Palaeogeography of the Australian-New Zealand Region in Lower Devonian Time

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Summary

IN Lower Devonian time, a shoreline is believed to have extended from Borneo down eastern Australia and then eastwards extending up the Marshall Line to the east of New Zealand, leaving Antarctica a land mass which isolated the Malvinocaffric marine faunas from those of these seaways Tasmantis is believed to have occupied most of the area in between Australia and New Zealand. The Tasman Geosyncline and the New Zealand Geosyncline are thought to have developed intracontinentally on the palaeogeographic continent of Austzealandia as parageosynclines.

Three new species of *Maoristrophia* (a genus formerly known only in New Zealand) are described, *M. careyi* and *M. banksi*, from Zeehan, Tasmania; and *M. keblei* from Mooroolbark, Victoria. Other palaeontological data for trans-Tasman Lower Devonian correlation are summarized. An attempt is made to reconstruct some of the conditions existing on the land and in the sea at that time.

INTRODUCTION

ALTHOUGH Australia and New Zealand are geotectonically parts of one great continent (Bryan, 1944; de Jersey, 1946; Marshall, 1947), they have been long separated from one another geographically. Much remains to be deciphered concerning the relationships of these two areas in geologic time, but the present paper is an attempt to outline some of the relationships which existed during the Lower Devonian period. The purpose is to record new information, and to summarize and interpret what is so far known.

Schuchert (1932) stressed the desirability of making palaeogeographic maps to cover as short a space of time as possible. Later on, no doubt, maps will be made for the various subdivisions of the Lower Devonian, but at present knowledge is too limited to allow one to attempt a palaeogeographical map for any length of time less than for the whole Lower Devonian period.

In New Zealand the Lower Devonian beds occur in the South Island in rough mountain country, where the structure consists of a jigsaw of fault blocks (Henderson, Grange, and MacPherson, 1930). The faunas of two localities have been described (Allan, 1935; Shirley, 1938), and these were visited by the writer under the kind guidance of Dr. Brian Mason. In Australia, Lower Devonian deposits extend down the eastern side of the continent associated with the Tasman Geosyncline. Recently, evidence has been put forward of Lower Devonian beds in Tasmania (Gill, 1948b, 1949b).

IMPORTANCE OF FACIES

Allan (1935, etc.) wisely called attention to the importance of facies in the study of the Lower Devonian marine deposits in New Zealand and elsewhere. The difference between the faunas of the Reefton Beds and the Baton River Beds in New Zealand was not understood until the factor of facies was taken into account. The same applies to the differences between the faunas of the same age

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in Australia. Twenhofel (1931, p. 424) went so far as to lay down the principle that "Correlation on the basis of fossils alone is not entitled to a great deal of respect."

In Victoria, the writer (Gill, 1939, 1942, 1945a, b, 1948a) has drawn attention to the Bohemian facies of the Lilydale and Killara faunas. Most of the faunules are of the Koneprusy or inner off-shore type, but the *Styliolina* mudstone found at Coldstream and at Killara (Gill, 1941) is rather of the Kosor or outer off-shore facies. The beds of the Whittlesea-Kinglake area are now recognized as being of the in-shore or Rhenish type, and therefore facially comparable with those at Reefton in New Zealand, as the Lilydale beds are with those at Baton River. The Whittlesea beds approximate to the inner in-shore or Siegen type, and those at Kinglake to the outer in-shore or Hunsrück type of facies. These are, of course, generalizations, the suites of sediments being considered as a whole, i.e., as megafacies. There is quite a range of variation in each case, and as knowledge advances the various microfacies will be differentiated.

None of the beds was laid down in particularly deep waters. They were all of the types which we find on the continental shelves of the present day. The *Styliolina* beds no doubt had over them the greatest depth of water of any of the sediments discussed. Modern studies of marine sediments show that sedimentation in really deep waters is so exceedingly slow that we must expect to find but rarely sediments of this type in geological successions. But it must not be taken for granted that there was a continental shelf in Lower Devonian times as now. This has yet to be proved. Many factors have contributed to give the continental shelves of the present time, including the glacio-eustatic changes of the Pleistocene, and it may be doubted whether similar shelves existed in Lower Devonian times. There may have been a gradual deepening off shore, and no continental slope as we know it.

Lower Devonian Ocean

In seeking to reconstruct the conditions of Lower Devonian times, the following characteristics of the ocean can be determined:

(1) The ocean was not as large in volume then as now. All the juvenile waters added by volcanic activity since Lower Devonian times have increased its volume.

(2) The seas of the region concerned were warmer then than now, as is witnessed by the presence of coral bioherms so much further south than at present. This can hardly be explained as merely the effect of a warm current, because, first, the present East Australian current is a warm one which flows southwards from the tropics down the east coast of Australia then swings east to New Zealand, and, secondly, there is evidence that world-wide climates were warmer then than now.

(3) Although fish constitute so conspicuous an element of the faunas of Lower Devonian age in some other parts of the world, they appear to be absent from Australasian faunas of this age.

(4) The presence of normal in-shore (Rhenish) and off-shore (Bohemian) sediments containing closely related faunas in both New Zealand and Eastern Australia indicates that a shoreline existed in Lower Devonian times which allowed migration from one area to the other. An attempt is made in this paper to arrive at some idea of the location of that shoreline.

AUSTRALASIAN LOWER DEVONIAN SHORELINE

It is at this point that the paucity of our knowledge becomes most apparent. The following is a summary of available evidence as interpreted by the writer:

(1) The more or less meridionally aligned deposits of Lower Devonian age in Eastern Australia are part of the enormous Tasman Geosyncline (Schuchert, 1916; Bryan, 1933, 1944; Andrews, 1938; Browne, 1947). This is a structure of world significance—a first order geosyncline. The sediments incorporated in this structure must have extended laterally something like 500 miles before being folded against the Australian shield, thus forming many of the mountain areas of Eastern Australia, including Tasmania.

The geosyncline extends from Queensland to Tasmania, but it apparently did not reach Antarctica. However, the geosyncline is still a major structure in the south of Tasmania. The large submarine bank south of Tasmania (*vide* fig. 2) is still probably a block of similar structure to Tasmania which has been let down under the sea in the general foundering of the crust between Tasmania and Antarctica.

The classification of the Tasman Geosyncline (*vide* Glaessner and Teichert, 1947) depends on whether the Tasman Sea area was an expanse of sea or land during the time concerned. If it were sea, then the Tasman Geosyncline may be regarded as an orthogeosyncline. The interpretation accepted in the accompanying palaeogeographic maps regards the Tasman Geosyncline as a parageosyncline developed between massifs in the big Austzealandic* continent. This interpretation pictures two more or less parallel geosynclines of large size—the Tasman Geosyncline and the New Zealand Geosyncline (so named by Schuchert in 1916). These geosynclines were preceded by earlier ones represented by the metamorphosed sediments of pre-Cambrian to early Cambrian age in Australia, New Zealand, and Antarctica.

(2) The Lower Devonian beds of the Tasman Geosyncline carry faunas of both in-shore (Rhenish) and off-shore (Bohemian) facies. They provide evidence of a Lower Devonian shoreline running roughly meridionally down the east side of Australia. Lower Devonian faunas have been recognized in East Borneo (Rutten, 1940), Queensland, New South Wales, Victoria, and Tasmania. The presence of lavas and tuffs interbedded with Lower Devonian sediments in Eastern Australia indicates a cycle of vulcanism, which no doubt was associated with a crustal instability to be associated with the edge of a large geosyncline. The presence of radiolarian cherts of this age in East Borneo suggests deeper waters than prevailed at that time in the Tasman Geosyncline, where sandstones, quartzites, shales, and limestones predominate. The Queensland radiolarian cherts belong to a later period, viz. Middle Devonian (Bryan and Jones, p 30).

(3) The Lower Devonian beds in New Zealand form a part of another large geosyncline, enclosing strata with a long time range.

(4) The more they are studied, the more alike one another the New Zealand and East Australian Lower Devonian faunas are found to be. Further

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* The name "Austzealandia" is here proposed for the palaeogeographic continent because the name "Australasia" stands for Australia and New Zealand as separate entities, and so does not lend itself to the description of a structure involving the space between the two areas in addition to the areas themselves.

evidence of this similarity is provided in this paper (fig. 1). Of special significance is the description from Victoria and Tasmania of three species of the brachiopod *Maoristrophia,* a genus previously known only from New Zealand (Allan, 1947; Gill, 1948c).

(5) A shoreline connected the beds in New Zealand with those in Australia, and the most likely location for this, in the writer's opinion, was to the south, because:

(a) There are no Silurian or Lower Devonian rocks in Antarctica, as far as is known. This suggests that the area was a land surface during the Lower Devonian. Some Upper Devonian fish plates have been found at Granite Harbour in the Ross Dependency at the base of the Beacon Sandstone, which is mostly Gondwana in age (Woodward, 1921; Seward, 1914; David and Priestley, 1914, p. 243). Moreover, the Beacon Sandstone appears to belong to a different tectonic cycle from that involving the Lower Devonian beds further to the north.

(b) The close similarity between the Lower Devonian faunas along the Tethys seaway (cf., for example, those from Indo-China) and those in Australia indicates a ready migration route from waters to the north of Australia into Australian waters. The string of Lower Devonian deposits from Northern Queensland (Chillagoe limestone) right down to Tasmania likewise indicates an uninterrupted coastline.

(c) The close similarity between the south-east Australian and New Zealand Lower Devonian faunas indicates a ready migration route along a coast between those two areas. (b) and (c) together thus indicate a ready migration route—and therefore coastline—all the way from the Tethys seaway to New Zealand. To draw a palaeogeographic map connecting the northern part of Australia with New Zealand in a continuous land mass is not in keeping with the presence of the Tasman Geosyncline, nor with the palaeontological evidence put forward in this paper.

(d) The series of coral bioherms of both Upper Silurian and Lower Devonian age extending down the east Australian states into Tasmania, suggests freedom from colder polar currents.

(e) The isolation in Lower Devonian time of the Australia-New Zealand region (part of the Boreal marine palaeobiological province) from South America and South Africa (the Austral province, recently renamed the Malvinocaffric province—*vide* Rud. and E. Richter, 1942) demands an arrangement of land and sea which biologically isolates Australia and New Zealand from South America and South Africa. A land bridge connecting Australia and New Zealand with Antarctica would materially assist such isolation.

Allan (1947) has recently shown that the Malvinocaffric element previously (1935, 1942, 1945) believed present in the brachiopod fauna of the Reefton Beds does not really exist. There was also an alleged Malvinocaffric element in the trilobite fauna. Allan described *Homalonotus* (*Burmeisteria*) *huttoni,* noting that the subgenus was based on a species from beds in South Africa and the Falkland Islands However, in a paper on Homalonotid trilobites, the writer (1949b) commented that "The presence of tubercles on Allan's species suggests its association with *Burmeisteria,* but it cannot be so placed because the facial sutures cut the genal angles. It is probably

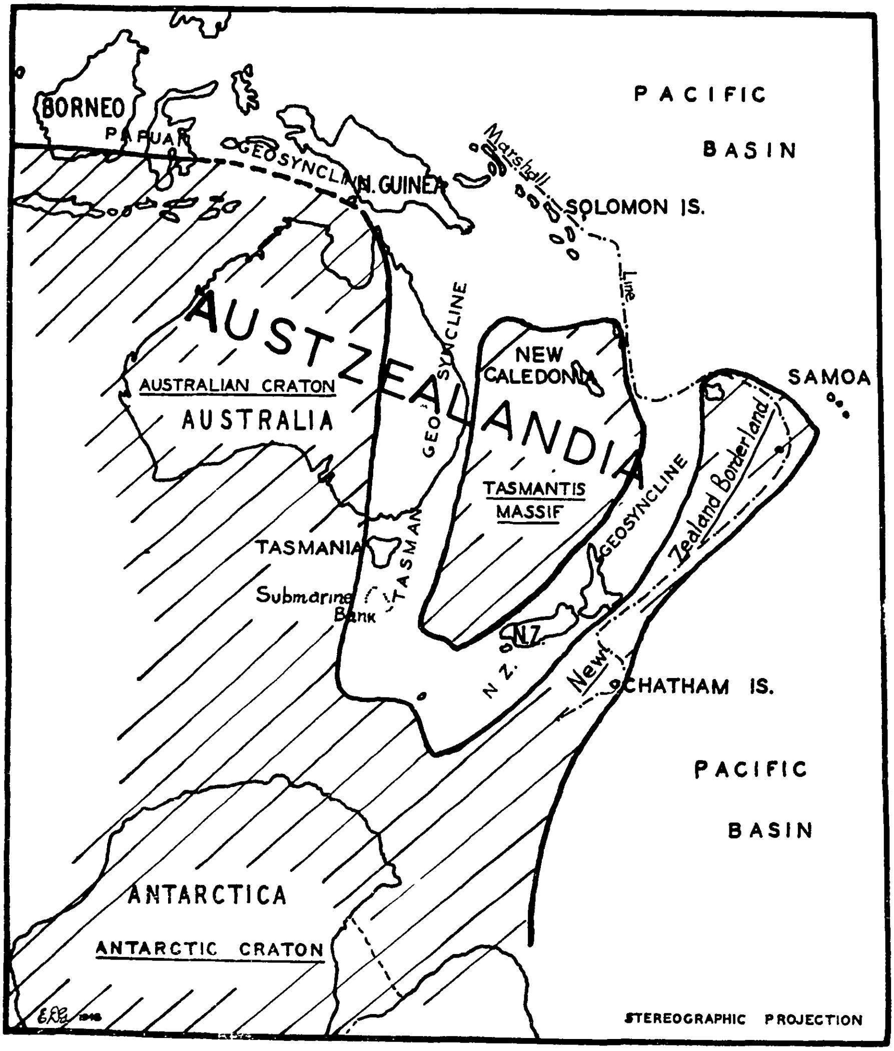
FIG. 1—FOSSILS FOR CORRELATION OF MARINE DEVONIAN STRATA OF NEW ZEALAND AND AUSTRALIA

Phylum	New Zealand Fossil	Literature Reference	Compared Australian Fossil	Literature Reference
PORIFERA	*Receptaculites australis* Salter	Shirley, 1938	*Receptaculites australis* Salter	Gill, 1942
COELENTERATA	*Pleurodictyum megastomum* Dun	Do.	*Pleurodictyum megastomum* Dun	Do.
	Eridophyllum bartrumi Allan	Allan, 1935	*Eridophyllum bartrumi* Allan	Hill, 1941
	Xystriphyllum dunstani (Etheridge)	Do.	*Xystriphyllum dunstani* (Etheridge)	Hill, 1939
	Favosites murrumbidgeensis Jones	Do.	*Favosites murrumbidgeensis* Jones	Jones, 1937
BRYOZOA	*Fenestrellina* cf. *exilis* Pocta	Shirley, 1938	*Fenestrellina margaritifera* (Chapman)	Chapman, 1903
BRACHIOPODA	*Schizophoria provulvaria* (Maurer)	Allan, 1935 Shirley, 1938	*Schizophoria provulvaria* (Maurer)	Gill, 1942
	Fascicostella gervillei (Defrance)	Shirley, 1938	*Fascicostella gervillei* (Defrance)	Do.
	Hipparionyx minor Clarke	Do.	*Hipparionyx minor* Clarke	Do.
	Eatonia bithynica Paeckelmann and Sieverts var.	Do.	*Eatonia* (*Eatonia*) aff. *bithynica* Paeckelmann and Sieverts	This paper
	Eospirifer togatus (Barrande)	Do.	*Eospirifer* spp.	Gill, 1942
	Eospirifer secans (Barrande)	Do.		
	Nucleospira cf. *marginata* Maurer	Do.	*Nucleospira* cf. *marginata* Maurer	Do.
	Cyrtinopsis perlamellosus (Hall) = *C.* aff. *cooperi* Gill	Shirley, 1938, & this paper	*Cyrtinopsis cooperi* Gill	This paper
	Chonetes (*Chonetes*) *maoria* Allan	Allan, 1935	*Chonetes* (*Chonetes*) *cresswelli* Chapman	Chapman, 1903, and Gill, 1945b
	Chonetes (*Chonetes*) *nigricans* Allan	Do.		
	Maoristrophia neozelanica Allan	Allan, 1947	*Maoristrophia careyi*, *M. banksi*, *M. keblei*, spp. nov.	This paper
TRILOBITA	*Gravicalymene angustior* (Chapman)	Shirley, 1938, & Gill, 1945a, 1948b	*Gravicalymene angustior* (Chapman)	Chapman, 1903, and Gill, 1945a, 1948b

TEXT-FIGURE 1

better accommodated in *Trimerus.*" Allan also re-described *Homalonotus (Digonus) expansus* Hector, but *Digonus* like *Trimerus* is a Boreal form.

It would thus appear that the trilobites, like the brachiopods, show no Malvinocaffric affinities. The Australia-New Zealand region was biologically isolated from the South American-South Africa region as far as marine faunas are concerned. This is an important fact to be taken into account when drawing palaeogeographic maps. It does not encourage the theory of a Samfrau geosyncline.



TEXT-FIGURE 2

(6) As already noted, the Tasman Geosyncline was of great lateral extent. Keeping in mind the principles of marine sedimentation, it is to be expected that sediments were provided from both sides of the geosyncline in order to give so wide a lateral spread of sediments all belonging to waters of moderate depth. A "Tasmantis" borderland on the east side of the Tasman

Geosyncline has already been hypothecated (Bryan, 1933, fig. 1; Andrews, 1938, pl. 1; Jensen, 1926, p. 151), and this may well have extended far enough eastwards to provide a western borderland for the New Zealand Geosyncline. This is in keeping with the fact that islands like New Caledonia have no Silurian and Devonian rocks in them. The pre-Cambrian rocks there may well have been part of a land mass in Lower Devonian times. In view of the probable permanence of the Pacific Ocean (Marshall, 1948), the tectonic importance of the Marshall Line (Bryan, 1944; de Jersey, 1946), and the sedimentational likelihood that the big New Zealand Geosyncline possessed a borderland to the east, such has been inserted in the palaeogeographic maps (figs. 2, 3). This interpretation is supported by the fact that the Chatham Islands and Fiji Group have a lacuna in their stratigraphical column similar to that found in New Caledonia. So the Chatham Islands and Fiji areas were probably land surfaces in Lower Devonian times

LOWER DEVONIAN LANDSCAPE

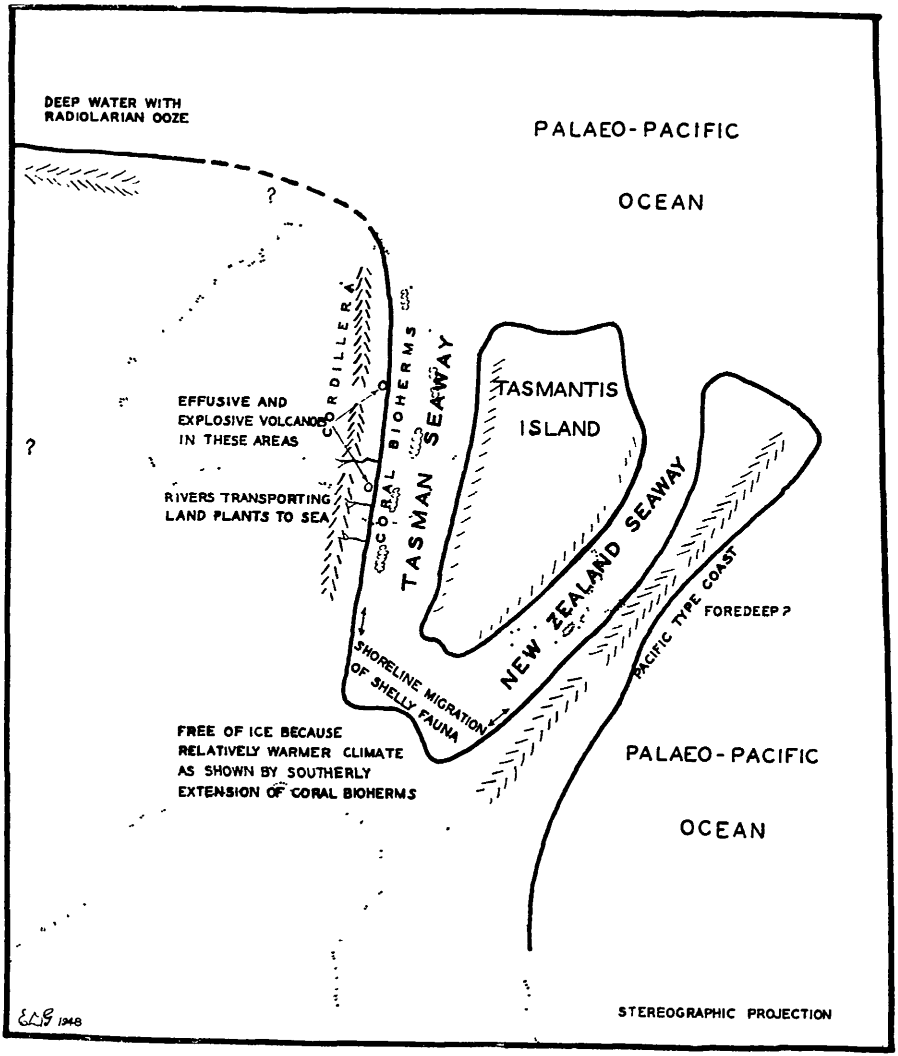
Quite high land must have existed in Lower Devonian times alongside the Tasman geosynclinal trough in order to provide such great thicknesses of strata over so wide an extent in so limited a period of time. This is diagrammatically represented on the palaeogeographic map (fig. 3) as a mountain range. Similarly, ranges are placed along the New Zealand eastern borderland and in Tasmantis.

Where land plants occur in Upper Silurian and Lower Devonian marine beds, it is concluded that some river system debouched into the sea in that area, and so rivers are shown diagrammatically in fig. 3. In those times the land must have been largely bare, simple plants like *Baragwanathia, Yarravia, Hedeia, Zosterophyllum,* and *Pachytheca* (Lang and Cookson, 1935; Cookson, 1935) occupying low areas where there was a sufficient water supply, and where the ground was flat enough to prevent scour. Being spread by spores, it is probable that the plants also occurred in such recesses in the landscape which fulfilled the required conditions of growth. Nevertheless, the land must have been largely bare.

The force of running water was much greater in those times because there were no trees and shrubs to control flowage of water. The physiography must have been very sharp and bare compared with most modern landscapes. The valleys were probably something like the "wadies" in present semi-arid areas where the stream beds are dry most of the time, but carry rushing torrents in wet weather.

Such a physiography would cause the formation of big alluvial fans, and would affect the nature of the sedimentation in the sea, especially in the areas near the river mouths. The influence of subaerial agencies (such as oxidation, heat and cold effects, winds) would be much more direct than is now the case in most climates, because of the bareness of the land. There would be little soil as we know it. One imagines that there would be lack of humus, and of soil populations as we know them.

The Lower Devonian plants were rather slender in structure. *Baragwanathia* appears to have been the largest plant in this flora, but it probably did not exceed 18 in. in height, and was usually much shorter. The thickness of the "stems" as seen on slabs of rock where they have been preserved as fossils is not, of course, their original diameter, but one greatly extended as a result of flattening on the bedding plane. The maximum diameter of a *Baragwanathia* stem was probably of the order of one centimetre. Such small plants, with their



TEXT-FIGURE 3

limited distribution (as suggested above), would afford very limited vegetative cover.

DATA FOR CORRELATION

Figure 1 sets out the names of the fossils on which correlation between strata in Australia and New Zealand is based. They are either identical or closely related forms. The determinations are those which have been published in literature, and to this references are provided. Some of the determinations are capable of refinement, but this is not of great moment for the present study, which aims at discovering to what extent the same or similar forms occurred in the two areas under discussion in Lower Devonian time.

Corals. It should be noted that the corals ***Eridiophyllum bartrumi, Xystriphyllum dunstani,*** and ***Favosites murrumbidgeensis*** are Middle Devonian forms, but are included because they occur at Reefton immediately above and conformably with the Lower Devonian strata, and because they occur in Australia also, *Maoristrophia.* Of the Lower Devonian fossils, one of the most significant is *Maoristrophia,* a genus of brachiopods recently erected by Allan (1947). When Allan described the genus, it was monotypic, but the writer had in hand the material now described as *Maoristrophia keblei* on which it was intended to erect a new genus. *Maoristrophia careyi* and *M. banksi* were then recognized in Tasmania. *Maoristrophia* is thus a genus of brachiopods found in both inshore and offshore facies, which is limited to Australia and New Zealand as far as is known at present. Such a brachiopod would require shallow water in which to migrate, and to find it on both sides of the Tasman Sea is indeed significant.

Cyrtinopsis. In 1942 the writer described a brachiopod from Mooroolbark, Victoria, as *Cyrtinopsis perlamellosa,* it being the same or very similar to a form so named from the Baton River Beds in New Zealand (Shirley, 1938). In 1944 Cooper (in Shimer and Shrock, 1944) referred *Cyrtinopsis perlamellosa* to the genus *Delthyris* (p. 327). In a recent letter, Dr. Cooper kindly further commented on this change relative to the Victorian form as follows: "I studied the figures of the specimens so identified and quite agree that it belongs to the genus *Cyrtinopsis,* but I cannot agree on the species. Our species *perlamellosa* quite clearly belongs to the genus *Delthyris.* It develops a spondylium-like structure secondarily and thus simulates *Cyrtinopsis.*"

The Victorian species is a new one, which I now name *Cyrtinopsis cooperi,* designating as the holotype the specimen figured in Gill, 1942, plate VI, fig. 7, which is reg. no. 1723 in the University of Melbourne Department of Geology Museum. Figure 6 on the same plate (reg. no. 1722) is then a paratype.

Chonetes. The New Zealand species do not belong to the gens of *Chonetes sarcinulata,* but to that of *Chonetes cresswelli* and *C. robusta* found in Victoria (Gill, 1945b). The external ornament, the length of the ventral median septum, and the size and degree of definition of the ventral muscle field are different from those found in *C. sarcinulata,* but similar to those found in *C. cresswelli* and *C. robusta.*

Eatonia. In the National Museum Collection, Melbourne, there is a steinkern (reg. no. 14,603) and an external mould (reg. no. 14,604) of a specimen of *Eatonia* collected by the author from the Seville limestone quarry, near Killara (*vide* map, Gill, 1945a), which belongs to the subgenus *Eatonia* because it has a poorly developed fold and sinus, a radially striate ornament, and an elongate ventral muscle field. The form is closely comparable with that described from the Baton River Beds in New Zealand by Shirley (1938) as *Eatonia bithynica* var. It is suggested that for the time being the Victorian form go under the name *Eatonia* (*Eatonia*) aff. *bithynica.* Like the New Zealand form, it has six ribs in the sinus and not four as in *E. bithynica.* Similar brachiopods have been collected from Lilydale and Mooroolbark.

Other Evidence for Correlation. The evidence for correlation set out in fig. 1 is by no means complete, as there are so many forms yet to be described. The genera *Leptostrophia, Cymostrophia, Rhytistrophia, Brachyprion, Camarotoechia, Conchidium, Cyrtina, Cypricardinia, Actinopteria, Grammysia, Palaeoneilo, Goniophora, Tentaculites, Platyceras, Trimerus,* and *Scutellum* are represented in both Australian and New Zealand Lower Devonian strata. However, the list given in fig. 1 is objective, the names referring to actual figured and/or registered specimens preserved in well-known collections, and thus capable of check. Lists of names only are of very limited value.

DESCRIPTION OF NEW SPECIES

Genus MAORISTROPHIA Allan, 1947

Maoristrophia careyi sp. nov. Pl. 36, figs. 1–4

Type Material. Holotype consisting of (a) steinkern (N.M.V.* reg. no. 14,605) and (b) external mould (N.M.V. reg. no. 14,606) of a ventral valve in light grey fine-grained arenaceous shale. *Paratype* consisting of (a) steinkern (N.M.V. reg. no. 14,607), (b) external mould (N.M.V. reg. no. 14,608) of a dorsal valve in the same matrix.

Locality. Right bank of Little Henty River, one mile S.E. from Zeehan, West Tasmania.

Stratigraphical Horizon. Lower Devonian

Description of Holotype (Pl. 36, figs. 1–2). Shell mildly convex, sub-semicircular—1 8 cm. wide and 1 2 cm. long. Hinge line straight, and approximately equal to greatest width of shell. Distinct but shallow median fold. (Holotype has also an artificially impressed fold on the right side of the median fold.) External surface covered with fine costellae with a frequency of 4 to 5 per mm. on the anterior margin of the valve. The costellae tend to alternate in size, smaller ones occurring between each pair of larger ones. This is due to the fact that the costellae increase in number by intercalation, and each new costella only gradually attains the diameter of the primary costellae. The costellae are rounded in cross-section. They are faintly impressed on most of the interior surface of the shell as is shown by the steinkern, and as is often the case in strophomenid shells. The ornament on the interior surface is much more strongly marked along the anterior margin of the shell. This is probably due to the animal continuing throughout its growing life to secrete shell substance on the inner surface of the exoskeleton so that it would have increasing strength with increasing size. This process would gradually cover the ornament on the interior surface margin where there had been a minimum of secondary deposition.

On the interior of the ventral valve there is a fine linear median septum 4 5 mm. long. Dental plates of similar length, but slightly wider and much higher, form angles of 40°–45° with the median septum. At the posterior end, the septum widens out into a platform which narrows again posteriorly. Up the middle of the platform is a furrow (i.e., a ridge in the steinkern). A similar structure is to be seen in other strophomenids, e.g., one was recently described in *Strophonella australiensis* (Gill, 1948b).

A row of teeth occurs on each side of the umbo, reaching a point 3·5 mm. therefrom on each side, i.e., a little more than a third of the distance to the cardinal angle. The teeth are regular in size, and slope inwards towards the umbo at about 80°. The teeth would thus prevent any side-slip of the valves. The palintrope is wider where the teeth are, but even there it is a little less than $\frac{1}{2}$ mm. wide. It tapers slightly towards the cardinal angles. The inter-area is smooth in the non-dentate parts. The shell is thickened in the region of the teeth-files.

The interior of the valve is very finely papillate, the papillae appearing as minute pits in the steinkern. The papillae are orientated to the costellae of the external surface.

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* N.M.V. = National Museum of Victoria, Melbourne.

Comment. Maoristrophia careyi conforms closely to Allan's diagnosis of the genus (1947, p. 440). The most obvious difference is its sub-semicircular instead of sub-quadrate outline. *M. careyi*, like all the Australian species of this genus described herein, is notably smaller than the New Zealand form, *M. neozelanica*. The cruralia vary also in the detail of their structure, and in the new species the costellae are rounded and not sharp-angled as described for the New Zealand species.

The species is named after Professor S. Warren Carey, of the University of Tasmania, who introduced the writer to the fossil locality from which these specimens were collected.

The shale in which these fossils is preserved has a well-developed cleavage at a sharp angle to the natural bedding as a result of crushing in the Zeehan syncline. This cleavage sometimes makes collection of fossils difficult, the rock breaking along the cleavage planes instead of the bedding planes. Even when it does break along the bedding plane the rock sometimes disintegrates into small pieces, thus destroying the fossils. This is one reason why the counterparts of some of the fossils described in this paper could not be collected.

Description of Paratype (Plate 36, figs. 3–4). Shell of same size, proportions, and ornament as the ventral valve, except that there is a sinus to correspond with the ventral median fold Interior surface with papillae and traces of costellae as in other valve. Teeth not well developed in this specimen; part of the structure has crumbled away. Bifid, sessile cardinal process. The prongs are directed into the interior of the shell, more or less at right angles to the plane of the valve as a whole. The prongs are elongated posterior-anteriorly, and are splayed apart. On each side are strong socket ridges. Median septum wide but not high. Posteriorly, it fuses with the cardinal process; anteriorly it flattens out into the floor of the shell.

Maoristrophia banksi sp. nov. Pl. 36, figs. 4–8

Type Material. Holotype consisting of the steinkern (N.M.V. reg. no. 14,609) of a ventral valve in light grey fine-grained arenaceous shale. *Paratype*, consisting of the steinkern (N.M.V. reg. no. 14,610) of a dorsal valve in the same matrix as the holotype. *Hypotypes* consisting of the steinkern (N.M.V. reg. no. 14,611) of the ventral valve of a young specimen; and the steinkern of a ventral valve on the same slab as the paratype external mould of *Maoristrophia careyi* (Pl. 36, fig. 4; N.M.V. reg. no. 14,608).

Locality. Same as *Maoristrophia careyi.*

Stratigraphical Horizon. Lower Devonian.

Description of Holotype (Pl. 36, fig. 7). Shell sub-quadrate in outline, 1 6 mm. long and 1 9 mm. wide approximately. Fine median septum reaching about 8 mm. from the umbo. Dental plates stronger in construction than median septum, but tapering anteriorly; they curve round the muscle field. Teeth files similar to those in *M. careyi.* Interior surface finely papillose, the papillae being aligned to the costellae, which are faintly shown on the interior surface, and also tend to alternate in size as in *M. careyi.* There are about the same number of costellae per mm. as in the compared species.

Description of Paratype (Pl. 36, fig. 8). Width 17 mm. and length about the same. Shell sub-quadrate with axial sinus exaggerated a little by crushing. Fine closely packed papillae associated with faint impressions of external costellae. In the steinkern, the pits left by the papillae are not on the ridges of the ornament, i.e., on the intercostellar spaces, but between them, i.e., on the underside of the external ridges. They would therefore (a) interfere with any structure of the mantle following the costellae, and (b) they would strengthen the costellae on the tops of the ridges, i.e., where the exoskeleton was most likely to suffer impulsive loading from impact with other bodies. In another paper (Gill, 1949a) the probable significance of similar structures in the genus *Chonetes* has been discussed. On the steinkern, counts of the number of costellae are generally less than for the external mould, because all the finer intercalated costellae do not show on the interior of the shell. Even on the exterior of the shell the count can vary in different parts according to the number of incipient or new intercalations present.

Cardinalia well developed. Two-pronged sessile cardinal process, more rounded than, and not splayed so much as, those in *M. careyi.* They merge into the median septum, which is much stronger than in the compared species. It is comparatively wide and high posteriorly, and gradually reduces in width and height anteriorly. It reaches about halfway down the length of the valve, merging imperceptibly into its floor. The crural ridges are much more knobby than in *M careyi.* They abut on the short tooth files, which are well developed in this species.

Pleurodictyum megastomum occurs on the same slab as the paratype.

Description of Hypotypes. The chief interest of the young ventral valve (Pl. 36, figs. 5–6) is that at this stage the median septum is short and but poorly developed, while the teeth files are well developed. The teeth files occupy 3·5 mm. of a total width of 7 5 mm.—nearly half the width of the hinge margin. The length is also 7·5 mm. It would appear that the articulation processes were an early development in this species, while the median septum grew as a secondary deposition with the general growth of the shell. It apparently lengthened as the size of the muscle field increased.

The hypotype on the same slab as *M. careyi* (Pl 36, fig. 4) is 12 mm. long and about 14 mm. wide. The left side of the valve is slightly overlapped by the paratype of *M. careyi,* and so a precise measurement of width cannot be given.

Comment. Maoristrophia banksi has the sub-quadrate outline of the genotype, but is much smaller. Our species has rounded and not sharp-edged costellae as in the genotype. The cardinal processes and socket ridges of *M. banksi* vary in shape and proportions from those of the genotype. The new species is named after Mr. M. R. Banks, B.Sc., who with Professor Carey guided the writer in the field and assisted in the collection of fossils.

Judging from poorly preserved material, *M. careyi* and *M. banksi* both occur on the Lyell Highway 100 yards east of the Queenstown 12-mile post.

Maoristrophia keblei sp. nov. Pl. 36, figs. 9–11

Type Material. Holotype consisting of a steinkern and an external mould of a ventral valve (N.M.V. reg. nos. 14,612 and 14,613 respectively), preserved in grey shale (compacted from exceedingly fine sand) with brown ferruginous staining *Paratype* consisting of a steinkern (N.M.V. reg. no. 14,614) of a dorsal valve in the same matrix.

Locality. Both types from Hull Road, Mooroolbark, Victoria (*vide* map in Gill, 1940).

Stratigraphical Horizon. Yeringian (Lower Devonian).

Description of Holotype (Pl. 36, figs. 9–10). Ventral valve sub-semicircular, slightly convex, with poorly developed umbo and well-marked median fold. Width

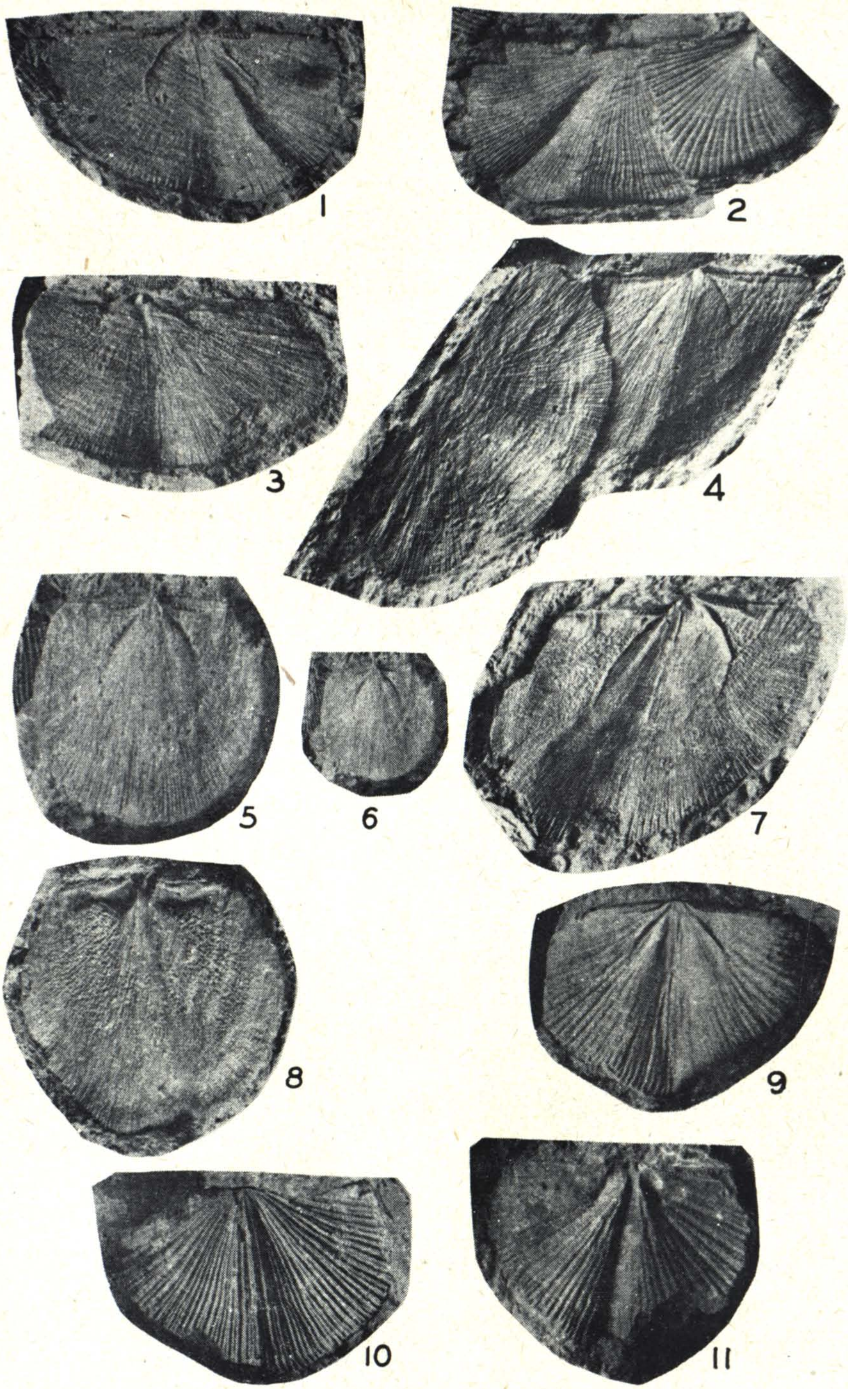

FIG. 1—Steinkern of ventral valve of *Maoristrophia careyi* sp. nov. FIG. 2—External mould of same. FIG. 3—Steinkern of dorsal valve of *M. careyi* sp. nov. FIG. 4—External mould of same, along with steinkern of ventral valve of *Maoristrophia banksi* sp. nov. FIGS. 5, 6—Steinkern of ventral valve of young *M. banksi* sp. nov. FIG. 7—Steinkern of ventral valve of *Maoristrophia banksi* sp. nov. FIG. 8—Steinkern of dorsal valve of *M. banksi* sp. nov. FIG. 9—Steinkern of ventral valve of *Maoristrophia keblei* sp. nov. FIG. 10—External mould of same. FIG. 11—Steinkern of dorsal valve of *M. keblei* sp. nov. N.B.—All figures are × 2 except for Fig. 5, which is × 4, and is of the same specimen as Fig. 6.

as preserved 17 mm., but full width, judging by the complete side, would be about 19 mm. Length 22·5 mm.

Interior surface shows external costellae, but much less defined. Surface covered with fine papillae which are orientated to the directions of the costellae. Strong dental lamellae, 4 mm. long, and a little over ¼ mm. wide. They are splayed apart to form an angle of about 80°. The lamellae are about as deep as wide anteriorly, but towards the umbo they are not so high. Very fine median septum. The muscle field is not well defined, but appears to reach a little further than halfway up the shell. Hinge-line straight. The hinge-line crenulations stretch to 4 mm. on each side of the midline. The crenulations occupy only the anterior half of the palintrope. The two sets or files of crenulations are directed inwards (when followed posteriorwards), thus providing an efficient mechanism for prevention of side-slip in addition to effecting articulation. An accessory articulating structure is present at the umbo in the form of two short, low ridges, one on each side of the midline; the median septum dies out at this point. They appear as grooves in the steinkern.

The external surface of the ventral valve is covered with fairly sharp-edged costellae, which usually increase by intercalation. The intercostellar spaces are about twice the width of the costellae. Fine growth-lines can be seen under the microscope. The ornament of the holotype is described from a plasticine squeeze of the external mould.

Description of Paratype (Pl. 36, fig. 11). Dorsal valve of similar outline to ventral valve, and with sulcus corresponding to fold of ventral valve. The ornament is similar, too Bifid sessile cardinal process with horizontally rounded but vertically flattish knobs. Between these, at the posterior extremity of the process, is a very minute knob (a cavity in the steinkern) which fits between the two accessory articulating ridges described in the ventral valve. Well-developed median septum, fused posteriorly with the cardinal process. Strong scapulate plates which are probably combined socket ridges and crural plates. Crenulate hinge margin to correspond with the crenulations of the ventral valve.

Comment. Maoristrophia keblei is nearest to the genotype of the three species described in this paper. It is flattish, with rather sharp costellae as in *M. neozelanica.* The interior of the ventral valve has very similar structures, and the dorsal cardinalia are also closely comparable.

M. keblei contrasts chiefly with the genotype in its sub-semicircular rather than sub-quadrate outline, in the shape of the crural plates *cum* socket ridges, and in size. *M. keblei* is characteristically only half the size of *M. neozelanica.*

A steinkern of a dorsal valve (N.M.V. reg. no. 14,615) which cannot be distinguished from *M. keblei* has been collected from Hull Road, Lilydale (Gill's loc. 1). A steinkern and external mould of a ventral valve (N.M.V. reg. nos. 14,616 and 14,617 respectively) have been collected from north of Lilydale (Gill's loc. 3; for these localities see Gill, 1940). *Maoristrophia keblei* is an additional index fossil for the Upper Yeringian (Gill, 1945b, p. 146).

The species is named in honour of my predecessor as palaeontologist of the National Museum, Mr. R. A. Keble.

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