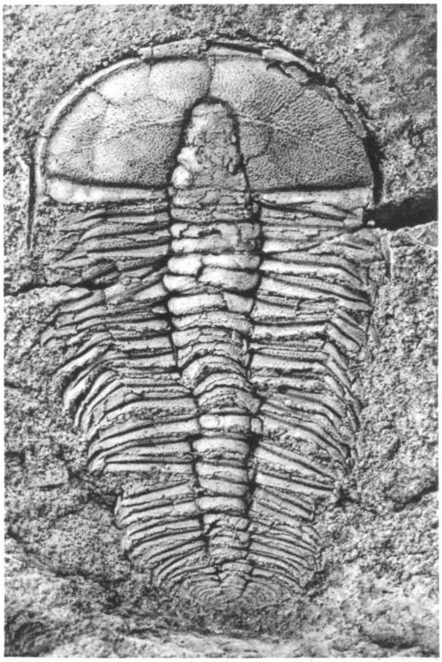

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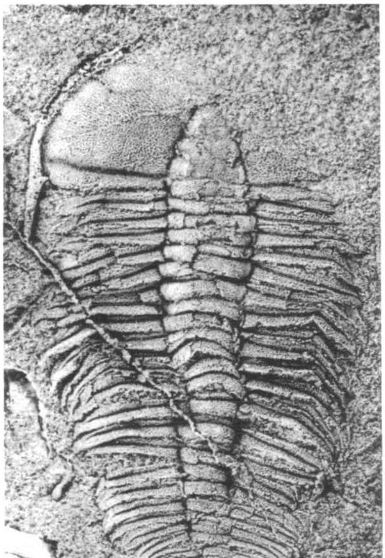

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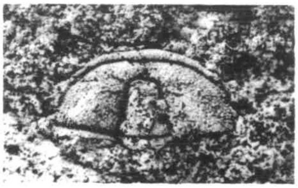
PLATE 12

Meneviella viatrix sp. nov.

Figure 1. CPC 9804. Internal mould of meraspid cranidium, x8.
Figure 2. CPC 9809. Internal mould of early holaspid cranidium, x8.
Figure 3. CPC 9807. Internal mould of holaspid cranidium, x8.
Figure 4. CPC 9806. Internal mould of holaspid cranidium, x8.
Figure 5. CPC 9810. Latex cast from external mould cranidium, x8.
Figure 6. CPC 9802b. Latex cast from external mould cranidium, x8.
Figure 7. CPC 9805b. Latex cast from external mould cranidium, x8.
Figure 8. CPC 9808. Internal mould large cranidium, x8.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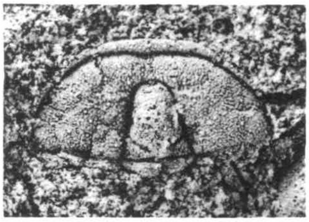
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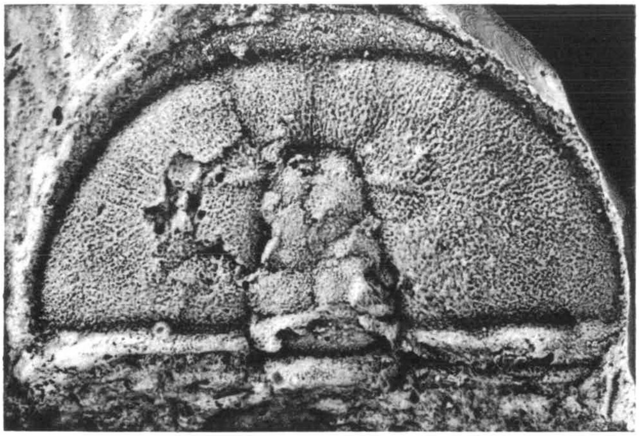
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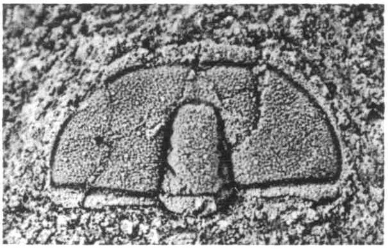
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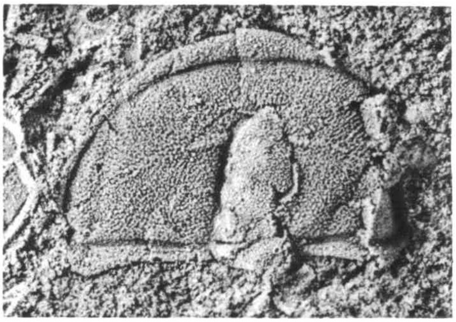
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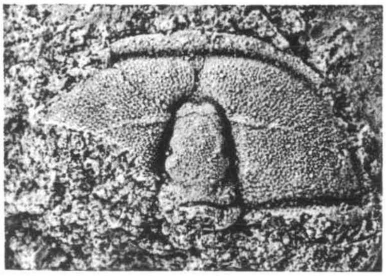
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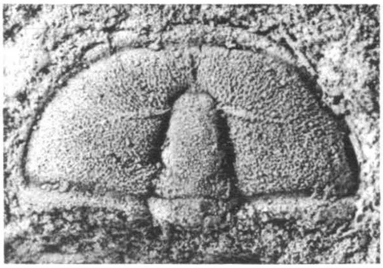
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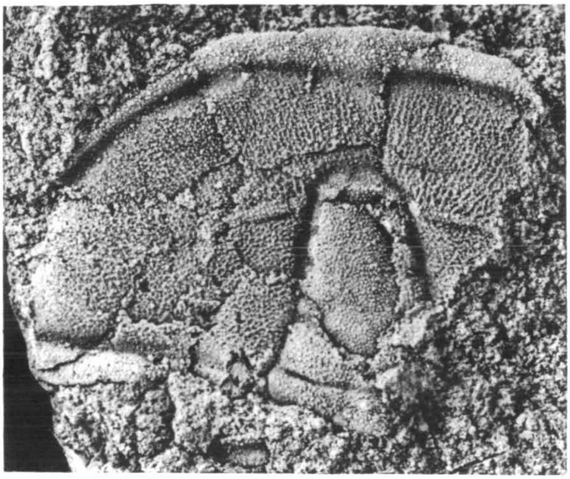
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border towards the genal angles, but its caecal system is not clearly defined in *Meneviella viatrix.*

The nature of the hypostome is not known.

There are 22 thoracic segments in the largest available holaspid carapace. The thoracic axis is spindle-shaped, widest at the fifth segment, tapering thereafter rapidly rearwards. The pleurae have marked geniculations (thus contrasting with the cephalon) at which their ends become extended into long free spines, which are longer than the corresponding 'fixed' pleuron. Each pleuron bears a strongly impressed pleural furrow which extends well into the bases of the free spines. The thoracic caecal system is not well defined.

The pygidium is very small, subtriangular, and without marginal or posterior spines. The conical axis has four well defined segments and a probable fifth. There are four pleural segments with strong pleural and weak interpleural furrows. A narrow border is present.

A faintly granulose prosopon is evident on the thoracic and pygidial segments of some specimens.

Occurrence. All the specimens described and illustrated here are from locality D476, approximately 10 km east of Duchess, western Queensland.

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MIDDLE AND UPPER TRIASSIC MOLLUSCA FROM YUAT RIVER, EASTERN NEW GUINEA

by

S. K. Skwarko

CONTENTS

Page

SYSTEMATIC DESCRIPTIONS—

Bivalvia

Gastropoda

Cephalopoda

Incertae sedis

SUMMARY

Fossils from ten collections made in the Yuat Formation, Yuat River Gorge, Western Highlands, New Guinea, are of upper Anisian (Middle Triassic) and of Carnian-Norian (Upper Triassic) age. The two collections which represent the sites Ab22 and 20NG0019 contain fossils described previously from the Upper Triassic strata of the Jimi River area and are dated as Carnian-Norian and correlated with the Jimi Greywacke in the Jimi River area. Two other collections, Ab45 and 20NG0018, contain hitherto unknown forms—including *Dacryomya tarua* sp. nov.—as well as elements of the Jimi Greywacke fauna; they are provisionally dated as Carnian-Norian but may be slightly younger than the typical Jimi Greywacke assemblage. The remaining collections contain fossils not hitherto described from New Guinea, some of which are new to science. They are dated as upper Anisian and represent the first assemblage of Middle Triassic age to be reported and described from New Guinea. The new species include: *Beyrichites (Beyrichites) yuati, Longobardites (Longobardites) maramuniensis,* and *Parapopanoceras wapii;* species already known but new to New Guinea are *Paraceratites* cf. *trinodosus* Mojsisovics, 1878, *Sturia japonica* Diener, 1916, *Ptychites* cf. *stachei* Mojsisovics, 1882, *Discoptychites* aff. *megalodiscus* Beyrich, 1867, *Germanonautilus* spp., *Hungarites (Israelites)* sp. There are also Halobiid indet., and Nautiloid indet. The zone represented is that of *Paraceratites trinodosus.*

The upper Anisian fauna, which is Tethyan in character and circum-Pacific in distribution, gives evidence of oceanic connexions in Middle Triassic time between New Guinea and the following areas: the Arctic (including Greenland and Spitzbergen), the western coast of North America, south-central Europe and Caucasus, the Himalaya-Indonesia belt, the Far East, and New Zealand., This is the first report of *Paraceratites, Longobardites, Beyrichites, Discoptychites, Sturia, Israelites,* and *Germanonautilus* in the southern hemisphere.

INTRODUCTION

The fossils from the Yuat River gorge described here were collected in June 1966 and April 1967, by members of the Bureau of Mineral Resources field party in the course of the regional mapping of New Guinea, and in October 1967 by me. They are the second collection of marine macrofossils of Triassic age to come from New Guinea, but the earlier collection is Upper Triassic, whereas a number of fossils in the new collections are unmistakably Middle Triassic and constitute the first macrofauna of this age to be recognized from mainland New Guinea.

The Upper Triassic assemblages which were described recently from New Guinea (Skwarko, 1967) consist mainly of Bivalvia. In contrast, ammonites predominate in the Middle Triassic assemblage, and the individual genera are widely distributed outside New Guinea.

ACKNOWLEDGMENTS

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AGES AND CORRELATION OF COLLECTIONS

The original four collections made by D. B. Dow, like the later ones, came from black shale called the Yuat Formation, which is exposed in the Yuat River gorge, about 100 km south of Angoram (see Fig. 1). Dow writes:

> 'The shale underlies dacite, conglomerate, and red siltstone which are very similar to the Upper Triassic Kana Formation found about 55 miles [88 km] to the east in the Bismarck Mountains, and with which they are tentatively correlated.
>
> 'The fossils were collected from gently folded strata which have been dislocated by many small faults. Though the beds are well exposed on both sides of the gorge, outcrops are discontinuous, and it was not possible to measure the thickness of the beds. However, the fossils were collected over a stratigraphic interval of about 300 feet. Also, though the relative stratigraphic positions of the four sample localities are not known with certainty, the following is the probable stratigraphic order:

Ab22	Uppermost.
Ab20 and 24	About 50 feet stratigraphically below Ab22. These two localities are within a few feet of each other stratigraphically.
Ab45	Possibly lowermost.'

The following fossils were identified from these collections:

Locality Ab22: Ambunti 1:250,000 Sheet area. Run Avieme 5 Photo 5003 Point Ab22. Western Bank of Yuat River at a point about 8 km south of its junction with Kingerim River.

'Gervillia (Gervillia) simbaiana Skwarko, 1967'
Guineana jimiensis Skwarko, 1967
?Parapopanoceras wapii sp. nov.

Locality Ab20: Ambunti 1:250,000 Sheet area. Run Avieme 5 Photo 5003 Point Ab20. In Yuat River gorge about 3 km upstream from Locality Ab22.

Beyrichites (Beyrichites) yuati sp. nov.
Parapopanoceras wapii sp. nov.
Ptychites cf. *stachei* Mojsisovics, 1882
Germanonautilus sp. A
Germanonautilus cf. A
Crinoid stems

Locality Ab24: Ambunti 1:250,000 Sheet area. Run Tarua R.R1 Photo 5065 Point Ab24. Same geographical position as Ab20.

Germanonautilus sp. B
Nautiloid indet.
Boring organisms indet.
Crinoid stems

Locality Ab45: Ambunti 1:250,000 Sheet area. Run Avieme 5 Photo 5002 Point Ab45. West bank of Yuat River at about 4 km south of its junction with Kingerim River.

Gervillancea coxiella Skwarko, 1967
Dacryomya tarua sp. nov.
Halobiidae indet.
Problematicum

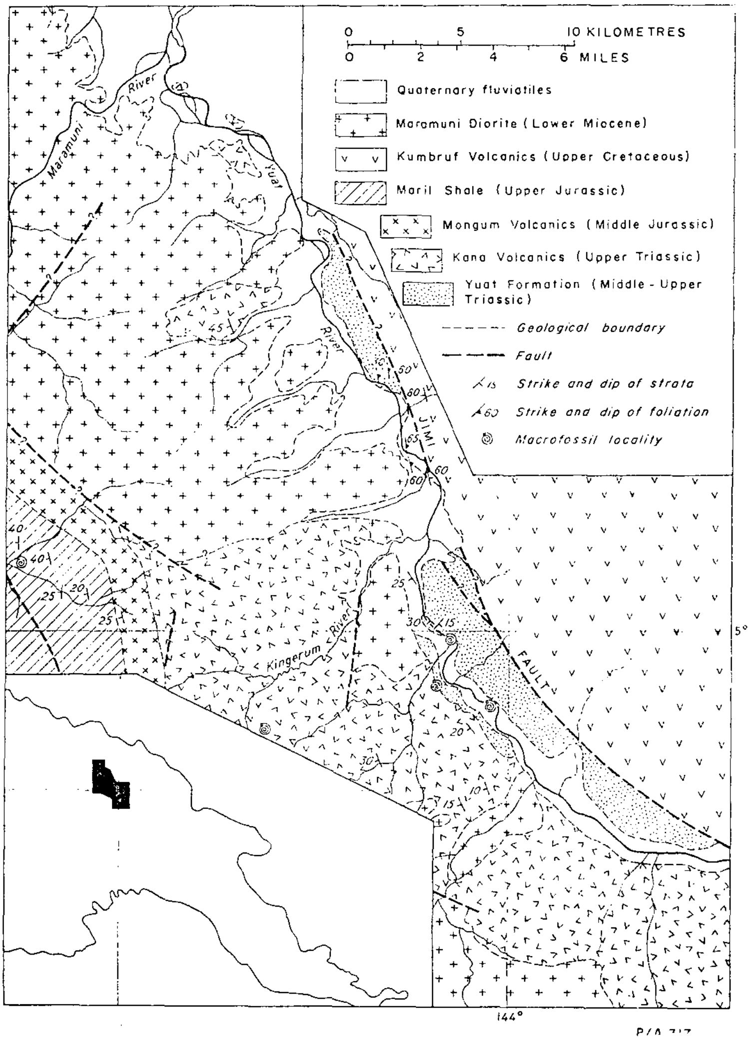

Figure 1. Geological setting and position of the Triassic fossiliferous localities in the Yuat River area, eastern New Guinea. (After J. H. C. Bain, D. B. Dow, and others)

In April 1967, J. H. C. Bain, Bureau of Mineral Resources, collected the following fossils at Locality Ab580 (same spot as 20NG0014):

Beyrichites (Beyrichites) yuati sp. nov.
Longobardites (Longobardites) maramuniensis sp. nov.

In 1967 I collected at four of these sites as well as at one additional spot. These collections were given numbers from a new numeration system and the relationship between the two sets of numbers and the collecting sites is shown in Figure 2. Their content is as follows:

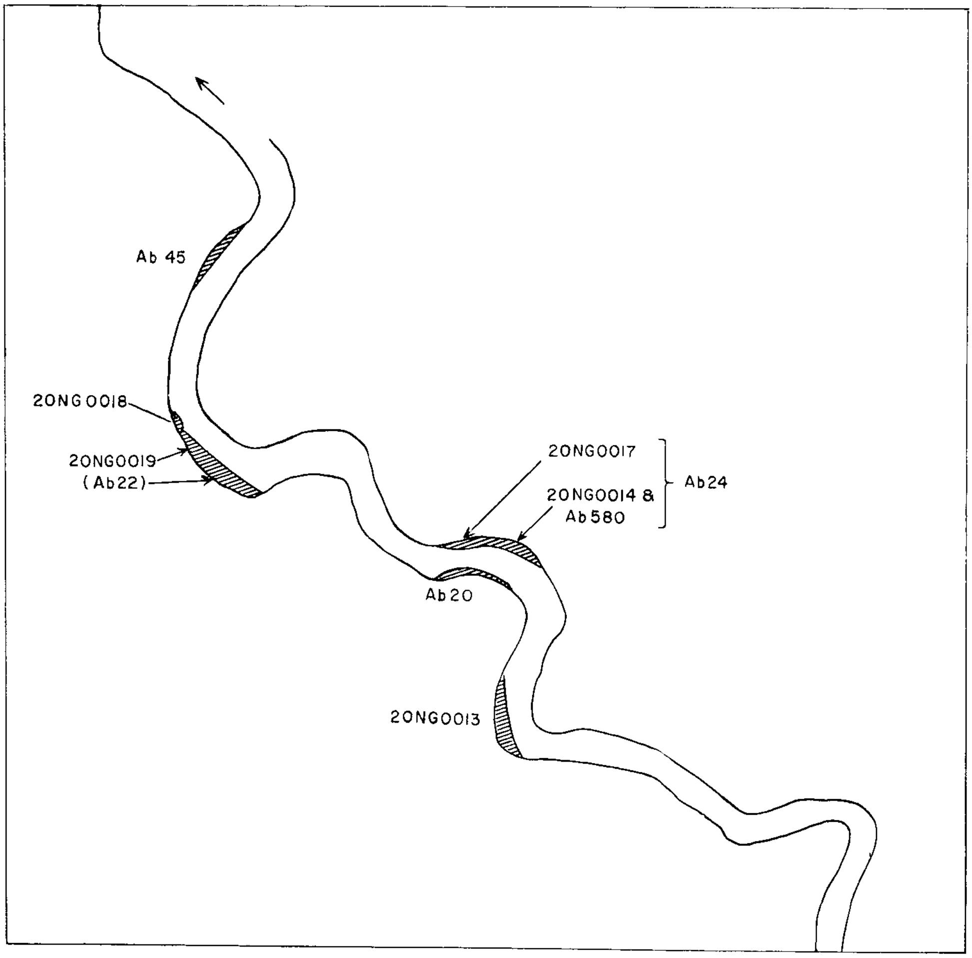

Figure 2. Distribution and relationship of Triassic fossil-bearing localities in the Yuat River gorge. Width of river and river banks exaggerated

20NG0018: *Dacryomya tarua* sp. nov.
?Gervillancea coxiella Skwarko, 1967
Sisenna? novoguineana sp. nov.

20NG0019: *?Bakevellia (Maizuria) bundiensis* Skwarko, 1967
'*Gervillia (G.) simbaiana* Skwarko, 1967'
Guineana jimiensis Skwarko, 1967
Myophoria kuuoruensis Skwarko, 1967
Bivalvia indet.
Beyrichites sp.
Bryozoa indet.
Crinoid stems

20NG0017: *Beyrichites (Beyrichites) yuati* sp. nov.
Sturia japonica Diener, 1916
Germanonautilus sp. A
Gastropoda indet.

20NG0014: *Longobardites (Longobardites) maramuniensis* sp. nov.
Crinoid stems

20NG0013: *Beyrichites (Beyrichites) yuati* sp. nov.
Paraceratites cf. *trinodosus* Mojsisovics, 1878
Hungarites (Israelites) sp.
Parapopanoceras wapii sp. nov.
Discoptychites aff. *megalodiscus* Beyrich, 1867
Crinoid stems

TABLE 1. AGES OF THE INDIVIDUAL COLLECTIONS AND DISTRIBUTION OF FOSSILS IN THE YUAT RIVER GORGE LOCALITIES

	Upper Anisian						Carnian-Norian		'Carnian-Norian'	
	20NG0013	AB20	Ab24	Ab580	20NG0014	20NG0017	Ab22	20NG0019	20NG0018	Ab45
Dacryomya tarua									×	×
Halobiidae indet.										×
?Bakevellia (M.) bundiensis								×		
'Gervillia (G.) simbaiana'							×	×		
Gervillancea coxiella									?	×
Guineana jimiensis							×	×		
Myophoria kuuoruensis								×		
Sisenna? novoguineana									×	
Gastropod indet.						×				
Beyrichites (B.) yuati	×	×		×		×				
Paraceratites cf. *trinodosus*	×									
Hungarites (I.) sp. indet.	×									
Longobardites (L.) maramuniensis				×	×					
Parapopanoceras wapii	×	×					?			
Ptychites cf. *stachei*		×								
Discoptychites aff. *megalodiscus* ..	×									
Sturia japonica							×			
Germanonautilus spp.		×	×				×			
Nautiloid indet.			×							
Crinoid stems	×		×		×			×		
Boring organism indet.			×					×		
Membraniporidae?								×		
Problematicum										×

Collections Ab22 and 20*NG*0019

These two collections were gathered at the same site. All the contained bivalves were previously described from the Carnian-Norian Jimi Greywacke in the Jimi River area some 80 km to the east-southeast, and although the limits of their time ranges are not definitely known, and despite the fact that *G. jimiensis* and *G.* (*G.*) *simbaiana* are here represented by uncommonly large specimens, the age of these collections is still regarded as Carnian-Norian because of the character of the assemblage. The poorly preserved *Beyrichites* sp. and probably *?Parapopanoceras wapii* sp. nov. were collected a few hundred metres upstream from the actual site of the bivalve assemblage, though still in the same outcrop, thereby giving evidence of the presence there of older strata.

Collections 20*NG*0018 *and* *Ab*45

A small ledge above the river a very short distance north from locality 20NG0019 yielded numerous specimens of *Dacryomya tarua* and *Sisenna? novoguineana*. The position of these, numbered 20NG0018, seems in the field to be stratigraphically higher—perhaps as much as 6 m—than the site which yielded collection 20NG0019, but the faulted nature of both outcrops as well as the presence of dykes between them makes this observation uncertain. The age of assemblage 20NG0018 is tentatively regarded as still essentially Carnian-Norian, though possibly a little younger than that of assemblage 20NG0019.

Originally, *D. tarua* was collected in 1966 at locality Ab45 (see Fig. 1), where its abundant occurrence was confirmed during a more recent visit. At this site it is accompanied by the commonly occurring problematicum, and not *Sisenna? novoguineana*. The presence of *Gervillancea coxiella* supports speculation that the age of this assemblage may be Carnian-Norian. This horizon is probably close to that at locality 20NG0018.

Collections *Ab*20, *Ab*24, *Ab*580, 20*NG*0014, 20*NG*0017, 20*NG*0013

So far as is known assemblage Ab20 was collected on the western bank of the river, and it is inferred that collection Ab24 came from the eastern bank. Identification and dating of the fossils subsequently collected in this area has shown that these two collections, as well as those numbered 20NG0017, Ab580, and 20NG0014, differ little if at all in age.

The age of this horizon is undoubtedly Anisian, as shown by the presence of the typical Middle Triassic ammonites *Beyrichites, Ptychites, Longobardites,* and *Sturia japonica*. The probability of the presence of *P. stachei* would place this assemblage high in the Anisian, possibly in the Chischa Zone of Tozer's (1967) classification. This is the first record of marine strata and macrofauna of Anisian age in mainland New Guinea. The collection from locality 20NG0013 yielded the same species of *Beyrichites* and *Parapopanoceras,* but in addition *Discoptychites, Israelites,* and *Paraceratites* cf. *trinodosus,* which further support the upper Anisian dating of this group of collections.

Evidence from the contained fossils suggests a stratigraphic order for the collections somewhat different from that deduced from field evidence. This is as follows (see Table 1): strata represented by collections Ab20, Ab24, Ab580, 20NG0013, 20NG0014, and 20NG0017 are the oldest, all late Anisian; localities Ab22 and 20NG0019 are Carnian-Norian; and at localities Ab45 and 20NG0018 the strata are probably still Carnian-Norian but slightly younger than at the previous two localities. The discrepancy between results from field evidence on the one hand and palaeontological evidence on the other may not be surprising in view of the imperfection of outcrop.

The presence of ammonites in the Middle Triassic sediments allows closer dating and more satisfactory correlation than was hitherto possible in the New Guinea Triassic sequence. The presence of such typically Middle Triassic genera as *Beyrichites, Longobardites, Ptychites, Parapopanoceras,* and *Discoptychites* places the assemblage immediately in the Anisian. Although the better preserved and relatively numerous genera such as *Beyrichites* and *Parapopanoceras* are represented by new species, while no definite comparison with the already established species is possible for the preserved genera, the provisional identifications are in themselves significant in detailed dating. Thus the possible presence of *Paraceratites trinodosus, Ptychites stachei,* and *Discoptychites megalodiscus* very strongly suggests correlation with the European upper Anisian *Trinodosus* Zone, or its North American equivalent 'upper Anisian' Substage, i.e. the Deleeni and Chischa Zones (Tozer, 1967; Silberling & Tozer, 1968). Apart from the obvious value in the dating of local strata the Anisian ammonites give evidence of marine connexions between New Guinea and both near and distant parts of the northern, and to a lesser extent the southern, hemispheres. This is shown in Table 2.

TABLE 2. WORLD DISTRIBUTION OF THE CEPHALOPOD GENERA OCCURRING IN THE MIDDLE TRIASSIC STRATA OF NEW GUINEA

	Arctic	Europe	Asia M.	Himalaya	Timor	Japan	N.W. America	N. Zealand
Beyrichites	×	×		×		×	×	
Paraceratites		×	×				×	
Israelites			×					
Longobardites		×		?			×	
Parapopanoceras							×	×
Ptychites	×	×		×	×	×		×
Discoptychites		×	×					
Sturia		×	×	×	×	×		
Germanonautilus				×			×	

It should also be stressed that only *Ptychites* and *Parapopanoceras* have previously been reported from the southern hemisphere.

Thus, although the Yuat River fauna is of considerable palaeogeographic interest, making as it does another link in the chain of the circum-Pacific Middle Triassic ammonite faunas, it contains, as Table 2 clearly shows, nothing new at supra-specific level, being basically a Tethyan fauna.

SYSTEMATIC DESCRIPTIONS

Class BIVALVIA

Family NUCULANIDAE Adams & Adams, 1858

Genus DACRYOMYA Agassiz, 1840

Type species: *Nucula lacryma* Sowerby, 1824

DACRYOMYA TARUA sp. nov.

(Pl. 13, figs 1-10)

Material. 35 left and right valves and their exterior or interior impressions.

Holotype. CPC 7749 (Pl. 13, figs 7, 10); mature right valve.

Paratypes. CPC 7744 (Pl. 13, fig. 1): immature right valve; CPC 7746 (Pl. 13, fig. 3): immature left valve; CPC 7747 (Pl. 13, fig. 5): internal impression of left valve; CPC 7748 (Pl. 13, fig. 6): internal impression of right valve.

Diagnosis. On reaching a certain size the members of this species exhibit a spectacular change in the direction of growth, which is seen in an accelerated posterior elongation coupled with considerable attenuation of the posterior part of both the right and the left valve.

The resilium pit situated beneath the umbo is flanked with up to 13 teeth forwards and about 17 teeth rearwards.

Separation from other species. Of all the Triassic *Dacryomyas* compared with the new species, *D. nogamii* Nakazawa, 1961, and possibly its subspecies *yakunoensis* from the Anisian and the late Eo-Triassic of Japan, is probably the closest. The new species can, however, be separated from *nogamii* by the uneven number of teeth in front of and behind the umbo, and by the thinner posterior projection. It is possible that the relationship between the long and the short specimens of *D. tarua* is similar to that of *D. nogamii* with its 'subspecies'. The greater concavity of the ventral margin of *'Leda' fibula* Mansuy, 1912, separates it from the new species.

Description. The mature shell is equivalve, inequilateral, produced moderately to the front and strongly rearwards. It is strongly inflated proximally, and has a depressed opisthogyrous umbo. It is up to 35 mm long and 16 to 17 mm high; each valve is about 13 mm thick, and the thickness of the wall of the shell is about 2.5 mm. Young and immature forms are much less strongly produced to the rear than mature specimens, and their rear attenuation is also less.

The umbo is obtuse, depressed, and directed to the rear. It is situated just a little behind the middle of the valve. The posterodorsal and posteroventral shell margins are broadly concave; the dorsal and ventral margins are gently convex; the anterior margin is convex, and the posterior margin is sharply arched. The shell is markedly attenuated to the rear.

The maximum inflation is in the mid-proximal portion of the shell. It decreases with about equal rapidity dorsally and ventrally, more slowly to the front of the shell and rather slowly rearwards, particularly in mature specimens. The post-umbonal or escutcheon carina connects the near rear part of the umbo with the posterodorsal shell margin. From the carina the shell plunges steeply into the commissure. There is in addition a short pre-umbonal carina from which the shell plunges vertically into the commissure.

Surface lineations are fine concentric riblets scarcely thicker than incremental lines. Though generally uniform in thickness and distribution they tend to be locally irregular in direction, and depart from concentric direction in the posterior, attenuated part of the shell.

The hinge-plate is separated into two parts by a resilium pit situated directly beneath the umbo. The anterior part is slightly convex outwards and 9 mm long. It is parallel-sided, about 1.7 mm thick, and carries in mature shells 12 or 13 taxodont teeth. The resilium pit is almost 2 mm across. The posterior portion of the hinge-plate is concave outwards, about 11 mm long, truncated sharply near the resilium pit, but attenuated gradually in its posterior end. It carries 16 or 17 taxodont teeth which, apart from the rearmost ones, are of more or less the same size.

The posterior adductor scar is more deeply incised than the anterior adductor scar, and becomes more elongated with the increasing attenuation of the shell. The two are joined together by a pallial line which parallels the ventral shell margin and which is entire.

Occurrence and age. Localities Ab45 and 20NG0018 in the Yuat River gorge. The probable age of these localities is Carnian-Norian, but slightly younger than that of the Jimi Greywacke in the Jimi River area.

Family HALOBIIDAE Kittl, 1912

Only two halobiid valves have been found in the Yuat River gorge. Both came from locality Ab45 and are quite small, probably representing young specimens. No attempt is made here to determine their identity more closely partly because of their unsatisfactory preservation and partly because of their suspected immaturity. (See also succeeding paper.)

Family BAKEVELLIDAE King, 1850

Genus BAKEVELLIA King, 1848

Type species: *Avicula antiqua* von Münster in Goldfuss, 1936

Subgenus MAIZURIA Nakazawa, 1959

Type species: *Bakevellia (Maizuria) kambei* Nakazawa, 1959

?BAKEVELLIA (MAIZURIA) BUNDIENSIS Skwarko, 1967

(Pl. 14, figs 10, 11)

1967 *Bakevellia (Maizuria) bundiensis* Skwarko, *Bur. Miner. Resour. Aust. Bull.* 75, 51-3, pl. 5, figs 15, 17, 18.

A single specimen, an internal and partial external impression of a right valve from locality 20NG0019, may be a *B. (M.) bundiensis.* It is about 8 cm long, 3.5 cm high, and 1.3 cm thick. It is well inflated with a strong and broad postumbonal ridge. Its external lineation seems to be limited to growth rugae which parallel the shell margin. The posterior margin is entirely and evenly convex and in this seems to differ from that of *bundiensis* (cf. Skwarko, 1967, pl. 5, figs 17, 18), while the anteroventral margin is also regularly convex and in this resembles at least the young *bundiensis* (cf. Skwarko, 1967, pl. 5, fig. 15). The anterior ear, if present, has not been preserved; the posterior ear is very small. Structures on the hinge-plate are poorly preserved, and those which are expected to occupy its centre are not preserved at all. There are six or seven short vertical linear teeth on the anterior extremity of the plate, and two strong longitudinal lateral teeth on its posterior extremity. What little musculature is preserved seems to be like that of *bundiensis.*

B. (M.) bundiensis is known only from the Jimi Greywacke localities in the Jimi River area. Its known age is Carnian-Norian.

Genus GERVILLIA Defrance, 1820

Type species: *Gervillia solenoidea* Defrance, 1820

GERVILLIA s. str.

'GERVILLIA (GERVILLIA) SIMBAIANA Skwarko, 1967'

(Pl. 14, fig. 9)

cf. 1967 *Gervillia (Gervillia) simbaiana* Skwarko, *Bur. Miner. Resour. Aust. Bull.* 75, 54-6, pl. 5, figs 7-11.

The two somewhat crushed, eroded, and incomplete specimens of the bivalve with the two valves more or less in position collected in 1966 from locality Ab22 probably belong to *G.* (*G.*) *simbaiana,* recently described from the Bismarck Mountains area, but are too poorly preserved for a definite comparison. On the other hand the examination of the one incomplete right and one left valve and five fragments of *Gervillia* found in the Yuat River gorge in 1967 shows them to be considerably larger than *G.* (*G.*) *simbaiana.* The reconstructed size is as follows: length 75 mm, height 30 mm, overall thickness about 22 mm, thickness of the shell wall up to 5 mm. Those morphological features still preserved, i.e. the general outline, the rear portion of the pallial line, and the rear adductor scar, are similar to those of *simbaiana.* Although the relationship between the large and the small specimens is obviously close, there is too little well preserved material to ensure whether or not the two groups of specimens are the same species.

Occurrence and age. Localities Ab22 and 20NG0019 in the Yuat River gorge. Previously the species was identified from localities H176, H185, and H200 in the Jimi Greywacke of the Jimi River area, which were dated as Carnian-Norian.

Genus GERVILLANCEA Skwarko, 1967

Type species: *Gervillancea coxiella* Skwarko, 1967

GERVILLANCEA COXIELLA Skwarko, 1967

(Pl. 13, figs 15, 16)

1967 *Gervillancea coxiella* Skwarko, *Bur. Miner. Resour. Aust. Bull.* 75, 52-4, pl. 7, figs 1-10; text-fig. 7.

Material. Three proximally incomplete and somewhat fractured left valves from locality Ab45, and one incomplete left valve possibly referable to this genus from locality 20NG0018.

Discussion. The three left valves from locality Ab45 are almost exactly 3 cm wide and of the order of 8 to 9 cm long. Two of the specimens still retain their fairly strong tumidity. The diagnostic proximal portion is missing in one specimen but preserved incompletely in the other two, and its examination shows the characteristic incurving of the umbo with its umbonal ridge and preumbonal depression (Pl. 13, fig. 15). A portion of the posterior wing is also preserved in one specimen (Pl. 13, fig. 15) and a small proximal part of the anterior wing is visible in the other. Although the dentition could not be examined, the affinity of the three specimens is unequivocal.

Occurrence and age. The only previous record of *G. coxiella* is from locality M26, Jimi Greywacke, Jimi River area, dated as Carnian-Norian.

Family TRIGONIIDAE Lamarck, 1819

Subfamily TRIGONIINAE Kobayashi, 1954 em.

Genus GUINEANA Skwarko, 1967

Type species: *Guineana jimiensis* Skwarko, 1967

GUINEANA JIMIENSIS Skwarko, 1967

(Pl. 14, figs 1-3, 6-8)

1967 *Guineana jimiensis* Skwarko, *Bur. Miner. Resour. Aust. Bull.* 75, 58, 59, pl. 6, figs 1-8, text-fig. 8.

Material. Three specimens from locality Ab22 with both valves in position; two left and one right internal impression from locality 20NG0019.

Discussion. The average size of *G. jimiensis* from the Yuat River gorge is high for the species, as is the height-to-length ratio, but the values fall within the limits of this variable species.

Occurrence and age. The previous record of *G. jimiensis* is from locality H782 in the Jimi Greywacke, Jimi River area, dated as Carnian-Norian.

Family MYOPHORIIDAE Bronn, 1849

Genus MYOPHORIA Bronn in Alberti, 1834

Type species: *Trigonellites vulgaris* von Schlotheim, 1820

MYOPHORIA KUUORUENSIS Skwarko, 1967

(Pl. 14, figs 4, 5)

1967 *Myphoria kuuoruensis* Skwarko, *Bur. Miner. Resour. Aust. Bull.* 75, 61, 62, pl. 6, figs 9-12.

The single internal impression of a left valve from locality 20NG0019 belongs to *M. kuuoruensis,* as shown by the general shape as well as by the faint imprint of the external ornament on the surface of the cast. The latex reproduction of the dentition shows tooth 2 less well developed than in a similar valve from locality H200 in the Jimi River area (cf. Skwarko, 1967, pl. 6, fig. 9). In this valve the 4a is anteriorly incomplete and seems to be smaller than 4a on the valve from the Yuat River gorge. It may or may not be of similar size.

Occurrence and age. The previous report of this species is from locality H200, Jimi River area, dated as Carnian-Norian.

Class GASTROPODA

Family RAPHISTOMATIDAE Koken, 1896

?Genus SISENNA Koken, 1896

Type species: *Pleurotomaria turbinata* Hornes, 1855, by subsequent designation of Cossman, 1897

SISENNA? NOVOGUINEANA sp. nov.

(Pl. 15, figs 3-9)

Material. Several more or less distorted incomplete specimens and fragments.

Holotype. CPC 11163 (Pl. 15, fig 4, 5, 8), the most complete and best preserved specimen.

Description. The shell is probably up to 3 cm across and 2 cm high, with a low broad spire, and incipient umbilicus. The aperture is laterally elongate, with a moderately prominent labral slit. The base is striated with sinuous incremental lines, and up to ten very narrow low spiral ridges, some of which incompletely break into elongate tubercles at the junction with growth-lines. The peripheral bulge seems to be absent. The ramp angle is made conspicuous by a row of tubercles which adorns it. The ramp itself is broad with an uneven slope, complicated by the presence of at least two rows of tubercles.

Remarks. The specimens tentatively referred to the Lower Triassic-Lower Jurassic genus *Sisenna* are commonly associated with *Dacryomya* at locality 20NG0018, but are crushed and distorted, and no complete specimens have been collected. The holotype itself may be vertically compressed.

GASTROPODA indet.

(Pl. 15, figs 1, 2)

It was not possible to assign satisfactorily the single large gastropod from locality 20NG0017 to any known genus because of poor preservation.

The shell is trochiform, 4.8 cm in diameter and about 4.2 cm high, with a broadly angular peripheral bulge and solenizone located in the upper half of the outer face of the whorl. The ramp is short and steep and the shell is ornamented with faint longitudinal striae.

Class CEPHALOPODA

Family BEYRICHITIDAE Spath, 1934

Genus BEYRICHITES Waagen, 1895

Type species: *Ammonites reutensis* Beyrich, 1867.

BEYRICHITES s. str.

BEYRICHITES (BEYRICHITES) YUATI sp. nov.

(Pl. 16, figs 1-5)

Material. Eight incomplete specimens and seven fragments which almost certainly belong to the same species. Localities Ab20, 20NG0017, and ?20NG0019.

Holotype. CPC 7756 (Pl. 16, figs 1, 5). Almost complete specimen.

Paratypes. CPC 7757 (Pl. 16, fig. 2), immature specimen; CPC 7758 (Pl. 16, fig. 4), fragments of a mature specimen showing detail of ribbing.

Diagnosis. The shell is large for the genus, with weak single ribs and secondary riblets, and subammonitic suture.

Separation from other species. B. yuati can be readily distinguished from previously described species of *Beyrichites* by the large size of its mature specimens and by the greater complexity of suture. Only in *B. osmonti* Smith, 1914, does the suture approach that of the new species in complexity, but its secondary striae are more pronounced, while ribbing on the early whorls seems to be less developed. *B. falciformis* Smith, 1914, though similar in general appearance, is a smaller form, and its suture is simpler than that of *B. yuati.*

Description. The shell is involute, compressed, weakly ribbed, with sub-ammonitic suture. It is large for the genus: the largest has a diameter of 12 cm. and is more than 3 cm thick.

The umbilicus is circular, slightly less than 2 cm across in mature specimens. The venter is narrowly arched; the whorl width increases in breadth gradually inwards until about its middle, after which the walls run parallel to each other, or even converge, before reaching the umbilicus.

The ribbing is of two orders and consists of falcoid ribs and striae. The ribs are single and occupy most of the outer wall, but are absent from the venter as well as from the umbilical wall. With the growth of the shell the distance between ribs and the inner and outer whorl margins seems to increase, with the result that ribs acquire the appearance of bullate tubercles. The falcoid striae are numerous, from 1 to 2 mm wide, of low relief, and separated from each other by very shallow interspaces of about the same width.

The suture is of subammonitic type. There are four lateral saddles in addition to the ventral and the internal lateral lobe. The number of accessory lobes—and hence the complexity of sutures—varies somewhat from specimen to specimen, but does not seem to increase with age.

Remarks. *Beyrichites* is a widely distributed genus, but this is the first time that it has been found south of the equator. Though well known from the Himalayas and Japan it is not known in Timor. *Beyrichites* is confined to sediments of upper Scythian and Anisian age.

Suborder CERATITINA Hyatt, 1884
Superfamily CERATITACEAE Mojsisovics, 1879
Family CERATITIDAE Mojsisovics, 1879
Genus PARACERATITES Hyatt, 1900

Type species: *Ceratites elegans* Mojsisovics, 1882

PARACERATITES cf. TRINODOSUS Mojsisovics, 1878

(Pl. 26, figs 2, 3, ?5, ?6)

Material. Two incomplete specimens of most of the body whorl, one of which has the last two sutures. Locality 20NG0013.

Description. In the more complete specimen the body whorl is 19 mm high, 13 mm thick in its widest part, and 5 mm thick in its narrowest part. It has a closely rounded venter which is bordered on both sides by a line of tubercles, and a second row of tubercles adorns each wall near its point of greatest width, i.e. about two-thirds the distance from the keel to the umbilical wall. In its cross-section the body whorl tends towards the fastigate shape. The tubercles which border the venter are pointed, but elongate parallel to the direction of the keel, and also diagonally across the keel. The dorsally placed tubercles are quite round in cross-section. Weak sinuous riblets join each pair of the ventral tubercles with each dorsal node.

The less complete specimen was the larger of the two when complete. The height of its body whorl is 21 mm, the width 17 mm in its widest part and 10 mm in its narrowest part. The venter is somewhat less tightly rounded, and the tubercles bordering it larger and less closely spaced than in the smaller specimen. The dorsal tubercles are quite robust and the ribs joining them with the ventral nodes more prominent than on the smaller specimen. The thickness of the body whorl increases with age more quickly in this specimen.

Family ?HUNGARITIDAE Waagen, 1895
Genus ?HUNGARITES Mojsisovics, 1879
Subgenus ISRAELITES Parnes, 1962

Type species: *Hungarites* (*Israelites*) *ranonensis* Parnes, 1962

HUNGARITES (ISRAELITES) sp. indet.

(Pl. 17, figs 1-3)

A large but very incomplete ammonite found at locality 20NG0013 may belong to the ?upper Anisian-lower Ladinian genus *Israelites* Parnes, 1962.

The specimen is 20 cm long and is an incomplete body whorl of a large ammonite. It is compressed, the whorl being 7.2 cm high and 4.2 cm across, with almost straight walls, and has a broadly rounded rather low keel. The keel carries impressions after narrow and closely spaced ribs. Two rows of well spaced large tubercles flank the keel, one on each side, while another row of similar tubercles is present much higher on each wall, about two-thirds the distance towards the umbilicus. In cross-section the whorl is vertically rectangular.

Family LONGOBARDITIDAE Spath, 1951 (nom. transl. emend.)

Subfamily LONGOBARDITINAE Spath, 1951 (nom. emend.)

Genus LONGOBARDITES Mojsisovics, 1882

Type species: *Longobardites breguzzanus* Mojsisovics, 1882

LONGOBARDITES s. str.

LONGOBARDITES MARAMUNIENSIS sp. nov.

(Pl. 18, figs 1-6, ?7, ?8; text-fig. 3)

Material. Two incomplete specimens and two fragments, all from locality 20NG0014.

Holotype. Pl. 18, figs 3, 6 (CPC 11169).

Paratype. Pl. 18, figs 4, 5 (CPC 11170).

Diagnosis. The diagnostic feature of the shell is the combination of its large size, strongly compressed whorl section, strong involution, lack of ribbing, type of suture, and absence of a raised keel.

Phylogeny. The New Guinea forms undoubtedly belong to *Longobardites,* as evidenced by their shape and appearance and the type of suture. Of the three subgenera recently recognized by Assereto (1966) during his revision of the genus, our forms seem most closely allied to *Longobardites* s. str., as they lack any form of ribbing or tuberculation, while their simple lanceolate compressed cross-section separates them from the more complicated cross-section of *Longobarditoides.*

Separation from other species. L. maramuniensis can be separated from its closest ally, *L. nevadanus* 'from the Shoshonensis Zone of Nevada, and apparently also upper part of Varium Zone in British Columbia . . .' (Tozer, pers. comm.) by the absence of a raised keel. It can be separated from other previously described species through the features listed under the diagnosis.

Description. The shell is oxycone, very compressed and involute, with a lanceolate cross-section ending in an apparently sharply pointed venter. The umbilicus is very small, with inconspicuous shoulders. Exterior lineation was probably limited to growth striae—there is no evidence of any sort of ribbing.

The suture is made up of eight entire lobes most of which are more or less evenly arched, but some, particularly those closer to the keel, are triangular in outline, and of eight saddles most of which are trifid and some more complex.

The species is large for the genus, the largest specimen in the collections being probably a full 9 cm high.

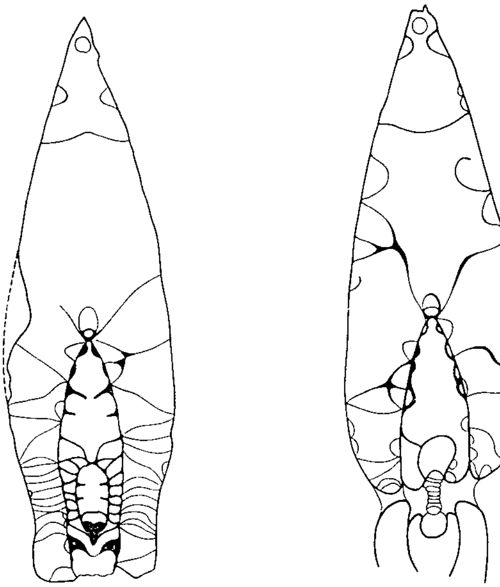

Figure 3. *Longobardites (Longobardites) maramuniensis* **sp. nov. Acetate peels of both sides of cross-section through an incomplete specimen (CPC 11488) from locality 20NG 0014. x 1½**

Distribution of the genus. The world distribution of the genus *Longobardites* and its subgenera was recently discussed in detail by Assereto (1966). The genus is so far known only from south-central Europe, the Caucasus, the Arctic Circle, and western North America. The subgenus is known only from northern Italy, Hungary, Bulgaria, and Nevada. Thus its reported occurrence in New Guinea greatly extends the known geographic range of this ammonite, which hitherto was regarded as a purely boreal form.

Superfamily ARCESTACEAE Mojsisovics, 1875
Family MEGAPHYLLITIDAE Mojsisovics, 1896
Genus PARAPOPANOCERAS Haug, 1899

Type species: *Popanoceras verneuili* Mojsisovics, 1886

PARAPOPANOCERAS WAPII sp. nov.

(Pl. 19, figs 1-7; text-fig. 4)

Material. Six specimens from locality Ab20; one specimen probably belonging to this species from an extension of locality Ab22.

Holotype. CPC 7760 (Pl. 19, figs 1, 2), specimen not quite mature.

Paratypes. CPC 7762 (Pl. 19, fig. 4) and CPC 7763 (Pl. 19, fig. 5), mature specimens showing ribbing and suture pattern.

Diagnosis. Venter rounded generally but sharp in mature portion of body whorl; umbilicus small but with a marked tendency for uncoiling; thin prorsiradiate riblets on later half of body whorl; suture ceratitic with ?eight entire weakly subphylloid saddles, and eight weakly serrated lobes.

Separation from other species. The combination of morphological features listed above under the diagnosis readily distinguishes the new species from the already described species of *Parapopanoceras* Haugh and *Ptychopopanoceras* and *Neopopanoceras* Spath, 1951.

Description. The specimens are up to 45 mm high and 13 mm thick. Their shell is compressed with a rounded venter except in late maturity. The aperture is well marked by what seems to resemble a constrictive band. The apertural venter is rounded.

Dorsally from the venter the shell attains its maximum thickness rapidly, and this once attained persists to near the umbilicus so that in the cross-section the shell is spindle-shaped.

The umbilicus is at most 8 mm across, but with a well marked tendency for uncoiling.

Figure 4. *Parapopanoceras wapii* **sp. nov. Detail of suture on an incomplete and partly exfoliated specimen (CPC 7763; Pl. 19, fig. 5) x 4**

The ornamentation consists of prorsiradiate riblets which are found only on the mature portion of the body whorl. Some of them are grouped into clusters of three or four, and these approach each other with increasing distance from the ventricle, merging together to form compound primary ribs near the umbilicus. Other riblets stay separate for their remaining length, which is invariably shorter than that of the primary riblets. The suture is ceratitic with possibly eight subphylloid saddles and eight weakly serrated lobes.

Remarks. Hitherto *Parapopanoceras* has been regarded as mainly a Boreal genus, as apart from New Zealand it has been reported only from Spitzbergen, Siberia, Greenland, British Columbia, and California (Kummel, 1960, p. 495). Its presence in New Guinea provides a link between its two areas of occurrence.

Superfamily PTYCHITACEAE Mojsisovics, 1882
Family PTYCHITIDAE Mojsisovics, 1882
Genus PTYCHITES Mojsisovics, 1875

Type species: *Ammonites rugifer* Oppel, 1865; SD Spath, 1951.

PTYCHITES cf. STACHEI Mojsisovics, 1882
(Pl. 19, figs 8-10)

Material. Single incomplete specimen. Locality Ab20.

Description. The specimen is involute, sphaerocone and ribbed, with a complex subammonitic suture. The preserved whorl is 5 cm high, more than 4 cm wide, and 2.5 cm thick.

The venter is broadly rounded, and proceeding inwards the thickness of the whorl, once attained, increases only slightly towards the umbilicus. The umbilicus is small and moderately deep, but because of poor preservation the details of its structure are not known.

The ribs are weak near the umbilicus, more prominent distally, though they do not extend on to the venter. They are simple, prorsiradiate, seemingly plicate, up to 4 cm across at their greatest width, where they are only slightly wider than the interspaces. The ribs and interspaces are symmetrically convex and concave in cross-section.

The suture is complex subammonitic. Its extremities are not preserved, but for the remaining length it consists of four lobes and four saddles, both carrying many secondary lobes.

Discussion. A species cannot be determined on the basis of the single incomplete specimen. However, the several diagnostic characters preserved enable tentative comparisons with previously described forms. Three close species are *P. studeri* (Hauer, 1857), *P. flexuosus* (Mojsisovics, 1882), and *P. stachei* (Mojsisovics, 1882). The ribbing on the New Guinea specimen seems to be more closely spaced and thicker than in *P. studeri*; its ribs are more rigid and the suture lobes deeper than those in *P. flexuosus.* Its similarities with *P. stachei* are very striking indeed, and it may in fact belong to this species.

P. stachei and *P. flexuosus* both occur in the Zone of *Paraceratites trinodosus,* while *P. studeri* occupies one zone lower in the upper Anisian, i.e. the Zone of *Paraceratites binodosus.* It would appear, therefore, that the presence of this particular *Ptychites* is evidence of upper Anisian.

Genus DISCOPTYCHITES Diener, 1916

Type species: *Ammonites megalodiscus* Beyrich, 1867.

DISCOPTYCHITES aff. MEGALODISCUS Beyrich, 1867
(Pl. 21, fig. 1; Pl. 22, figs 1, 2; Pl. 26, fig. 1; Text-fig. 5)

Material. A large fragment representing about a fifth of a complete whorl of a large specimen. Locality 20NG0013.

Description. The specimen is large, exceeding 36 cm in diameter, apparently smooth, involute, compressed, with the preserved portion of the whorl about 17 cm high and probably 7 cm wide.

The venter is tightly arched. The walls are broadly and uniformly convex, diverging from each other for about three-fifths of their distance to the umbilicus, and then converging with similar curvature. The maximum thickness of the walls is about 3.5 mm both on the venter and near the umbilicus.

The suture is ammonitic with complex adventitious and auxiliary elements.

Discussion. The sole specimen is too poorly preserved for a definite identification, but comparison of its suture with that of *D. megalodiscus* suggests that the New Guinea specimen represents a different though closely related species.

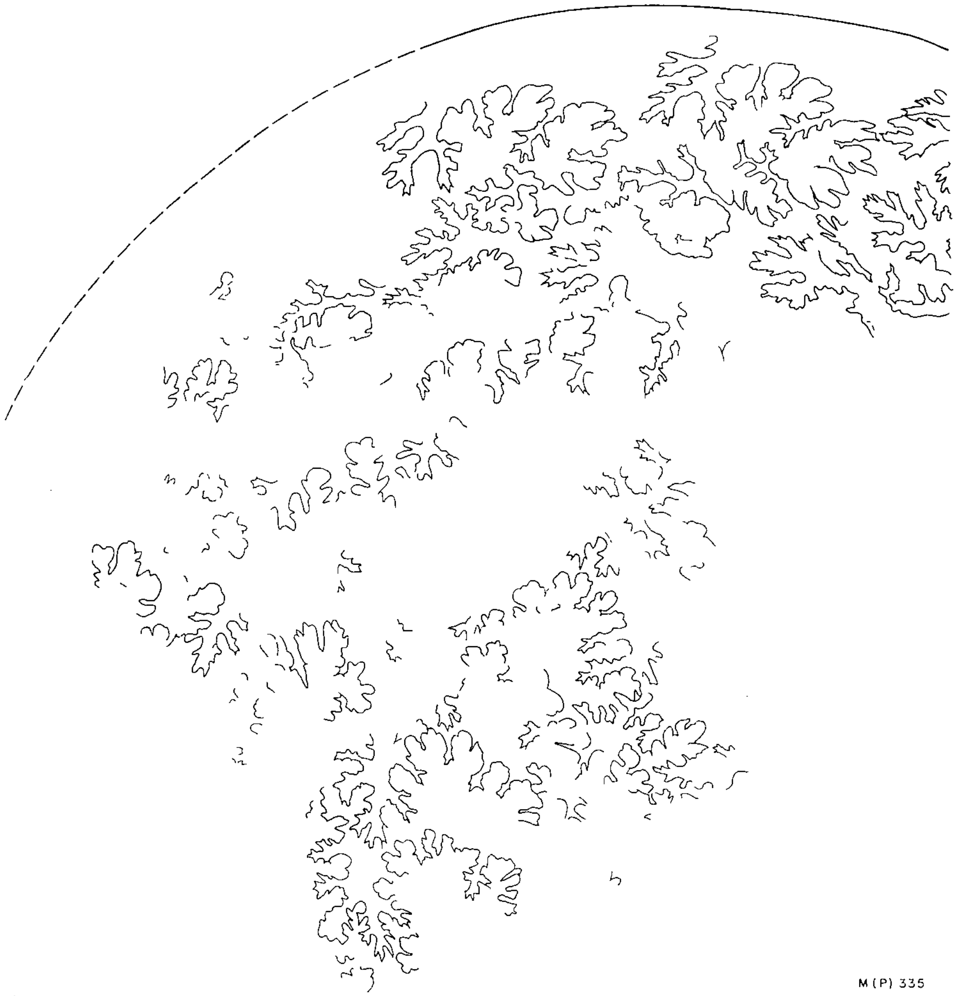

Figure 5. Suture pattern of the only fragment of *Discoptychites* **aff.** *megalodiscus* **in the collection**

Remarks. Examination of the acetate peel taken off a transverse section of the whorl (Pl. 26, fig. 1) shows that one side of the specimen is badly crushed. In contrast to both the external and the internal left whorl walls, which retain their original shape, the right exterior wall is broken in several places and offset inwards while the inner right wall seems to have 'flowed' inwards until it is now subparallel to the left inner wall.

Genus STURIA Mojsisovics, 1882

Type species: *Amaltheus sansovinii* Mojsisovics, 1869

STURIA JAPONICA Diener, 1916

(Pl. 20, figs 1, 2)

1916 *Sturia japonica* Diener, *Denkschr. K. Akad. Wiss., math.-nat.Kl.*, 92, 18, pl. 6, figs 1, 2.
1961 *Sturia japonica* Diener; Kiparisova, *VSEGEI* (N.S.) 48, 108, 181, pl. 36, fig. 1.

Specimens of *Sturia* are fairly common in outcrops on both sides of the river at localities Ab20 and 20NG0017, but as their tall, narrow shells are invariably crushed and shattered it was only possible to collect small fragments. The two figures on Plate 20 are thus not of the actual specimens but of latex casts taken off the impressions of the shell in rock *in situ*. They were slightly deformed during the subsequent transit to Canberra.

The Yuat River *Sturia,* which is the first representative of the genus to be reported from New Guinea, is large: more than 20 cm high. Little is known of its cross-sectional shape beyond that it was narrow, possibly discoidal; and nothing at all of the pattern of its sutures. It is, however, an involute form with a very small umbilicus. The surface ornament is well preserved and similar in both specimens: it is strigate, consisting of numerous longitudinal low and flat-topped ribs separated by fairly broad and shallow interspaces. The ratio of the width of ribs to that of interspaces varies greatly in different parts of the shell, a feature characteristic of the species. It is greatest in the umbilical region of the youngest portion of the last whorl, where it is more than two to one (ribs are 4.0 mm wide, interspaces about 1.8 mm wide), and decreases both ventrally and with the decreased size of whorls to the smallest measured value of one to two.

The specimens of *Sturia* from New Guinea are referred to the originally Japanese species *S. japonica,* which occurs in strata of Anisian age both in that country and in the Primorye Region of the Soviet Union (Kiparisova, 1961, pp. 180, 181).

Family TAINOCERATIDAE Hyatt, 1883

Genus GERMANONAUTILUS Mojsisovics, 1902

Type species: *Nautilus bidorsatus* Schlotheim, 1832

GERMANONAUTILUS sp. A

(Pl. 23, figs 1, 4, 5; Text-fig. 6)

Material. One almost complete internal cast. Locality Ab20.

Description. The shell is 78 mm high and about 60 mm long. It is evolute, with whorls only slightly overlapping. The umbilical perforation is fairly large, measuring 10 mm in diameter, and the whorl departing from it expands rapidly.

The body chamber is 50 mm wide and 40 mm high. It is subquadrate in cross-section. The umbilical walls are steep and pass into straight or slightly convex flanks through sharply rounded shoulders. The flanks converge slightly distally. The ventrolateral shoulders are uniformly rounded, and the venter is gently concave.

Lineations on the internal cast of the conch, which are interpreted as growth-lines, trace a deep rounded hyponomic sinus on the venter. A low and almost linear longitudinal ridge is present in the position of a keel.

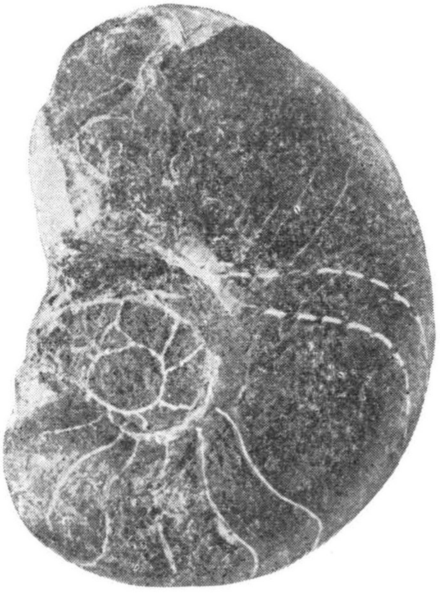

Figure 6. *Germanonautilus* **sp. A with accentuated suture and growth line pattern. CPC 7770 (see also Pl. 24, fig. 1)**

There are 16 chambers in addition to the body chamber, the last three being about 10 mm deep, measured along the venter. The body chamber is long, forming almost half of the length of the shell.

The suture has shallow ventral and lateral lobes.

Discussion. The single specimen shows sufficient characters to enable a generic determination. As, however, the nature of its external ornamentation is not known, specific determination must necessarily be postponed until more and better material becomes available for comparison.

Germanonautilus is a widely distributed genus, so far known to have occurred in North America, Europe, Egypt, Israel, Himalayas, and Japan. It has not, however, been hitherto reported from South-East Asia, and consequently its presence in eastern New Guinea fills an important gap in our knowledge of its distribution.

GERMANONAUTILUS sp. cf. A

(Pl. 23, figs 2, 3)

It is possible that the only other coiled nautiloid from locality Ab20 is specifically identical with *Germanonautilus* sp. A, but poor preservation does not allow definite comparison and it is described separately.

The inner whorl is preserved almost in its entirety (see Pl. 23, figs 2, 3), and there is also a portion of the body chamber attached to it. The umbilical perforation is slightly larger than in *Germanonautilus* sp. A and is oval in shape, its dimensions being 1.4 cm and 1.2 cm. The initial whorl departs from the antero-ventral portion of the umbilicus, i.e. in the same manner as in *Germanonautilus* sp. A, and its initial increase in growth is similarly rapid. Only the first twelve chambers are preserved, and their spacing seems to be more regular than in sp. A.

Some shell is preserved on the ventral side of the inner whorl. It is less than 1 mm thick and lined with closely but irregularly spaced thin longitudinal striae. In addition there are much finer and more regular growth striae which form an arch convex away from the aperture.

In its initial stage of development the conch is about twice as broad as it is high. Its free lateral walls are convex outwards, while the ventral wall is equally uniformly, though less, convex.

Only a portion of the body whorl is preserved. Its examination reveals that the specimen when whole must have been somewhat larger than *Germanonautilus* sp. A, but otherwise rather similar. This similarity is seen in the steepness of the umbilical whorls, in the rapid increase in size of the outer whorl, in sharpness of umbilical shoulders, and in the broadly arched ventral shoulder. The surface of the venter is not, however, concave as in *Germanonautilus* sp. A, but uniformly though gently convex. The linear ornamentation extends throughout the whole conch.

GERMANONAUTILUS sp. B

(Pl. 24, figs 4-6; Pl. 25, fig. 4)

Material. Two incomplete specimens showing the structure of the body chamber and the first fifteen chambers. Locality Ab24.

Description. The shell is slightly involute, depressed, with the width of the individual chambers exceeding height.

The umbilicus is deep, oval, with steeply dipping convex walls. The inner whorl is moderately involute. The visible lateral walls of the inner whorl chambers are convex. Fifteen inner chambers are preserved. They increase in size rapidly, and are separated from each other by seemingly straight simple sutures whose spacing increases regularly with the development of the whorl. The portion of the shell between the fifteenth chamber and the body chamber is not preserved.

The body chamber is 10 cm long, 7.2 cm wide, and about 5.2 cm high. It has rounded umbilical and ventral shoulders with straight flanks in between, converging ventrally only very slightly. There is a longitudinal open groove in one umbilical shoulder, but not in the other. It seems to be absent from the other specimen, and may in fact be an aberrant feature. The venter is broad, flattened, and straight or very slightly convex. The siphuncle is placed proximally. The exterior of the shell is ornamented with rather fine reticulate pattern formed by criss-crossing incremental lines and thin longitudinal striae.

NAUTILOID indet.

(Pl. 25, figs 1, 3)

In addition to *Germanonautilus* sp. B there is in collection Ab24 another nautiloid whose determination has also proved problematical. Its preserved portion is almost 12.5 cm long and 3.5 cm in diameter. It consists of most of the body chamber, and two complete sutures. From the outside the cylindrical specimen has the appearance of a straight orthocone, but acetate peels taken off polished

PLATE 13

All figures natural size and photographed in lateral view unless stated otherwise.

Figures 1-10.—*Dacryomya tarua* sp. nov.

1. Paratype, CPC 7744. Right valve.
2. Left valve, CPC 7745.
3. Paratype, CPC 7746. Left valve.

4, 5. Paratype, CPC 7747. Internal cast of left valve and its latex impression.
6. Paratype, CPC 7748. Latex cast showing internal aspect of right valve.
7, 10. **Holotype,** CPC 7749. Right valve and latex impressions showing internal structure.
8, 9. Left valve in lateral and dorsal views. CPC 7750.
Locality Ab45 ('Carnian-Norian')

Figures 11-14.—Problematicum indet.

11, 13. Dorsal and lateral view of valve. CPC 7751.
12, 14. Clusters of several specimens. CPC 7752 and CPC 7753.
Locality Ab45 ('Carnian-Norian')

Figures 15, 16.—*Gervillancea coxiella* Skwarko, 1967.

15. Dorsal view of partly crushed left valve. CPC 7754.
16. Lateral view of distal portion of left valve. CPC 7755.
Locality Ab45 ('Carnian-Norian')

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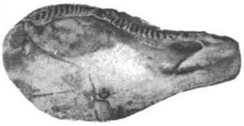

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PLATE 14

All figures natural size and photographed in lateral view unless stated otherwise.

Figures 1-3, 6-8.—*Guineana jimiensis* Skwarko, 1967.
  1, 2. Specimen in lateral and dorsal views. CPC 7766.
    Locality Ab22 (Carnian-Norian)
  3, 6. Latex cast and its mould of internal impression of right valve. CPC 11156.
    Locality 20NG0019 (Carnian-Norian)
  7, 8. Latex cast and its mould of internal impression of large left valve. CPC 11157.
    Locality 20NG0019 (Carnian-Norian)

Figures 4, 5.—*Myophoria kuuoruensis* Skwarko, 1967.
  Latex cast and its mould of internal impression of left valve. CPC 11158.
    Locality 20NG0019 (Carnian-Norian)

Figure 9.—'*Gervillia* (*Gervillia*) *simbaiana* Skwarko, 1967'.
  Proximally incomplete left valve. CPC 11159.
    Locality Ab22 (Carnian-Norian)

Figures 10, 11.—*?Bakevellia* (*Maizuria*) *bundiensis* Skwarko, 1967.
  Latex cast showing part of incomplete external impression and near complete internal impression of same specimen. CPC 11160.
    Locality 20NG0019 (Carnian-Norian)

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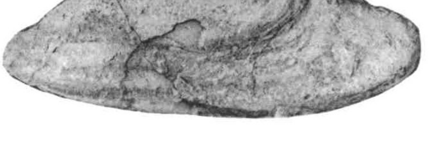

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PLATE 15

All figures natural size and photographed in lateral view unless stated otherwise.

Figures 1, 2.—Gastropoda indet.

Lateral and oblique dorsal views of specimen CPC 11161.

Locality 20NG0017 (upper Anisian)

Figures 3-9.—*Sisenna? novoguineana* sp. nov.

3. Oblique dorsal view of latex cast of incomplete dorsal impression of shell. CPC 11162.

4, 5, 8. Anterior, ventral (x4) and dorsal (x4) views of latex cast of incomplete external impression of valve. **Holotype,** CPC 11163.

6, 7. Latex casts of tectonically distorted partial impressions of shell. CPC 11164.

9. Detail of ornamentation of ventral surface of shell with secondary striae. CPC 11165.

Locality 20NG0018 (?Carnian-Norian)

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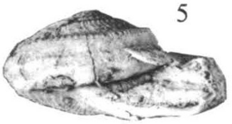

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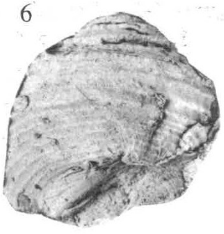

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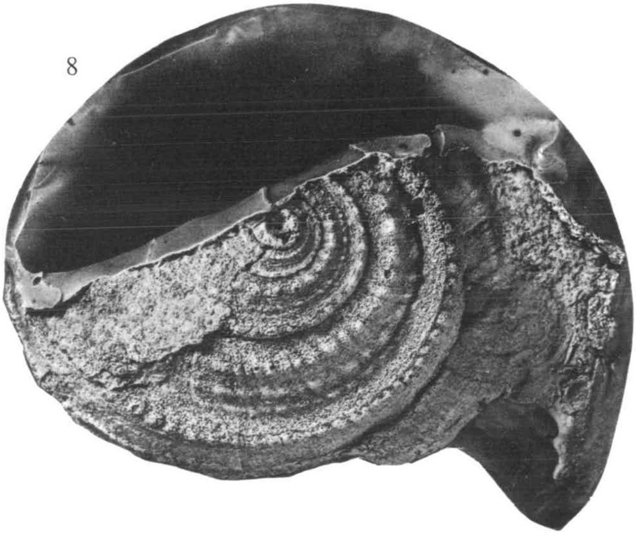

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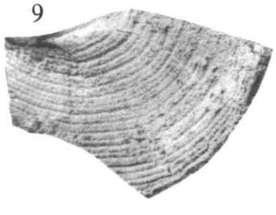

PLATE 16

All figures natural size and photographed in lateral view unless stated otherwise.

Figures 1-5.—*Beyrichites* (*Beyrichites*) *yuati* sp. nov.

1, 5. **Holotype,** CPC 7756. Complete specimen (x½) and detail of suture (x1).
2. Paratype, CPC 7757. Immature specimen.
3. Acetate peel of cross-section of specimen. CPC 11166.
4. Paratype, CPC 7758. Showing detail of secondary ribbing.

Locality Ab20 (upper Anisian)

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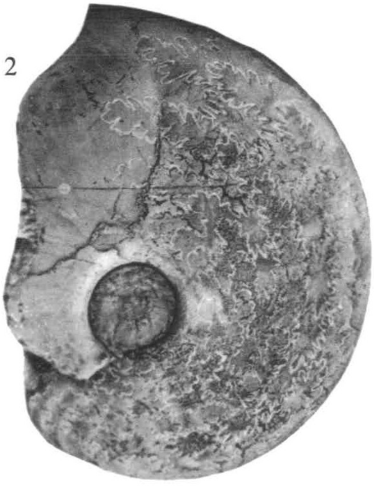

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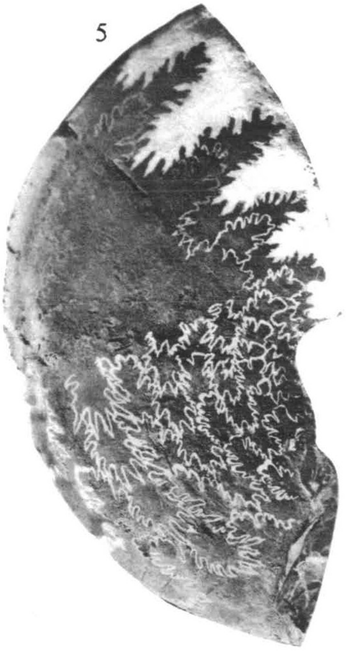

PLATE 17

Figure 1-3.—*Hungarites* (*Israelites*) sp. indet.

1, 2. Specimen in lateral and ventral views. CPC 11167 (x1½).

3. Cross-section of specimen, CPC 11167.

Locality 20NG0013 (upper Anisian)

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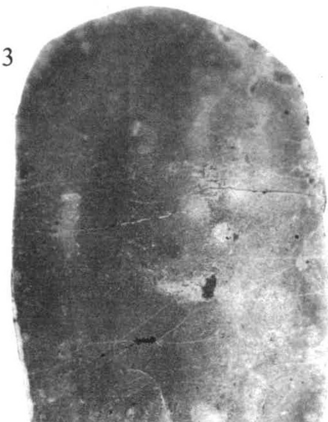

PLATE 18

All figures natural size and photographed in lateral view unless stated otherwise.

Figures 1-6.—*Longobardites* (*Longobardites*) *maramuniensis* sp. nov.

1, 2. Fragment of ventral portion of shell with sutures accentuated with white Indian ink and coated with ammonium chloride respectively. CPC 11168.

3, 6. **Holotype,** CPC 11169, incomplete specimen with suture accentuated with Indian ink and coated with ammonium chloride respectively.

4, 5. Paratype, CPC 11170, acetate peels of specimen showing cross-sectional view on both sides of dissection.

Locality 20NG0014 (upper Anisian)

Figures 7, 8.—?*Longobardites* (*Longobardites*) *maramuniensis* sp. nov.

Largest specimen in collection, coated with ammonium chloride and with sutures accentuated with Indian ink respectively. CPC 11171.

Locality 20NG0014 (upper Anisian)

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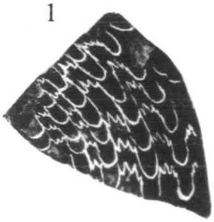

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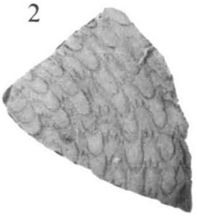

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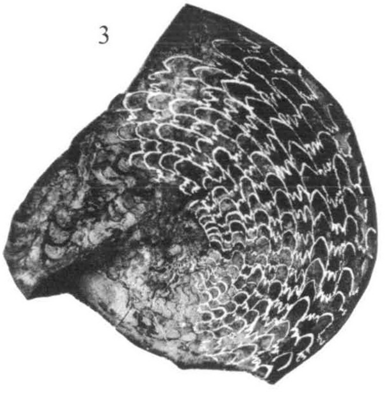

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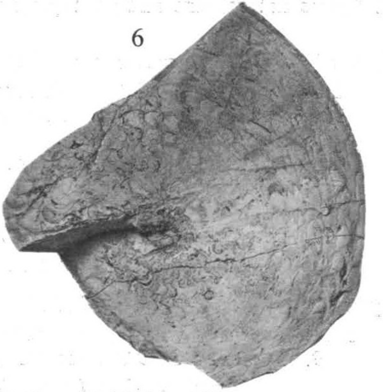

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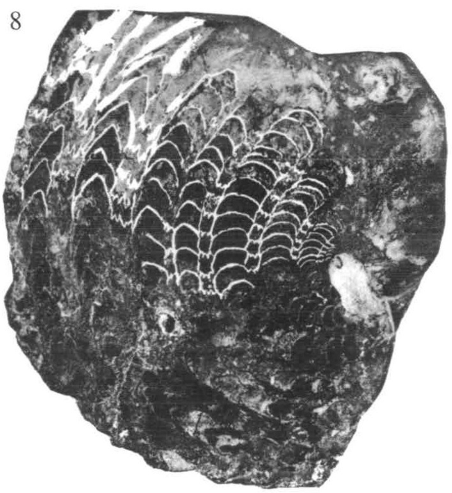

PLATE 19

All figures natural size and photographed in lateral view unless stated otherwise.

Figures 1-7.—*Parapopanoceras wapii* sp. nov.

1, 2. **Holotype,** CPC 7760, in anterior and lateral views.
3, 6. Partly distorted specimen in anterior and lateral views. CPC 7761.
4. Paratype, CPC 7762. Specimen showing ribbing.
5. Paratype, CPC 7763. Incomplete specimen showing partly cleared inner whorl with suture.
Locality Ab20 (upper Anisian)
?7. Incomplete specimen. CPC 7773.
Locality Ab22 (upper Anisian)

Figures 8-10.—*Ptychites* cf. *stachei* Mojsisovics, 1882.

8, 10. Specimen with and without ammonium chloride coating. CPC 7764.
9. Specimen CPC 7764 showing partly reconstructed cross-sectional shape.
Locality Ab20 (upper Anisian)

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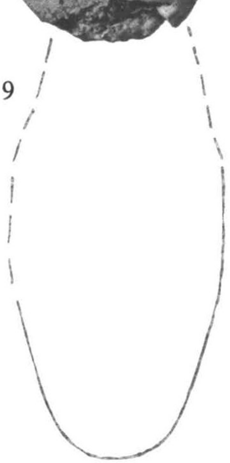

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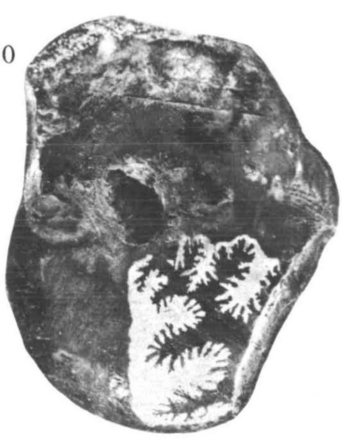

PLATE 20

Figures 1, 2.—*Sturia japonica* Diener, 1916.

Latex casts of two incomplete and somewhat tectonically distorted external impressions of shells. CPC 11172 and CPC 11173 respectively. (x½).

Locality 20NG0017 and Ab20 respectively (upper Anisian)

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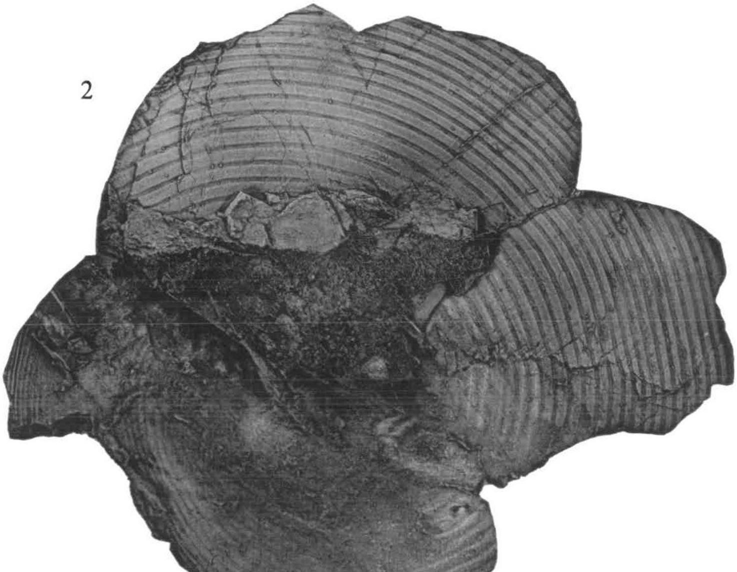

PLATE 21

Figure 1.--*Discoptychites* aff. *megalodiscus* Beyrich, 1867.
Incomplete specimen CPC 11174 (x3/5 approx.) in lateral view.
Locality 20NG0013 (upper Anisian)

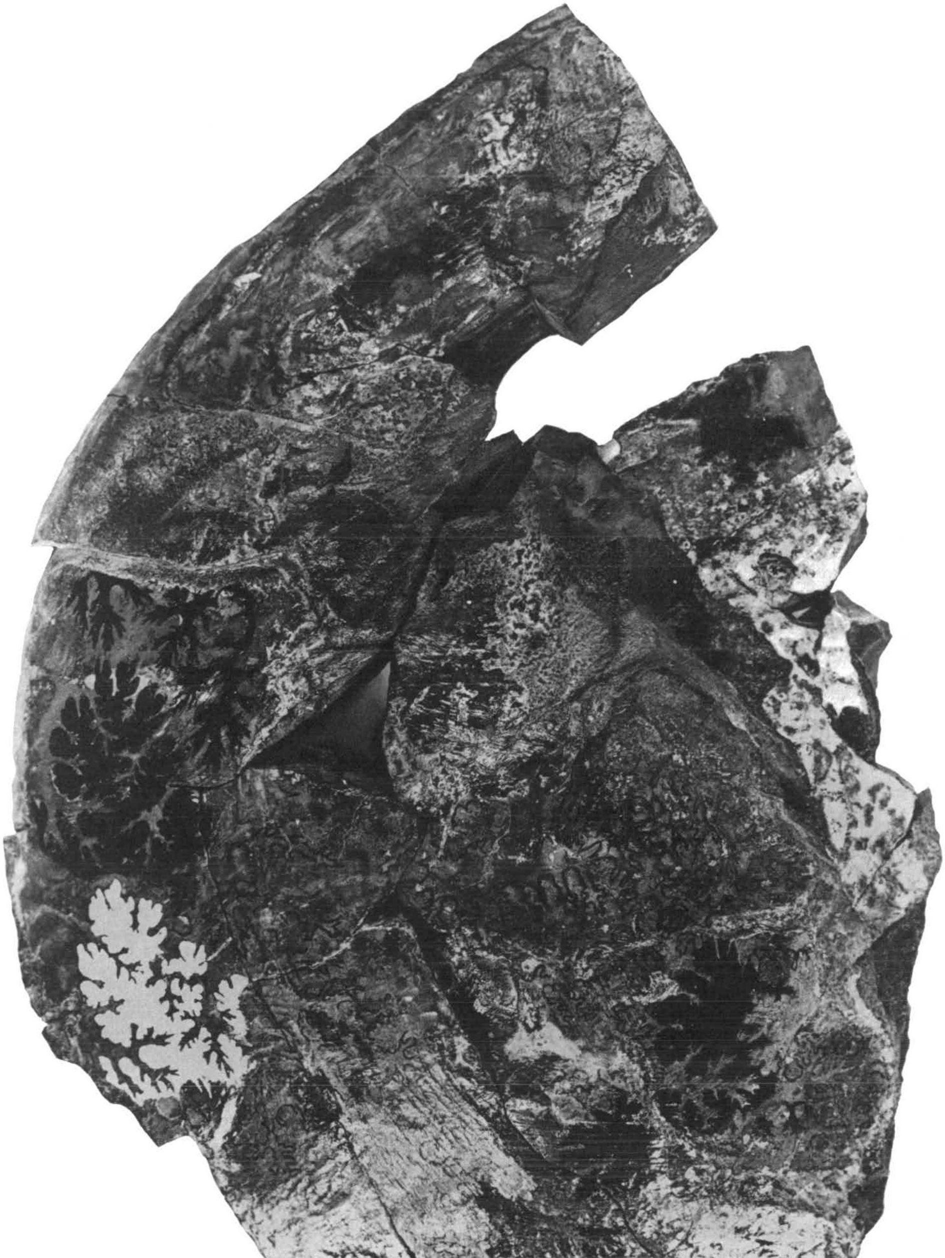

PLATE 22

Figures 1, 2.—*Discoptychites* aff. *megalodiscus* Beyrich, 1867.
Detail of suture pattern on specimen CPC 11174. (x1.8).
Locality 20NG0013

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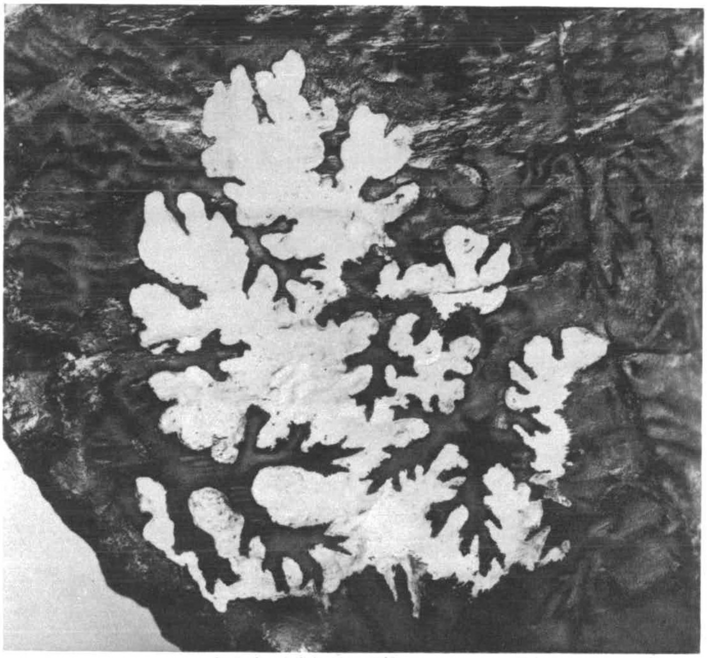

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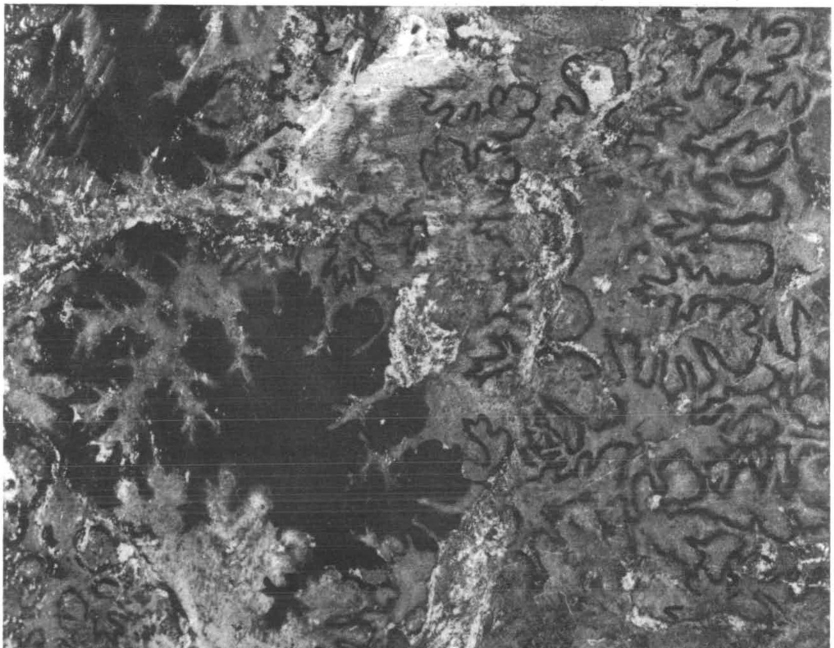

PLATE 23

All figures natural size and photographed in lateral view unless stated otherwise.

Figures 1, 4, 5.—*Germanonautilus* sp. A.

Lateral, anterior, and posterodorsal views of same specimen. CPC 7770.
Locality Ab20 (upper Anisian)

Figures 2, 3.—*Germanonautilus* cf. sp. A.

Internal whorl in dorsal and lateral views. CPC 7771.
Locality Ab20 (upper Anisian)

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PLATE 24

All figures natural size and photographed in lateral view unless stated otherwise.

Figures 1-3, 7.—Crinoid stems.

1, 7. Cross-section through stem. CPC 11175 (x1 and x2½ respectively).

2, 3. Stems in lateral view. CPC 11176 and CPC 11177.

Locality 20NG0013 (upper Anisian)

Figures 4-6.—*Germanonautilus* sp. B.

Specimen in ventral, dorsal, and posterior view. CPC 7767.

Locality Ab24 (upper Anisian)

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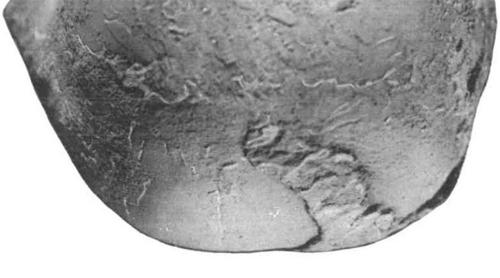

PLATE 25

All figures natural size and photographed in lateral view unless stated otherwise.

Figures 1, 3.—Nautiloid indet.

Acetate peels of both sides of longitudinally cut specimen showing internal structure. CPC 7768.

Locality Ab24 (upper Anisian)

Figure 2.—Boring organisms in nautiloid.

Specimen showing septum of orthocone bored through by burrowing organisms. CPC 7769.

Locality Ab24 (upper Anisian)

Figure 4.—*Germanonautilus* sp. B.

Specimen CPC 7767 in lateral view.

Locality Ab24 (upper Anisian)

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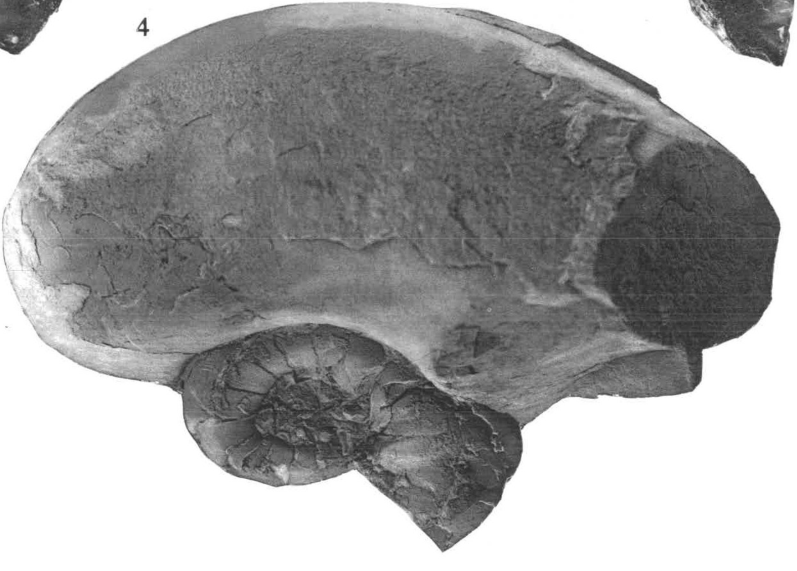

PLATE 26

All figures natural size and photographed in lateral view unless stated otherwise.

Figure 1.—*Discoptychites* aff. *megalodiscus* Beyrich, 1867.
Acetate peel of cross-section through specimen CPC 11174.
Locality 20NG0013 (upper Anisian)

Figures 2, 3.—*Paraceratites* cf. *trinodosus* Mojsisovics, 1878.
Specimen in lateral and ventral views, CPC 11178.
Locality 20NG0013 (upper Anisian)

Figure 4.—*Beyrichites* sp.
Acetate peel of cross-section through specimen CPC 11179 showing distortion by tectonism.
Locality 206G0019 (upper Anisian)

Figures 5, 6.—*?Paraceratites* cf. *trinodosus* Mojsisovics, 1878.
Specimen in lateral and ventral views, CPC 10422.
Locality 20NG0013 (upper Anisian)

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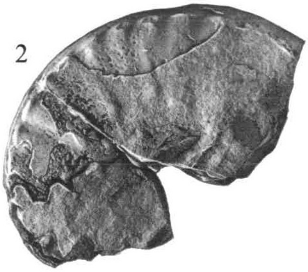

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PLATE 27

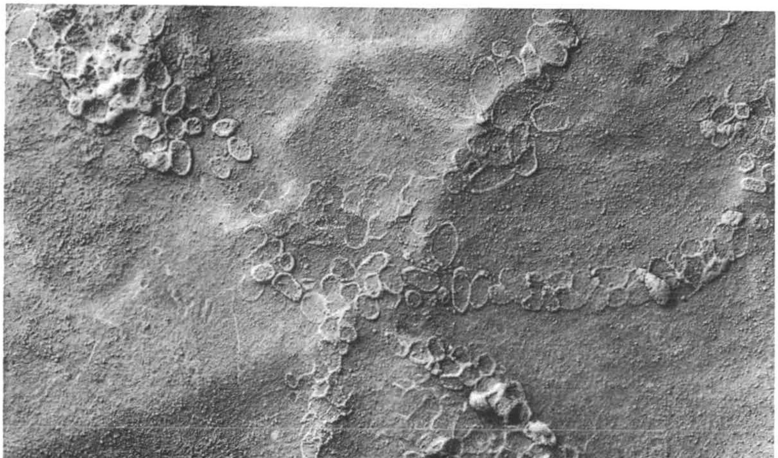
Figures 1-3.—Membraniporidae?

1, 2. View of detail of colony. x2. CPC 11180.
3. More magnified view of part of figure 1 (x4).
Locality 20NG0019 (upper Anisian)

1

2

3



surfaces exposed after the fossil was cut longitudinally in half revealed that it is somewhat curved. The dissection cuts through two septa, which are spaced 1.5 cm apart. One septum shows the presence of a septal foramen, which is 2.5 mm across; the neck is of suborthochoanitic type, and less than 2 mm long.

INCERTAE SEDIS

PROBLEMATICUM

(Pl. 13, figs 11-14)

Material. About 30 specimens occurring singly, or in clusters of up to four specimens. In most specimens the shell material is at least partly exfoliated, and in some almost completely removed. Locality Ab45.

Description. The shell is up to 25 mm long, 22 mm broad, and 11 mm high, apparently bilaterally symmetrical, oval in shape and strongly inflated with a submesial summit. The tumidity reaches its maximum a little behind the middle of the shell; in profile the outline is generally convex. The apex is well defined, pointed, somewhat depressed, and situated above the front shell margin or a little in front or behind it. The shell wall is thin and black in colour, possibly made up of two layers, and composed entirely of calcite. It is ornamented with fine concentric incremental lines which in the broad part of the shell parallel its outline, but which change their direction gradually, becoming concentric around the umbo. No internal structure has been discerned.

Discussion. There is no proof that the Problematicum is Monoplacophora as originally suspected by the author. All attempts to assign it to any of the more obvious of the known phyla, such as Gastropoda, Brachiopoda, Monoplacophora, and Echinodermata by Dr Y. L. Yochelson of U.S. Geological Survey, Washington, and some of his colleagues, as well as the author, have not been successful. Dr Yochelson comments: 'The specimens cannot be certainly identified. It seems somewhat more likely that they are allied to the capulids or a similar group of sedentary gastropods, adapted for clinging, than to any other group. However, even this interpretation is speculative' (Pers. comm.).

DERIVATION OF NEW NAMES

maramuniensis (*Longobardites*): after Maramuni River, New Guinea.
tarua (*Dacryomya*): after Tarua River, New Guinea.
wapii (*Parapopanoceras*): after Wapi people who inhabit the Yuat River District.
yuati (*Beyrichites*): after Yuat River, New Guinea.
novoguineana (*Sisenna?*): after New Guinea.

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ON THE DISCOVERY OF HALOBIIDAE (BIVALVIA, TRIASSIC) IN NEW GUINEA

by

S. K. Skwarko

SUMMARY

This is the first report of the widely occurring Middle-Upper Triassic molluscan family Halobiidae Kittl, 1912, from mainland New Guinea. Some small and indeterminate specimens occur in the probably Carnian-Norian (Upper Triassic) strata of the Yuat River gorge, Western Highlands, and numerous large and well preserved specimens were recently collected in the possibly Ladinian or Ladino-Carnian sediments in the Jimi River area, about 80 km to the east-southeast.

A new species, *Daonella novoguineana,* is described. It has marked affinities with the well known and widely distributed *Daonella indica* Bittner, 1899.

INTRODUCTION

The discovery of representatives of the family Halobiidae Kittl, 1912, in New Guinea is important, as this family comprises several genera of Triassic bivalves whose value in both local and intercontinental correlation and dating—owing to their wide geographic distribution and short stratigraphic range—is established.

Although this paper is primarily concerned with the description and discussion of some mature well preserved Daonellas found near the village of Tabibuga in the Mount Hagen area, Western Highlands, in October 1967, the first Halobiidae were collected in New Guinea in June 1966 by geologists of the Bureau of Mineral Resources at locality Ab45 in the Yuat River Gorge, Western Highlands. These two specimens are quite small and probably immature, and although one of them is figured here for the sake of completeness (Pl. 28, fig. 4), no attempt is made to identify them below the family level.

LOCALITY AND AGE

The specimens were collected from a large boulder (No. 20NG0016) on a track leading northeast from the village of Tabibuga, Mount Hagen area, to the Monogi Village, about 8 km (70 minutes' walking distance) from Tabibuga. In this general area fossils were collected in September 1962 by geologists of the Bureau of Mineral Resources, and the following species were later identified (Skwarko, 1967, p. 45, locality M26): *Gervillancea coxiella, Ostrea* sp., *Costa-*

toria melanesiana and *C. melanesiana sparsicostata, Rhaphistomella? kumbrufensis, Rhynchonella* cf. *mutabilis*. During a subsequent visit I collected about 20 specimens of Halobiidae from a boulder which also yielded the following previously described genera and species: *C. melanesiana*, Bakevellidae indet., *Rhaphistomella? kumbrufensis, Spiriferina* cf. *abichi* Oppel, and *Rhynchonella* cf. *mutabilis* Stoliczka. In the M26 assemblage the species listed occur in abundance, but particularly the *Costatoria,* which also dominates other outcrops in the Jimi River area (e.g. localities M29, H157, H199, H574, H782—Skwarko, 1967). One hesitates, however, at this early stage to term these the '*Costatoria* facies' as *C. melanesiana* has not been identified from, among other places, the Upper Triassic of the Yuat River gorge, where the assemblage is otherwise similar to that in the Jimi River area some 80 km away. Carnian-Norian age was suggested for the whole of the Jimi River assemblage (Skwarko, 1967) and for the younger portion of the Yuat River gorge section (Skwarko, this vol.). In the boulder from near Tabibuga there is evidence of a distinct and hitherto unreported shell layer in which the *Daonella* occurs in abundance associated directly with only some indeterminate shell fragments, whereas *C. melanesiana* and the other fossils listed above occur scattered singly throughout the boulder or in considerable concentration at a distance of about a metre from the Daonellas. It is necessary to distinguish the *Daonella*-rich bed from the Carnian-Norian sediments with the already described Jimi River fauna because of the suspected Ladinian or Ladino-Carnian age of the *Daonella* bed. The *Daonella* present in the boulder, described here as a new species, *D. novoguineana,* seems very closely related to *D. indica* Bittner, 1899, a form found in the Ladinian or Ladino-Carnian rocks in southern Europe (Kittl, 1912), Himalayas (Bittner, 1899), Japan (Kobayashi & Tokuyama, 1959), North Vietnam (Khuc, Dagys, Kiparisova, Nguyen, Srebrodolskaya, & Bao, 1955), and Indonesia (Krumbeck, 1924; Kobayashi, Burton, Tokuyama, & Yin, 1967), though probably not in New Zealand (Marwick, 1953). Probably the new species is of Ladinian or Ladino-Carnian rather than Carnian-Norian age, particularly as the genus reached its greatest development in the Ladinian, and less than 15% of its described species are Carnian and younger. While two lower Carnian or Ladino-Carnian species, *sumatrensis* Volz and *lilintana* Wanner, are known from the Pacific region, none are known from the Norian rocks of this region (Prof. T. Kobayashi, pers. comm.). It is not possible to draw definite conclusions on the age relationship between '*Daonella* facies' and the 'Carnian-Norian facies' on the basis of evidence now available.

DESCRIPTION OF THE SPECIES

BIVALVIA

Family HALOBIIDAE Kittl, 1912

Genus DAONELLA Mojsisovics, 1874

Type species: *Halobia lommeli* Wissmann, 1841, p. 22; S. D. Diener, 1923, p. 46.

Cox & Newell *in* Cox et al., 1969, p. 342) have placed the Halobiidae in synonymy with Posidoniidae Frech, 1909. On the basis of the hinge structure, however, Dickins (1963, p. 71) concluded that the Halobiidae should be referred to the Pteriacea, whereas *Posidonia* belongs with the Pectinacea.

DAONELLA NOVOGUINEANA sp. nov.
(Pl. 28, figs 1-3, 5-7)

Material. About twenty incomplete external impressions of both right and left valves. All specimens collected at locality 20NG0016.

Holotype. CPC 10420 (Pl. 28, fig. 7). Large boulder about 8 km from Tabibuga, along Tabibuga-Monogi Village track.

Paratype. CPC 10417 (Pl. 28, fig. 3). Same locality.

Diagnosis. The diagnostic feature of the new species is the combination of the large size, the presence of about thirty primary ribs, which are usually separated into two secondary ribs by weaker interspaces originating near the umbo, and the disappearance of ribs near the cardinal margin.

Description. The shell is subequivalve and subequilateral, subquadrate-rounded in outline, large weakly but uniformly inflated, and its height-to-length ratio is a little less than one. Its umbones are orthogyrous or slightly prosogyrous, with the beaks situated medially on the cardinal margin.

The holotype, which is the largest valve in the collection, is 46 mm high and about 48 to 50 mm long. Its cardinal margin is straight, about 35 mm long, with a narrow pointed beak overhanging it slightly near the middle. The shell margin, which seems to be fairly uniformly rounded, meets the cardinal margin in a well curved obtuse angle.

The ribs are a prominent feature of the shell, but tend to become shallow and finally disappear near the cardinal margin. There are about 30 straight or slightly flexed primary radial ribs which radiate distally from the umbo more or less equally in all directions, but with a weak posteroventral flexure. They are usually broad and flat-topped and separated from each other by prominent narrow interspaces. The secondary interspaces which divide the primary ribs into two secondaries are weaker than the primary interspaces, and originate at a distance of 5 to 10 mm distally from the beak. There are two main types of mode of ribbing; in some specimens the ribs tend to be narrower while the first and second order interspaces are equally and excessively wide (Pl. 28, fig. 1); in other forms some ribs rarely or repeatedly carry two longitudinal grooves resulting in tripartite subdivision of the primary ribs (Pl. 28, fig. 3). Another variation in shell structure is the lack of regularity of distribution or density of concentric rugae. One specimen has a very low height-to-length ratio.

Discussion. D. novoguineana sp. nov. shares with the Himalayan *D. indica* the overall shape, the large size, the type and position of beaks, the number and the general type of ribs, the nature of interspaces, and the place of origin of the secondary interspaces. According to Mojsisovics (1874, p. 7) most of these features are characteristic of his group of *D. tyrolensis*. However, as distinct from *D. indica,* in which the radial ribbing near the cardinal margin is as pronounced as elsewhere on the shell, in *D. novoguineana* the ribs lose their relief near the cardinal margin and become indistinct and rapidly disappear. This feature is also found in *D. lommeli* and *D. richthofeni,* and was associated by Mojsisovics with his group of *D. lommeli,* in contrast to the group of *D. tyrolensis,* which included

D. indica, D. badiotica, D. parthanensis, and *D. tyrolensis.* It is not possible to group the New Guinea specimens in this way, as it is felt that they represent a species very closely related to *D. indica.*

Age. Possibly Ladinian or Ladino-Carnian.

ACKNOWLEDGMENTS

I wish to express most sincere thanks to Professor T. Kobayashi, Tokyo University, for the critical reading of the manuscript, and for the suggestions he has made.

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PLATE 28

All figures natural size and photographed in lateral view unless stated otherwise.

Figures 1-3, 5-7.—*Daonella novoguineana* sp. nov.

1. Latex cast of impression of proximal portion of valve. CPC 10415.
2. Aberrant valve with untypically low height-to-length ratio. CPC 10416.
3. Paratype CPC 10417. Incomplete valves showing uncommon subdivision of some primary ribs into three secondary ribs.
5. Almost complete valve. CPC 10418.
6. Portion of shell bed preserved along bedding plane. CPC 10419.
7. **Holotype,** CPC 10420. (Large near-complete specimen in bottom-left corner).

Locality: 20NG0016, Jimi River area
Age: possibly Ladinian or Ladino-Carnian

Figure 4.—Halobiidae indet.

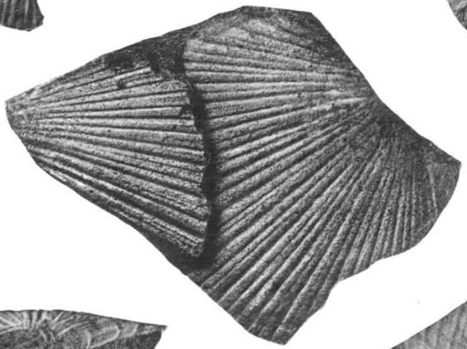
Small immature valve. x3. CPC 10421.

Locality: Ab45, Yuat River gorge
Age: Carnian-Norian

1

2

3



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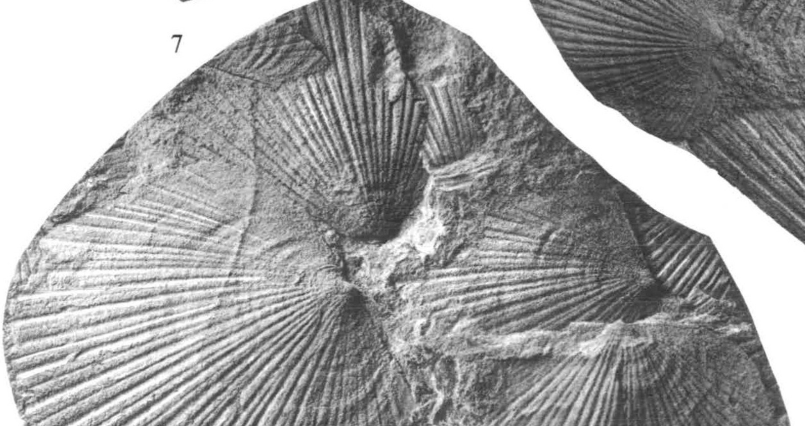

A CORRELATION CHART FOR THE CRETACEOUS SYSTEM IN AUSTRALIA

by

S. K. Skwarko

INTRODUCTION

This paper was first presented to a symposium on 'The Development of Petroleum Resources in Asia and the Far East' held by the U.N. Economic Commission for Asia and the Far East in Canberra in November 1969. Its content has been slightly amended for publication in this volume.

Charts similar to Figure 1 have been or are being issued for the preceding and following systems (Banks et al., in press; Ludbrook, 1967).

Concise descriptions of the sedimentary basins of Australia are to be found in Brown, Campbell, & Crook (1968); and although some new information has come to hand since that book was published, any description given here would be largely repetitive. These notes, therefore, are hardly more than a thinly veiled list of selected references for those interested in the detail of the Cretaceous rocks and fossils of all or part of Australia. It is hoped the reader will find in these all available data which may interest him. Many of the accumulated references deal purely with the stratigraphy, the rock types, and ages, and in this respect partly supplement the bibliography of the Mesozoic palaeontology of Australia and eastern New Guinea (Skwarko, 1969b) recently published. Figure 2 gives the locations of the Cretaceous basins.

WESTERN AUSTRALIA

In Western Australia, sediments of Cretaceous age occur mainly in four basins aligned along or close to the margins of the Australian continent. They are all shallow-water or moderately shallow-water deposits laid down in a variety of environments. Their thicknesses vary from place to place, from a few to a few thousand metres, and they may be entirely subsurface as in the Eucla Basin, or entirely in outcrops as in the Gibson Desert, or mixed as along the western coast of the State.

McWhae, Playford, Lindner, Glenister, & Balme (1958) summarized the stratigraphy of Western Australia; theirs is the most recent complete discussion of all the established Cretaceous sedimentary units of this State and should be regarded as a basic reference. Much of what it includes has been supplemented

Figure 2. Locality map of Cretaceous basins in Australia

in the past few years in publications and in many unpublished company and State Survey reports. The following notes, grouped for ease of reference according to sedimentary basins in the order set out in the accompanying correlation chart, give suggested references to later literature.

West Australian Petroleum Pty Limited (WAPET) has an active petroleum drilling programme in many parts of the State and the completion reports on some of their bores contain much recent information on the Cretaceous strata of Western Australia. Copies of the reports on the Government-subsidized drilling operations are held in the Bureau of Mineral Resources library in Canberra.

EUCLA, POLDA, AND 'DENMAN' BASINS

Wopfner (1969, p. 16) refers to the entrance of seas into the Polda Basin and the 'Denman Basin' in Neocomian time. The Denman Basin supposedly underlies in part the Eucla Basin. The Polda Basin is referred to under the name of Elliston Trough by Smith & Kamerling (1969), who also mention the presence of Upper as well as Lower Cretaceous sediments in the Eucla Basin.

PERTH BASIN

South Perth. Lowry (1965) summarizes most of what is known of the Cretaceous rocks, their age and sequence in the area, and the bibliography contained in his report includes numerous references to unpublished reports. Some units have accumulated in a non-marine environment (e.g. Yarragadee Formation, South Perth Formation, Osborne Formation), and are dated on spores and pollen (Balme, 1964; Edgell, 1964a); others are dated on Foraminifera (Belford, 1958, 1960). In the last few years WAPET has drilled in the area (e.g. Cobar No. 1).

Gingin Area. The older Cretaceous sediments in this area are non-marine (Balme, 1957, 1964) and are known both from surface outcrop and from bores. The younger units—Molecap Greensand, Gingin Chalk, and probably Poison Hill Greensand—are marine, as shown by their faunas, both large (Feldtmann, 1963) and small (Belford, 1958, 1960; Edgell, 1964b). Low (1965) described auger drilling of the marine units.

CARNARVON BASIN

The Cretaceous stratigraphy of the Carnarvon Basin was recently summarized by Condon (1968) and the reader is referred to his bulletin for exhaustive information—much of it very recent and not easily available elsewhere—on rock types, boundaries, and definitions of individual units. However, some of his conclusions regarding ages of formations are not supported by the most reliable fossil evidence and, in the construction of the chart, the following additional references were consulted: Balme (1957, 1964); Belford (1958, 1960); Brunnschweiler (1957, 1966); Caye (1968); Cox (1961); and Skwarko (1966).

CANNING BASIN

Canning, Fitzroy, and Kidson. Cretaceous sediments outcropping in this area were described in detail by Veevers & Wells (1961). Some of the stratigraphic units used in their bulletin (e.g. Parda Formation, Anketell Formation, Frazier Sandstone) are no longer used by WAPET geologists currently working in the area as they 'are based on minor variations of silt content, silicification, etc., so for simplicity should be replaced by Broome Sandstone' (M. H. Johnstone, pers. comm.).

Dampier Peninsula. Brunnschweiler (1957, 1960) described and dated outcropping sediments on the Dampier Peninsula. Some of his conclusions have since been revised (Skwarko, 1969a). The names Leveque Sandstone and Melligo Quartzite, though included in the Broome Sandstone by the WAPET geologists, are retained in the chart as they represent marine horizons of different ages, each horizon containing a distinct macrofauna.

GREAT ARTESIAN BASIN

Gibson Desert. Wells (1963, unpubl.) mapped and described Cretaceous sediments in the Gibson Desert. These were dated by macrofossils collected during the survey. The fossils are similar to some occurring in the eastern and southern portions of the Great Artesian Basin, and give evidence of the extension of the basin into Western Australia (Skwarko, 1967a).

NORTHERN TERRITORY

Cretaceous sediments occur in two main areas in the Northern Territory.

In the north they are called Mullaman Beds and occur partly on islands north of Darwin, where they are thick and unweathered. But mostly they occur on the mainland, where they are almost entirely exposed and their original thickness has been considerably reduced by long periods of erosion following uplift.

In the south they are present in the subsurface of the Hay River area and form prominent flat-top outcrops in the Rumbalara area. Both the sediments of the south and the youngest mainland Mullaman Beds were laid down in the westward extension of the Great Artesian Basin.

The most detailed and complete account of the stratigraphy and palaeontology of the Cretaceous sediments of the Northern Territory is by Skwarko (1966; and 1967b, unpubl.). The sediments cropping out on Bathurst Island north of Darwin, were described in considerable detail by Daily (1956, unpubl.). Wright (1963) described the ammonites collected by Daily.

QUEENSLAND

The Cretaceous sea which covered a large part of the Australian continent in Lower Cretaceous time extended over most of Queensland, and sediments which were laid down then still cover much of the State. This sea was, and to some extent still is, referred to as the Great Artesian Basin, but lately with more detailed work continually adding to our knowledge, it has become both useful and fashionable to divide the Basin into a number of constituent sub-basins. In time these have acquired the status of sedimentary basins, and their names are listed on the correlation chart.

I have adopted the layout of the Queensland portion of the chart—with a few minor modifications by R. Vine, BMR, and myself—from Hill, Playford, & Woods (1968), who in turn mainly followed the work of the geologists of the Bureau of Mineral Resources. References to BMR publications and other works will be found under the headings of the individual basins. They supplement the latest, but now partly out-dated, description of the geology of Queensland by Hill & Denmead (eds, 1960).

Surat Basin. The Cretaceous stratigraphy of part of the Surat Basin is discussed by Day (1964). A more recent reference, mainly to nomenclature of individual lithological units of the area, is that of Vine, Day, Milligan, Casey, Galloway, & Exon (1967).

Eromanga Basin. (a) Boulia area: the area to the south and east of Boulia was mapped by geologists of the Bureau of Mineral Resources, and the explanatory notes for the Boulia, Springvale, Mackunda, and Brighton Downs geological Sheets contain descriptions of Cretaceous stratigraphy in the area. (See also Casey, 1959.) (b) Richmond-Winton area: the reader is referred to Vine et al. (1967) for a summary of the rock units in this area, and to Day (1967) for a description of the fauna. (c) Tambo area: Vine & Day (1965), Exon (1966), and Vine et al. (1967) all discuss Cretaceous strata cropping out in the Tambo area.

Carpentaria Basin. This basin is currently being mapped by geologists of the Bureau of Mineral Resources. Little is published on the area apart from Woods (1961) and Rade (1966).

Laura Basin. Even less has been hitherto published on the Cretaceous sediments of the Laura Basin, but the reader is referred to a paper by de Keyser (1963) and to explanatory notes by Lucas & de Keyser (1965) for a description of units, to Woods (1962) and Skwarko (1966) for some palaeontological determinations, and to de Keyser & Lucas (1968) for an overall summary.

Maryborough Basin. Hawthorne (1960) and Ellis (1968) described in considerable detail the Cretaceous sediments cropping out in the Maryborough Basin. For recent revisions of the fauna of the Maryborough Formation the reader is referred to Skwarko (1963) and Fleming (1966a, 1966b).

Rockhampton area. In the first description of the Neocomian marine fauna of the Stanwell area, Whitehouse (1946) listed references to previous literature dealing with both marine and non-marine strata. More recently Skwarko (1968) revised the marine fauna.

Palynological fauna from near the base of Aquarius No. 1 well drilled by the Australian Gulf Oil Co. 238 km east-northeast from Rockhampton is distinct from younger, Tertiary, faunas known from Queensland, and an Upper Cretaceous age was suggested for it (Paten *in* Carlsen & Wilson, 1968).

Styx Basin. A summary of the Cretaceous rocks of the Styx Basin appears in Malone, Olgers, & Kirkegaard (1969), who mapped the area at 1:250,000 scale.

NEW SOUTH WALES

Only in recent years has a great deal of interest been shown in the Cretaceous rocks of New South Wales—mainly by petroleum exploration geologists—and as a result of this much more is known now about the individual areas of Cretaceous sedimentation in this State than was the case several years ago.

The Cretaceous rocks can be divided into two groups—those in the northern part of the State, which represent the extension southwards of the sediments of the

Great Artesian Basin (Crespin, 1956), and those which underlie the Murray Basin Tertiary sediments in the southern part of the State (Evans & Hawkins, 1967, unpubl.). Little more can be said about the Great Artesian Basin sediments in New South Wales.

MURRAY BASIN

Both microfloral and microfaunal evidence is used in correlation between bores sunk in the Cretaceous sediments underlying the Murray Basin. Two areas of occurrence are known: the Ivanhoe area and the southwestern or Renmark area.

Ivanhoe area. The sediments are Aptian in age and marine in origin. Their fossil content gives evidence of connexion between the Murray Basin and the Great Artesian Basin in Aptian times.

Southwestern or Renmark area. Here the lowest Aptian sandstone is overlain by marine Aptian and early Albian rocks, which are overlain in turn by non-marine Albian sediments. Of these the marine sediments give evidence of connexion between the Murray and the Great Artesian Basins in Aptian and early Albian times, while the non-marine sediments have aspects similar to those of the corresponding sediments in the Otway Basin (Evans & Hawkins, 1967, unpubl.).

VICTORIA

In Victoria the Cretaceous sediments are mainly subsurface, but are widespread both onshore and offshore and represent a variety of basins of sedimentary deposition as shown by numerous bores recently drilled in the State. The *Murray Basin* sediments extend south from New South Wales into the Mallee Region of Victoria (Lawrence, 1966). Along the coast, starting from the east, there are the *Gippsland Basin* (Dettman, 1963; Dettman & Playford, 1968, 1969; Reynolds, 1967; Taylor, 1964; Traill, 1968); the *Bass Basin* which is represented onshore at Torquay (Esso-Bass 3, unpubl. rep.); and the *Otway Basin* (Bock & Glenie, 1965; Dettman, 1963; Leslie, 1966; Reynolds, Evans, Bryan, & Hawkins, 1966; Reynolds, 1967; Taylor, 1964a, 1964b; McQueen, 1961; Sprigg & Woolley, 1963). The Victoria part of the correlation chart is mainly after D. J. Taylor (pers. comm.).

SOUTH AUSTRALIA

The general reference for the Cretaceous stratigraphy of South Australia is Glaessner & Parkin (eds, 1958), but a wealth of newer data is available both from a recent revision of the outcropping sediments and the fauna (Ludbrook, 1966) and from several bores sunk in recent years.

The subsurface Cretaceous sediments of the *Otway Basin* extend from Victoria into South Australia in the Gambier Embayment and the sequences are comparable on both sides of the border (Dettman, 1963). Part of the *Murray Basin* Cretaceous also extends subsurface into the State in the Renmark area (Evans & Hawkins, 1967; Ludbrook, 1961, 1966; Dettman, 1963)—an overlap from both New South Wales and Victoria. Finally the *Great Artesian Basin* and the *Eucla Basin* also find expression in this State, covering large surface areas as well as being present subsurface (Dettman, 1963; Freytag, 1966).

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CORRELATION CHART FOR THE CRETACEOUS SYSTEM IN AUSTRALIA

Figure 1. Correlation chart for the Cretaceous System in Australia

THE LOWER ORDOVICIAN GASTROPOD TEIICHISPIRA IN NORTHERN AUSTRALIA

by

Joyce Gilbert-Tomlinson

SUMMARY

The detailed description and geological background of the gastropod *Teiichispira cornucopiae* Tomlinson, 1969 (*in* Hills, Playford, & Woods, editors), are presented. Among species of *Teiichispira* Yochelson & Jones, 1968, *T. cornucopiae* is the first to be described from the Southern Hemisphere and the third for which both conch and operculum are known. Like other species securely assigned to the genus, *T. cornucopiae* is based on the tubulose, keeled, horn-shaped operculum, which is closer to that of the Malaysian type-species *T. kobayashi* than to North American forms. *T. cornucopiae* is restricted to the Lower Ordovician (Arenig.) Coolibah Formation of Queensland and the Northern Territory, where its operculum is a reliable index-fossil (the conch is very rare) and its association with actinoceratoids casts doubt upon the commonly accepted estimate of a Middle Ordovician date for the first appearance of this group of nautiloids. Another species of *Teiichispira*, represented by very fragmentary opercula from the Lower Ordovician (Canadian) Emanuel Formation of Western Australia, is illustrated but not named. This and *T. cornucopiae* are the first macluritids illustrated from the Australian mainland (as distinct from Tasmania). A brief review of Australian macluritids includes (a) an examination of the possible upward extension of *Teiichispira* into the Chazyan Gap Creek Formation (overlying the Emanuel Formation) and (b) a comparison of an unidentified plate-like operculum from the Gordon Limestone at Railton, Tasmania (the 'Railton operculum'), with two undescribed Lower Ordovician opercula, one from Malaysia, the other from Alabama, and the tentative assignment of all three to macluritids of the *Lecanospira-Barnesella* group.

INTRODUCTION

HISTORY OF INVESTIGATION

The discovery of Ordovician fossils in the Prices Creek area of Western Australia (Text-fig. 3) by Dr A. A. Öpik and D. J. Guppy, Bureau of Mineral Resources, in 1949 (Guppy & Öpik, 1950) not only provided the first biological evidence for the occurrence of rocks of the System within the State, but brought to light the existence of a sequence of fossil assemblages composed partly of endemic genera, partly of forms showing extra-Australian resemblances. Among the latter was an unidentifiable form now recognized as the operculum of the Ordovician macluritacean gastropod *Teiichispira* Yochelson & Jones, 1968. A fire in April 1953 badly damaged the collection and destroyed all labels and written records pertaining to it. Of later collections, the only one available for study was made in 1953 by Drs G. A. Thomas and J. J. Veevers, then of the Bureau of

Mineral Resources. The two Prices Creek opercula sectioned and illustrated in this paper (BMR loc. Kog 410, Pl. 33, figs 5, 10) were taken from this collection.

The Bureau's investigations of another important area of Ordovician outcrop, the Toko Range, crossing the boundary-line between Queensland and the Northern Territory (Text-fig. 4) and lying about 1350 km southeast of Prices Creek, began in 1954 with a preliminary reconnaissance by J. N. Casey. Among the fossils collected from the northwestern end of the Range were silicified horn-shaped forms composed of narrow tubules running the length of the fossil. They showed a general resemblance to the Prices Creek fossils but were larger and of a finer texture. Thin sections (BMR loc. T2; Pl. 33, fig. 8; Pl. 34, figs 1, 4, 6) failed to establish their systematic position. Geological mapping in the area in 1958 and 1959 by geologists of the Bureau and by Messrs R. J. Paten, Queensland Geological Survey, and D. J. Taylor, Frome-Broken Hill Pty Ltd, showed that the fossil was an important and easily recognized component of the fauna of the part of the Ordovician sequence later named 'Coolibah Formation'. Material recovered during this phase of the investigation revealed a consistent and distinctive shape—strongly tapering, slightly curved and twisted, and having an acute longitudinal keel that gave it a narrowly triangular transverse section. The best preserved of the larger specimens from these collections was eventually chosen as holotype operculum of *T. cornucopiae* by the author in 1969, all the remaining Coolibah specimens being assigned to the same species, but for the preceding decade the fossils remained impossible to classify and were listed as '?corals', '?horn-shaped corals' or 'horn-shaped fossils' in published geological reports (Reynolds, 1965, 1968; Smith, 1965). (Unlike southeastern Australia, northern Australia displays a remarkable dearth of Ordovician corals, and recording the fossils in this form underlined the presence of a most unusual index-fossil in the Coolibah Formation.)

In 1968, what had seemed a purely local taxonomic problem was unwittingly solved by E. L. Yochelson and C. R. Jones, with the publication of the macluritid gastropod *Teiichispira*. The similarity of the operculum of the Malaysian type-species, *T. kobayashi,* to the Coolibah 'horns' left no doubt of their generic identity, and, moreover, a large macluritid conch in the Taylor collection from the Northern Territory (loc. FBH/G 41654; Pl. 33, figs 1-4, 6, 7, 9) proved a reasonable match to that of *T. kobayashi* and related species and was accordingly assigned to the Queensland species. Far from being indigenous, the Coolibah and Prices Creek mystery fossils belong to a group widely distributed over more than half the circumference of the globe, with representatives in Malaysia, Utah, Alabama, and possibly Newfoundland (Text-fig. 1).

Because of its stratigraphic importance, the Queensland species *T. cornucopiae* (BMR loc. G317, Pl. 29, figs 1-11, Pl. 34, fig. 3) was illustrated by the holotype operculum and the assigned conch in the Queensland Palaeontographical Society's brochure 'Ordovician and Silurian fossils of Queensland' (Hill, Playford, & Woods, 1969; pl. 0 I, figs 12, 13).

SIGNIFICANCE OF DISCOVERY

Teiichispira is of interest from the morphological, stratigraphic, and palaeogeographic viewpoints. First, it sheds new light on the organization of a group of long-extinct (Upper Cambrian and Ordovician) gastropods. The conch itself

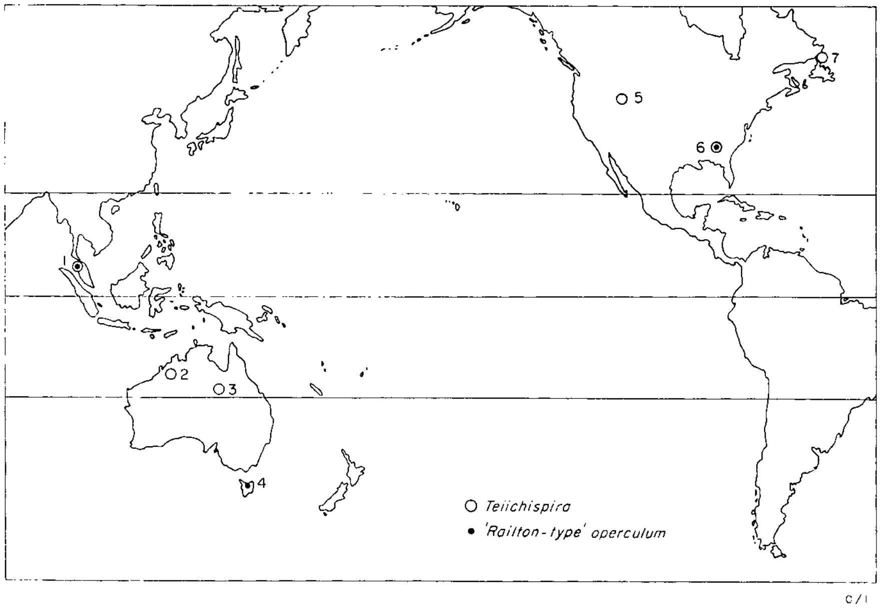

Figure 1. Distribution of macluritacean gastropods with tubulose opercula. 1—Langkawi Islands, Malaysia; 2—Prices Creek, Western Australia; 3—Toko Range, Queensland and Northern Territory; 4—Railton, Tasmania; 5—northeastern Utah; 6—northeastern Alabama; 7—Cape Norman, Newfoundland

conforms to the general macluritacean pattern, but the operculum, of unusual size, shape, and texture, furnishes a good example of the diversity to be expected in the superfamily and opens up avenues of enquiry into aspects of the mode of life of the animal and the possible non-defensive functions of the structure itself. Unlike the typical *Maclurites* operculum, shield-shaped and composed of solid shell material, that of *Teiichispira* is horn-shaped and built up of a bundle of close-set longitudinal tubules. Also, the thickness of the *Teiichispira* operculum (from initial tip to anterior surface) is so great that it is easily the greatest dimension and is more conveniently designated 'length'. Indeed, when laid along the periphery of the conch, bases flush, the operculum corresponds in length to at least one-third of a mature volution. This extreme elongation, combined with a slight disjunct torsion, produces a horn-shaped structure far removed from conventional ideas on the appearance of a gastropod operculum, even without the curious texture. The latter gives it a superficial resemblance to the skeleton of a colonial organism. If any confirmation of the accuracy of Yochelson & Jones' identification of the parts of *Teiichispira* is needed, the association of operculum and conch of *T. cornucopiae* in northern Australia may help to provide it.

Secondly, *Teiichispira* seems to have considerable correlative power. All but one of the occurrences have been independently dated as late Lower Ordovician, and the genus, wherever it occurs, appears to be restricted to short time-intervals. It would, of course, be imprudent to assume that all species of the genus are strictly contemporaneous. Already there is evidence that the Newfoundland *T? sylpha* (Billings, 1865) is somewhat older than the other two described North American forms, and a species from the Gap Creek Formation (Prices Creek

Group) of Western Australia originates in part of the sequence dated as Chazyan, though the generic identification is subject to verification. The eventual recognition of a succession of species of zonal significance may perhaps be envisaged. (Compare Yochelson & Bridge's, 1957, survey of the stratigraphy of another Lower Ordovician 'operculum' gastropod, the pleurotomariacean *Ceratopea.*) The discovery also highlights the value of discrete gastropod opercula as index fossils, and it is perhaps appropriate to mention that all four species now securely assigned to the genus *Teiichispira* are based on opercula as types, as are most of the *Ceratopea* species. Apart from their significance as 'indicators of biologic diversity' (Yochelson & Jones, 1968, p. B7), calcified gastropod opercula are likely to be the most durable part of the animal and potentially better preserved fossils than the comparatively fragile conch. The wide distribution of *Teiichispira* may help solve problems of intercontinental correlation, still all too common in Ordovician stratigraphy. The difficulties evidently arise from our own misconceptions on the time-spans of particular taxa. The solution thus lies in pin-pointing the taxa we have misjudged and correcting mistaken ideas on their ranges. Judging by the *Teiichispira* associates in Queensland and the Northern Territory, one of the main stumbling-blocks to stratigraphic coherence may be the current conviction that the actinoceratoid nautiloids, except possibly *Polydesmia,* make a first appearance in Middle Ordovician time. In the Lower Ordovician (Arenig.) Coolibah Formation the group is represented by a number of specimens of an *Armenoceras*-like form.

Finally, from the palaeogeographic standpoint, the Australian *Teiichispira* provides evidence for a considerable extension in the known lateral range of the genus and suggests that an even wider distribution may be proved when the genus is better known. In this connexion it may be noted that all the species at present recognized are represented by silica replacements of the original calcium carbonate shell material that have been developed from the matrix either by the natural processes of weathering or by acid digestion in the laboratory. Thus the characteristic shape, particularly of the operculum, is immediately apparent. On the other hand, natural sections of unsilicified opercula embedded in matrix, especially those having rather coarse polygonal tubules, show a vague resemblance to tabulate corals and may easily be misidentified. Comparisons of palaeogeographic findings from the study of different groups of fossils are instructive, and it is interesting to note that, except for the Malaysian species, all known *Teiichispira* species occur within the area of distribution of the 'Bathyurid fauna' of Arenig-Llandeilo time (Whittington, 1966, text-fig. 2 on p. 708). The fact that no bathyurid trilobites have been noted in association with Australian *Teiichispira* does not invalidate the palaeogeographic concept. Trilobites are extremely rare in the Coolibah fauna, which is dominantly molluscan. In this respect it resembles the Setul fauna of Malaysia from which *T. kobayashi* is described. Whether this observation is applicable to other *Teiichispira* species is uncertain.

COLLECTIONS AND REPOSITORY

All the *Teiichispira* opercula illustrated in the paper were collected by geologists of the Bureau of Mineral Resources between 1953 and 1959. The single conch assigned to *T. cornucopiae* Tomlinson, 1969, was collected by Mr D. J. Taylor, then of Frome-Broken Hill Pty Ltd. The described and illustrated material is deposited in the Commonwealth Palaeontological Collection, as indicated by the prefix 'CPC' to the registered numbers, and is held at the Bureau of Mineral Resources, Canberra. The co-operation of the management of Frome-Broken Hill Pty Ltd in presenting their collection to the Commonwealth for study and safe-keeping, and in making available the relevant stratigraphic and topographic data, is gratefully acknowledged.

TERMINOLOGY

Into a field in which the morphological terminology has in the past tended toward the esoteric, Yochelson & Jones (1968) have introduced a welcome simplification of the nomenclature of the parts of the hyperstrophic conch and its operculum. Based on the orientation current in English-speaking countries, and the assumption that the conch is resting flat on its base with the operculum fitted into a position to close the aperture, it is, for the most part, vernacular and self-explanatory. The terminology is used here with one or two minor modifications (Text-fig. 2).

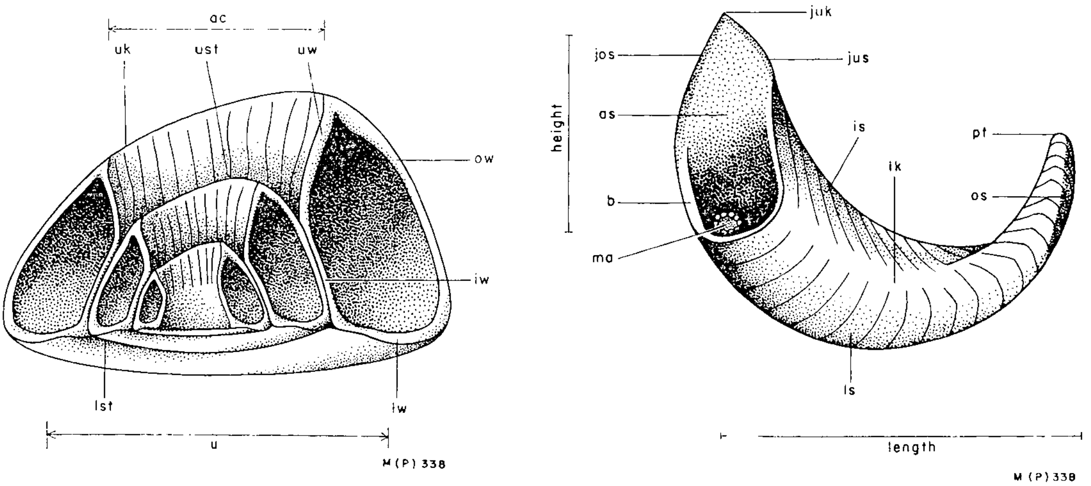

Figure 2. Morphological terminology, *Teiichispira cornucopiae* **Tomlinson, 1969, x 1.3. (a) Conch, last three whorls in vertical section (nucleus and inner whorls unknown), based on CPC 11311; (b) operculum, viewed from junction of anterior, inner, and lower surfaces (posterior tip restored), based on CPC 11296 (holotype), 11297, 11300, 11301.** ac—**apical cavity;** as—**anterior surface;** b—**bevelled rim to anterior surface (shown surrounding lower part of surface; available material inadequate to determine whether it also surrounds upper part of surface);** iw—**inner wall;** is—**inner surface;** jos, juk, jus—**junctions of outer surface, upper surface, and outer surface (all obscured) with anterior surface;** lk—**lower keel;** ls—**lower surface;** lst—**lower suture;** lw—**lower wall;** ma—**postulated site of attachment of main retractor muscle (depicted diagrammatically);** os—**outer surface (revealed by torsion at posterior end);** ow—**outer wall;** pt—**posterior (initial) tip;** u—**umbilicus;** uk—**upper keel;** us—**upper surface (not exposed in right-hand figure);** ust—**upper suture;** uw—**upper wall.**

anterior, posterior (operculum)—The opposite ends of the operculum, *anterior* being the wider, last-formed end, attached to the fleshy part of the animal, and having its margins in contact with the walls of the aperture of the conch when the animal is retracted. *Posterior* is obviously the initial, narrow end. The terms are retained from earlier usage because of their undoubted convenience. *Anterior surface,* the surface of the operculum at its anterior end. Yochelson & Jones (loc. cit.) seem to use the term *attachment surface* in this sense and in this they were followed by the author (Tomlinson *in* Hill, Playford, & Woods, 1969, expl. to pl. 0 1, fig. 12) in the original publication of *T. cornucopiae.* It now seems desirable to restrict the term attachment surface to a particular point of muscle-attachment on the anterior surface.

apical cavity (conch)—The opening at the top of the conch formed by the upward coiling of successive whorls and in which all the early whorls can be seen. A term introduced by Yochelson & Jones (loc. cit., p. B7) to replace the earlier term *depressed spire,* more appropriate to such forms as *Palliseria,* in which the spire protrudes from the base of the conch. Banks & Johnson (1957) use *apical depression.*

base (conch)—The abapical side. Yochelson & Jones use *basal surface* for one of the surfaces of operculum, but the term *lower surface* (see *surfaces*) is here preferred for the operculum, mainly on the grounds of consistency. *Basal angulation* (operculum), see *keel.*

conch—The hard mineralized part enclosing and supporting the soft body of the animal, as distinct from the other main hard part of the gastropod, the operculum. The term *shell* is thus available for the material of which both conch and operculum are formed.

keel (conch, operculum)—A revival of earlier usage, replacing *angulation* of Yochelson & Jones. *Inner keel* (operculum), at junction of upper and inner surfaces, known from a single immature operculum of *T. cornucopiae. Lower keel* (operculum), at junction of inner and lower surfaces, present in *T. cornucopiae* and *T. rossi* Yochelson & Jones, 1968. (The latter authors use *basal angulation.*) *Upper keel* (conch, operculum), at junction of outer and upper surfaces of operculum, junction of outer and upper walls of conch whorls (see *surfaces*), invariably acute and present in all species (except, perhaps, *T. rossi,* known only from damaged opercula).

length (operculum)—The dimension measured between the anterior and posterior ends. In opercula of more usual form, this would strictly be regarded as thickness but the extreme thickening of the *Teiichispira* operculum results in the thickness becoming by far the greatest dimension, so that *length* is a more appropriate term. Also, the English language has some facility in words relating to length, very little in words relating to thickness; consequently, descriptive terms based on the latter produce expressions not only grotesque but opaque. Finally, the use of *longitudinal* admits the complementary *transverse,* convenient in some contexts.

surfaces (operculum), *walls* (conch)—It is in this field that the simplification in terminology is most evident. For the walls of the conch whorl the designations *inner, lower, outer,* and *upper* hardly need explanation. The same terms are applied to the opercular surfaces: provided the operculum is in position plugging the aperture, the outer wall of the conch is in contact with the outer surface of the operculum, and so on around the periphery of the operculum. *Anterior surface* (operculum), see *anterior.*

transverse (operculum)—In sections of uncertain orientation, cut at an angle of 80°-100° to the lower surface, the term *transverse* is used for want of more precise information.

tubulose (operculum)—'Abounding in tubules'; designates the texture of the operculum of *Teiichispira* and of other gastropods with a similar fabric (e.g., the unnamed macluritacean of Yochelson & Jones, 1968, below, p. 86), and replaces the term *fibrous* of those authors.

GEOLOGICAL BACKGROUND TO AUSTRALIAN ORDOVICIAN MACLURITACEANS

NORTHERN AUSTRALIA

Coolibah Formation

Upper Cambrian and Ordovician sediments are exposed on the flanks of the Toko Syncline, which crosses the Northern Territory/Queensland border (long. 138°E) with a northwest to southeast trend. The geology has been summarized by Reynolds (1965, 1968) and Smith (1968). The Coolibah Formation (Casey, *in* Smith, 1965), which is underlain by Kelly Creek Formation and overlain by Nora Formation, in each case without angular discordance, consists of grey calcilutite, in places oolitic, and green-white marl, with chert lenses ('buck quartz'), and minor calcarenite and dolarenite. Its estimated thickness is 15 to 160 m, and on published maps (Text-fig. 4), it appears to pinch out to the southeast.

Although its fossils are distinctive, it may not be lithologically distinguishable from the Nora Formation in all areas of outcrop. The Tarlton Range, west of the Toko Range, for example, where Coolibah Formation is not recognized, has yielded fossils of undoubted Coolibah aspect from areas mapped as Nora Formation. The mention of 'buck quartz' in the lithological description indicates some uncertainty in determining the position of the lower boundary against the Kelly Creek Formation. At an early stage in the study of the area, samples of a very hard fossiliferous rock fitting this description were collected at the northwestern end of the Syncline (localities not marked on map) by J. N. Casey and by N. O. Jones while Resident Geologist at Alice Springs. The rock, informally named '*Euchasma* chert' from its ribeirioid content, was at that time assigned to the Kelly Creek Formation, rather than the Coolibah. Other than this, most of the Coolibah fossils in the collections are silica replacements in limestone. The silicification is commonly superficial, and may be too coarse for the preservation of fine detail; the matrix may also be siliceous. The fossils, many of which are weathered out of the matrix and lie loose on the surface, are almost invariably broken but are not noticeably distorted. A less common mode of preservation is as moulds in a silicified matrix. No attempt has been made to determine the level within the formation of individual samples.

Teiichispira cornucopiae Tomlinson, 1969, is the first species to be formally described from the Coolibah Formation. Specimens of the nautiloid *Kochoceras* are illustrated by Hill, Playford, & Woods (1969, Pl. 0 II, fig. 8; Pl. 0 III, figs 6, 7), from the same formation, but the authorship of the identification is not stated. E. C. Druce, Bureau of Mineral Resources, is studying the conodonts.

In a somewhat restricted fauna, sponges are locally plentiful, but the most obvious fossils are gastropods and nautiloid cephalopods. Two macluritacean species are fairly common, the operculum of *T. cornucopiae* and the conch of an undescribed form resembling *Maclurítella.* Although the ratio of finds of operculum to conch of *T. cornucopiae* is about 80:1, no other opercula have been noted. Rarer gastropods include the euomphaloids *Ecculiomphalus,* aff. *Helicotoma,* and cf. *Lesueurilla;* the pleurotomarioids cf. *Calaurops, Lophospira,* and an unidentified raphistomatoid; and cf. *Hormotoma* and cf. *Raphistomina.* The nautiloids have not been studied in detail. They are mostly straight forms among which actinoceratoids with nummuloidal siphuncles, here listed as *?Armenoceras,* are conspicuous. Other groups are present, including ?endoceratoids and at least two discoidal forms, one of them superficially resembling *Hardmanoceras.* Pelecypods are rare, a single unidentified specimen representing the Class. The same applies to the ribeirioids, unless the '*Euchasma* chert' fauna is included, when the nominate genus and, possibly, *Ischyrinia* will swell the list. Four trilobite genera are present, each known from a single pygidium. Of the two asaphoids, one resembles *Niobella,* and the other might belong to any of a number of Arenigian genera. Of the two cheiruroids, one is very close to a form from the Lower Ordovician Horn Valley Formation of the Amadeus Basin (Text-fig. 3) at present listed as cf. *Prosopiscus;* the other is probably new, aff. *Cybelopsis.* Inclusion of the '*Euchasma* chert' fauna adds the North American hystricuroid *Psalikilus.* A single unidentified ostracod has been noted. Two isolated brachiopod valves, an orthoid and a syntrophioid *?Clarkella,* both exteriors, complete the list. Algae have been recorded at one locality.

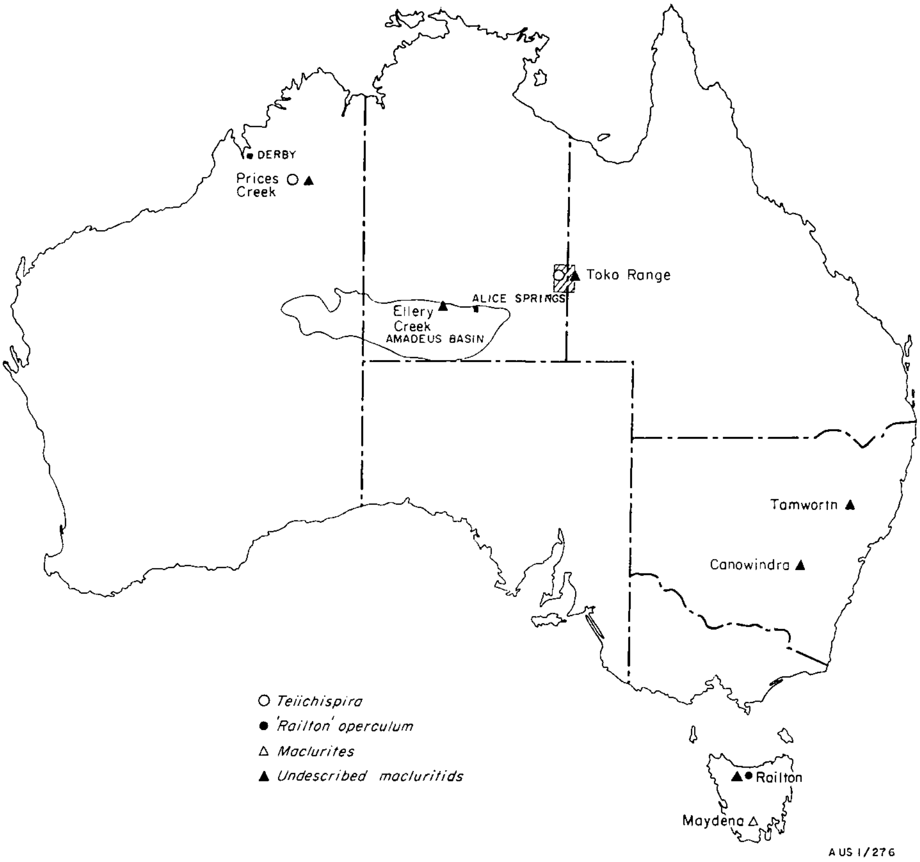

Figure 3. Localities for Australian Ordovician macluritid gastropods

Some stratigraphic anomalies are evident. Perhaps more than one assemblage is present, but until this is conclusively demonstrated by more sophisticated collecting techniques, it seems advisable to regard the fauna as a unit. Lower Ordovician forms include all the trilobites, the brachiopod *Clarkella,* the two macluritacean gastropods, the pleurotomariacean *Calaurops,* the ribeirioid *Euchasma,* and the conodonts (written communication, E. C. Druce). Long-ranging forms of little stratigraphic significance are the gastropods *Ecculiomphalus, Lophospira,* and *Raphistomina. Hormotoma* is also long-ranging; it is, however, provisionally recorded by Kobayashi (1959) in the Setul Formation of Malaysia in association with the species later described as *Teiichispira kobayashi* by Yochelson & Jones, 1968, who discuss some aspects of the Setul fauna and its age (loc. cit., p. B2). The nautiloid *Hardmanoceras* is dated as Upper Canadian to ?Chazyan (late Lower to ?Middle Ordovician of the North American scale). Middle Ordovician or younger forms are the actinoceroid nautiloids, here heavily outnumbered.

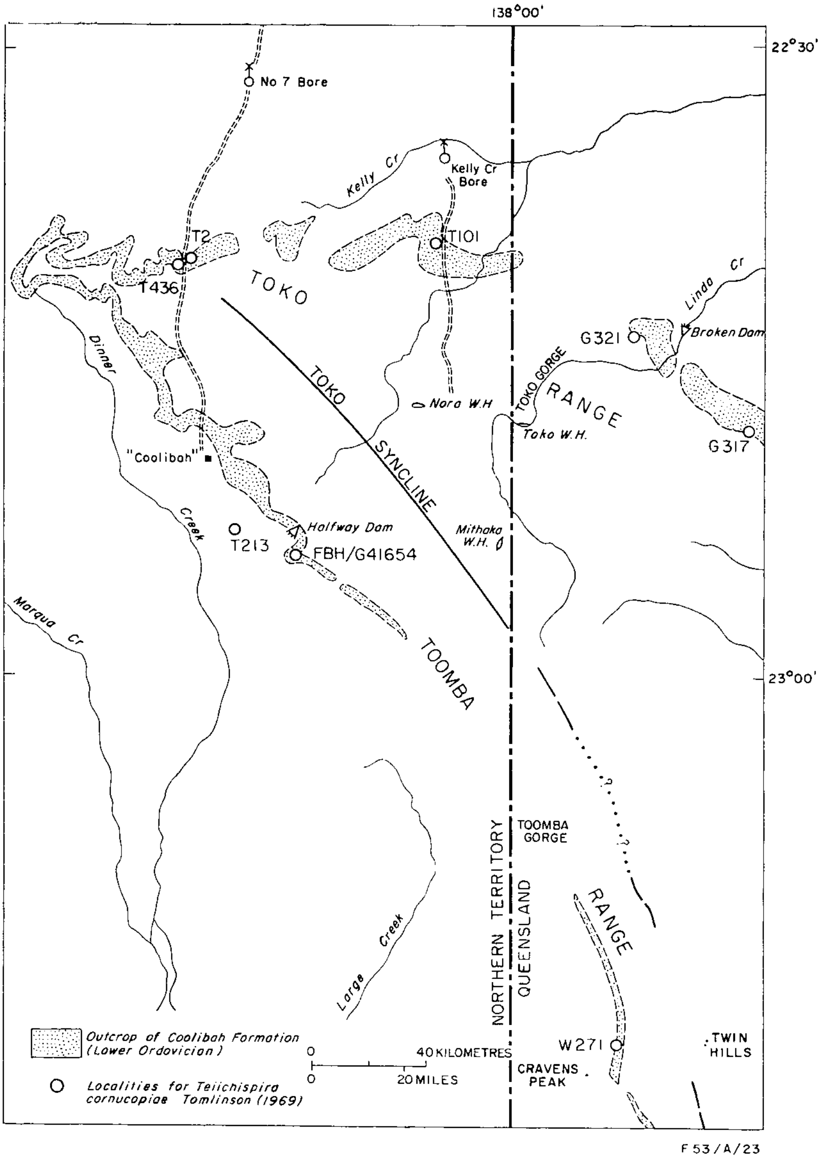

Figure 4. Outcrop of Coolibah Formation, Toko Syncline, and localities for *Teiichispira cornucopiae* Tomlinson, 1969

The occurrence in the overlying Nora Formation of the cosmopolitan trilobite *Carolinites,* nowhere younger than Llanvirnian, confirms the Arenigian (late Lower Ordovician) age of the Coolibah Formation.

Prices Creek Group

The Prices Creek Group was named by Guppy & Öpik (1950). Of a total thickness of 745 m, it consists of two conformably superimposed formations, the

Emanuel Limestone (lower) and the Gap Creek Dolomite. The Prices Creek area on Christmas Creek Station is 290 km east-southeast of Derby, W.A., and 70 km on a bearing of 145° from Fitzroy Crossing (Text-fig. 3). The Ordovician sequence is unconformably overlain by late Middle Devonian Pillara Formation; its base is faulted.

The formation-names have since been changed to 'Emanuel Formation' and 'Gap Creek Formation' (Guppy, Lindner, Rattigan, & Casey, 1958) and are cited in this later form in Bureau publications. In the absence of the primary records, the original authors' stratigraphic subdivisions of the Group are restored by collating later collections with two published faunal charts, both based on the 1949 collection and therefore definitive. In the first (Öpik *in* Guppy & Öpik, 1950, table 1 on p. 206), five successive Faunal Stages, each with a distinct faunal assemblage, are recognized—Stages I to IV (ascending order) in the Emanuel Formation and Stage V in the Gap Creek Formation. The fossils are mostly recorded under the names of suprageneric categories, but a few generic names are listed. In the second (Teichert & Glenister, 1954, table 2 on p. 18 (164)), the ranges of species of nautiloid cephalopods described by them in that and an earlier paper (1952) are plotted. Teichert & Glenister (1954) date Stages II and III as Canadian, Stage IV as late Canadian or ?Chazyan, and Stage V as Chazyan. Stages II to V are readily recognizable in the collection made by Drs G. A. Thomas and J. J. Veevers in 1953. Stage I was apparently not collected. The stratigraphic basis of the collection is an unpublished section of the Prices Creek Group measured by geologists of West Australian Petroleum Pty Ltd.

Teiichispira is present in three, possibly four, of the samples collected from the upper part of the Group by Thomas and Veevers: (ascending order) BMR localities Kog 410, 411, 412, and possibly, 413. Kog 410, about 175 m below the top of the Ordovician sequence, and Kog 411, about 6 m higher than 410, are similar in lithology and fossil content. The rock is a light grey silty limestone, with a little dolomite in 411. The fossils are generally calcified, but in two hand-specimens of 410 the brachiopod *Spanodonta* is silicified although associated fossils remain in their calcareous state, and in 411 an unidentified macluritid conch is silicified in a layer of interbedded dolomite. The plectambonitid *Spanodonta* Prendergast, 1935, is the commonest fossil. Other brachiopods are rare, being known only from exteriors of a clitambonitid and an unidentified orthoid. Most of the gastropods are too worn for identification; exceptions are *Raphistomina,* a macluritid cf. *Barnesella,* and six very worn *Teiichispira* opercula, five of them from 410. Nautiloids are represented by an external mould of *Hardmanoceras* in 411. The only other fossils are rare trilobites—an undetermined agnostid cephalon, a worn asaphoid pygidium cf. *Niobella,* cranidia and pygidia of an undescribed cheiruroid aff. *Cybelopsis,* and a single *Encrinurella* pygidium. Two *Teiichispira* opercula are illustrated from 410 (Pl. 33, figs 5, 10). A fragmentary operculum recovered from the original collection probably originates from this part of the sequence.

The association of *Spanodonta,* clitambonitids, and *Hardmanoceras* indicates Faunal Stage IV, the top of the Emanuel Formation. As noted above, Teichert & Glenister date the Stage as late Canadian or ?Chazyan. The present association tends to tip the scales in favour of the earlier date. The *Raphistomina* is very close to a form from the Arenigian Horn Valley Formation of the Amadeus Basin, and *Barnesella* is generally regarded as being Lower Ordovician. Moreover, as observed by Yochelson & Jones (1968, pp. B2, 4), it is very close to *Malayaspira* Kobayashi, 1958, an associate of *Teiichispira kobayashi* in the Setul Formation. Of the trilobites, the pygidium of the cheiruroid here listed as 'aff. *Cybelopsis*' is close to that of the form recorded under the same name in the Coolibah Formation (above). The long-ranging *Encrinurella* is not diagnostic; it makes an earlier appearance in Stage III of the Emanuel Formation, and in other parts of northern Australia has an Arenigian span, but in New South Wales is recorded in rocks dated as Middle Ordovician (Packham et al., 1969).

Kog 412, about 5 m above 411, is a greyish yellow dolomite with some limestone. Its only observed fossils are silicified *Teiichispira* opercula (not illustrated) and unidentified articulate brachiopods. The sample may represent the base of the Gap Creek Formation.

Kog 413, from the Gap Creek Formation about 110 m above 412, is a massive dolomite with coarse superficial silicification of the fossils. Of these, the best preserved are gastropods: cf. *Raphistomina, ?Ectomaria,* and two hyperstrophic forms, one with a wide shallow apical cavity (not identified), the other, with a deep rather narrow cavity, resembling *Teiichispira.* In association are elongated fossils with internal polygonal tubules. They may be *Teiichispira* opercula, but the preservation is inadequate for firm identification. These problematical forms are not illustrated. Unidentified articulate brachiopods are present in the sample.

The upper part of the Prices Creek Group, Stages IV and V, is evidently rich in tubulose opercula, and a deliberate search for describable material is indicated. Collections from Stage V (Gap Creek Formation) are particularly necessary in order to confirm or refute the doubtful identification of *Teiichispira* from sample Kog 413 and to supply data on the upper limit of the range of the genus in Australia.

Stairway Sandstone

Macluritacean gastropods are rare in collections from the Ordovician sequence of the Amadeus Basin, Northern Territory, the only known representative of the superfamily being an undescribed *Macluritella*-like conch in the upper part of the Stairway Sandstone (author, unpublished). It is invariably preserved as external moulds, and morphological details are obscure. The operculum is unknown. In age the formation, which overlies the Arenigian Horn Valley Formation without angular discordance, is no younger than Llandeilan and may be Llanvirnian. The locality plotted on the map (Text-fig. 3) indicates the exposures at Ellery Creek, but the gastropod has been observed at a number of other localities in the Basin.

SOUTHEASTERN AUSTRALIA

Cliefden Caves Limestone; Trelawney Beds (Text-fig. 3)

Shelly Ordovician faunas in New South Wales are a comparatively recent discovery. The first to be identified, the Cliefden Caves Limestone in the Canowindra district of the central part of the State, was first assigned to the System by Dr A. A. Öpik about the time of the discovery of the Ordovician of the Prices Creek area of Western Australia. A number of other discoveries were later made by New South Wales geologists in the same area, and the present state of knowledge is summarized by Packham et al. (1969). *Maclurites* is listed as a constituent of the fauna of the lower part of the Limestone. It has not been described.

The Trelawney Beds of the Tamworth area in the northeast of the State are an even later discovery, first reported by Prof. G. M. Philip, University of New England, in 1966. In a brief summary, Packham (1969) lists 'cf. *Maclurites*' among the identified fossils. The age is stated to be 'Trentonian to Maysvillian . . . which may be broadly correlated with the Eastonian'. The latter is middle Upper Ordovician on the Victorian graptolite scale.

Florentine Valley Mudstone; Gordon Limestone

Apart from *Teiichispira cornucopiae* Tomlinson, 1969, the only macluritaceans formally described from Australia occur in central Tasmania: *Lecanospira tasmanensis* Kobayashi, 1940, from the Florentine Valley Mudstone, near Junee, and *Maclurites florentinensis* Banks & Johnson, 1957, from the Gordon Limestone at Benjamin, Florentine Valley, near Maydena (Text-fig. 3). Each is known from the conch alone.

L. tasmanensis is illustrated by two fragmentary specimens lying on the same bedding-plane; they are tectonically-deformed external moulds, apparently of the base of the hyperstrophic conch (Kobayashi, 1940, pl. XI, fig. 11). A plaster replica of a third specimen from the same locality, in the same aspect, and apparently conspecific is held in the Bureau of Mineral Resources collections. The larger of the two illustrated specimens shows at least four, possibly five, volutions in a diameter of about 20 mm. In all three specimens the sutures are deeply impressed, the whorl surfaces are distinctly and evenly inflated, and the rate of expansion is somewhat greater than is usual in *Lecanospira*. In the plaster replica the base is shallowly umbilicate. Comparison with Yochelson & Jones (1968, Pl. 1, fig. 5a) reveals a striking resemblance to the base of *Teiichispira kobayashi*. On the other hand, the description of an unfigured specimen of *L. tasmanensis* records the presence of 'a low carina on the apical side from which the inner slope forms a concavo-convex curvature', and, in the same paragraph, the spire is said to be 'slightly sunken'. As neither a low carina nor a slightly-sunken spire is consistent with the diagnosis of *Teiichispira*, the generic identity of the species must remain, for the present, uncertain. The association with the dikelokephalinid trilobite *Asaphopsis* indicates a Lower Ordovician (Arenigian) age for this part of the formation, which in this area is overlain by the Gordon Limestone with a gradational contact. The latter has yielded the second of the described Tasmanian macluritids, *Maclurites florentinensis*.

Rocks assigned to the Gordon Limestone (Banks et al., 1962) are scattered over a large part of the State and cover a considerable time-span from Arenigian upwards. A number of macluritaceans of uncertain generic reference are evidently present. One, from Railton in northern Tasmania, unnamed and unillustrated, is described by Banks & Johnson (loc. cit., p. 639; UTGD 25334) as having 'a rather wide, deep apical depression. The upper edge of the whorl is sharply angulated and the angle is distinctly sharper than in *M. florentinensis*'. The description reads rather like *Teiichispira*, or, perhaps, *Barnesella*, and the fossil certainly merits re-examination. Three specimens of a hyperstrophic gastropod in the collections of the Bureau of Mineral Resources (F 23579-23581), preserved in blue-black limestone from the Goliath Cement Quarry at Railton, are too deformed for generic identification.

The Goliath Quarry has yielded a number of opercula, three of which are illustrated but not named by Banks & Johnson (1957, p. 639, pl. 74, figs 3, 6, 8, 9). None resembles *Teiichispira,* but one (pl. 74, fig. 3), said to resemble *Maclurites logani* in flatness, though dissimilar in other features, is reminiscent of two plate-like opercula illustrated but not named by Yochelson & Jones (1968, pp. B4, B11, pl. 2, figs 1, 2), one from the Setul Formation of Malaysia, the other from the Odenville Limestone of Alabama. It is briefly described below (p. 86), compared with the other two forms, and informally named 'Railton operculum'.

SYSTEMATIC DESCRIPTION

Superfamily MACLURITACEA Fischer, 1885

Family MACLURITIDAE Fischer, 1885

Genus TEIICHISPIRA Yochelson & Jones, 1968

Type species (by original designation). *T. kobayashi.* In the text (p. B9) the authors imply that the conch is chosen as holotype. But on the same page, under the heading *Numbered specimens,* the holotype is listed as USNM 159947. As shown on their plate 1, figure 3, this specimen is an operculum.

Distribution. Malaysia and Thailand—Setul Formation, *T. kobayashi;* Western Australia—Prices Creek Group, *T.* sp. indet; Queensland and Northern Territory—Coolibah Formation, *T. cornucopiae* Tomlinson, 1969; Utah—Garden City Formation, *T. rossi* Yochelson & Jones, 1968; Alabama—Odenville Limestone, *T. odenvillensis* (Butts, 1926); Newfoundland—Quebec Group, *T? sylpha* (Billings, 1865) (Text-fig. 1).

Age. All the listed species are late Lower Ordovician, except *T.* sp. indet. from the Prices Creek Group of Western Australia, either late Canadian or Chazyan.

Diagnosis. 'Slowly expanding hyperstrophic gastropods having a steeply-inclined, moderately high outer whorl face, distinct sutures, and an elongate, curved, calcified, operculum. Apical cavity deep with smooth, slightly arched walls. Outer wall face steep except for rounded basal angulation where it curves strongly inward. Basal sutures distinct. Operculum elongate, slightly torted, with a sharply carinate upper surface; composed of elongate polygonal to rounded tubes' (Yochelson & Jones, 1968, p. B7).

Material. In all described species, conch and operculum are discrete. All species except *T.? sylpha* are based on the operculum as type. Neither the operculum of *T.? sylpha* nor the conch of *T. rossi* is yet known. The conch of the unnamed Prices Creek form has not been identified.

Preservation. In the diagnosis of *T. cornucopiae* (below, p. 79), the shape of the tubules composing the operculum is listed among the characters distinguishing it from other species. As differences in preservation may impair the apparent validity of such generalizations, some amplification is desirable.

1. In two Australian species of *Teiichispira,* rounded and apparently polygonal tubules may be observed in different parts of the same operculum. A partly silicified specimen of *T. cornucopiae* (CPC 11299; Pl. 30, fig. 9) shows

rounded tubules in the silicified part and, apparently, polygonal ones in the calcified part. The observation may be repeated on a number of specimens of the paradigm; the polygonal outline of the tubules is invariably found in the calcified part of the operculum, and on weathered natural transverse sections, where differential solution may produce shallow furrows at the junctions of the tubules separating the gentle protuberances of the tubules themselves and their infilling. The fact that the polygonal appearance of the tubules is restricted to calcified opercula may suggest that the polygonal framework is original and the rounded appearance the result of silicification, a conclusion that seems to be strengthened by the polygonal meshwork of the unsilicified opercula from the Emanuel Formation (CPC 11301; Pl. 33, fig. 5). But all the thin sections of *T. cornucopiae* display rounded tubules without a hint of a fundamental polygonal framework (Pl. 34, figs 1, 2, 5, 6) and, although the opercula have a thin crust of silica, the interior is predominantly, if not entirely, calcite. The polygonal appearance may result from the combination of two causes: (a) the crowding of the cylindrical tubules to give a space-saving hexagonal cross-section at their contact with neighbouring tubules, and (b) the subsequent weathering of this line of weakness. Weathering seems to be the cause of the apparently polygonal tubules in another species, an undescribed form from the base of the Gap Creek Formation of Western Australia

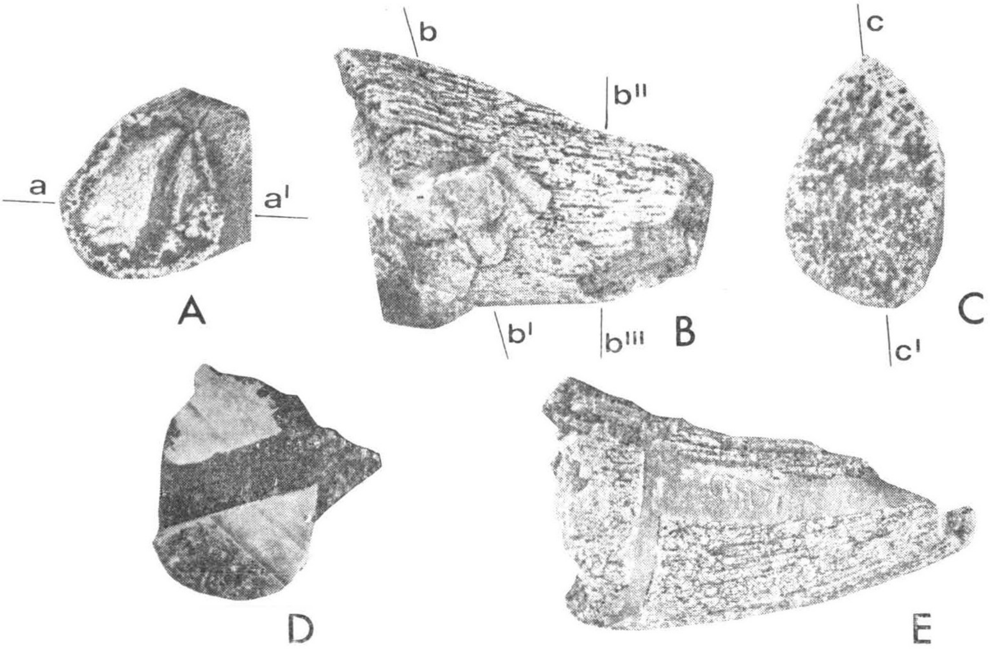

Figure 5. Orientation of thin sections of opercula, *Teiichispira cornucopiae* **Tomlinson, 1969, x 1.5.** A. **CPC 11307, anterior view of damaged and imperfectly silicified specimen, partly embedded in matrix:** a-a', **longitudinal section at widest part of operculum (Pl. 32, fig. 8).** B. **CPC 11308, inner view of specimen with superficial silicification;** b-b', **section roughly parallel to anterior surface;** b''-b''', **section roughly perpendicular to lower surface (Pl. 34, figs 2, 5).** C. **CPC 11304, anterior view of damaged specimen with silicified tubules;** c-c', **vertical section through upper keel and middle of lower surface (Pl. 33, fig. 8).** D, E. **CPC 11302, anterior and inner views of specimen with superficial silicification, restored with modelling clay after sectioning (Pl. 34, fig. 4)**

(above, p. 75; BMR loc. Kog. 412 not illustrated). As in the examples of *T. cornucopiae* cited above, polygonal tubules are observed on a weathered natural transverse section, but on more recent fractures of the same specimen, the tubules are undoubtedly rounded. In this sample the silicification may be complete, not merely superficial as in most specimens of *T. cornucopiae.*

2. As observed by Yochelson & Jones (p. B6), the association in Newfoundland of two different kinds of silicified opercula, solid *Ceratopea* and tubulose *Teiichispira,* demonstrates that the texture of the *Teiichispira* operculum is organic, and not simply the result of silicification. Nevertheless, the original texture is not inevitably retained in the fossil, and some opercula illustrate the destructive effects of recrystallization and silicification. The transverse section from the Emanuel Formation already referred to (Pl. 33, fig. 5) shows tubules in the upper part but none in the lower part, which is a mass of recrystallized calcite. The holotype of *T. cornucopiae* (Pl. 29; Pl. 34, fig. 3), which on the silicified exterior is completely tubulose, is also composed internally of recrystallized calcite, as may be seen on fresh surfaces exposed in the fracture near the posterior end (not illustrated). In another specimen of the same species (BMR loc. T2; not illustrated), broken surfaces show the interior to consist of solid silica, although the exterior preserves the longitudinal striation of a slightly exfoliated tubulose operculum. Moreover, the thin section of an operculum of *T. cornucopiae* (Pl. 34, fig. 5) shows no obvious layer of fine tubules immediately below the non-tubulose integument, although the lower part of the surface of this operation is not abraded (Text-fig. 5B). Their absence may be interpreted as another case of obliteration by silicification.

3. Some opercula of *T. cornucopiae* (Pl. 30, fig. 9) show very fine 'quasi-tubules' in the intertubular walls on weathered silicified surfaces. Thin sections of opercula from the same (Coolibah) Formation reveal a fine crackled structure in the calcite of the shell-matter between the tubules (Pl. 32, fig. 8; Pl. 34, fig. 5). Presumably the quasi-tubules represent thin laminae of silica deposited in the interstices between the calcite crystals and retained as minute walls after the solution of the calcite.

From the foregoing observations it is concluded that the external morphology alone is reliable for specific identification, the size and shape of the tubules, and even their presence or absence, being treacherous grounds for taxonomic discrimination, although of undoubted geochemical interest. Publication of thin sections of *Teiichispira* opercula collected from other climatic zones may shed light on the problem.

T. CORNUCOPIAE Tomlinson *in* Hill, Playford, & Woods, 1969
(Pls 29-32; Pl. 33, figs 1-4, 6-9; Pl. 34; Text-figs 2, 5, 6)

1969 *Teiichispira cornucopiae* Tomlinson, *in* Hill, Playford, & Woods, ORDOVICIAN AND SILURIAN FOSSILS OF QUEENSLAND, pl. O I, figs 12, 13.

Material. Holotype operculum CPC 11296, other opercula CPC 11297-11308, 11312; assigned conch CPC 11311. All are damaged and are incompletely silicified.

Diagnosis. Teiichispira with gently curved and slightly torted operculum, rapidly increasing in height, and composed of irregularly rounded tubules; upper keel moderately acute, lower keel blunt, inner and upper surfaces meeting at a low angle in upper half of operculum, rarely forming a keel (inner keel), anterior surface narrowly triangular, lower surface very slightly arched downward; a shallow saucer-like depression on lower part of anterior surface, and site of major retractor muscle near junction of lower and outer surfaces. *T. cornucopiae* resembles *T. kobayashi* in the apparent lack of a deep pit or prominent prong for muscle-attachment and in having the walls of the tubules thicker in the lower part of the operculum than the upper part; it differs in the more rapid increase in height, the greater overall width, the presence of the lower keel, the flatter base, and in having its greatest width in the lower third, rather than about the horizontal midline, when viewed from the anterior. It resembles *T. rossi* in the presence of the lower keel, and in having the main muscle-attachment nearer the outer than the inner surface, but differs in the more pronounced torsion and the lack of a deep pit for muscle-attachment. It resembles *T. odenvillensis* in the rather robust appearance, but differs in possessing rounded rather than angular tubules, in the faint angulation at the junction of the upper and inner surfaces, the well-marked lower keel, more acute upper keel, less pronounced curvature, lack of a prong for muscle-attachment, and in having the site of main muscle-attachment nearer the outer than the inner surface. *T. cornucopiae* resembles the undescribed species from the Emanuel Formation in the occasional presence of the inner keel; it differs in having fine rounded tubules rather than coarse angular ones.

Stability and torsion of operculum. Yochelson & Jones (1968, p. B12) compare the stability of the three known *Teiichispira* opercula when placed on their bases and the appearance of the upper keel when the operculum is in this position. *T. kobayashi* and *T. rossi* are stable, *T. odenvillensis* is not. The upper keel is more central in *T. rossi* than in *T. kobayashi,* in which it is 'fairly close to the periphery'. In its present incomplete state the holotype of *T. cornucopiae* is unstable, but, when the posterior tip is restored with modelling clay, stability is acquired. At the rear the operculum rests on the restored tip; at the anterior end it rolls over toward the inner surface to rest on the lower keel. Whether the posterior tip is restored or not, the upper keel shows a distinct outward sweep from anterior to posterior. The operculum of *T. cornucopiae* is apparently the most strongly torted of known species.

Characters of conch. The conch assigned to *T. cornucopiae* is somewhat wider in proportion to its height than other described species (as are also the individual whorls). Its proportions are nevertheless well within acceptable limits for the genus. Its rather rotund upper part is reminiscent of *Palliseria,* but the umbilicate base excludes that genus. The upper suture is not impressed in the earliest preserved whorl, but gradually becomes apparent and deepens steadily toward the mature whorl. It is so deep in the last preserved volution that the possibility of the whorl's becoming disjunct is inescapable. The basal suture is not impressed. The basal whorl surface is slightly and asymmetrically arched, with the convexity nearer the outer side of the surface; a complementary shallow furrow may be present on the inner side. Comparison of some characters of the conch with other species is given in Table 1.

Localities (Text-fig. 4)

Bureau of Mineral Resources localities (opercula)

G317—19.6 km east of Toko Waterhole, Glenormiston (1:250,000) Sheet, Queensland. CPC 11296 (holotype), 11297, 11298, 11299.

G321—4.8 km west of Broken Dam, Toko Range, Glenormiston (1:250,000) Sheet, Queensland. CPC 11300.

W271—4.0 km northeast of Cravens Peak, Mount Whelan (1:250,000) Sheet, Queensland. CPC 11301.

T2—16.4 km south-southwest of No. 7 Bore, Toko Range, Tobermory (1:250,000) Sheet, Northern Territory. CPC 11302, 11303, 11304.

T101—8 km south of Kelly Creek Bore, Toko Range, Tobermory (1:250,000) Sheet, Northern Territory. CPC 11305.

T213—4.8 km west of Half-way Dam, Tobermory (1:250,000) Sheet, Northern Territory. (The point, as plotted, lies on mapped outcrop of underlying Kelly Creek Formation; lithology and fauna of the sample are undoubtedly Coolibah.) CPC 11306, 11307, 11308.

T436—0.8 km southwest of T2 (above). CPC 11312.

Frome-Broken Hill locality (conch)

FBH/G 41654—0.8 km south of Half-way Dam, Tobermory (1:250,000) Sheet, Northern Territory. CPC 11311 (Fragmentary *Teiichispira* opercula occur in the sample).

Formation and age. Coolibah Formation: Lower Ordovician (Arenig).

Derivation of specific name. Cornucopiae (Latin, noun in apposition), 'the horn of plenty', in allusion to the shape of the operculum.

TABLE 1. COMPARISON OF CHARACTERS OF CONCH IN *Teiichispira* SPECIES

	Species			
Character	*cornucopiae*	*kobayashi*	*odenvillensis*	*sylpha*
Base of conch	umbilicate, c. 170°	umbilicate, c. 165°	flat	flat
Basal whorl surface	asymmetrically arched	symmetrically arched	very slightly arched	flat
Basal suture	not impressed	impressed	not impressed	not impressed
Basal angulation (whorl)	absent	absent	?	present
Upper suture	absent (early whorls) deep (late whorls)	moderately shallow	?	not impressed

DESCRIPTION

The operculum of *T. cornucopiae* has the horn shape, curved and torted, typical of the genus. The stumpy appearance of most of the fragments results partly from damage (transverse fractures are common, and the narrow posterior tip is invariably lost), partly from the rapid increase in height toward the anterior, and partly from the natural width (between inner and outer surfaces) of the operculum. One result of the fragmentary preservation is that estimates of length and curvature are inconclusive. At a conservative estimate, the arc of the lower keel of the longest operculum (CPC 11297; Pl. 30, figs 1, 2, 4-8), when the posterior tip is reconstructed, is 50 mm. The length corresponds to at least one-third the circumference of a mature volution of the conch. The torsion is quite perceptible. Its presence is deduced from (a) the outward slope of the upper keel from anterior to posterior when the operculum is viewed from above (CPC 11296, holotype, Pl. 29, fig. 1; CPC 11300, Pl. 31, fig. 4; CPC 11301, Pl. 32, fig. 6); (b) the upward slope of the lower keel from anterior to posterior when the operculum is viewed from the inner side (Pl. 29, fig. 2; Pl. 30, figs 4, 8); (c) in exfoliated specimens, the twist of the inner tubules (Pl. 30, fig. 7); and (d) the rotation of the midline of the growth-line surface (i.e., the line joining upper keel to centre of lower surface on the anterior surface of successive growth-stages). The last alone permits measurement: in the holotype (Pl. 34, fig. 3), the rotation is about 50° in a chordal length of 29 mm (measured between the anterior and posterior extremities of the lower keel of the fragment); in an immature operculum, CPC 11300 (Pl. 31, fig. 3), the rotation is about 40° in a chordal length of 11 mm. In the holotype, the increase in height in the same interval is 13 mm (13 mm, posterior; 26 mm, anterior), the increase in width being about 7.5 mm (6 mm, posterior; 14.5 mm, anterior). In CPC 11300, the height increases from 10.5 mm to 14.5 mm, and the width from 6.0 mm to 8.0 mm.

The inclination of the anterior surface to the lower surface, when viewed from the inner side of the holotype, is about 125°. The anterior surface of the holotype (Pl. 29, fig. 3) is rather worn, but its junctions with other surfaces are well preserved, except at the periphery of the outer surface. The shape of the surface is roughly that of an isosceles triangle, about twice as high as wide. In less worn specimens (Pl. 31, fig. 6; Pl. 32, figs 3-5), a shallow depression is visible on the lower part of the surface, overhung by the protrusion of the upper part of the surface, and bounded on the remaining sides by a bevelled rim formed by the forward extension of the walls of the lower surface and the lower part of the outer and inner surfaces. The unworn surface of CPC 11301 shows no scar marking the site of attachment of the main retractor muscle. On several damaged anterior surfaces, however, an area of imperfect silicification, lying near the evenly curved junction of the outer and lower surfaces, is interpreted as a muscle-spot. Presumably the shell matter was too dense at this point to admit the penetration of silica-bearing solutions, once the initial impervious crust was formed. The area of imperfect silicification may be no more than a narrow transverse parting at the base of the bevel, immediately to the left of the vertical midline (Pl. 29, fig 3; Pl. 31, figs 6, 7). The parting may be arcuate (Pl. 30, fig. 9) or may be enlarged to a conspicuous cavity with a central rod (Pl. 30, fig. 1). A comparatively large cavity appears in CPC 11306 (Pl. 32, fig. 11), but, as the silicification in this operculum is very imperfect, the size of the cavity may not be very significant. A thin section (Pl. 34, fig. 5) shows a cluster of elongate radiating tubules in an area of dense shell material.

At the anterior end of the holotype, in the plane of the anterior surface, the upper part of the outer surface meets the top of the inner surface to form the prominent upper keel (Pl. 29, figs 1, 3, 4, 6). The upper surface is very slightly convex and slopes steeply downward at a mean angle of 30° to the vertical midline. At the anterior end of the surface, the holotype, retaining the integument, has preserved two very shallow longitudinal furrows, lying one above the other and roughly parallel to the upper margin of the surface (Pl. 29, fig. 2). The junction of the upper and inner surfaces is obscure in most specimens. The unique occurrence of the inner keel is preserved in the immature CPC 11300 (Pl. 31, figs 1, 4), where the inner surface is atypically concave. The shallow growth-wrinkles die out where they cross the inner keel. The passage from inner to lower surface is marked by the obtuse lower keel (Pl. 29, figs 2, 3, 10; Pl. 30, figs 1, 4, 5, 8; Pl. 31, figs 1, 2). The lower surface is gently convex both longitudinally and transversely (Pl. 29, figs 3, 5, 11; Pl. 30, figs 1, 5, 6). In exceptionally favourable preservation (Pl. 31, figs 2, 7), or in foreshortened view (Pl. 29, fig. 9), it shows a very faint median angulation. The passage from lower to outer surface is an uninterrupted curve (Pl. 29, figs 5, 8). The upper part of the outer surface shows a slight concavity (Pl. 29, fig. 3; Pl. 30, fig. 9; Pl. 31, fig. 6; Pl. 32, fig. 9; Pl. 34, fig. 5).

The well-preserved opercula of *T. cornucopiae* reveal zones of contrasting internal texture, as well as some variability between individual specimens. To facilitate comparison, all the thin sections are illustrated at the same magnification (x 3). The thin outer integument, without tubules, is occasionally preserved, mostly on concave surfaces. Immediately beneath it is a layer of fine laterally contiguous tubules, giving a striated appearance to exfoliated surfaces (Pl. 29, figs 5, 7; Pl. 32, fig. 1). Within this is a zone of dense shell material containing fine but rather scattered tubules. It corresponds to the rim surrounding the shallow depression on the lower part of the anterior surface (above) and extends upward to the upper keel (Pl. 31, fig. 6). This zone is also evident in *T. kobayashi* Yochelson & Jones (1968, pl. 1, fig. 3a). The inner edge of the zone may be marked by a row of radially elongate tubules opposite the lower surface (Pl. 34, fig. 5), or by a row of widely-spaced coarse tubules opposite the inner and lower surfaces, each surrounded by an aureole of smaller tubules (Pl. 34, fig. 6).

In some specimens, the tubules of the lower part of the main body of the operculum are fine, with thick walls; in the upper part, the walls are thinner and the tubules correspondingly coarser. They are variable in size and shape but mostly rounded. Longitudinal sections show irregular blebs of dark material within the tubules, and, in one specimen (CPC 11304; Pl. 33, fig. 8), transverse partitions. Evenly spaced spine-like projections from the walls of the tubules are seen in another specimen from the same locality, CPC 11302 (Pl. 34, fig. 4).

About 2½ whorls of the conch are preserved (Pl. 33, figs 1-4, 6, 7, 9). The initial whorls are missing, and the mature whorl is preserved, in its latest stages, as the remnant of the inner wall in contact with the outer wall of the preceding whorl, which is itself partly broken away to reveal the silicified steinkern. At the crest of the mature whorl the shell is greatly thickened. The thickening at the periphery of the whorl (Pl. 33, figs 3, 4) is apparently due to algal encrustation. The apical angle of the preserved part is about 60°. It should perhaps be larger if the mature whorl were better preserved. The upper wall is slightly arched and, because of the thickening of the shell, even steeper than the corresponding surface of the operculum. The gradual increase in the apical angle is a function of the unique upper suture, which becomes steadily wider and deeper with advancing age, while preserving the characteristic V-shaped profile. The base is shallowly umbilicate (c 170°). Basal sutures are distinct but not impressed. The asymmetrical convexity of the basal whorl surface (above, p. 80) is best seen on the artificial mould (Pl. 33, fig. 2). Coarse silicification obscures the growth-lines. Faint orthocline grooves are preserved on the upper wall of the mature whorl (Pl. 33, fig. 1). Indistinct prosocline furrows are preserved on the upper part of the steinkern of the outer wall (Pl. 33, fig. 3), which also shows a shallow revolving furrow at the top of the whorl (Pl. 33, fig. 4). The penultimate whorl is 15 mm high at a diameter of 25 mm. The greatest preserved diameter is about 45 mm.

RECONSTRUCTION

Specimens of *Teiichispira* with the operculum in position closing the aperture of the conch have not yet been recovered, and the attitude of the operculum in this position thus becomes a matter of enquiry. At first sight the most likely position seems to be that in which the basal whorl-surface is confluent with the lower surface of the operculum. This idea is rejected for *T. cornucopiae,* because the obtuse-angled junction of the opercular anterior and lower surfaces would require an oblique opisthocline margin to the aperture of the conch. This, in turn, would entail a squarish vertical whorl-section similar to that seen in transverse sections of the operculum perpendicular to the lower surface (Pl. 32, figs 9, 10). Hence, in order to match the observed narrowly triangular vertical whorl-section with the similarly shaped anterior surface of the operculum, the aperture must itself be vertical and produce orthocline growth-lines on the conch. In this position, the posterior part of the operculum droops below the level of the base of the conch (Text-fig. 6). It might act as an anchor on a sandy bottom when the animal is retracted.

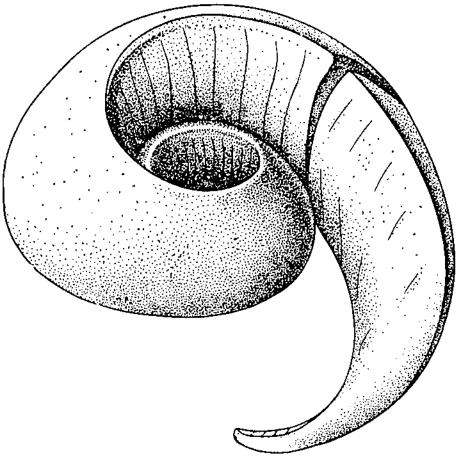

Figure 6. *Teiichispira cornucopiae* **Tomlinson, 1969, reconstruction (x 1.0) of conch in upper oblique view with operculum in position closing the aperture. Conch based on CPC 11311, operculum on CPC 11296 (holotype)**

The question of the attitude of the operculum when the animal is extended and moving about taxes the imagination. In gastropods with the usual button-like operculum, it is carried immediately behind the conch, which partly overlaps it and even rests on it. A similar position for the position of the operculum has been postulated by Knight (1952) for the Ordovician macluritid *Palliseria longwelli* (Kirk), but it seems hardly feasible for the *Teiichispira* operculum. Also, even if the tubules were hollow in life, thus reducing the weight, the great length of the operculum would disturb the stability of the animal if it were carried in the usual position with the anterior surface attached to the soft parts and the rest of the 'horn' towering above it. The restriction of such a monumental operculum to a purely passive defensive function seems unlikely. Some modern gastropods use the operculum as a locomotory organ. A large specimen of *Strombus* is said to effect leaps 8 cm long and 5 cm high by pressing the tip of the long pointed operculum against hard objects or by digging it into the sand and suddenly extending the foot. The wide distribution of *Teiichispira* suggests an active and efficient animal, and the use of the operculum partly as an organ of locomotion seems probable.

TEIICHISPIRA sp. indet.
(Pl. 33, figs 5, 10)

Material. Two worn and fragmentary calcified opercula, CPC 11309, 11310, illustrated in thin section. Recrystallization obscures the structure of one of the opercula. Three additional opercula from the same sample (Kog 410) and one from the overlying sample (Kog 411) are held in the collections but are not illustrated. A single specimen recovered from the burnt material is subjectively assigned to the species. The conch is not identified.

Localities. Gap Creek, Christmas Creek Station, Western Australia. Lat. 18°35′S, long. 125°55′E. BMR locality Kog 410, c. 175 m below top of Ordovician sequence; Kog 411, c. 168 m below top of sequence.

Formation and age. Emanuel Formation (Prices Creek Group), Faunal Stage IV. Lower Ordovician (Late Canadian).

Description. In the transverse section (Pl. 33, fig. 5), the tubules of the upper part of the operculum are wide and are separated by relatively thin walls. Though irregular in size and shape, they are generally angular in outline. Recrystallization of the lower part of the operculum prevents observation of the thickness of the walls, the width of the tubules, or the position of the muscle-attachment. Superficial abrasion has removed the integument and any outer zone of different texture that may have existed. The longitudinal section (Pl. 33, fig. 10) shows a gently-curved structure with rather wide tubules. Those on the concave side (upper part of illustration) show indistinct cross-partitions, but, on the opposite side, the infilling of matrix indicates that the tubules were hollow when the specimen was embedded. Two unfigured specimens, one each from Kog 410 and 411, show obtuse but distinct inner and lower keels, separated by a transversely concave inner surface. Growth wrinkles are preserved on the upper surface of the specimen from Kog 410. Until the specimens are freed from the adhering matrix neither significant measurement nor decisions on torsion can be made.

Comment. Opercula from these two samples have a misleading appearance of extreme thinness and a very sharp upper keel. This is due, however, to planing off by erosion of the convex outer side, which removes a good deal of the width and probably accentuates the acuteness of the keel. The relationship of this species to *T. cornucopiae* is not evident, but it is fairly clear that the species from Kog 412, 5 m above 411, is distinct from *T. cornucopiae*. Of about 8 poorly preserved specimens, one, embedded in matrix, displays a very long slowly tapering form, very gently curved at the mature (anterior) end, but slightly hooked at the posterior end. The extreme length preserved on a fairly flat surface suggests little torsion and separates it from the distinctly torted *T. cornucopiae*. The available material is insufficient for other comparisons. As indicated above (pp. 77-9), apparent differences in size and shape of tubules may merely reflect differences in preservation. The fact that the dubious opercula in Kog 413 (above p. 75) appear to have coarse angular tubules cannot be considered significant until the generic status is securely established.

Macluritacean incertae sedis

Railton operculum

An undescribed gastropod operculum of unusual appearance has been noted in acid residues from Ordovician limestones in Tasmania, Malaysia, and Alabama (Text-fig. 1), and a specimen from each area has been illustrated by its discoverers. The first to be published, from the Goliath Cement Company's quarry at Railton in northern Tasmania, was identified as *Maclurites* sp., briefly described, and illustrated in a single view (Banks & Johnson, 1957, p. 639, pl. 74, fig. 3; UTGD ?25311 or 25331). The other two opercula were published simultaneously by Yochelson & Jones (1968, pp. B4, B11), identified as unnamed macluritaceans, and illustrated in three views. The Malaysian form (pl. 2, fig. 1; USNM 159954) was collected from the Setul Formation at the eastern end of Pulau Langgun in association with a new brachiopod of 'late Early Ordovician' aspect (p. B4). The authors suggest that it represents about the same level of the Formation as that exposed at the type locality of *Teiichispira kobayashi* at the southern point of the island. The Alabama form (pl. 2, fig. 2; USNM 159955), from the Odenville Limestone 11 km north of Pelham, occurs in association with *T. odenvillensis* at its type locality. The same kind of operculum has also been tentatively identified in the top of the El Paso Limestone section of Texas and New Mexico (loc. cit., p. B11). It has not been noted in mainland Australia.

The terminology adopted for *Teiichispira* is largely inappropriate for the present form, in which the thickness is the least rather than the greatest dimension. A new terminology depends on a final decision on details of orientation, which will remain obscure until the conch is identified. The same impediment applies to naming the genus; a name based on the conch may already exist. For the present, the informal name 'Railton operculum', after the form first illustrated, is a convenient means of distinguishing the taxon.

In its flatness the operculum differs from *Teiichispira* and resembles *Maclurites,* but is distinguished from the latter by its roughly triangular plan. Authors are silent on the texture of the operculum, and no firm conclusions can be drawn from examination of the illustration of the Tasmanian form. A weathered surface of the Alabama form (Yochelson & Jones, 1968, pl. 2, fig. 2b), however, shows distinct tubules arising from the point named *apex* by Banks & Johnson (1957, p. 639), and, on unweathered surfaces of the same (Odenville) specimen, traces of the underlying tubules in the form of shallow striations may be detected radiating from the apex. Unweathered surfaces of the Setul form show a similar striation.

The two opposed surfaces of the operculum may be provisionally designated *external* and *internal,* the internal surface corresponding to the anterior surface of the *Teiichispira* operculum in the terminology used elsewhere in this paper. It shows two well defined features: (1) a *marginal rim* extending on both sides of the apex, and (2) a prominent oval *boss* for muscle-attachment. The external surface, almost flat in the Setul form, shows, in the Odenville form, a shallow fold near the left-hand margin in the orientation (apex uppermost) adopted by all authors. The fold widens in the abapical direction. Both exteriors show undulating growth-lines. At its inner edge, the marginal rim of the internal surface is separated from the *main body* of the operculum by a distinct *step.* The boss lies on the surface of the main body with its abapical end in contact with the step. It is elongated in the same direction as the tubules.

Of the three species of the Railton operculum, the Tasmanian form has the most prominent apex and the Alabama form the least prominent. In the opercula from Alabama and Malaysia, the marginal rim is widest opposite the apex and narrows rather rapidly to either side of it. In the Tasmanian form, however, the rim on the right-hand side is considerably wider than that on the left-hand (boss) side and neither shows obvious tapering. In this form, the junction of the inner edges opposite the apex is angulate, in contrast to the rounded junction of the other two forms.

Banks & Johnson's observations that the apex of the Tasmanian form is slightly sinistral establishes the coiling of the unknown conch as dextral. The orientation published by these authors and by Yochelson & Jones places the main muscle-attachment in an unusual position near the top, whereas in both *Maclurites* and *Teiichispira* it is near the base. When the operculum is rotated to bring the boss toward the lower surface (and, incidentally, the apex nearer the position seen in *Maclurites*), the shape of the aperture of the conch may be predicted—higher than wide and with a distinct upper keel. If the step between the marginal rim and the main body of the operculum corresponds to the basal and outer whorl surfaces, the Tasmanian form would show a basal angulation to the whorl and the other two forms a rounded junction between the basal and outer walls. If the conch is indeed hyperstrophic, the apical cavity would be wider and shallower than that of *Teiichispira*, with, at least in the Alabama form, a concave upper whorl surface. Of known macluritid conchs, *Lecanospira* and its subgenus *Barnesella* best fit these specifications, the older *Lecanospira* matching the Tasmanian species, and *Barnesella* the slightly younger Malaysian and Alabama forms.

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PLATES 29 TO 34

Thin sections by H. M. Doyle and G. A. J. Terpstra; photography by H. M. Doyle.

PLATE 29

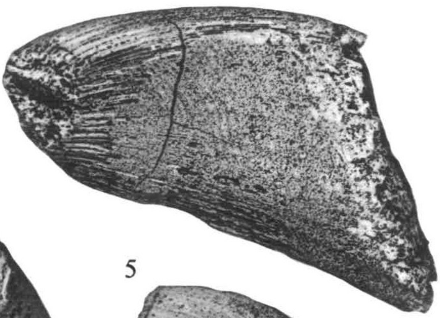
Figures 1-11. *Teiichispira cornucopiae* Tomlinson, 1969. **Holotype** operculum, CPC 11296, x 1.5. BMR loc. G317, 19.6 km east of Toko Waterhole, Glenormiston (1:250,000) Sheet, Queensland. Lower Ordovician (Arenig), Coolibah Formation.

Orientation. Anterior end at right in figures 1, 2, 7, 8, and 11; at left in figure 10. Outer surface at right in figures 4 and 5; at left in figures 3, 6, and 9. In figures 2, 5, and 9, specimen is illustrated upside-down with lower surface at top of picture.

1. Keeled junction of upper surface and upper part of outer surface.
2. Junction of upper, inner, and lower surfaces.
3. Anterior surface.
4. Posterior view of upper keel.
5. Junction of anterior and lower surfaces.
6. Anterior view of upper keel.
7. Lower surface.
8. Junction of lower and outer surfaces.
9. Posterior view of lower surface.
10. Junction of inner, lower, and anterior surfaces.
11. Outer surface.

1

2



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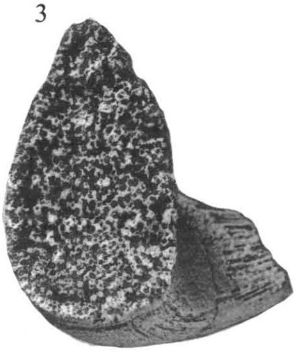

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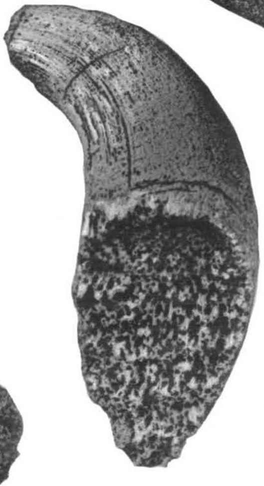

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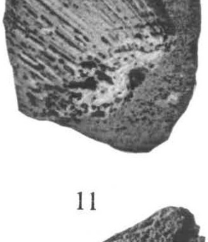

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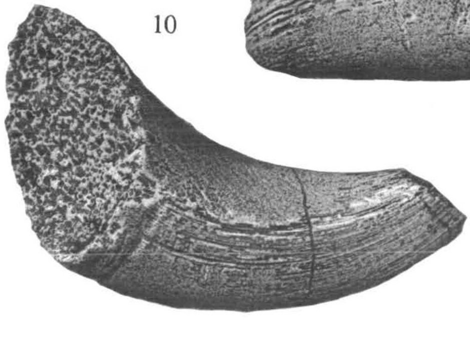

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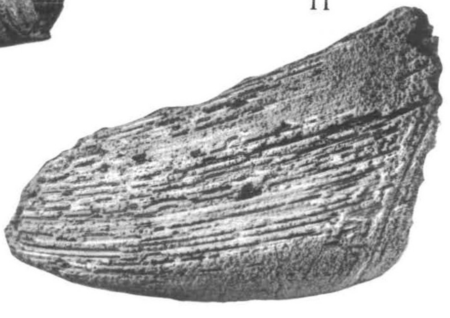


PLATE 30

Teiichispira cornucopiae Tomlinson, 1969. Three opercula. BMR loc. G317, 19.6 km east of Toko Waterhole, Glenormiston (1:250,000) Sheet, Queensland. Lower Ordovician (Arenig), Coolibah Formation.

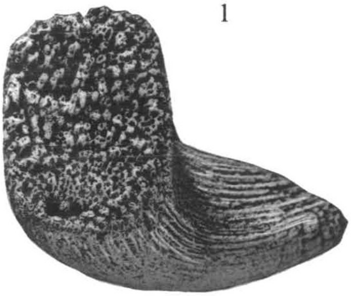
Orientation. Anterior end at right in figures 2, 3, 6, and 7; at left in figures 4 and 8. Outer surface at right in figures 1, 5, and 9. In figure 5, the specimen is illustrated upside-down.

Figures 1, 2, 4-8. CPC 11297, x 1.5.

1. Anterior surface showing possible site of muscle-attachment (lower left) and lower keel (foreshortened).
2. Lower surface.
4. Junction of anterior, inner, and lower surfaces.
5. Posterior view of lower surface.
6. Outer surface.
7. Upper view (upper keel eroded).
8. Junction of inner, lower, and anterior surfaces.

Figure 3. CPC 11298, x 1.5. Outer surface, showing two successive interruptions to growth (?healed fractures). The earlier (posterior) interruption generates a notch in the upper profile.

Figure 9. CPC 11299, x 3.3. Natural section parallel to anterior surface of imperfectly silicified specimen, showing possible site of muscle attachment in silicified part (lower left) and ?angular tubules in unsilicified part (centre and upper right).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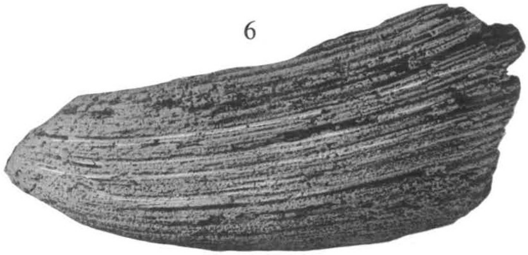
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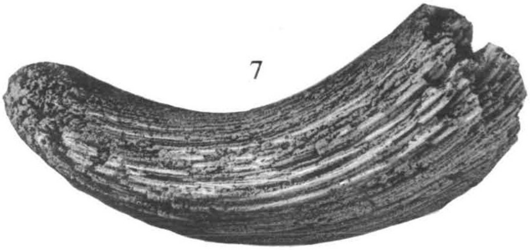
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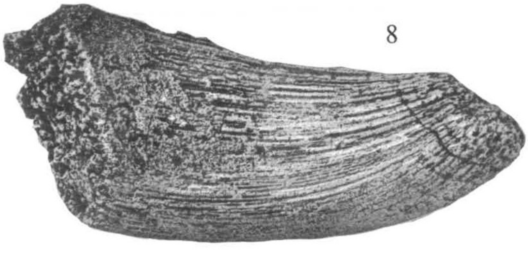
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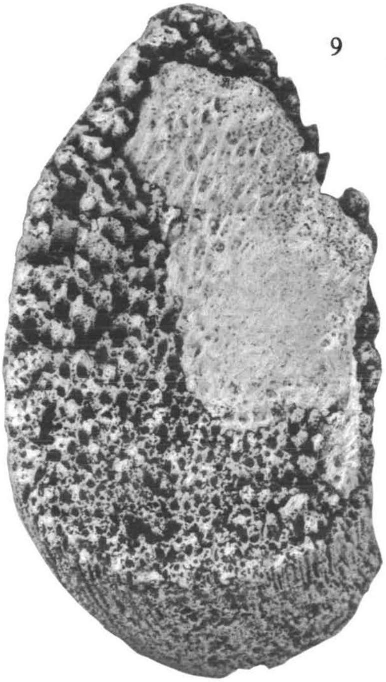
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PLATE 31

Figures 1-9. *Teiichispira cornucopiae* Tomlinson, 1969. Immature operculum, CPC 11300, x3. BMR loc. G321, 4.8 km west of Broken Dam, Toko Range, Glenormiston (1:250,000) Sheet, Queensland. Lower Ordovician (Arenig), Coolibah Formation.

Integument preserved on inner surface and on greater part of lower and upper surfaces. Specimen preserves unique known occurrences of inner keel, transversely concave inner surface, and faint angulation at junction of outer and lower surfaces. Bevelled rim to lower part of anterior surface and site of muscle-attachment are well preserved. White streak on lower part of anterior surface is an immovable fleck of chert.

Orientation. Anterior end at right in figures 2, 4, and 9: at left in figures 1, 5, and 8. Outer surface at right in figures 3 and 7; at left in figure 6.

1. Junctions of inner surface with upper, lower, and anterior surfaces.
2. Lower surface and, lower right, its junction with inner surface.
3. Posterior view, showing torsion. Longitudinal midline of anterior surface is vertical.
4. Keeled junction of upper and outer surfaces and, left, trace of inner keel.
5. Junction of upper and inner surfaces with anterior surface.
6. Anterior surface.
7. Junction of lower and anterior surfaces. Lower surface shows a faint longitudinal angulation.
8. Upper and inner surfaces. Stepped upper profile results from damage to upper keel.
9. Outer surface.

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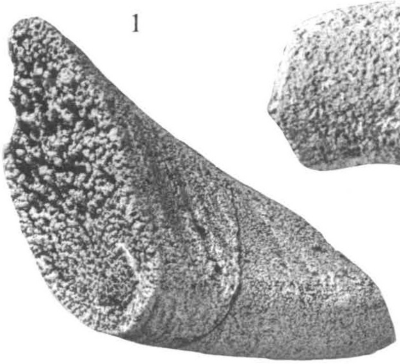

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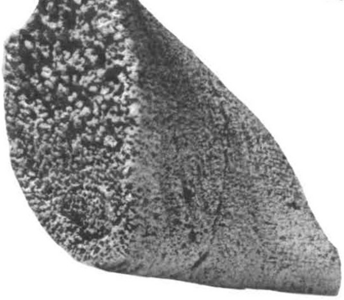

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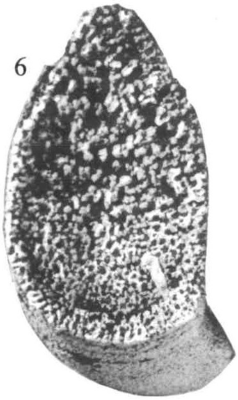

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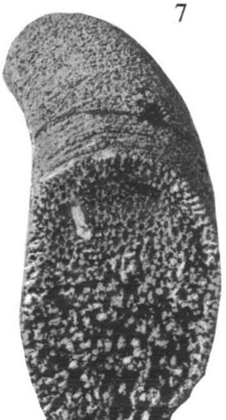

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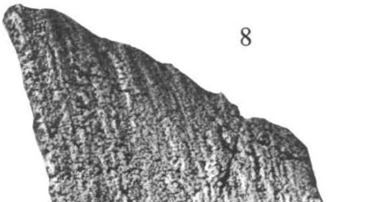

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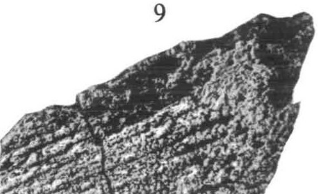

PLATE 32

Teiichispira cornucopiae Tomlinson, 1969. Five opercula. Lower Ordovician (Arenig), Coolibah Formation.

Orientation. Anterior end at right in figures 1, 6-8; at left in figures 2 and 5. Outer surface at right in figures 4 and 10; at left in figures 3, 9, and 11. In figure 4, the specimen is illustrated upside-down.

Figures 1-7. CPC 11301, x1.5. BMR loc. W271, 4.0 km northeast of Cravens Peak, Mt Whelan (1:250,000) Sheet, Queensland.

1. Outer surface, exfoliated, showing outer layer of fine contiguous tubules.
2. Upper and inner surfaces, showing deeper layer of coarse tubules (upper right).
3. Anterior surface, showing elongate radiating tubules near junction with lower surface.
4. Junction of anterior, lower, and inner surfaces.
5. Junction of anterior and inner surfaces, showing saucer-shaped depression on lower part of anterior surface, overhung by protruding upper part of same surface.
6. Keeled junction of outer and upper surfaces.
7. Lower surface.

Figure 8. CPC 11307, x3. BMR loc. T213, 4.8 km west of Half-way Dam, Tobermory (1:250,000) Sheet, Northern Territory (see note on identification of Formation, p. 81, above). Thin section roughly parallel to lower surface (see Text-fig. 5A). Tubules show as dark streaks or, particularly in anterior part, as light areas with darker walls. Origin of dark granules within tubules unknown. Ragged contact of inner surface with matrix (top) indicates considerable abrasion before burial.

Figures 9, 10. Natural sections roughly perpendicular to lower surface, showing effect of orientation of section on shape (compare the nearly triangular section of figure 11) and particularly on inclination of upper surface (gently sloping on 9, 10; steeply sloping on 11), x2. The mode of preservation, silicified crust enclosing recrystallized interior, is common.

9. CPC 11305. BMR loc. T101, 8 km south of Kelly Creek Bore, Tobermory (1:250,000 Sheet, Northern Territory. Anterior view. Definition of upper and lower keels accentuated by peeling of adjacent tubules.
10. CPC 11308, BMR loc. T436, c 18 km south-southwest of No. 7 Bore on track to Coolibah Yard (0.8 km south of T2), Tobermory (1:250,000) Sheet, Northern Territory. Posterior view. The ridge on the left, simulating the inner keel is, in fact, an adhering flake of matrix.

Figure 11. CPC 11306, x1.5 BMR loc. T213 (see figure 8, above). Natural section roughly parallel to anterior surface of partially silicified specimen. Imperfect silicification enlarges the postulated site of muscle-attachment.

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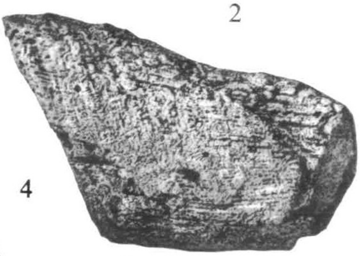

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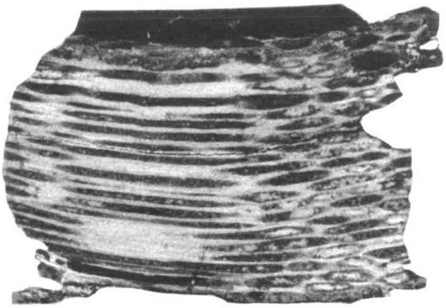

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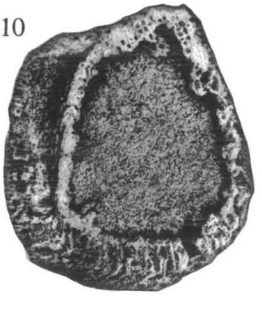

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PLATE 33

Figures 1-4, 6, 7, 9. *T. cornucopiae* Tomlinson, 1969. Assigned conch. CPC 11311, x1. Loc. FBH/G 41654, 0.8 km south of Half-way Dam, Tobermory (1:250,000) Sheet, Northern Territory. Lower Ordivician (Arenig), Coolibah Formation.

1. Artificial external mould of base.
2. Oblique apical view.
3. Lateral view.
4. Apical view.
6. Oblique basal view.
7. Basal view.
9. Lateral view, showing aperture.

Figures 5, 10. *Teiichispira* sp. indet. Thin section of opercula, x3. BMR loc. Kog 410, Gap Creek, Christmas Creek Station, Western Australia, lat. 18°35′S, long. 125°55′E. Lower Ordovician (late Canadian), Emanuel Formation (Faunal Stage IV).

5. CPC 11310. Transverse section, outer surface to left, all surfaces deeply eroded. On upper and middle parts, tubules show as dark patches with somewhat angular outlines. Texture of lower part obscured by recrystallization.
10. CPC 11309. Longitudinal section, orientation of section uncertain, anterior end at left. Tubules in upper part of picture ?partitioned; others filled with dark matrix.

Figure 8. *T. cornucopiae* Tomlinson, 1969. Thin section of operculum, CPC 11304, x3. BMR loc. T2, 16.4 km south-southwest of No. 7 Bore on track to Coolibah Yard. Toko Range, Tobermory (1:250,000) Sheet, Northern Territory. Lower Ordovician (Arenig), Coolibah Formation. Section cut through upper keel and middle of lower surface, anterior end to right (see Text-fig. 5C). Tubules in upper part are wider in proportion to their walls than those in lower part. Just above centre, a wide anterior tubule shows complete transverse partitions.

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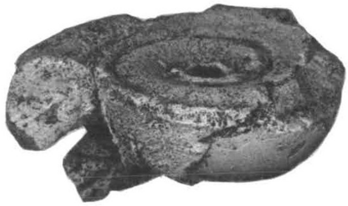

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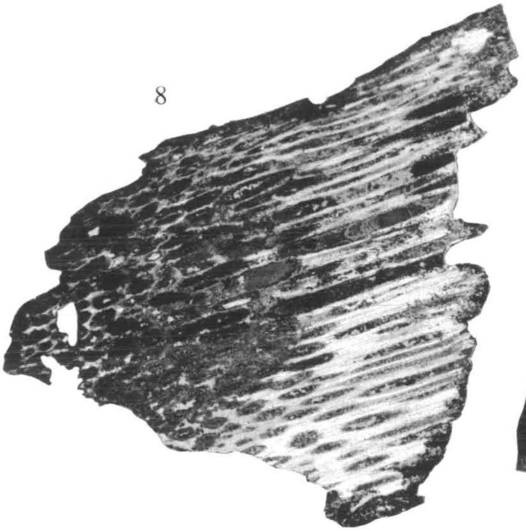

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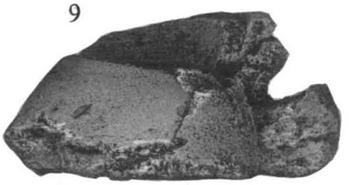

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PLATE 34

Teiichispira cornucopiae Tomlinson, 1969. Four opercula. Lower Ordovician (Arenig), Coolibah Formation.

Orientation. Anterior end at right in figure 4. Outer surface at right in figure 3; at left in figures 1, 2, 5, and 6.

Figures 1, 6. CPC 11303, x3. BMR loc. T2, 16.4 km south-southwest of No. 7 Bore on track to Coolibah Yard, Toko Range, Tobermory (1:250,000) Sheet, Northern Territory. Transverse sections, figure 1 posterior to figure 6, showing rounded tubules in main body of operculum, slightly elongate tubules near lower margin, and fine close-set tubules at lower margin of Figure 1.

Figures 2, 5. CPC 11308, x3. BMR loc. T213, 4.8 km west of Halfway Dam, Tobermory (1:250,000) Sheet, Northern Territory (see notes on identification of Formation, p. 81 above). Thin sections cut perpendicularly to lower surface (figure 2) and parallel to anterior surface (figure 5) (see Text-fig. 5B).

Figure 3. CPC 11296, **holotype,** x1.5. BMR loc. G317, 19.6 km east of Toko Waterhole, Glenormiston (1:250,000) Sheet, Queensland. Posterior view, showing torsion.

Figure 4. CPC 11302, x3, BMR loc. T2 (see figures 1, 6). Longitudinal section; for orientation see Text-fig. 5D, E.

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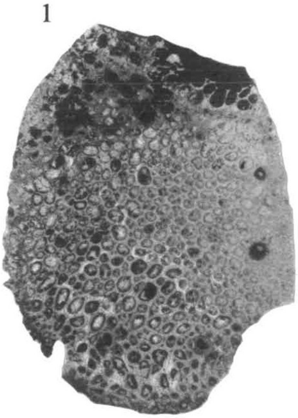

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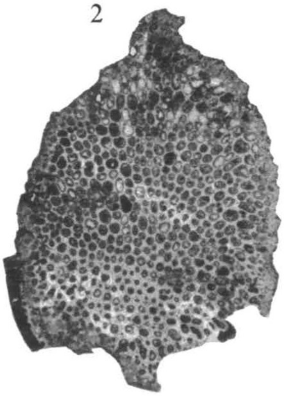

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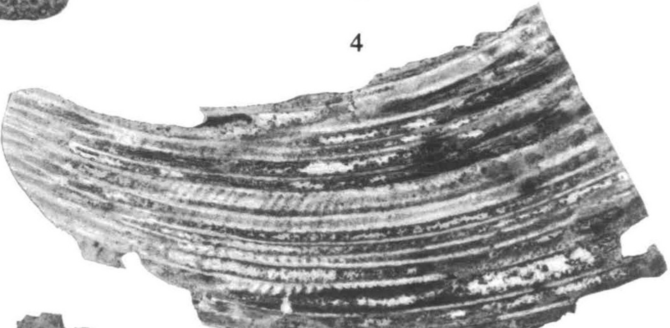

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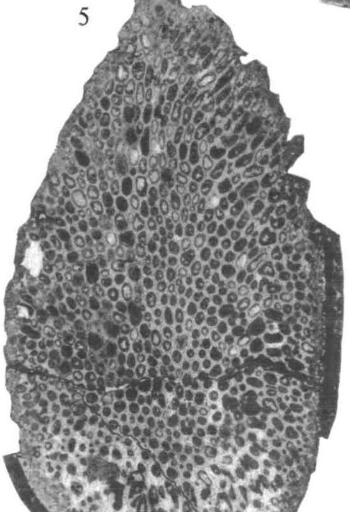

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