A collection of papers
mainly concerning

THE GEOLOGICAL HISTORY OF TASMANIA WITH SPECIAL REFERENCE TO EVENTS DURING THE PALAEOZOIC ERA

submitted to the University of Tasmania for the degree of Doctor of Science

by Maxwell R. Banks
VOLUME 2

EARLY AND MIDDLE PALAEOZOIC
CONTENTS

   (junior author) 1954.


   (joint authors) 1961.

   (contributor and co-ordinating author) 1962.


   (Corbett senior author, others joint) 1972.

   (contributor and co-ordinating author) 1962.


   (junior author) 1975.


   (senior author) 1968.


LOWER PALAEOZOIC UNCONFORMITIES IN TASMANIA

by

S. Warren Carey and Maxwell R. Banks

Hobart, 1954
Lower Palaeozoic Unconformities in Tasmania

By

S. WARREN CAREY AND MAXWELL R. BANKS

University of Tasmania

(WITH 1 PLATE AND 13 TEXT-FIGURES)

ABSTRACT

Lower Palaeozoic unconformities are now known in some 29 exposures in Tasmania which are broadly equivalent to the Tyennan Unconformity of Browne. However, the time interval is found to vary and it is clear that different orogenic pulses are involved, all belonging to a general period of orogeny. The Tyennan Orogeny as defined by Browne is anomalous and requires re-definition. It is therefore proposed that the name Tyennan Orogeny be retained to mean the general orogenic period of the Cambrian as exposed in the Tyenna Valley where the Ordovician Junee Group rests on pre-Dundas strata. An unconformity between the Cambrian Dundas Group and pre-Dundas rocks is defined as the Stichtan Unconformity. An unconformity between the Junee Group and the Dundas Group is defined as the Jukesian Unconformity.

The Dundas Group has a eugeosynclinal facies with rhythmic recurrence of coarse conglomerates, breccias and greywackes, which reflect at least six orogenic pulses (as yet unnamed), all later than the Stichtan Movement and earlier than the Jukesian Movement. All eight orogenic pulses occur within the time interval of the Tyennan Unconformity, which includes the upper half of the Cambrian Period and perhaps some earlier time.

It is uncertain whether Dundas sediments were ever deposited over the regions now exposing the Tyennan Unconformity. The Jukesian regression was the most widespread emergence to be recorded in Tasmania between the Lower Cambrian and Middle Devonian Epochs.

INTRODUCTION

The report by Stephenson (this volume) of an exposure of a Lower Palaeozoic unconformity in south-west Tasmania makes it desirable to place on record some hitherto unreported exposures of similar unconformities, to examine their stratigraphic and geographic relationships, and to provide more precise nomenclature.
LOWER PALAEOZOIC UNCONFORMITIES IN TASMANIA

- Tyennan Unconformity Exposed
- Unconformity Exposed Correlated With Tyennan
- Tyennan Unconformity Inferred
- Jukesian Unconformity Exposed
- Jukesian Unconformity Inferred
- Stichert Unconformity Exposed
- Stichert Unconformity Inferred
- Unconformity Within The Dundas Group Inferred

Fig. 1.
UNCONFORMITY BETWEEN JUNEE AND DUNDAS GROUPS

The first mention of possible unconformable relations between what are now known as Junee and Dundas Groups was by Officer, Balfour, and Hogg (1895, p. 122) who expressed the opinion that unconformably below the Owen Conglomerate* near Mt. Owen there was an older group of conglomerates intercalated with the schists and sandstones which are now known to belong to the Dundas Group. In the same year Montgomery (1895, p. ix) stated that near Mining Sections 106-94 (Red Hill area) conglomerate which he correlated with the Mt. Owen beds, appeared to overlie the schist formation unconformably. This relationship has recently been confirmed by one of us and is described in detail below. Later, Twelvetrees (1909, pp. 124-5) stated that the Leven Slates, &c., in the Gunns Plains district “underlie” the Ordovician limestone with unconformable angle of dip. No outcrop of the unconformity has been seen and on available evidence other interpretations are not impossible. Hills (1914) gave the first detailed description of a definite unconformity between the Junee and Dundas Groups which he mapped in the vicinity of Mt. Jukes, Mt. Darwin and Mt. Sorell; he recorded angular and metamorphic discordance between the two groups and described the presence in abundance in the Jukes Breccia (Junee Group) of pebbles and boulders derived from the “porphyroids” of the Dundas Group and from the Darwin Granite which is intrusive into the Dundas Group. Later Reid (1919, p. 25) reported similar evidence from Mt. Claude where Owen Conglomerate is unconformable on the Dundas Group and “some of the porphyroid boulders contained in the conglomerate are as much as two feet in length”. This unconformity in the Mt. Claude district has been confirmed recently by Elliston (1953, p. 1195), who cited exposures at Cethana and Bell Mount. Since the Junee Group extends down to the Canadian and the Dundas Group extends up into the Upper Cambrian, the time interval of this unconformity is the remainder of the Upper Cambrian.

Nye (1929, p. 10) reported that the West Coast Range Conglomerate of the Ragged Range rests unconformably on slates, cherts and breccias which he correlated lithologically with the Dundas Group. He stated that the lower rocks are very similar to the feldspathic breccias in the Magnet district. If Nye is correct in his correlation, then this is the same unconformity as that described by Hills. The Adam River unconformity and its relation to the unconformities at Adamsfield and Tim Shea are shown on Figs. 2 and 3.

Red Hill and Walfords Peak.

Along the West Coast Range north of Queenstown unconformable relations between the Owen Conglomerate and the Dundas Group have been mapped by one of us (M.R.B.) at Walfords Peak, Red Hill and the Gooseneck (Figs. 4 and 5). On the eastern slope of Walfords Peak a medium-grained siliceous conglomerate with thin beds of ferruginous sandstone and siltstone overlies a sheared scoriaceous biotite keratophyre.

* Owen Conglomerate is a synonym of West Coast Range Conglomerate and on grounds of priority of proper definition has now replaced the latter term (see Bradley, this volume, p. 205).
FIG. 2.—Geological Map of the Adamsfield-Tyenna area with section showing relations of Adam River, Adamsfield, and Tyenna unconformities.
Approximate Scale: One mile to an inch.

Fig. 3.—Geological sketch-map of the Needles-Tim Shea area at the head of the Tyenna valley, showing the relations of the Needles Quartzite and the Tim Shea conglomerate. Formal definitions of new formations used will be published shortly by A. H. Spry who has found that the whole section above the Needles Quartzite is largely dolomite. This includes the Humbolt "Slate" which Lewis correlated with the Dundas Group and which Spry finds to be thin-bedded dolomite.
The shear planes of the lava dip more steeply than the bedding in the conglomerate which dips about 45° to the west. The lava close to the contact is more weathered than elsewhere. The dip of the underlying sub-greywacke conglomerate is very steep to the west. There is no sign of faulting in the vicinity. On the northern foothills of Walfords Peak near Lake Rolleston the Owen Conglomerate overlies a sub-greywacke conglomerate of the Dundas Group.

A mile south of Walfords Peak, however, finely-bedded deep red sandstone and siliceous conglomerates appear, to pass transitionally downwards into greywacke conglomerate and breccia with an interbedded flow of altered biotite quartz keratophyre. This section is well exposed on and eastward from a low ridge near the centre of the western shore of Lake Dora. Here, apparently, there is no unconformity between the Owen Conglomerate, represented by the quartzites and siliceous conglomerates, and the Dundas Group, represented by the greywacke breccia and lava. At Red Hill, on the western flank of Mt. Murchison, the contact between the Owen Conglomerate and Dundas Group is again revealed as an unconformity: The underlying rock is a greywacke breccia with boulders of haematite, porphyry and quartz. It is at least 150 feet thick and thought to be conformably overlain to the west by a massive pyritic keratophyre. Eastwards, however, the greywacke breccia is overlain by beds of siliceous conglomerate dipping to the east at about 30°. The basal bed of this conglomerate is extremely coarse-grained with boulders up to three feet in diameter. The conglomerate is unsorted and the boulders show little rounding. The boulders are mainly siliceous but there are a number composed of porphyries (like the keratophyres of the underlying Dundas Group) and of greywacke breccia like the underlying rock. On the eastern side of Red Hill, near the southern end, the conglomerate, still dipping east, is underlain by a scoriaceous keratophyre in which the flow lines dip steeply west. At the Gooseneck, a mile or so to the west, the conglomerate, folded into a syncline and locally dipping south, overlies a keratophyre, apparently dipping west. The basal beds of the conglomerate locally contain large boulders of the underlying keratophyre. The presence of such porphyritic boulders is also seen again in the basal beds of the conglomerate a mile north of Lake Julia. Thus, in the Red Hill area the evidence for the unconformable relations between the Dundas and Carbine Groups includes angular discordance, boulders of the older rock in the younger and the deposition of conglomerate on different beds of the Dundas Group.

Bradley (this volume, p. 227), while conceding that actual unconformity exists in some places in this area, interprets some of the evidence differently. He prefers to explain the porphyry boulders in the basal conglomerates not as evidence of Cambrian erosion of the underlying porphyries but as being due to the Devonian metasomatic porphyritization of both Cambrian rocks and similar pebbles derived from them in the immediately overlying conglomerates.

The Needles, Tyenna Valley.

Lewis (1940, p. 48) suggested the possibility of an unconformity between the quartzite forming the ridge of the Needles some two miles south-west of Tim Shea, and the slates near the Humbolt Mine under the
Fig. 4.—Geological map of the Walfords Peak and Sticht Range area, with section showing unconformities.
eastern shadow of the Needles. Lewis correlated (p. 47) this Needles Quartzite with the Ordovician Tim Shea Conglomerate, and the Humbolt Slate with the Cambrian Dundas Series. The unconformity appears only on a table of stratigraphic succession (p. 48) as "probable unconformity" between the "Junee Series" above and "Grey slates probably referable to the Dundas Series" below. The unconformity is not mentioned in Lewis's text and is not shown in his section through the relevant area (Plate IX, section 4). In fact, Lewis was careful to point out (p. 47) that the dip of the slate corresponds with that of the Needles Quartzite. He also stated (p. 48) that "it may be established later that the slates are of Cambrian age, but there is no justification at present for this assumption". However, further investigation of the area has shown that (a) the Needles Quartzite is not correctly correlated with the Tim Shea Conglomerate but is a very much older formation; (b) the Humbolt Slate is not correctly correlated with the Dundas Group, and (c) the contact of the Needles Quartzite and Humbolt Slate is conformable (see our maps, Figs. 2 and 3). The Needles Quartzite and Humbolt Slate are both parts of a conformable sequence of pre-Dundas Group rocks which includes the thick dolomite on the south flank of Tim Shea. The alleged unconformity between Junee Group and Dundas Group in the Tyenna Valley is therefore invalidated. This is unfortunate since Browne subsequently selected this area as the type area for his Tyennan Unconformity; for although there is in fact a major unconformity beautifully exposed in the Tyenna Valley, the age and stratigraphic relations assigned by Browne to the Tyennan Unconformity do not fit it. (See discussion below under "Nomenclature").

UNCONFORMITY BETWEEN JUNEE GROUP AND PRE-DUNDA Group ROCKS

Tim Shea.

Tim Shea, formerly known as Mt. Stephens, is a peak at the head of the Tyenna Valley on the watershed of the Florentine River. The Tim Shea unconformity seen on Fig. 6 was first reported by Twelvetrees (1908) but he referred to the upper beds as Permian. He corrected this error the next year (1909c, p. 27). The unconformity was next mentioned by Henderson (1939). The area was described by Lewis (1940, pp. 46-7, and plate VIII), but he wrongly interpreted the south-eastern escarpment of Tim Shea as the "Tim Shea Escarpment Fault" whereas this is the exposure of the unconformity. He correctly showed the conflicting strikes of the two groups of rocks but mapped both the Owen Conglomerate and the thick underlying dolomites as "quartzites and conglomerates of the Junee Group". The unconformity here is very clear despite some talus. The crest of Tim Shea is composed of well-bedded conglomerates and quartzites of the Owen Conglomerate Formation which dip to the north-west at about 15° and form a regular cuesta. These are underlain conformably by thinly-bedded chocolate-red shales, and these by a conglomerate composed almost entirely of detritus from the under-
Fig. 5.—Geological map of the Red Hill area with a section from the Gooseneck to Red Hill.
Fig. 6.—Geological Map of the Elliott Range Area, Western Tasmania.

Fig. 7.—Section through Elliot Range area showing the Tyennan Unconformity (Symbols, legend and scale as for Fig. 6).
lying dolomite. The dolomite strikes north-west and dips steeply north-east. The bedding of the Junee Group is about at right angles to that of the dolomite. The dolomitic basal conglomerate of the Junee Group, being more permeable than the dolomite, is penetrated by several caves and solution channels. The age of the basal Junee Group is very early Ordovician. The age of the dolomite is not really known; it has been correlated broadly with the Smithton Dolomite on the assumption that all the pre-Dundas dolomite of Tasmania is of one age, which might well be true but is not established. The time interval of the Tim Shea unconformity includes therefore at least the greater part of the Cambrian Period up to the base of the Ordovician, and possibly also the Lower Cambrian and some of Precambrian time.

**Elliott Range.**

A fine unconformity on the north slopes of the Elliott Range was examined in 1951 by Mr. B. F. Glenister and one of us (S.W.C.). The unconformity can be seen clearly from a distance of two miles (see Figs. 1, 5 and 7, and Plate I, Fig. 1). The rocks below are schistose quartzites correlated lithologically with the Carbine Group. The beds above are well-beded white quartzites and subordinate fine quartz-pebble conglomerates (Owen Conglomerate) which form the prominent cuesta of the Elliott Range. At the foot of the dip-slope they are followed conformably by highly calcareous sandstones which yielded trilobites, followed in turn by the Gordon Limestone and the Eldon Group. The Dundas Group is missing. The only previous report of this unconformity is a brief mention by one of us (Carey, 1953, p. 1112).

**Bubbs Hill.**

Unconformable relations may be inferred between the Junee Group and pre-Dundas strata at Bubbs Hill which rises beside the Lyell Highway on the watershed between the Nelson and Cardigan Rivers, sixteen miles east of Queenstown. The hill is crowned with siliceous sandstone belonging to the Crotty Quartzite which passes down with transition into the Gordon Limestone which dips 220° magnetic at 5°. This block is bounded on the south by a normal fault against strongly folded and contorted quartzites and schists of the Raglan Range which have been correlated generally with the Carbine Group though the Davey Group may also be present. On the north side the boundary is also a normal fault, and in the road cuttings of the Lyell Highway highly folded quartzites and schists are exposed (Fig. 8). Although no actual erosional contact between the Junee Group and older rocks is exposed, the difference in tectonic grade of the two groups is clear and an unconformity may be inferred.

**Hastings and Ida Bay.**

An unconformity between the Junee and Carbine Groups can also be inferred in the area between Hastings Caves and Cave Hill, Ida Bay. At Hastings, a dolomite occurs which is presumably conformable with the fine white rather saccharoidal quartzite of the Hog's Back, about half a mile to the south. This quartzite dips 65° magnetic at 53°. The dolomite and quartzite are correlated with the Carbine Group on lithological grounds. At Cave Hill, Ida Bay, a limestone of Ordovician age in part, and thus equivalent in part to the Gordon Limestone of the Junee Group, dips towards the south-west at about 6°. The base of this
Fig. 8.—Section through Bubb's Hill and the Raglan Range, Western Tasmania.
limestone is apparently near the foot of the northern slope of Cave Hill but neither the base of the limestone nor the underlying rock has been seen. An unconformity may be inferred, however, between the Carbine and Junee Groups in this area. (See Figs. 9 and 10.)

**Howth.**

An unconformity with strong discordance between Owen Conglomerate and slates correlated with the Carbine Group is well exposed around the shore of a small headland between Sulphur Creek and Howth on the north coast of Tasmania (Figs. 11 and 12). The conglomerate consists of fine siliceous pebbles cemented by silica and haematite, and dips flatly landward in a gentle syncline. The rocks of the Carbine Group dip steeply.

The base of the conglomerate is irregular and a thin breccia composed of fragments of the underlying rocks forms the basal bed. Mr. A. H. Spry has found another outcrop of this unconformity just west of Penguin where the Owen Conglomerate dips westward and rests with marked angular discordance on the Carbine Group.

**Frankford.**

An unconformity is clearly exposed at Frankford between Owen Conglomerate and quartz schists which are provisionally referred to the Davey Group. The unconformity was first reported by Nye (1928) and was recorded by Nye and Blake (1938, p. 34).

**Denison Range:**

Twelvetrees (1908, p. 30) described an unconformity in the Denison Range. The upper formation, which strikes west of north, is now known to be Owen Conglomerate, and from Twelvetrees' description the lower formation, which strikes east of north, clearly belongs to the Precambrian group of quartz and mica schists. At the base of the conglomerate formation Twelvetrees described a basal breccia which corresponds with the Jukes Breccia:

"At the junction of the two systems on the north side of the gap is a long and high crest composed of a breccia of large angular stones of quartz and quartz schist which is situated between the upper members of the schists and the basal sandstones of the conglomerate series."

**Mount Arrowsmith.**

An unconformity between Owen Conglomerate and Precambrian quartz and mica schists about two miles east of Mt. Arrowsmith was described by Ward (1908A, p. 37, and 1909, p. 32).

**Unconformity Between Dundas and Older Groups**

Unconformable relations between the Dundas Group and older rocks were first reported by Twelvetrees (1909A) at Lodders Point near Penguin. However, the contact area is covered with basalt and the unconformity is one of interpretation rather than of observation.
Fig. 9.—Geological map of the Ida Bay area, S.E. Tasmania.
Sticht Range.

In the Sticht Range, rocks correlated on lithological grounds with the Carbine Group at Dundas are strongly folded and overfolded to the south. The overlying Dundas Group rocks, correlated with the type area on lithological grounds, dip steeply and consistently west at 75°. The Carbine Group rocks beneath the unconformity surface are saccharoidal quartzites, black micaceous schists and glistening mica schists. The basal rocks in the Dundas Group vary along the strike. On the Sticht Range they are very coarse siliceous conglomerates with many boulders of rocks from the Carbine Group. On the southern end of the range the basal rocks of the Dundas Group are black phyllites overlain by a thin bed of limestone followed by greywackes, sub-greywackes, black slates and lavas. The presence of a lens of very coarse-grained conglomerate on the western flank of the Sticht Range suggests the presence of higher land on the pre-Dundas surface in this vicinity. The evidence for this unconformity is given on the accompanying sketch map and section (Fig. 4). The age of this unconformity can only be inferred. The age ascribed to the oldest fossils in the Dundas Group is Upper Middle Cambrian (see Elliston, this volume, p. 167) and these fossils occur in the Judith Slate and Tuff, the lowest formation in the Dundas Group in the type area. No fossils have yet been found in the Carbine Group or its correlates in any part of the State, and because of its unconformable relation to the Dundas Group it is generally considered to be Lower Cambrian or Upper Precambrian. Thus, the Stichtan Unconformity is older than Upper Middle Cambrian and extends down to an undetermined time in the Lower Cambrian or Upper Precambrian.

Other Areas.

Similar unconformable relations between Carbine Group and Dundas Group have been found in a number of other areas. At Dundas, Elliston (this volume, p. 174) suggests the presence of this unconformity on Wallace’s Tram, on the Avon Rivulet, and on Judith Creek. On Wallace’s Tram, 100 feet above the Stables, contorted slates of the Carbine Group are overlain along an irregular surface by relatively unfolded “tuff” of the Dundas Group. On the Avon Rivulet the basal Dundas “tuff” bed overlies slates in one place and quartzites in another along its strike. On Judith Creek there are marked changes in the grade of metamorphism and the direction and angle of dip between the two groups. At Deloraine,
Wells (1954) inferred an unconformity just north of the Lake Highway for several miles from Golden Valley towards Deloraine. Highly contorted and metamorphosed rocks of the Davey Group are overlain transgressively by Dundas Group sub-greywacke slates and siltstones dipping-north-east at about 70°.

**FIG. 11.—Geological Map of a headland between Sulphur Creek and Howth, N.W. Tasmania.**

**FIG. 12.—Geological section through the unconformity near Howth.**

**UNCONFORMITIES WITHIN THE DUNDAS GROUP**

**Lynch Creek.**

Bradley (this volume, p. 221) has inferred an unconformity between the Lynch Conglomerate and the Miners Slate. Both these formations are considered by us to be correlates of parts of the Dundas Group as defined by Elliston (this volume).
Rosebery.

Graham Hall and Cottle (1953, p. 1146) stated that at Rosebery there is structural discordance in addition to faulting between a younger formation referred to as "massive pyroclastics" and an older sedimentary formation. The pyroclastic formation, which consists of agglomerates, tuffs and lavas, is regarded by Elliston (this volume) as part of his Dundas Group, a correlation which we accept. The older formation is probably Dundas Group also. The implied unconformity would therefore be within the Dundas Group.

UNCONFORMITIES BETWEEN JUNEE GROUP AND ROCKS OF UNCERTAIN AGE

Mt. Hopetoun.

Stephenson has recorded an unconformity in the vicinity of Mt. Hopetoun in the Cracroft River Valley (this volume, p. 151, and plate I, fig. 1). The upper formation, from his description and photograph, fits exactly the facies of the Owen Conglomerate which might be expected in this area. It closely resembles the occurrence on the Elliott Range. The lower formation of quartz schists and mica schists closely fits the Davey Group. It could scarcely be the Dundas Group, though the Carbine Group cannot be wholly excluded. This unconformity can therefore be correlated with some confidence with the unconformities between Junee Group and pre-Dundas Group rocks.

Wedge Valley.

Twelvetrees (1909b, p. 29) inferred unconformable relations between Precambrian schists and quartzites, slates and conglomerates, which he described as "Cambrian", in the Wedge River Valley about four miles north-west of Mt. Wedge. Twelvetrees used the word Cambrian to include what is now accepted as lower Ordovician (e.g., Tremadoc, &c.), and his map includes in the Cambrian the whole of the Owen Conglomerate and Florentine Valley shales now known to be Ordovician Junee Group. This unconformity is therefore provisionally correlated with the unconformities between Junee Group and pre-Dundas Group rocks.

Adamsfield.

The contact between serpentine and Owen Conglomerate at the head of Main Creek at Adamsfield was originally described as a fault (Nye, 1929, p. 17). The actual contact zone has been mined for some years in the past for osmiridium, first by open cut and subsequently by stopes. In 1943 Thomas collected trilobites from dark-green shales immediately overlying the stoped zone. The outcrop was visited in 1952 by a party consisting of Dr. O. P. Singleton, Mr. B. F. Glenister, Miss E. M. Smith and one of the present authors (S.W.C.). More trilobite fragments were collected from the shales. Examination of the exposure revealed the fact that the contact is not a fault but an unconformity. Overlying the serpentine is a conglomerate made up entirely of pebbles of serpentine in a matrix also consisting largely of serpentine detritus. Although somewhat masked by crushing, careful scrutiny reveals that the whole deposit
is bedded, with grainsize varying down to that of the trilobite-bearing shales which also appear to be made up largely of serpentine detritus. There are sedimentary concentrations of magnetite and what appears to be chromite. The osmiridium occurs as detritus in the basal conglomerate. The lode is therefore a placer deposit, probably marine, since trilobites are present a few feet above.

These basal beds, derived from the disintegration of the underlying serpentine, are followed conformably by the Owen Conglomerate and then again conformably by the Gordon Limestone and the Eldon Group. The map and section Fig. 2 show the structural relations of the Tim Shea, Adamsfield and Adam River unconformities. One of the facts which led Nye to the fault interpretation was the great reduction in thickness of the Owen Conglomerate southwards from The Thumbs to the workings at the head of Main Creek. However, this is now known to be due to depositional lensing of the conglomerate in which such thickness variation is not uncommon.

The recognition of this unconformity has two important corollaries. In the first place, the osmiridium occurrence at the head of Main Creek has been quoted as a primary lode (e.g., Elliston, 1953, p. 1253) whereas it is now shown to be a placer. In the second place, the serpentine has been regarded as a Devonian intrusion whereas now it is shown to be pre-Ordovician.

The lower limit of the age of the serpentine is still uncertain. If it is to be correlated with the serpentine at Dundas, as seems reasonable, then it is probably late Middle Cambrian or Upper Cambrian (see Elliston, this volume, p. 172). This would imply that the time break for the Adamsfield unconformity was not longer than the Upper Cambrian, and that the unconformity belongs to the group of unconformities between the Dundas and Junee Groups.

**Nomenclature**

From the foregoing descriptions it is clear that at least three kinds of unconformable relations occur in the Lower Palaeozoic rocks of Tasmania: (1) between Junee Group and Dundas Group; (2) between Junee Group and pre-Dundas Group rocks; (3) between Dundas Group and pre-Dundas Group rocks. These unconformities imply orogenic movements within the Upper Cambrian, within the Cambrian Period or late Precambrian, and within the Lower Cambrian or late Precambrian respectively. In addition, there is Bradley’s inferred unconformity between the Lynch Conglomerate and Miners Slate within the Dundas Group. Complementary information is provided by the sediments of the Dundas Group, which is largely developed in a eugeosynclinal tectofacies, with a rhythmic repetition of coarse conglomerates, breccias and greywackes on the one hand, alternating with slates and fine-grained tuffs on the other (Elliston, this volume, p. 165). This sequence of orogenic sediments, if they have been correctly interpreted, implies at least six orogenic pulses during the Middle and early Upper Cambrian, that is, between the earliest and latest movements implied by the unconformities. In order to be precise in our nomenclature and thinking, it is therefore necessary to use ultimately separate names for each of the eight Cambrian
orogenic movements indicated. In addition, a general group name is required to refer to the broad period of orogenesis which is seen to have recurred throughout most of the Cambrian Period.

Tyennan Orogeny.

The only existing name is the Tyennan Orogeny of Browne (1949, p. 38) which he uses with Australia-wide application and has defined as follows: "it is not until we reach the upper part of the Cambrian sequence that we meet the next big orogenic hiatus. In Tasmania this is well marked in the neighbourhood of Adamsfield and in the Tyenna Valley (Fig. 3) [Browne's Fig. 3 is reproduced here as Fig. 13], hence we may perhaps call the movement to which it is related the Tyennan. The Dundas Series of Middle to (?) Lower Cambrian age is said to be overlain with strong unconformity by the Junee Series of heavy conglomerates which pass up into sandstone, overlain by shales containing lowest Ordovician and Canadian fossils. Since this series contains 2000 feet of strata below the shales, we may fairly assume that the conglomerates descend to the Upper Cambrian, and that the Tyennan Orogeny is fairly widespread in Central and Western Tasmania."

FIG. 13.—The Tyennan Unconformity of Browne.
The base of the conglomerates is now known to be Lower Ordovician so that Browne's definition would need to be revised as the orogeny between the Middle Cambrian and Lower Ordovician. Apart from this adjustment, the definition as it stands is anomalous. For it is clear from Browne's text and figure that his Tyennan Orogeny refers to an orogeny involving the Middle-Cambrian Dundas Group. However, no Dundas Group rocks are known from the Tyenna Valley, and the unconformity which is beautifully exposed at Tim Shea at the head of the Tyenna Valley, and which fits Browne's figure except for the age of the lower group, is between Junee Group rocks and thick dolomites which are certainly pre-Dundas. What then is the Tyennan Unconformity? If it is the pre-Junee unconformity exposed in the Tyenna Valley, then it belongs to the first group of unconformities above described. If, however, it is the unconformity between the Junee and Dundas Groups, then it belongs to the second group of unconformities described. Since a choice has to be made or the name has to be dropped altogether, we propose to redefine the Tyennan Unconformity as the unconformity exposed at the head of the Tyenna Valley. This course preserves for Tyennan Unconformity the meaning it might be expected to have, and permits the Junee-Dundas unconformity to be named after the Jukes-Darwin area where it was first recognized and described.

Tyennan Unconformity (revised definition).

The Tyennan Unconformity may be defined as the angular discordance between pre-Dundas rocks below and the Junee Group above as revealed on the south-eastern slope of Tim Shea, at the head of the Tyenna Valley. Stratigraphically the Tyennan Unconformity may be considered as the erosional surface of pre-Dundas rocks on which the Junee Group was deposited. The Jukesian surface, to be defined below, will be the continuation of this surface where Dundas Group rocks were present. The Stichtan surface, also to be defined below, will intersect the Tyennan and Jukesian surfaces. From the tectonic viewpoint, this unconformity may be considered as the expression of eight or more orogenic movements, the earliest being older than Upper Middle Cambrian and the latest being younger than lower Upper Cambrian but older than Lower Ordovician, together with a period of erosion or non-deposition prior to the deposition of the Junee Group. The orogenic movements occurring within the span of time represented by the Tyennan Unconformity may be referred to as the Tyennan Orogeny. This span of time is at least that during which the Dundas Group was deposited. The lowest formation of this Group at Dundas contains trilobites, indicating (Opik, 1951A) an horizon near the base of the Upper Middle Cambrian, and the youngest fossils so far recognized in the Group are trilobites from the Huskisson River and Leven Gorge, indicating an horizon near the top of the lower Upper Cambrian (Opik, 1951B). The fossils in the Owen Conglomerate indicate Lower Canadian age (Opik, 1951A) so that the last pulse of the Tyennan Orogeny must be older than this.

Stichtan Unconformity (definition).

The Stichtan Unconformity may be defined as the angular discordance between the Carbine Group below and the Dundas Group above as revealed on the western flank of the Sticht Range and its southern
continuation to a point east of Lake Dora in the West Coast Range. Stratigraphically, the Stichtan Unconformity may be considered as the erosional surface on which the Dundas Group was deposited. From the tectonic viewpoint, on the other hand, this unconformity may be considered as the expression of an orogenic movement of pre-Upper Middle Cambrian age, followed by a period of erosion or non-deposition prior to the deposition of the Dundas Group. This orogenic movement may be referred to as the Stichtan Movement of the Tyennan Orogeny.

**Jukesian Unconformity (definition).**

The Jukesian Unconformity may be defined as the angular discordance between the Dundas Group below and the Junee Group above as revealed at the northern end of Mt. Jukes, south of Queenstown. Hills (1913) was the first author to identify unambiguously and describe an unconformity between what are now known as the Junee and Dundas Groups. It is therefore appropriate that the type section for this unconformity should be chosen from the Jukes-Darwin area and in particular the exposure which Hills considered (p. 45) to be the best exposure of the unconformity. Stratigraphically the Jukesian Unconformity may be considered as the erosional surface of Dundas Group on which the Junee Group was deposited. From the tectonic viewpoint this unconformity may be considered as the expression of an orogenic movement of post-Lower Upper Cambrian but pre-Lower Ordovician age, followed by a period of erosion or non-deposition prior to the deposition of the Junee Group. This orogenic movement may be referred to as the Jukesian Movement of the Tyennan Orogeny.

**Movements within the Dundas Group.**

Six orogenic movements have been inferred within the Dundas Group, and actual angular discordance has been inferred on Lynch Creek. However, we do not at this stage propose any formal nomenclature. This might be deferred until an objective exposure can be cited as the type area for the name. Meanwhile, the name of a particular orogenic formation within the Dundas Group might be used to specify any such inferred movement.

**Palaeogeographic Implications**

**Limits of Cambrian Sedimentation.**

In discussing palaeogeography we shall speak of Stichtan, Jukesian and Tyennan areas as meaning those areas in which those respective types of unconformity are now found.

It is clear at the outset that the Jukesian areas received Dundas sedimentation, followed by the Jukesian Movement and erosion before the Junee transgression. It is not clear, however, whether Dundas sediments were ever deposited on the Tyennan areas. Two interpretations are possible. *(a)* The Tyennan areas were emergent belts during the
Dundas sedimentation, supplying sediment to the intervening Dundas trough, which was folded during the Jukesian Movement and eroded so that a common surface was established over the Tyennan, Jukesian and non-folded Dundas areas, on which the Junee Group was deposited. (b) The Tyennan areas received Dundas sedimentation, perhaps in reduced thickness, but were uplifted more strongly during the Jukesian Movement than the Jukesian areas, so that the whole of the Dundas sediment was stripped off and the underlying pre-Dundas rocks exposed. The following considerations bear on this question:

1. The Dundas sedimentation thins rapidly towards the Tyennan areas. This is noticeable south of Deloraine, eastwards from Mt. Farrell, and across the King Syncline. The impression gained is of depositional thinning rather than erosional thinning though evidence is not conclusive on this point. This would favour the first alternative.

2. The Dundas Group contains basic lavas and ultrabasic intrusives which appear to be cognate. Such ultrabasic rocks are normally correlated with active geosynclines and are not normally associated with cratonic areas. If this theory is adopted and the numerous serpentinites in Tasmania are regarded as of Cambrian age and as originally intrusive into Dundas sediments, then the area of Dundas sedimentation would be greatly extended and any cratonic geanticlines of non-deposition would be narrow. This interpretation would favour the second alternative, but the theoretical assumptions involved are open to challenge.

Jukesian Regression and Junee Transgression.

The Jukesian and Tyennan Unconformities imply a widespread regression during the Upper Cambrian followed by erosion and then a transgression over much of the eroded surface. What happened east of the meridian of Hobart is not yet clear, as the older rocks are either covered by younger sediments or exposed in the north-east where the facies is likely to be different and little detailed work has been done.

Both the Jukesian and Tyennan areas were subjected to erosion during at least part of the Upper Cambrian. The youngest fossils so far found in the Dundas Group belong to the top of the lower part of the Upper Cambrian. The beds in which these occur are not the topmost beds in the Group so that the age of the youngest beds involved in the Jukesian Movement is uncertain although certainly pre-Ordovician. However, some time during the Upper Cambrian the sea withdrew from the region in the most extensive regression between the Lower Cambrian and the Middle Devonian.

After an interval of erosion following the Jukesian Movement, deposition began in the Lower Ordovician in a transgressive sea which had spread by Upper Ordovician time at least as far north-west as Heazlewood, as far west as Eden and as far south as New River.
Hills and Carey (1949, p. 25) pointed out that the basal formation of this transgressive group is commonly a greywacke breccia or conglomerate consisting of blocks of rock derived from the immediately adjacent basement—the Jukes Breccia. Thus, at Mt. Darwin and Mt. Sorell the breccia is rich in blocks of Darwin Granite and locally derived "porphyroids", at Adamsfield overlying a serpentine basement it is composed largely of detrital serpentine, at Tim Shea overlying a dolomite basement, it is composed almost entirely of boulders of dolomite and in the Denison Range overlying quartzite schists it is composed of similar rocks. Commonly, however, where the underlying rock is quartzite or quartz schist as at Frankford, Elliott Range and near Mt. Hopetoun, the Jukes Breccia seems to be missing and the total thickness of the conglomerate less. Moreover, the Jukes Breccia always passes up into Owen Conglomerate which is composed for the most part of pebbles of quartzite, quartz schist, vein quartz and chert. This conglomerate shows no correlation with the type of underlying basement.

The varying composition and the texture of the Jukes Breccia indicate that the landscape that was being buried was geologically varied and that there was considerable relief. In addition, rapid initial sinking of the floor of deposition is implied. As the rate of sinking decreased the Jukes Breccia type of sediment was followed upwards by the sandy and conglomeratic sediments of the Owen Conglomerate, indicating, by the degree of rounding of hard rocks and the complete absence of weak rocks, considerable transport or re-working before deposition. The rapid thinning characteristic of the conglomerates combined with well developed undisturbed bedding suggest that prolonged re-working near shorelines rather than long transport was the principal factor. These facts, combined with the wide area through which the conglomerates recur with surprising uniformity of lithology, suggest the presence of a number of islands in the early Ordovician sea. These necessarily all contained outcrops of quartzite, quartz schist and probably chert. However, the absence of pebbles of weaker rocks such as serpentine, slate, "porphyroids", dolomite and mica schist which occur in the Jukes Breccia, could mean that these softer rocks formed only the lower relief on the Jukesian landscape and hence were the first to be buried by the rising tide of Junee sedimentation. However, even if the last-surviving islands still exposed such rocks, perhaps even in dominance, the weaker rocks would scarcely be expected to have survived the severe attrition indicated by the highly rounded quartzite pebbles of the conglomerate. The absence of "porphyroids" and other such rocks from the pebbles of the Owen Conglomerate has already been discussed by Ward (1908b, pp. 26-7) and Hills (1913, pp. 58-9). Both these authors suggested the early covering of the Dundas Group rocks; but whereas this is a possible explanation it is clearly not necessarily the correct one.

As the last-surviving islands and the main cratonic area were reduced, the Owen Conglomerate passed upwards into the Caroline Creek Sandstone and this into the Gordon Limestone by which time the islands had probably disappeared and the craton was approaching a peneplain.
REFERENCES

BRADLEY, J., 1954. - Geology of the West Coast Range of Tasmania. This volume, pp. 193-240.


ELLISTON, J., 1953. - Platinoids in Tasmania. ibid, pp. 1250-1254.


## Locality Index

<table>
<thead>
<tr>
<th>Quadrangle</th>
<th>Latitude</th>
<th>Longitude</th>
</tr>
</thead>
<tbody>
<tr>
<td>Adam River</td>
<td>Huntly 73</td>
<td>42° 44'</td>
</tr>
<tr>
<td>Adamsfield</td>
<td>Huntly 73</td>
<td>42° 44'</td>
</tr>
<tr>
<td>Avon Rivulet</td>
<td>Zeehan 50</td>
<td>41° 50'</td>
</tr>
<tr>
<td>Bell Mount</td>
<td>Sheffield 37</td>
<td>41° 27'</td>
</tr>
<tr>
<td>Bubb's Hill</td>
<td>Lyell 58</td>
<td>42° 07'</td>
</tr>
<tr>
<td>Cardigan R.</td>
<td>Lyell 58</td>
<td>42° 08'</td>
</tr>
<tr>
<td>Cave Hill</td>
<td>Adamson 93</td>
<td>43° 27'</td>
</tr>
<tr>
<td>Cethana</td>
<td>Sheffield 37</td>
<td>41° 28'</td>
</tr>
<tr>
<td>Cracroft. R.</td>
<td>Arthur 86</td>
<td>43° 10'</td>
</tr>
<tr>
<td>Deloraine</td>
<td>Quamby 46</td>
<td>41° 31'</td>
</tr>
<tr>
<td>Denison Range</td>
<td>Huntly 73</td>
<td>42° 34'</td>
</tr>
<tr>
<td>Dundas</td>
<td>Zeehan 50</td>
<td>42° 53'</td>
</tr>
<tr>
<td>Eden Siding</td>
<td>Zeehan 50</td>
<td>41° 59'</td>
</tr>
<tr>
<td>Elliott Range</td>
<td>Pillinger 65</td>
<td>42° 30'</td>
</tr>
<tr>
<td>Florentine R.</td>
<td>Huntly 73</td>
<td>42° 35'</td>
</tr>
<tr>
<td>Frankford</td>
<td>Frankford 38</td>
<td>41° 19'</td>
</tr>
<tr>
<td>Golden Valley</td>
<td>Quamby 46</td>
<td>41° 37'</td>
</tr>
<tr>
<td>Gooseneck</td>
<td>Murchison 51</td>
<td>41° 52'</td>
</tr>
<tr>
<td>Guns Plains</td>
<td>Sheffield 37</td>
<td>41° 18'</td>
</tr>
<tr>
<td>Hastings Caves</td>
<td>Adamson 93</td>
<td>43° 24'</td>
</tr>
<tr>
<td>Heazelwood</td>
<td>Magnet 35</td>
<td>41° 30'</td>
</tr>
<tr>
<td>Hog's Back</td>
<td>Adamson 93</td>
<td>43° 24'</td>
</tr>
<tr>
<td>Howth</td>
<td>Devonport 29</td>
<td>41° 05'</td>
</tr>
<tr>
<td>Humbolt Mine</td>
<td>Styx 81</td>
<td>42° 45'</td>
</tr>
<tr>
<td>Huskisson R.</td>
<td>Corinna 43</td>
<td>41° 39'</td>
</tr>
<tr>
<td>Ida Bay (district)</td>
<td>Adamson 93</td>
<td>43° 27'</td>
</tr>
<tr>
<td>Judith Creek</td>
<td>Zeehan 50</td>
<td>41° 54'</td>
</tr>
<tr>
<td>Lake Dora</td>
<td>Murchison 51</td>
<td>41° 58'</td>
</tr>
<tr>
<td>Lake Julia</td>
<td>Murchison 51</td>
<td>41° 54'</td>
</tr>
<tr>
<td>Lake Rolleston</td>
<td>Murchison 51</td>
<td>41° 55'</td>
</tr>
<tr>
<td>Leven Gorge</td>
<td>Devonport 29</td>
<td>41° 15'</td>
</tr>
<tr>
<td>Lodders Point</td>
<td>Devonport 29</td>
<td>41° 07'</td>
</tr>
<tr>
<td>Magnet</td>
<td>Magnet 35</td>
<td>41° 28'</td>
</tr>
<tr>
<td>Main Creek</td>
<td>Huntly 73</td>
<td>42° 44'</td>
</tr>
<tr>
<td>Mount Arrowsmith</td>
<td>St. Clair 59</td>
<td>42° 12'</td>
</tr>
<tr>
<td>Mount Claude</td>
<td>Sheffield 37</td>
<td>41° 30'</td>
</tr>
<tr>
<td>Mount Darwin</td>
<td>Lyell 58</td>
<td>42° 16'</td>
</tr>
<tr>
<td>Mount Farrell</td>
<td>Mackintosh 44</td>
<td>41° 44'</td>
</tr>
<tr>
<td>Mount Hopetoun</td>
<td>Picton 87</td>
<td>43° 13'</td>
</tr>
<tr>
<td>Mount Jukes</td>
<td>Lyell 58</td>
<td>42° 11'</td>
</tr>
<tr>
<td>Mount Murchison</td>
<td>Murchison 51</td>
<td>41° 50'</td>
</tr>
<tr>
<td>Mount Sorell</td>
<td>Pillinger 65</td>
<td>42° 15'</td>
</tr>
<tr>
<td>Mount Wedge</td>
<td>Pedder 80</td>
<td>42° 50'</td>
</tr>
<tr>
<td>Needles</td>
<td>Huntly 73</td>
<td>42° 44'</td>
</tr>
<tr>
<td>Nelson R.</td>
<td>Lyell 58</td>
<td>42° 07'</td>
</tr>
<tr>
<td>New River</td>
<td>Adamson 93</td>
<td>43° 27'</td>
</tr>
<tr>
<td>Penguin</td>
<td>Devonport 29</td>
<td>41° 07'</td>
</tr>
<tr>
<td>Ragged Range</td>
<td>Pedder 80</td>
<td>42° 46'</td>
</tr>
<tr>
<td>Raglan Range</td>
<td>Lyell 58</td>
<td>42° 08'</td>
</tr>
<tr>
<td>Red Hill</td>
<td>Murchison 51</td>
<td>41° 52'</td>
</tr>
<tr>
<td>Rosebery</td>
<td>Murchison 51</td>
<td>42° 48'</td>
</tr>
<tr>
<td>Stables</td>
<td>Zeehan 50</td>
<td>42° 53'</td>
</tr>
<tr>
<td>Sticht Range</td>
<td>Murchison 51</td>
<td>41° 52'</td>
</tr>
<tr>
<td>Sulphur Creek</td>
<td>Devonport 29</td>
<td>41° 07'</td>
</tr>
<tr>
<td>Thumbs</td>
<td>Huntly 73</td>
<td>42° 41'</td>
</tr>
<tr>
<td>Tim Sheq</td>
<td>Huntly 73</td>
<td>42° 43'</td>
</tr>
<tr>
<td>Tyenna Valley</td>
<td>Huntly 73</td>
<td>42° 44'</td>
</tr>
<tr>
<td>Walfords Peak</td>
<td>Murchison 51</td>
<td>41° 56'</td>
</tr>
<tr>
<td>Wallace's Tram</td>
<td>Zeehan 50</td>
<td>42° 50'</td>
</tr>
<tr>
<td>Wedge River</td>
<td>Huntly 73</td>
<td>42° 45'</td>
</tr>
</tbody>
</table>
PLATE I, FIG. 1.—Unconformity between Owen Conglomerate and pre-Dundas Group quartzites, Elliott Range, W. Tasmania. (Photo. by B. Glenister)
Reprints from the Geology Department, University of Tasmania


* Signifies Paper out of print.
XX CONGRESO GEOLÓGICO INTERNACIONAL

EL SISTEMA CÁMBRICO,
SU PALEOGEOGRAFÍA
Y EL PROBLEMA DE SU BASE

TOMO II.—PARTE II: AUSTRALIA, AMÉRICA

EDITADO POR
JOHN RODGERS

SOBRETÍPO DE 1000 EJEMPLARES DE

THE MIDDLE AND UPPER CAMBRIAN SERIES
(DUNDAS GROUP AND ITS CORRELATES)
IN TASMANIA

POR
MAXWELL R. BANKS
(University of Tasmania, Hobart, Tasmania)

MÉXICO
1956
THE MIDDLE AND UPPER CAMBRIAN SERIES
(DUNDAS GROUP AND ITS CORRELATES)
IN TASMANIA

Maxwell R. Banks
University of Tasmania, Hobart, Tasmania

ABSTRACT

Over 10,000 feet of greywacke and sub-greywacke breccia, conglomerate and sandstone, argillite, chert, and lavas and pyroclastics of the spilitic suite were deposited in Tasmania between the time of the Middle Cambrian Ptychagnostus gibbus Zone and that of the Upper Cambrian Glyptagnostus reticulatus Zone. These rocks are the Dundas Group and its correlates. Trilobites, brachiopods, dendroids, cystoids and worms have been found in these sediments. Basic and ultrabasic rocks were intruded during the Upper Cambrian as dykes through the Precambrian and as slightly transgressive sheets into the Dundas Group. Granite was also emplaced during the Jukesian Movement before the Lower Ordovician. The trough, in which deposition occurred, was part of a eugeosyncline.
Plus de trois milles trois cents mètres de grauwacke et sous-grauwacke brèches, conglomerats et grès, d'argillite, de pierre de come, et des laves et des roche pyroclastiques de la type spilitique ont été déposés en Tasmanie pendant l'intervalle de la Zone de Ptychagnostus gibbus (Cambrien moyen) à la Zone de Glyptagnostus reticulatus (Cambrien supérieur). Ces roches-ci constituent la "Dundas Group" et ses corrélatives. On a trouvé des trilobites, des brachiopodes, des dendroides, des cystoïdes et des annélides dans ces sédiments. Pendant le Cambrien supérieur des roches basiques et ultrabasiques ont introduit de force à travers les roches Ante-Cambrien comme des dykes et à travers la "Dundas Group" comme les filons couches transgressives. Du granite s'est aussi mis en place pendant le Mouvement jukesien auparavant l'Ordovicien inférieur. Le fond de bateau, dans lequel les dépots se sont formé, était une partie d'un eugeosynclinal.

INTRODUCTION

Evidence that Cambrian rocks occur in Tasmania was first given by Twelvetrees (1905, p. 10), although rocks now known to be Cambrian were first described by Gould in 1867. The first definite evidence of the age of these rocks was the report of the discovery of dendroids in 1945 by Thomas and Henderson at Dundas. Since then Elliston and others have found trilobites in many places, and most of these have been identified by Opik. The discovery of these trilobites and the mapping of a number of formations of the Dundas Group at Dundas by Elliston mark an important advance in the knowledge of the Cambrian System in Tasmania. Since the discovery of dendroids many geologists have added greatly to the knowledge of the system and the time is opportune for a comprehensive review.

The author wishes to acknowledge the assistance of Mr. J. G. Symons, Director of Mines, who made available unpublished material from the Mines Department files, Mr. F. Blake, geologist with the Mines Department, Miss E. Smith, who provided lists of literature and criticized the preliminary manuscript, and Dr. A. A. Opik and Professor S. W. Carey who criticized the manuscript.

DISTRIBUTION

The distribution of the Dundas Group and its correlates in Tasmania is shown on the map (fig. 1). This can be summarized as a major...
synclinorium of Dundas Group rocks extending from the Mainwaring River on the West Coast, north to the Pieman River, thence through an arc to Sheffield and Deloraine where it disappears trending southeasterly below Permian sediments. Correlates of the Dundas Group outcrop at Beaconsfield on the eastern edge of an anticlinorium and probably trend south as part of a major synclinorium beneath Permian sediments east of the Tyennan Anticlinorium (approximately the Tyennan Block of Carey [1953]). They occur at Adamsfield and extend sporadically to New River Lagoon. Another synclinorium containing sediments correlated with the Dundas Group trends northwesterly from the Arthur River south of Smithton, through Smithton to King Island, where it swings to the north or even northeast (Waterhouse, 1916a). In some places Ordovician rocks directly overlie pre-Dundas Group rocks, always unconformably. These areas are shown on the map (fig. 4) as Tyennan Unconformities. They occur on the Tyennan Anticlinorium or its margins, and on the outer margin of the main synclinorium at Zeehan and Penguin. It is not known whether the lack of Dundas Group correlates on the Tyennan and Rocky Cape Anticlinoria (see Carey, 1953, fig. 3) is a sedimentational feature or is due to Upper Cambrian erosion. This question is discussed further under STRUCTURE.

HISTORICAL REVIEW

The earliest reference to rocks now known to be Cambrian was by Gould (1867) who described the sequence near Penguin. During the next twenty years the system received little attention even from Johnston (1886), but from about 1895 (Officer, Balfour and Hogg), onwards there has been more or less constant addition of new information. This has been greater during the early part of this century and within the last ten years than in the intervening period.

The term “Dundas Group” was introduced by Waller (1905a) but the same rocks have also been called “Dundas Slates” and “Dundas Series.” Following work by Elliston (1954) the term “Dundas Group” is now used. The age assigned to rocks considered coeval with the Dundas Group has varied. Twelvetrees (1902) considered them Middle to Upper Silurian but in 1905 and 1909b the same author regarded them as Cambrian as they were overlain by the Owen Conglomerate of Ordovician age. Twelvetrees and Ward (1910) considered them as
Fig. 1. Map of Tasmania showing the distribution of the Dundas Group.
Cambro-Ordovician, as did Hills (1924), but this latter author also included rocks not now considered as coeval. In 1928, Nye and Lewis restricted the known Cambrian to the Hatfield Plains Slate and placed the Dundas Group in the Ordovician because of a supposed intrusion of Gordon Limestone (Ordovician) by a dyke of porphyroid at Paloona. The so-called intrusion is a flow or sill in contact with a bed of chert of Cambrian age. Nye (1932) considered the Dundas Group as Upper Cambrian to Ordovician, a conclusion based on Hall’s identification of graptolites from the North-East Dundas Tram (1902), an identification later rejected by Thomas (1945). Only the Hatfield Plains and Arthur River Slates were considered to be Cambrian by Nye and Blake (1938) and the Dundas Group was placed in the Devonian. Thomas (1944) placed the Dundas in the Cambrian with an epi-Cambrian orogeny followed by Ordovician sedimentation. Then in 1945, Thomas and Henderson demonstrated, on the evidence of dendroids, that part of the Dundas Group was Middle Cambrian. Later, Thomas (1947) included the Dundas “Series,” the Farrell Slate and Arthur River and Hatfield Plains Slates in the Cambrian. Hills and Carey (1949) included rocks now correlated with the Dundas in their Pieman Group of Upper Pre- cambrian and Cambrian age. Finally, Elliston (1954) redefined the Dundas Group, defined its constituent formations, and summarized the evidence showing it to be of Middle and Upper Cambrian age.

The first palaeontological work on the Dundas Group was the erroneous identification of graptolites by Hall (1902). Chapman (1926) described a phyllocarid and later (1929) a worm from the Dundas Group. In 1945, Thomas and Henderson made an important contribution with the discovery of dendroids from Dundas. In 1950, Elliston, B. G. May, and others, while carrying out a survey of the Dundas district, discovered trilobites. Later, Taylor and Elliston found trilobites in the Huskisson River area, and R. J. Cooper and the author found trilobites in the Leven Gorge. Trilobites from all areas were sent to A. A. Opik, who identified them and showed them to be of Middle and Upper Cambrian age.

A vexing question has been the age and nature of the “porphyroids”, a name introduced into Tasmanian literature by Twelvetrees and Petterd (1899) following a letter from Rosenbusch. These authors regarded them as sheared eruptive rocks and Twelvetrees (1902) gave their age is Middle and Upper Silurian. Later, Twelvetrees (1909b) recognized volcanic rocks in the Dundas but thought that the porphyroids were
intrusive and Cambrian as they did not intrude the Ordovician Owen Conglomerate. Hills (1924) also considered the porphyroids Cambrian because the Owen Conglomerate unconformably overlies them on Mount Darwin. He also considered them to be highly metamorphosed plutonic, effusive and fragmental rocks. In 1928, Nye and Lewis placed the porphyroids in the Ordovician because of MacIntosh Reid’s erroneous interpretation of the situation at Palooona, mentioned above. Finucane (1932) postulated that the porphyroids were entirely intrusive, basing his ideas on observation of dykes near Rosebery, and of Devonian age. This view was followed by Nye and Blake (1938) and other writers until Carey (1946), who reverted to earlier views that the porphyroids were effusive, basing his ideas on observations east of Rosebery. Carey (1953) postulated that the porphyroids were due to hydrothermal alteration of Cambrian lavas and sediments during the Devonian. This idea was followed by Scott (1954) who considered the porphyroids as sheared, silicified and albitized Cambrian spilites. Bradley (1954) advanced the view that some of the porphyroids were originally keratophyres but that the quartz and some of the feldspar porphyries were albitized and silicified sediments, especially greywackes and greywacke-conglomerates, the alteration having taken place in the Devonian.

The ultrabasic rocks of Tasmania have been considered co-magmatic with the Devonian granites since Twelvetrees (1909b) wrote on them, but earlier he had considered them Middle to Upper Silurian. Hills and Carey (1949) were the first to suggest that some of the serpentine might be older than the Lower Ordovician Owen Conglomerate, and Carey (1953) showed this to be the case.

In an unpublished report, Nye (1928) suggested that the cherts are silicified argillites, a view followed by all later writers.

Hills, in 1924, remarked on the similarity between the Dundas Group and the Heathcotic Series of Victoria, a similarity which has since been strengthened by the discovery of dendroids by Thomas and Henderson in 1945.

The first writer to consider the tectonic conditions under which the Dundas Group was deposited was Carey (1950; 1953), who, following a suggestion by the author, postulated deposition in a eugeosyncline. In 1950, Carey postulated the presence of a number of cycles of sedimentation in the Dundas Group, an idea developed further in this paper. Carey considered that the cycles were initiated by orogenic
movements, but Elliston (1954) considered that vulcanism was the controlling factor.

STRATIGRAPHY

In this paper the term Dundas Group will be used in a strict sense when referring to the sediments in the type area, and in the sense of those rocks correlated with the Dundas Group, *sensu stricto*, when referring to rocks outside the type area. The reason for the correlation will be given in each case where the term is used in the loose sense.

THE DUNDAS SECTION

The section at Dundas is summarized below and as figure 2 (c):

*Formations:*

<table>
<thead>
<tr>
<th>Formation</th>
<th>Thickness in feet</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gordon Limestone (Ordovician)</td>
<td></td>
</tr>
<tr>
<td>fault</td>
<td></td>
</tr>
<tr>
<td>Misery (Sub-greywacke) Conglomerate</td>
<td>500</td>
</tr>
<tr>
<td>Climie Slate and Tuff</td>
<td>2000</td>
</tr>
<tr>
<td>Fernflow Sub-greywacke and Conglomerate</td>
<td>470</td>
</tr>
<tr>
<td>Comet Slate and Sub-greywacke, with <em>Blackwelderia</em>, etc.</td>
<td>1050</td>
</tr>
<tr>
<td>Fernfields Sub-greywacke and Conglomerate</td>
<td>1950</td>
</tr>
<tr>
<td>Brewery Junction Slate and Tuff, with trilobites, = Curtin Davis Volcanics (1000)</td>
<td>2450</td>
</tr>
<tr>
<td>Razorback (Sub-greywacke) Conglomerate</td>
<td>225</td>
</tr>
<tr>
<td>Hodge Slate, with <em>Archaeocryptolaria</em>, etc.</td>
<td>530</td>
</tr>
<tr>
<td>Red Lead Conglomerate</td>
<td>250</td>
</tr>
<tr>
<td>Severn Slate</td>
<td>800</td>
</tr>
<tr>
<td>South Comet Greywacke</td>
<td>150</td>
</tr>
<tr>
<td>Judith Slate and Sub-greywacke, with <em>Ptychagnostus</em>, etc.</td>
<td>200</td>
</tr>
<tr>
<td><em>unconformity</em></td>
<td></td>
</tr>
<tr>
<td>Carbine Group</td>
<td></td>
</tr>
</tbody>
</table>

This section is essentially that of Elliston (1954, p. 163), but the author considers that many of Elliston’s tuffs are sub-greywackes (in Pettijohn’s [1949] sense) as will be seen from the descriptions which follow. In addition, the Curtin Davis Volcanics are considered as probably contemporaneous with the Brewery Junction Slate and Tuff, as both overlie the Razorback Conglomerate, and both are volcanic.

The basal formation, the Judith Slate and Greywacke has a micaaceous greywacke (or tuff) at the base and this contains *Lorenzella*, 172
MIDDLE AND UPPER CAMBRIAN IN TASMANIA

Pachyaspis, Peronopsis, Ptychagnostus, Pagetia and Triplagnostus. Opik (1951a and c; and pers. comm.) correlated it with the Scandinavian Middle Cambrian Zone with Ptychagnostus gibbus. The South Comet Greywacke contains small angular fragments of grey and black chert and feldspar. The Severn Slate consists of interbedded slates and greywackes or sub-greywackes with intraformational brecciation. Some of the greywackes are dolomitic. The Red Lead Conglomerate belongs to the sub-greywacke suite as it contains angular, sub-angular and rounded fragments, from a fraction of a millimetre up to three feet across, of banded chert, chert, greywacke, quartzite, banded slate and jasper in a silt grade matrix. The feldspar content is low. Graded and cross bedding occur in this formation. Elliston suggested (1954, p. 168) that this may be in part glacial.

An important horizon is the Hodge Slate, a micaceous carbonaceous slate with thin beds of greywacke and tuff. This formation contains trilobites, cystoids and dendroids such as Archaeolofoaea serialis, Archaeocryptolaria skeatsi, etc. (Thomas and Henderson, 1945) and is considered (Opik, 1951c) to be upper Middle Cambrian. Thin basic flows occur in this formation northeast of Dundas. Solenoparia, Bathyriscids, and perhaps Homagnostus occur in tuff on the power line 100 yards west of Bonnie Point on the North-East Dundas Tram which is shown on Elliston's map as part of the Hodge Slate.

The Razorback Conglomerate is a sub-greywacke conglomerate with angular and rounded fragments, up to 6 inches in diameter, of chert, jasper, quartzite, black slate, and, rarely, basalt. A striated pebble collected by Waller near Montezuma Falls (see Elliston, 1954, p. 166) possibly came from this formation.

In the type area, the Razorback Conglomerate is overlain by the Brewery Junction Slate and Tuff which is composed of grey, light greenish or black slate with thin tuff bands which become rarer near the top. A relatively thick bed of keratophyric tuff occurs near the base of the formation and outcrops on the track to the Comet Mine about a quarter of a mile from Dundas township. It consists of angular fragments of keratophyre in a matrix of angular fragments of albite and quartz. Recently, the author found trilobites and cystoids just below the top of this formation on the South Comet Tram several hundred yards east of Brewery Junction. They were badly deformed and Opik was unable to identify any genera other than Agnostus (or Homagnostus ?) and Ptychagnostus ?.
Above the Razorback Conglomerate near Montezuma Falls is a thick sequence of porphyritic basalts and associated pyroclastic rocks (see Scott, 1954, p. 134) called the Curtin Davis Volcanics. Because of their position they are correlated with the Brewery Junction Slate and Tuff which also contains pyroclastic rocks.

The succeeding formation, the Fernfields Conglomerate and Greywacke is a sub-greywacke conglomerate near the base and becomes finer-grained upwards where sparse boulders occur in a sub-greywacke matrix. Higher still it passes into slates with occasional pebbles which have been suggested to be of glacial origin. The top of the formation is a sub-greywacke conglomerate.

Light grey slates with thin bands of sub-greywacke comprise the Comet Slate and Sub-greywacke. This formation contains Blackwelderia cf. biloba Kobayashi, Conocephalites (?), Oidalagnostus and Anomo carella (?) (see Opik, 1951a). These are still only upper Middle Cambrian. A lava flow occurs in this formation to the southeast of Dundas.

The Fernflow Conglomerate and Sub-greywacke consists of siliceous and slaty fragments in a slate matrix. It has been suggested by Elliston (1954, p. 171) that this also is glacial.

The succeeding formation is dominantly slaty, with some tuff (?) or sub-greywacke beds and rare conglomerate. This is the Climie Slate and Tuff and is followed by the Misery Conglomerate which consists of graded and cross-bedded sub-greywacke conglomerates with boulders of quartzite, chert, jasper, basalts, etc., in a matrix of angular quartz, chert and jasper grains. The contact with the overlying Ordovician Gordon Limestone is probably a fault and several thousands of feet more of sediment could well occur above the Misery Conglomerate. Younger formations, at least basal Upper Cambrian in age (Opik, 1955, letter) are apparently present on the North-East Dundas Tram, as shown by the occurrence of Coosia and Pseudagnostus, a Dikelocephalid and Aphelaspis (?) in a greenish mudstone in the first re-entrant east of Bonnie Point. The erroneous allocation of this bed to the Hodge Slate by Elliston (1954, map) apparently arose from misinterpretation of earlier conversation and correspondence with Opik.

The succession at Dundas could be regarded as consisting of parts of at least eight cycles, as indicated in the columnar section (fig. 2 [c]). A perfect cycle would commence with a coarse sub-greywacke conglomerate, pass upwards into alternating conglomerate and sub-grey-
wacke, sub-greywacke, alternating sub-greywacke and slate, and then into slates with subordinate sub-greywacke, and finally perhaps into slate. Volcanic and pyroclastic rocks would be accidental interruptions to these cycles, although vulcanism seems to occur at intermediate stages in three of the cycles. Elliston (1954, p. 165) regarded rough alternation of conglomerate and finer beds as due to periods of vulcanism and non-vulcanism, but the author disagrees with this and points out that the lava flows seem, from Elliston's description, to occur in his finer-grained formations, e.g. Hodge Slate, Brewery Junction Slate and Tuff, and Comet Slate and Tuff. The author's interpretation of the succession as consisting of eight cycles differs considerably from Elliston's and the author (following Carey, 1950) suggests that each cycle is initiated by a rise in the area supplying the sediments to the trough, due to an orogenic movement, part of the Tyennan Orogeny, and that each cycle represents the erosion of these uplifted areas. Vulcanism seems to occur at an intermediate stage in the cycles. In at least one case the beginning of a new cycle is marked by a sharp change, e.g. between the Brewery Junction Slate and Tuff and the Ferrifield Formation (Elliston, 1954, p. 171).

Dundas Group rocks also occur east of Dundas (Elliston, 1954, p. 177) and provide a link with the slates, tuff and breccias of the Williamsford and Rosebery area (Hall et al., 1953, p. 1147). Many of the Dundas Group formations can be traced north to Renison Bell (Loftus Hills, pers. comm.) where quartzite, slate, conglomerate and tuff occur. Elliston remarked (1954, p. 177) that purple slates, tuffs, breccias and conglomerates like those in the Dundas Group occur northwest of Renison Bell in the Poiseidon-Bon Accord area.

SOUTH OF MACQUARIE HARBOUR

The farthest area south in which Dundas Group rocks have been studied on the West Coast is in the vicinity of the Wanderer and Mainwaring Rivers. Here Blake (1936) recorded slates, quartzites, breccias, chlorite and talc schists, chert, feldspathic breccia and basic porphyries. Scott (1954, p. 129) recorded a spilite from the Mainwaring River area.

On the coast south of the Spero River area, Taylor (1949) found tuff and impure limestone, and near Asbestos Point, Macquarie Harbour, sericite and quartz sericite schists, slates, schisted tuffs and fine conglomerates. Scott (1954, p. 129) noted spilite at Double Cove, on the southern shore of Macquarie Harbour.
No fossils have been found yet in these rocks south of Macquarie Harbour, but on lithological grounds they are correlated with the Dundas Group.

WEST COAST RANGE

There are almost continuous outcrops of the Dundas Group from Mount Sorell north to Mount Murchison. In the Mount Darwin area Hills (1913, p. 32) recorded felsites, keratophyres, tuffs and breccias, and noted the presence of purple schist, quartz chlorite schist, black slate and coarse-grained feldspathic sandstone. Bradley (1954, p. 235) noted the presence of black, fine-grained greywacke hornfels, black fine-grained laminated greywacke and sericite schist on Mount Darwin. Bradley also recorded (1954, p. 232) feldspar porphyry and chlorite sericite pyrite schist from Snake Spur.

The section along Lynch Creek, south of Queenstown, as computed from a section kindly supplied by M. Solomon, of the Mount Lyell Mining Company, is given below and as text-figure 2 (a):

<table>
<thead>
<tr>
<th>Sequence</th>
<th>Thickness</th>
</tr>
</thead>
<tbody>
<tr>
<td>Owen Conglomerate (Ordovician)</td>
<td></td>
</tr>
<tr>
<td>unconformity</td>
<td>200-300 ft.</td>
</tr>
<tr>
<td>Conglomerate</td>
<td>200 ft.</td>
</tr>
<tr>
<td>Slate</td>
<td>350 ft.</td>
</tr>
<tr>
<td>Pyroclastics</td>
<td></td>
</tr>
<tr>
<td>Porphyritic Pyroxene Basalt</td>
<td>2000 ft.</td>
</tr>
<tr>
<td>Pyroclastics</td>
<td></td>
</tr>
<tr>
<td>Lava (missing in places)</td>
<td>200 ft.</td>
</tr>
<tr>
<td>Pyroclastics</td>
<td>400 ft.</td>
</tr>
<tr>
<td>Grey sandstone</td>
<td></td>
</tr>
<tr>
<td>Pyroclastics</td>
<td></td>
</tr>
<tr>
<td>Lava (spilitic)</td>
<td></td>
</tr>
</tbody>
</table>

Bradley (1954, p. 231) provided a different section on the assumption of a sequence of formations dipping steeply west but recent detailed work by Solomon has demonstrated the presence of two anticlines and an intervening syncline.

The Lyell Schists in which the main copper bodies occur at Queenstown were regarded by Hills (1927, p. 130) as metamorphosed tuffs and he observed that they passed westward into lava flows and volcanic breccias. Later the schists were considered as schisted intrusive porphyries by Edwards (1939) and others. Alexander (1953, p. 1134) quoted Connolly as noting porphyries, rhyolite breccias, conglomerates and well-bedded slates in the Lyell Schists. Bradley (1954) regarded the
Lyell Schists as metamorphosed Dundas Group rocks with some of the schists due to metamorphism of the Owen Conglomerate, a view also expressed earlier by Hills (1927, p. 130). Along the Comstock Tram north of Queenstown there is a section of the Dundas Group with slates, spilites, a keratophyre with flow structure, cherts, greywacke conglomerates and greywackes. Bradley (1954, p. 228) equated a greywacke conglomerate at the King River Bridge with the Dora Conglomerate (see later), but without adequate evidence. This unit also contains slate bands near the road at the mouth of Linda Creek. It appears to be overlain unconformably by the Owen Conglomerate.

At Mount Sedgwick, Bradley (1954, p. 228) recorded conglomeratic quartz porphyry, i.e. quartz porphyry fragments in a quartz porphyry matrix (= aa keratophyre perhaps), and thin hornfels.

East of Walford's Peak and near Lake Dora a number of sections were measured by Dr. F. Ahmad and the author. One cross-section, taken just north of Lake Dora is summarized below and as text-figure 2 (b); (thicknesses are approximate only):

Owen Conglomerate (Ordovician)

unconformity

u. Scoriaceous quartz biotite keratophyre 125 ft.
t. Scoriaceous quartz keratophyre 250 ft.
s. Quartz chlorite schist with bed of greywacke conglomerate 375 ft.
r. Quartz keratophyre 160 ft.
qu. Quartz chlorite schist 110 ft.
p. Quartz biotite keratophyre 110 ft.
o. Quartz chlorite schist 225 ft.
n. Chlorite schist 160 ft.
m. Conglomeratic quartz chlorite sericite schist 110 ft.
l. Pebbly quartz feldspar chlorite schist 470 ft.
k. Sub-greywacke conglomerate
j. Biotite keratophyre
i. Quartz chlorite schist with slate bands 1900 ft.
h. Keratophyre

g. Quartz chlorite schist
f. Black slate

e. Greywacke 250 ft.
d. Greywacke conglomerate 80 ft.
c. Feldspathic sandstone 100 ft.
b. Quartz chlorite schist < 40 ft.
a. Crenulated chlorite schist with limestone lenses 100 ft.

unconformity

TOTAL 4600 feet.

Carbine Group
This section may be regarded as composed of at least four cycles, as shown in figure 2 (b), but detailed stratigraphy may reveal the presence of more. The volcanic rocks occupy an intermediate position in the cycles except in the case of the biotite keratophyre (unit j.) which is followed by a sub-greywacke conglomerate (unit k.). The succession quoted above is capped, a little south of Walford's Peak, by a sub-greywacke to greywacke conglomerate, called by Bradley (1954, p. 228) the Dora Conglomerate. This passes transitionally up into the Owen Conglomerate. Correlation of units in four sections of the Dundas Group just west of Lake Dora suggests that the Dora Conglomerate is unconformable on the underlying beds and this in turn indicates that the Dora Conglomerate may be equivalent to the Jukes Breccia at the base of the Junee Group of Lower Ordovician age.

North of Walford's Peak another section of the Dundas Group is partially exposed between the Sticht Range and Anthony Creek. The basal beds consist of a coarse siliceous conglomerate with very large boulders of Precambrian quartzite and quartz schist. The next rock type exposed is a keratophyre, followed by a chloritic schist, by several keratophyres, and then by a haematitic quartzite.

To the west of the Tyndall Range, Blake (1931) recorded green-grey and dark grey slates, green quartzite and acid and basic porphyries near the Langdon River, the quartzites containing an echinoderm stem. Later, the author found a hornblende keratophyre near Basin Lake, described by Scott (1954, p. 142), associated with slates, greywackes and greywacke conglomerates. At Red Hills, southwest of Mount Murchison, the Owen Conglomerate unconformably overlies a greywacke conglomerate dipping steeply west and about 150 feet thick. This is succeeded to the west by a keratophyre with flow structure, and aa or brecciated keratophyres, then by feldspar chlorite schists and then by quartz keratophyre on the flanks of the Gooseneck.

About two miles south of the Gooseneck, and west of Lake Julia, greywackes, greywacke conglomerates, keratophyres and aa keratophyres occur.

These rocks along the West Coast Range are correlated with the Dundas Group on grounds of lithological similarity and their position unconformably beneath the Junee Group of Ordovician age. In fact
MIDDLE AND UPPER CAMBRIAN IN TASMANIA

there is a continuous outcrop of these rocks from Dundas east to Mount Murchison and south to Macquarie Harbour. Thus, although individual formations have not been traced throughout this area, the probability of all the rocks mentioned in this section being part of the Dundas Group is high.

ZEEHAN

Beneath the Junee Group on the western side of the Zeehan Syncline, the Dundas Group outcrops and isolated observations have been made on it. Three miles east of Trial Harbour, Waterhouse (1916b, p. 100) recorded sub-greywacke breccia, slate, sandstone and tuff. According to Elliston (1954, p. 175) the Zeehan Tillite occurs at the Swansea Mine, Zeehan, and, in the vicinity, Taylor (1953) reported an argillaceous sandstone, a sub-greywacke conglomerate and a black shale. Just north of Zeehan, the Zeehan Tillite (Waller, 1905b; Twelvetrees and Ward, 1910, p. 41) outcrops just below or at the base of the Dundas Group (Spry, pers. comm.) but its structural relationships are still obscure. Low in the Dundas section north of Zeehan is the Montana Melaphyre, a formation of spilitic lavas, tuffs and breccias with some development of spherulitic felsites (see Scott, 1954). The Montana Melaphyre is overlain by the Nubeena Quartzite and Slate from which indistinct gastropods, brachiopods and echinoderms have been recorded by Waller (1905b). The Nubeena Quartzite and Slate is followed by the so-called ‘‘Keratophyric Tuff’’ described by Twelvetrees and Ward (1910, p. 15). This latter formation consists of vitric and lithic keratophytic tuffs and breccias with interbedded slates and sandstones and contains fossils in the Summit Cutting on the Comstock Tram west of Zeehan, in a black slate. Opik (1951c) recorded Diplagnostus sp., and cystoids, and suggested correlation with the Hodge Slate. The section is summarized as figure 2 (d).

NORTH PIEMAN, ROSEBERY AND MOUNT FARRELL DISTRICTS

Taylor (1954a), in an important contribution, gave the succession from the mouth of the Stanley River to Rosebery. This is summarized below and as text-figure 2 (e):

179
MAXWELL R. BANKS

<table>
<thead>
<tr>
<th>Layer Description</th>
<th>Thickness</th>
</tr>
</thead>
<tbody>
<tr>
<td>Conglomerate</td>
<td>420 ft.</td>
</tr>
<tr>
<td>Black shales with <em>Glyptagnostus</em></td>
<td>420 ft.</td>
</tr>
<tr>
<td>Sandstone</td>
<td>130 ft.</td>
</tr>
<tr>
<td>Conglomerate</td>
<td>450 ft.</td>
</tr>
<tr>
<td>Chert Breccia</td>
<td>120 ft.</td>
</tr>
<tr>
<td>Black slate with <em>Protorthis</em> and dendroids</td>
<td>110 ft.</td>
</tr>
<tr>
<td>Shales and tuffs</td>
<td>890 ft.</td>
</tr>
<tr>
<td>Conglomerate</td>
<td>260 ft.</td>
</tr>
<tr>
<td>Grey shales</td>
<td>610 ft.</td>
</tr>
<tr>
<td>Tuff</td>
<td>90 ft.</td>
</tr>
<tr>
<td>Shale</td>
<td>160 ft.</td>
</tr>
<tr>
<td>Conglomerate</td>
<td>160 ft.</td>
</tr>
<tr>
<td>Shale</td>
<td>300 ft.</td>
</tr>
<tr>
<td>Conglomerate and shale</td>
<td>350 ft.</td>
</tr>
<tr>
<td>Shale</td>
<td>260 ft.</td>
</tr>
<tr>
<td>Sandstone</td>
<td>170 ft.</td>
</tr>
<tr>
<td>Dark grey shales with dendroids</td>
<td>390 ft.</td>
</tr>
<tr>
<td>Quartzite with some shale and conglomerate</td>
<td>350 ft.</td>
</tr>
<tr>
<td>Black shale</td>
<td>380 ft.</td>
</tr>
<tr>
<td>Argillite</td>
<td>6020 feet</td>
</tr>
</tbody>
</table>

The unconformity with the Davey Group occurs west of the mouth of the Stanley River. The basal beds are jasper followed by quartzite with interbedded shale and tuff, shale, quartzite, and a shale with some breccia beds. Taylor correlated this with the Carbine Group (Elliston, 1954) but the presence of tuff bands is not usual in the Carbine.

The argillite which outcrops roughly from the mouth of the Wilson to the mouth of the Ring River along the Pieman, overlies the lower group unconformably and is about 12,000 feet thick. The formation consists of deep red to purple or blue-green to deep-green argillites with subordinate pyritic grey to black shale and bands of pyroclastics throughout, but commoner towards the top. Near the top of the formation is a flow, thirty feet thick, of vesicular basalt consisting of labradorite, biotite and some interstitial albite in a glassy groundmass. Taylor also equated this formation with the Carbine Group but the presence of volcanic material in it and the lithology of the slates suggest correlation with the Dundas Group rather than with the Carbine.
Overlying this formation on the Huskisson River are 6000 feet of conglomerate, breccia, greywacke, slate and volcanics, with formations higher in the column than any recorded so far from Dundas. The basal formation consists of thinly-bedded black shales, followed by a formation of coarse, green-grey quartzite, dark shales, fine-grained conglomerates and then light-grey quartzites at the top. The present author would prefer to split this formation beneath the conglomerate and regard this conglomerate as the beginning of a new cycle. The next unit on Taylor's scheme is a fine-grained, thinly-bedded, dark grey shale containing dendroids, which Taylor equated to the Hodge Slate. This is followed by a coarse-grained blue-grey sandstone. A thickly-bedded yellow-brown to grey shale follows, and this is succeeded by a unit containing three conglomeratic members with two interbedded shaly members. The present author prefers to regard these as five separate formations. The next unit in Taylor's succession is a thinly-bedded blue-grey shale, and this is followed by a dark-grey conglomerate with quartz and chert pebbles in a coarse sandy matrix. A thinly-bedded shale follows and is succeeded in turn by a massive feldspathic tuff and then thinly-bedded grey shales. The next cycle commences with a cherty conglomerate which is overlain by thinly-bedded shales with tuffaceous bands and then a unit of black slate with Protorthis, Otusia (?), Sphenoecium and Archaeolofoaea (Örik, 1951b). Örik (1951b; and letter, 1955) correlated this with the Hodge Slate. This view requires the non-deposition or erosion in this area of all the formations above the Hodge Slate in the Dundas area.

Taylor's next three units comprise the lower part of the next cycle and are a chert breccia, a coarse conglomerate and a brown sandstone with some conglomerate. The higher beds of this cycle are black pyritic shales with thin sandy laminae and contain Glyptagnostus reticulatus and Protospongia (Örik, 1951b). The top unit is a greywacke conglomerate with pebbles of sandstone and chert in a sandy matrix. The topmost group thus consists of eleven cycles ranging from upper Middle Cambrian to lowermost Franconian in age. A notable contrast with the section at Dundas is the paucity of volcanics. In addition, the sediments of this group appear to be finer-grained on the whole than those of the Dundas Group at Dundas.

West of Rosebery, Taylor recorded chlorite sericite schist, black shale, tuff, devitrified rhyolite, quartzite, slate, fuchsitic agglomerate
MAXWELL R. BANKS

and purple slate. Tuffs, slate and slate breccia occur on Colebrook Hill (Ward, 1911).

In the Rosebery area, slates, breccias, chloritic keratophyres and chloritic, calcareous, talc and sericitic schists occur (Hills, 1915a and b). A fuchsitic “breccia conglomerate” occurs in several places west and northwest of Rosebery (Finucane, 1932; Taylor, 1954a). At Rosebery and Williamsford, chlorite and sericite schists containing the zinc ore are overlain by a black slate which increases in thickness to the north, and this in turn is overlain by the “Eastern Massive Fragmentals,” a group of porphyritic lavas (or intrusive rocks, see Finucane, 1930), breccias and tuffs which extends north beyond Farrell Junction and east to Tullah (Hall et al., 1953; Carey, 1946). Black and grey slates occur near Tullah and near Mount Farrell a conglomerate occurs which is overlain by the Owen Conglomerate (Ward, 1908, p. 20).

Just north of Farrell Siding on the Hatfield Plains, in the cutting on the Emu Bay Railway between 49.9 and 50.25 miles from Burnie, Hurdia davidi was found in thin-bedded, black, fissile slate, similar to that underlying the “Eastern Massive Fragmentals” at Rosebery (Finucane, 1932, p. 24). Later mapping suggests that the Hatfield Plains Slate is continuous with the slate at Rosebery (Taylor, 1954). If Elliston’s correlations are correct, this would be in the upper beds of the Climie Slate.

These rocks in the Rosebery and Tullah areas are correlated with the Dundas Group on the grounds of lithological similarity, and structural continuity (see Elliston, 1954, p. 177).

Porphyries and felsites, probably keratophyres, occur in the Que River district where they are associated with chlorite schists, quartz sericite schists and buff-purple fine-grained breccias (Henderson, 1938).

Near the Pinnacles, keratophyre, conglomerate, slate, breccia and feldspathic tuff (or greywacke) have been noted (Reid, 1918, pp. 28-30). The Que River and Pinnacles rocks are correlated with the Dundas Group because of lithological similarity.

WARATAH

Slates, tuffs, lavas, greywackes and a chert (the Cleveland Chert) occur at Mount Cleveland near Waratah (Hughes, 1953a). Just west of Waratah, red, buff, grey and black slates, red and white cherts,
volcanic breccias, and tuff or greywacke are associated with a hornblende basalt (Nye, 1932). *Tasmanadia twelvetreesi* occurs in slates on the Arthur River a few miles northwest of Waratah (Chapman, 1929). The Magnet Dyke (see Cottle, 1953) was considered by Scott (1954, p. 129) to be a sequence of spilitic flows. South of Waratah in the Mount Ramsay area Finucane and Blake (1933) noted the presence of purple, black, and grey slates, black cherts, and fine-grained green or grey breccias (or greywackes). These rocks are correlated with the Dundas Group on the basis of lithological similarity.

**SMITHTON AND KING ISLAND**

In the Smithton area Carey and Scott (1952) placed 5000 feet of slates, breccias, tuffs, spilites and perhaps tillite in the Dundas Group on grounds of lithological similarity. The tillite occurs at the base of the section. A little west of Smithton at Montagu, black slates and greywacke breccias occur. Limestones may be present in this group near Smithton (Nye, Finucane and Blake, 1934). On the east coast of King Island at City of Melbourne Bay, slates, quartzites, breccias, tuffs, lavas and tillite occur (Waterhouse, 1916a). Carey (1946) suggested a Lower Palaeozoic or Precambrian age for the tillite. Scott (1951) published a more detailed section and described the volcanic rocks as dominantly spilitic. There is disagreement over the precise stratigraphy, especially the position of the tillite and the associated varved argillites. By analogy with the situation at Zeehan, the tillite has been considered as near the base of the Dundas Group and the lavas and tuffs correlated with those of the Dundas Group on grounds of lithological similarity.

**THE DIAL RANGE AREA**

Thomas and Henderson (1943) recorded sandstone, mudstone, conglomerate and breccia conglomerate at Natone, Blythe and on Penguin Creek. Twelvetrees (1905) reported Cambrian also at Stowport.

East of Penguin, Hughes (1953b) noted purple, black and white slates, now silicified to form cherts with beds 1 to 2 inches thick of volcanic breccia (or greywacke). These rest with an inferred unconformity on the Precambrian east of Lonah Point and are followed up-
wards and westwards by lavas and pyroclastics. These include spilites described by Scott (1952) from Groom's Slip. These are followed further west by greywacke and sub-greywacke conglomerates and breccia conglomerates near Penguin. Purple slates and white quartzites west of Penguin recorded by Hughes (1953b, p. 5) as Dundas Group are considered (Spry, pers. comm.) to be Precambrian.

In a road-cutting on the Preston Road just south of Gawler the section is as shown below:

<table>
<thead>
<tr>
<th>Spilitic tuff</th>
</tr>
</thead>
<tbody>
<tr>
<td>Argillite, dark grey, thin-bedded, with beds of greywacke up to 2&quot; thick, sponge spicules and carbonaceous markings.</td>
</tr>
<tr>
<td>Argillite, buff, thick-bedded</td>
</tr>
<tr>
<td>Feldspathic rock</td>
</tr>
</tbody>
</table>

Cherts and chert breccias outcrop further along the road, and then, moving down dip, along Gunn's Plains Road, spilitic lavas, tuffs and breccias, and then a greywacke breccia occur. Basic lavas, sub-greywacke conglomerate, argillite, greywacke breccia and quartzite outcrop in cuttings along the east side of the Leven River below Gunn's Plains. Near Gunn's Plains the following section, which overlies these last rocks, was measured:

<table>
<thead>
<tr>
<th>Owen Conglomerate (Ordovician)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Unconformity</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
</tbody>
</table>

gap of soil-covered rock

The lowest argillite in this section contains fossils 55 feet from the top. The fossils include trilobites, (Clavagnostus; Ópik, pers. comm.), sponge spicules and inarticulate brachiopods. The overlying volcanic formation consists of keratophyric tuffs to the north and a vesicular keratophyric lava to the south. The argillite above the lava contains
MIDDLE AND UPPER CAMBRIAN IN TASMANIA

agnostid trilobites 181 feet above the base. These agnostids include Leiopyge laevigata, L. laevigata armata (Opik, 1951c; letter, 1955), and suggest correlation with the Comet Slate and Tuff. The conglomerate is composed of siliceous boulders in a matrix of rock fragments, quartz and chlorite. This succession could be considered as consisting of parts of two cycles.

The succession exposed in an old timber road along the west side of the Leven Gorge is summarized below:

Quartz biotite keratophyre
Argillite
Micaceous salmon pink greywacke with Pseudagnostus, a dikelocephalid, and another trilobite with affinities to Monocheilus (Opik, 1951c)
gap
Argillite
Greywacke
gap of hundreds of feet
Chert and argillite, thinly-bedded
Argillite (40-50 feet)
Argillite with greywacke beds up to 18" in thickness.

The fossiliferous greywacke was considered by Opik (1951c) as basal Dresbachian, and as such is above the argillite with Leiopyge in the road section which Opik considered (1955, pers. comm.) as Middle Cambrian. The road section is summarized as text-figure 2 (f).

Acid tuffs, greywackes, argillites, quartz keratophyre, and micaceous quartzites occur near Nietta (Carey, 1946, p. 25; and author). At Paloona, a few miles southwest of Devonport, cherts and argillites are overlain by a chloritic, albitic tuff and keratophyre.

SHEFFIELD AREA

Keratophyres, slates, and volcanic sediments occur near Lorinna (Reid, 1919a); Elliston (1953) recorded slates and volcanic rocks near Moina, and Twelvetrees (1913) reported grey and purple slates, schistose conglomerates and sheared quartz albite tuffs and quartz biotite keratophyre a little further north. Near Mount Claude just south of Sheffield, hornblende porphyries, tuffs, slates, schistose conglomerate, chlorite schist, talc schist, haematite schist and quartz sericite schist are overlain by Owen Conglomerate, in one place unconformably (Twelve-
MAXWELL R. BANKS

trees, 1913; Reid, 1919b; Hughes, 1948; and Elliston, 1953). East of Sheffield, porphyries, slates, schists and feldspar porphyrite have been noted (Twelvetrees, 1911; Reid, 1924; Nye, 1927a; and Hughes, 1950).

These rocks are correlated with the Dundas Group because of lithological similarity and their position below the Owen Conglomerate.

DELORAINE

The sequence of rocks below the Owen Conglomerate and above the schists correlated with the Davey Group in this area has recently been measured by Wells (1954) and is summarized below, and as text-figure 2(g):

<table>
<thead>
<tr>
<th>Layer</th>
<th>Thickness</th>
</tr>
</thead>
<tbody>
<tr>
<td>Owen Conglomerate (Ordovician)</td>
<td></td>
</tr>
<tr>
<td>unconformity</td>
<td></td>
</tr>
<tr>
<td>Siltstone</td>
<td>2000 ft.</td>
</tr>
<tr>
<td>with keratophyre member (1300 ft.)</td>
<td></td>
</tr>
<tr>
<td>and spilite member (1400 ft.)</td>
<td></td>
</tr>
<tr>
<td>Slate</td>
<td>880 ft.</td>
</tr>
<tr>
<td>Slate and 'sub-greywacke'</td>
<td>2000 ft.</td>
</tr>
<tr>
<td>unconformity</td>
<td>6280 ft.</td>
</tr>
<tr>
<td>Davey Group</td>
<td></td>
</tr>
</tbody>
</table>

The lowest formation, the slate and sub-greywacke, consists of dark brown to orange brown slates, mottled pink and white coarse sub-greywackes and pink to orange siltstone and sandstone. These are succeeded by the slate formation which to the south apparently overlaps the lowest formation and rests unconformably on the Precambrian. The basal beds in the south are coarse greywacke conglomerates but most of the formation consists of black slates and calcareous sub-greywacke.

The siltstone, including the keratophyre member in the north and the spilite member in the south, is about 3400 feet thick, of which about 2000 feet is siltstone. The siltstone is thin-bedded, rather soft, pink to reddish-brown in colour, and there are inter-bedded greenish-brown and blue-grey slates. The spilite and breccia formation consists of sheared, chloritized and epidotized spilites and spilitic breccias. The keratophyre has phenocrysts of quartz and albite in a quartzo-feldspathic or chloritic groundmass.
MIDDLE AND UPPER CAMBRIAN IN TASMANIA

About 20 miles southeast of Deloraine, on the slopes of O'Connor's Peak and beside the Lake River south of Cressy, Voisey (1949) recorded slates, phyllites and sheared tuffs, correlates of the Dundas Group on lithological grounds.

BEACONSFIELD

Taylor (1949, p. 31) noted the presence of clay slates, claystones, and sandstones at Anderson's Creek, and Scott (1954, p. 129) reported spilite from near Beaconsfield. These rocks are correlated with the Dundas Group on lithological grounds.

ADAMSFIELD

Rocks correlated with the Dundas Group on lithological and structural grounds occur in the valley of the Adam River below the Silver Falls (Nye, 1929, p. 10). Slates, cherts and fine-grained breccias are present. The slates include thin-bedded purple slates and white, grey-green, brown and red cherts are also present. The breccias are greywacke breccias with quartz and feldspar.

The author noted greenish micaceous siltstone and interbedded slaty siltstones and red siltstones west of Silver Falls.

SOUTH COAST

Dark-grey to green-grey slates, black cherts and breccias overlain, presumably unconformably, by the Owen Conglomerate, occur near Rocky Boat Harbour just east of New River Lagoon (Blake, 1938). These are correlated with the Dundas Group on lithological and structural grounds.

PALAEONTOLOGY AND CORRELATIONS

Sponge spicules, brachiopods, trilobites and other crustaceans, worm tracks, cystoids and dendroids have been recorded from the Dundas Group. Their known occurrence is summarized below:
MAXWELL R. BANKS

Porifera
Protospongia
Spicules

Brachiopoda
Protorthis
Otusia (?)

Inarticulate brachiopods

Annelida
Tasmanadia twelvetreesi

Arthropoda
Trilobita
Ptychagnostus (?)

Triagnostostus

Peronopsis

“perhaps Homagnostus”

Diplagnostostus

Phalacroma

Clavagnostostus

Leiopyge laevigata

Leiopyge laevigata armata

Cycle 10, Huskisson River Section, Huskisson River (Opik, 1951b).
Preston Road, North Motton. Clavagnostus Bed, Gunn's Plains Road, Leven Gorge.

Near top of cycle 9, Huskisson River section, Huskisson River (Opik, 1951b).

Near top of cycle 9, Huskisson River section, Huskisson River (Opik, 1951b).

Clavagnostus Bed, Gunn's Plains Road, Leven Gorge.

Arthur River (Chapman, 1929).

Judith Slate and Sub-greywacke, Dundas Group, Dundas (Opik, 1951b).

Judith Slate and Sub-greywacke, Dundas Group, Dundas (Opik, 1951b).

Judith Slate and Sub-greywacke, Dundas Group, Dundas (Opik, 1951c).

Hodge Slate, 100 yards west of Bonnie Point, North-East Dundas Tram, Dundas (Opik, 1951c).


Comet Slate and Tuff, Dundas Group, Dundas (Opik, 1951c).

Argillite below tuff, Gunn's Plains Road, Leven Gorge (Opik, letter, 2.8.1955).

Argillite between tuffs, Dundas Group, Gunn’s Plains Road, Leven Gorge (Opik, letter, 19.6.1955).

Argillite between tuffs, Dundas Group, Gunn’s Plains Road, Leven Gorge (Opik, letter, 19.6.1955).
**MIDDLE AND UPPER CAMBRIAN IN TASMANIA**

*Oidalagnostus*

Comet Slate and tuff, Dundas Group, Dundas (Öpik, 1951c).

*Pseudagnostus*

Salmon Greywacke, road west of Leven Gorge (Öpik, 1951c).

1000 ft. southeast of Bonnie Point, North-East Dundas Tram, in Hodge Slate (?) (Elliston, 1954; and Öpik, letter, 2.8.1955).

*Glyptagnostus reticulatus*

Cycle 10, Huskisson River section, Huskisson River (Öpik, 1951b).

*Pagetia*

Judith Slate and Sub-greywacke Dundas Group, Dundas (Öpik, 1951a).

*Lorenzella*

Judith Slate and Sub-greywacke, Dundas Group, Dundas (Öpik, 1951a).

*Pachyaspis (= Conaspis of Öpik, 1951a)*


*Bathyuriscids*

Hodge Slate, Dundas Group, 100 yards west of Bonnie Point, North-East Dundas Tram, Dundas (Öpik, 1951c; and letter, 2.8.1955).

*Solenoparia*

Hodge Slate, Dundas Group, 100 yards west of Bonnie Point, North-East Dundas Tram, Dundas (Öpik, 1951a).

*Blackwelderia cf. biloba*

Comet Slate and Tuff, Dundas Group, Dundas (Öpik, 1951a).

*Conocephalites (?)*

Comet Slate and Tuff, Dundas Group, Dundas (Öpik, 1951a).

*Anomocarella (?)*

Comet Slate and Tuff, Dundas Group, Dundas (Öpik, 1951a).

*Dikelocephalid*

Salmon Greywacke, road west of Leven Gorge (Öpik, 1951c).

1000 ft. southeast of Bonnie Point, North-East Dundas Tram, in Hodge Slate (?) (Elliston, 1954; and Öpik, letter, 2.8.1955).

*aff. Monocheilus*

Salmon Greywacke, road west of Leven Gorge (Öpik, 1951c).

*Coosia*

1000 ft. southeast of Bonnie Point, North-East Dundas Tram, in Hodge Slate (?) (Elliston, 1954; and Öpik, letter, 2.8.1955).
Aphelaspis (?)  
(= aff. Wilbernia (?)

1000 ft. southeast of Bonnie Point, North-East Dundas Tram, in Hodge Slate (?) (Elliston, 1954; and Ópik letter, 2.8.1955).

Phyllocarida
Hurdia davidi

Dundas Group, railway cutting, Hatfield Plains (Chapman, 1926).

Echinodermata
Cystoidea


Hemichordata
Dendroidea

Archaeocryptalaria skeatsi
Mastigograptus
Cactograptus flexispinosus
Protohalicium hallianum
Protistograptus
Archaeolofoaea serialis
Sphenoecium filicoides
Archaeolofoaea
Sphenoecium
Dendroids

Hodge Slate, Dundas Group, Dundas (Thomas and Henderson, 1945).
Hodge Slate, Dundas Group, Dundas (Thomas and Henderson, 1945).
Hodge Slate, Dundas Group, Dundas (Thomas and Henderson, 1945).
Hodge Slate, Dundas Group, Dundas (Thomas and Henderson, 1945).
Hodge Slate, Dundas Group, Dundas (Thomas and Henderson, 1945).
Hodge Slate, Dundas Group, Dundas (Thomas and Henderson, 1945).
Hodge Slate, Dundas Group, Dundas (Thomas and Henderson, 1945).
Near top of cycle 9, Huskisson River section, Huskisson River (Opik, 1951b).
Near top of cycle 9, Huskisson River section, Huskisson River (Opik, 1951b).
Near top of cycle 3, Huskisson River section, Huskisson River (Taylor, 1954a).

Near top of cycle 9, Huskisson River section, Huskisson River (Opik, 1951b).

The lowest formation at Dundas contains Ptychagnostus (?), Triplagnostus, Peronopsis, Pagetia and Lorenzella, suggesting correlation with the Ptychagnostus gibbus Zone of the Middle Cambrian of the Camooweal area of Queensland (Ópik, 1954; and this symposium). The
next assemblage is in the Hodge Slate which contains dendroids in the type area and Solenoparia and Bathyruriscids just west of Bonnie Point on the North-East Dundas Tram. This may be correlated with the upper part of the Ptychagnostus atavus Zone or the P. punctuosus Zone and is older than the Amphoton bed in Victoria (Öpik, 1955, letter). Diplagnostus occurs in slate in the “Keratophyre Tuff,” Zeehan, which Öpik (1951a) correlated with the Hodge Slate. The Comet Slate and Sub-greywacke contains Blackwelderia cf. biloba, Phalacroma, Oidalagnostus, and Conocephalites, and Öpik (1951b; and letter, 1955) correlated this with the lower part of the range of Leiopyge laevigata. On the North-East Dundas Tram, in the type area of Waller (1905a), trilobites occur in a greenish mudstone about 1000 feet southeast of Bonnie Point. Öpik has identified Pseudagnostus, Coosia, Aphelaspis (?) and a Dikelocephalid, and he suggested (letter, 14.6.1955) a correlation with the lower Dresbachian (Cedaria Zone). This locality is shown on Elliston’s map (1954) as Hodge Slate, but this would seem to be an error.

Fossils occur in the Huskisson River section on three horizons. Taylor (1954a) noted dendroids in his third formation and correlated them with those of the Hodge Slate. However, near the top of cycle 9 in the same section, Öpik (1951b) recorded the dendroids Archaeolofoaea and Sphenoecium with the brachiopods Protorthis and Otusia (?), and correlates this horizon with the Hodge fauna. Several possibilities arise from this situation:

(a) the lower fossils were misidentified;
(b) there is isoclinal folding;
(c) Taylor’s correlation is correct and the local range of dendroids extends higher in the column than has been previously supposed;
(d) Öpik’s correlation is correct and there is a major break in the succession at the end of cycle 9.

In the slates of cycle 10, Öpik (1951b) recorded Glyptagnostus reticulatus and Protospongia, and considered these to be basal Franconian.
Of the possibilities arising from the occurrence of the two beds of
dendroids, the author does not consider the first two likely. Elliston
found the lower dendroids and had had some previous experience in
identifying dendroids in the Dundas area. Dips are consistently east-
ward in the Huskisson section and Taylor made no mention of westward
or overturned eastward dips and it is difficult but not impossible to
draw sections consistent with the succession as proposed by Öpik. Thus
the second alternative is considered possible but unlikely. If the third
possibility is correct, the range of the dendroids would be extended into
the Upper Cambrian and this does not seem impossible. Öpik’s corre-
lation involves an unconformity or a fault between beds which he
placed in the *Ptychagnostus punctuosus* Zone and beds which he placed
as basal Franconian. Öpik (letter, 21.7.1955) said, “...the chert breccia
and coarse conglomerate in between (i.e. between the dendroids and the
*Glyptagnostus*) is, consequently, connected with a significant break.”
This possibility does not contravene any known fact and must be given
at least equal weight with the third one. The author considers that there
are insufficient facts known to chose between the third and fourth pos-
sibilities.

Four fossiliferous horizons are known in the Leven Gorge area.
The lowest one, on the Preston Road, contains, as far as is known, only
sponge spicules and carbonaceous markings, and cannot be dated. On the
Gunn’s Plains Road in the Leven Gorge, the lowest argillite in the
measured section contains *Clavagnostus*, sponge spicules and inarticulate
brachiopods. In the next argillite member, *Leiopyge laevigata* and *L.
laevigata armata* are found, which suggests correlation with the *Leiopyge
On the west side of the Leven Gorge, *Pseudagnostus*, a Dikelocephalid
and a trilobite with affinities to *Monocheilus* occur in a salmon-coloured
greywacke which Öpik (letter, 14.6.1955) correlated with the fauna east
of Bonnie Point, Dundas, as being Lower Dresbachian.

Thus the Dundas Group covers at least the upper part of the Mid-
dle Cambrian from the *Ptychagnostus gibbus* Zone upwards through the
basal Upper Cambrian to the *Glyptagnostus reticulatus* Zone near the
base of the Franconian. Correlation of these zones with those on other
continents is considered by Öpik (Cambrian Geology of Queensland,
this symposium).
MIDDLE AND UPPER CAMBRIAN IN TASMANIA

PALAEOCLIMATOLOGY

The climate under which the Dundas Group was deposited cannot readily be deduced from the information at present available. The Zeehan Tillite is associated with thin-bedded dark and light grey argillite which may be a formation of glacially varved silts and clays. Elliston (1954, p. 177) correlated the Zeehan Tillite with the Red Lead Conglomerate, which would place it in the upper Middle Cambrian. However, detailed mapping by Spry has not revealed the stratigraphic position of the Zeehan Tillite beyond establishing the fact that it rests unconformably on Pre-Dundas Group rocks, but its precise relationship to the Dundas Group is not yet known. On King Island a tillite with associated thin-bedded argillites underlies and is partly interbedded with, a sequence of spilitic flows which has been correlated with the Dundas Group on lithological grounds. Thus at King Island also there is some suggestion of glaciation at or near the base of the Dundas Group.

In his description of the geology of the Dundas Group, Elliston (1954) suggested that the Red Lead Conglomerate on upper South Comet Creek is a tillite because it consists of sparse large pebbles in a very fine purple silt matrix (p. 168). The Razorback Conglomerate is thought to have been the formation from which a striated pebble was obtained by Waller (see Elliston, 1954, p. 166). Elliston (1954, p. 171) thought that there was a possibility that the Fernflow Conglomerate, with its rare pebbles in a slate or greywacke matrix, might also be glacial. The author doubts that these conglomerates are glacial, but cannot prove this contention until the petrology and distribution of the formations are thoroughly worked out.

Carey and Scott (1952, p. 67) suggested the possibility that a silicified breccia at Smithton is the silicified equivalent of the Zeehan and King Island Tillites. Later (p. 70) they advocated a Cambrian age for the tillites which they considered to belong to the Dundas Group. However, until detailed stratigraphy is done at King Island, Zeehan and Smithton, the author prefers to regard the age of the tillites as an open question.

Just east of Penguin, Scott (1952, p. 123) reported a tillite and laminated slates, and correlated these with the King Island and Zeehan
occurrences. However, these rocks at Penguin are not tillites as the rocks are too well-sorted and lack the rock flour matrix of true tillites. They are sub-greywacke breccias.

Purple slates, argillites and cherts are common in the Dundas Group, but no detailed work on them has been done so that it is not known whether the colouring is due to oxidation on exposure or not.

From the above it will be seen that no accurate information is yet available on the Middle and Upper Cambrian climate of Tasmania.

**IGNEOUS ACTIVITY**

Volcanic, hypabyssal and acid and ultrabasic plutonic activity occurred in Tasmania during or just after the deposition of the Dundas Group. The areal distribution of the Cambrian igneous rocks is shown on the map (fig. 3). Some aspects of the petrology of the volcanic rocks have been dealt with by Scott (1954).

Picrite basalt, olivine spilite, porphyritic pyroxene basalt, spilite, hornblende andesite or keratophyre, biotite keratophyre, quartz keratophyre and rhyolite have been recorded from the Dundas Group (see Scott, 1954; Bradley, 1954; Finucane, 1930; Taylor, 1954a). Pillow structure is common in the spilites (Scott, 1951; 1952; 1954) and Bradley (1954, comments on Mount Owen sheet) noted columnar structure in a keratophyre. The basic members of this spilitic suite have usually been regarded as volcanic in origin, but there is still controversy on the origin of the acid members. Finucane (1930) maintained that they were intrusive, basing his conclusions on the occurrence of dykes near Primrose Siding, Rosebery, and on the discordance of porphyry with associated rocks near Rosebery. This discordance may, however, be an unconformity, and there is ample evidence to show that many of the acid porphyries are extrusive (see Carey, 1946; Hall et al., 1953; Bradley, 1954). Basically, the evidence is that glass and pseudo-inclusions are common in the porphyries, angular fragments of porphyry occur in a porphyry matrix and fragments of glass and porphyry occur in the tuffs and breccias associated with the porphyries. Scott (1954) regarded the acid porphyries as originally basalts which had been silicified and albitized, supporting her contention with the argument that where the least altered basaltic rocks occur, there are no keratophyres, and that the acid porphyries seem to be restricted to the zone of structural weak-
Fig. 3. Map of Tasmania showing the distribution of Middle and Upper Cambrian Volcanic Rocks.
ness (the Porphyroid Anticlinorium) where metasomatism has probably been at its greatest. She also adduced the association of a "spherulitic felsite" with the Montana Spilite and the occurrence of apparently intermediate stages between these two rocks at Zeehan and elsewhere to support the idea of silicification of original basalts. However, acid porphyries and tuffs are not restricted to the Porphyroid Anticlinorium, as they occur at Zeehan, the Leven Gorge, Paloona and Nietta, and in these areas are not associated with albitization of the sediment. Spherulitic rhyolite in a breccia occurs near Farrell Siding (Carey, 1946). Spherulites occur in a tuff from Smithton (Nye, Finucane and Blake, 1934), spherulitic basalt occurs on King Island, a fragment of spherulitic glass occurs in a greywacke at Magnet (author), and fragments of spherulites occur in a greywacke in the "Fuchsitic Breccia-Conglomerate" near Rosebery (Finucane, 1932). These observations indicate that at least some of the lavas were spherulitic by the time they consolidated. Spry (pers. comm.) has observed that angular fragments of fresh albite are common in the greywackes and tuffs, and that angular epidote is also present in some of the greywackes on Lynch Creek, Queenstown. He interprets this to mean that the albitization and epidotization took place before or very soon after the lavas were erupted and was deuteric. All of these lines of evidence suggest that Scott’s hypothesis is based on invalid evidence. Yet another hypothesis (Bradley, 1954) postulates derivation of some of the feldspar porphyries and quartz feldspar porphyries from sediments by albitization and silicification. Quartz and albite porphyroblasts seem to be present in what were originally greywackes and greywacke conglomerates near Queenstown as suggested by Bradley (1954) and there is abundant evidence of secondary albitization along the West Coast Range. However, keratophyric and quartz keratophyric tuffs occur at Zeehan, Dundas, the Leven Gorge and Paloona away from areas of relatively intense alteration. Keratophyres occur with greywackes and sub-greywackes lacking porphyroblasts of albite in the Leven Gorge and at Paloona, and at Deloraine. These observations are not in favour of the application of this hypothesis throughout Tasmania. In view of the evidence quoted above, and earlier in the paper, it is here considered that most of the acid members of the spilitic suite in Tasmania represent originally acid volcanic rocks.

Volcanic breccias and crystal, lithic and somewhat vitric tuffs have been described from the Dundas Group (Bradley, 1954; Scott, 1954;
Twelvetrees and Ward, 1910; Finucane, 1932; Carey, 1946; Carey and Scott, 1952; Scott, 1951; Twelvetrees, 1909a; Wells, 1954). Many other authors have reported tuffs, but on examination of the descriptions or the rocks it is more likely that the majority of the tuffs recorded are sub-greywackes or greywackes. The tuffs vary in composition from spilitic to quartz keratophyric for the lithic tuffs, and from albite-augite tuffs to quartz-albite tuffs for the crystal tuffs.

One remarkable feature that emerged from this review was the position of the volcanic rocks in the cycles of sedimentation. In the Dundas section it is notable that they normally occur associated with the finer-grained rocks, the argillites, in the cycles. The same observation applies at Smithton, the Leven Gorge and Deloraine, and probably at King Island and Penguin. At Lake Dora there are several cases where this is true and one exception; at Zeehan there appear to be exceptions at this stage of our stratigraphic knowledge, which may be removed as knowledge advances; and at Lynch Creek it does not seem to apply. There is enough evidence to suggest that usually the volcanic activity occurred during deposition of the finer-grained sediments in the cycles. The significance of this is not yet known, and it needs to be tested in all sections.

Sills and dykes of Middle or Upper Cambrian age are comparatively rare. However, augite porphyrites, quartz feldspar porphyries, spilitic dykes, feldspar porphyry, dolerite, hornblende porphyrite and albitic dolerite have been recorded as intruding the Dundas Group (Blake, 1932; Nye, 1930; Twelvetrees and Ward, 1910; Finucane, 1932; Carey and Scott, 1952; Scott, 1954). A mass of igneous rocks considered by most authors (see Cottle, 1953) as a composite basic dyke occupying a fault at Magnet has been interpreted by Scott (1954) as probably volcanic, because of its concordance with the adjacent sediments, the presence of numerous amygdules, and of volcanic breccia. Another mass of igneous rock, called a complex dyke by Nye, Finucane and Blake (1934) has been interpreted by Carey and Scott (1952) as a suite of basic volcanic rocks. This mass at Smithton contains an abundance of vesicles and amygdules, pillows, volcanic bombs and breccia, so that a volcanic origin is indicated. However, there is no doubt that dykes of rocks belonging to the spilitic suite, and ranging from basic to acid in composition do cut the Dundas Group or part thereof, but have not been observed definitely to cut the Lower Ordovician rocks of the Junee Group.
Granites, supposed to be of Upper Cambrian age, have been reported from Mount Darwin and the Dove River area. Syenites from the Murchison Gorge, Mount Farrell and the Dial Range, are doubtfully also Upper Cambrian. The Darwin Granite which apparently is a tabular body occupying the core of an asymmetric anticline is said by Bradley (1954) to be a sill or several sills. The granite contains orthoclase, oligoclase, quartz, biotite, chlorite and hornblende, and possibly palimpsest pebbles (Bradley, 1954). The origin of the Darwin Granite is controversial, Bradley (1954) proposing that it was produced, at least in part, by granitization of the Dundas Group sediments and the Lower Ordovician Jukes Breccia, during the Tabberabberan Orogeny in the Middle Devonian. Hills (1913) noted the presence of pebbles of Darwin Granite in the overlying Jukes Breccia and postulated that it was a Cambrian intrusion. The problem requires detailed field and laboratory studies before the controversy can be settled.

The granites in the Dove River area also contain some chlorite pseudomorphing biotite and hornblende (Twelvetrees, 1913). These granites are associated with Dundas Group rocks but their relationship to the Ordovician is unknown. They are generally considered to be Cambrian but there is no real evidence on the point.

Syenite outcrops on the east bank of the Murchison River between Mount Farrell and Rosebery (Ward, 1908; Nye, 1930; Bradley, 1954). This has been considered as an intrusion on the one hand and as the result of granitization on the other. The age and origin of this body must remain controversial until such time as detailed work is done on it.

Basic and ultrabasic rocks, ranging in composition from quartz mica gabbros to dunites, but mainly pyroxenites, are common in Tasmania. Many of these have been extensively serpentinized. For a long time these were all considered to be co-magmatic with the Middle Devonian granite. In 1949, however, Hills and Carey suggested that some of them were pre-Lower Ordovician, and Carey (1953) considered that most of them were Cambrian, with the possibility that some were Devonian. Evidence of a Cambrian age for some of them is that they intrude Dundas Group rocks up to at least the Fernflow Conglomerate, that the Owen Conglomerate contains osmiridium, chromite and some gold, and that on the Sawback Range near Adamsfield, the serpentinite is overlain by the Junee Group, the basal beds of which are conglomerate, sandstone and shale, composed almost entirely of serpentinite fragments (Carey and Banks, 1954). The shale contains inarticulate brachiopods,
MIDDLE AND UPPER CAMBRIAN IN TASMANIA

gasteropods including *Scaevogyra*, and trilobites. This is overlain by Owen Conglomerate, Caroline Creek Sandstone and Gordon Limestone, the base of which contains brachiopods, cephalopods and trilobites of Middle Arenigian age (Brown, 1948; Teichert, 1947; Kobayashi, 1940). Thus the serpentinite at Adamsfield is not younger than Middle Arenigian, and is probably pre-Ordovician.

On the other hand, serpentinite is in contact with Eldon Group rocks at the Spero River and in the Wilson Huskisson, and Bald Hill belts. The Wilson River belt has argillite on its western side, and the argillite dips east beneath the serpentinite (Taylor, 1954a). On the eastern side the serpentinite is in contact with east-dipping beds of the Cambrian Huskisson River section, and, further north, the Junee and then the Eldon Groups. Reid (1921) noted that the beds of the Eldon Group were displaced up to 2½ miles horizontally on almost vertical planes, and Taylor (1954a) remarked that these faults do not displace the serpentinite. The author carefully examined the air-photos and Taylor’s remark seems to be true. Thus the emplacement of the Wilson River serpentinite is post-Lower Devonian. Further north, this belt is intruded by large dykes and a batholith of granite which also intrudes the Eldon Group.

The ultrabasic rocks of Tasmania were intruded as slightly transgressive sills and occasional dykes into the Dundas Group and Precambrian rocks, and into faults or unconformities between the Junee or Eldon and Dundas Groups (Taylor, 1954b; 1954c; 1949; Elliston, 1954; Reid, 1921; Twelvetrees, 1909b). There are either two separate and unrelated intrusions of ultrabasic rock in Tasmania, one of Upper Cambrian, the other of Middle Devonian age, or, an intrusion during the Upper Cambrian as slightly transgressive sills and dykes of ultrabasic material, some of which was re-intruded during the Middle Devonian into faults or the unconformities between the Junee or Eldon and Dundas Groups. No evidence seems to be available at this time to allow any conclusion on this point.

The ultrabasic intrusions introduced chromite, osmiridium, gold and rare diamonds. The serpentinite bodies bear no clear relationship to the major tectonic framework of Tasmania.

During the Middle and Upper Cambrian, lavas and pyroclastic rocks of the spilitic suite, varying from picrite basalt to quartz keratophyre, were extruded, mainly during deposition of fine-grained sediments. The main zone of eruption was on or close to the Porphyroid
Anticlinorium, but vulcanism was by no means confined to this zone. Granite and syenite may have been intruded or developed, also mainly along this zone, in the Upper Cambrian. Pyroxenites, with minor amounts of other ultrabasic types, were intruded during the Upper Cambrian as transgressive sheets in the Dundas Group, or as dykes in the Precambrian, and carried osmiridium which is associated with the bronzitite or peridotite members of the suite. These were serpentinized before the deposition of the Junee Group, and may have been re-intruded in some places in the Middle Devonian.

METAMORPHISM

The Dundas Group has been metamorphosed to some extent wherever it occurs. The finer-grained sediments are commonly argillites or slates and the coarser ones have been compacted and are cemented by chlorite. Chert is common, and has usually been regarded as silicified argillite. In a restricted zone, schists are developed (see fig. 4).

Chert, which means locally any cryptocrystalline siliceous sediment, occurs mainly in an arcuate belt from Paarloa and Ulverstone west to Waratah, at Smithton, in the Mainwaring-Wanderer Rivers area, and near New River Lagoon. Cherts in the northwestern arcuate belt would appear on general structural grounds to be relatively close to the base of the Dundas Group, and near Carey's (1953) Rocky Cape Geanticline. These cherts have usually been considered as silicified argillites, possibly following Nye (1928). Several people (e.g. Hughes, 1953b) have noted that they pass laterally into slates or argillites. This may imply silicification, but it is possible that some of the cherts were originally siliceous oozes.

Chlorite, quartz chlorite, quartz sericite and sericite schists occur along a belt from the Mainwaring River area to Rosebery and the Que River, and also in the Lorinna-Round Hill area. Chlorite and talc schists occur in the inland area of the Mainwaring-Wanderer district (Blake, 1936). On the southern shore of Macquarie Harbour, near Asbestos Point, sericite and quartz sericite schists outcrop (Taylor, 1949). Chlorite and sericite schists are found along the West Coast Range from Mount Darwin to Mount Murchison (Hills, 1913; 1927; Alexander, 1953; Bradley, 1954; Blake and Henderson, 1939). In the Rosebery area chlorite and quartz sericite schists have been recorded (Hall et al., 1953). A little further north in the Que River area, quartz sericite schists and chlorite schists were noted by Henderson (1938).
Fig. 4. Map of Tasmania showing the structure of Lower Palaeozoic rocks, and distribution of metamorphosed Dundas Group.
The only other occurrence of schisted Dundas Group rocks appears to be in the Round Hill area, where talc schists, haematite schists, chlorite schists and quartz chlorite schists have been noted by Hughes (1948), and earlier writers.

With the exception of this last occurrence, the schisted Dundas Group rocks fall into a narrow meridional belt from Low Rocky Point almost to Waratah. In this belt rocks of the Dundas Group have apparently been subjected to considerable shearing stress, and the action of mineral-bearing solutions at intermediate temperatures. Feldspar porphyroblasts occur in sediments in this belt at South Queenstown and near Tullah at least (Bradley, 1954), and the possible Cambrian granites are in or close to this belt. As the result of work along the West Coast Range, Bradley proposed a number of zones of alteration which in sequence are: silicification, haematitization, sericitization, chloritization and pyritization, feldspathization, epidotization, a potash zone with orthoclase and biotite, and finally, silicification. The early development of sericite and epidote is not in accord with the zones of metamorphism shown on Bradley's maps, in particular the Mount Darwin sheet, and with observations made by the author in the Lake Dora-Red Hills area, where it appears that chloritization and the development of quartz and feldspar porphyroblasts all precede the development of sericite. Chlorite is very widespread in Dundas Group sediments, and is probably developed during normal diagenetic processes affecting the greywackes and sub-greywackes. Epidote is also found in rocks which have not gone beyond the feldspar zone, and, to the author, appears usually deuteric. Metamorphism of Cambrian lavas in this belt and elsewhere in Tasmania, considered by Scott (1954) to be hydrothermal, is also considered to be deuteric by the author, as pointed out earlier, and the zonal arrangement of this alteration as proposed by Scott has also been considered earlier to be incorrect.

It is noticeable that economic mineralization seems to have accompanied the intense sericitization at Mount Lyell and Rosebery, and that some mineralization has occurred wherever chlorite schists occur. The schist belt was apparently a focus of metamorphism and mineralization. Carey (1953) suggested that the Porphyroid Anticlinorium was also such a focus. The schist belt does not, however, correspond to the Porphyroid Anticlinorium, as mapped by Carey (1953, fig. 3), nor does it lie along the structures so far mapped, as it cuts across the main anticlines obliquely. It corresponds to some extent with the belt of close
Tyennan folding deduced in the next section, and it is interesting to speculate on the possibility of its correspondence with Carey’s (1953, p. 1126) possible transcurrent fault in the basement rocks.

The metamorphism of the Dundas Group, especially along the schist belt, has generally been considered to have occurred in conjunction with the Tabberabberan Orogeny in the Lower and Middle Devonian, but there seems to be at least a possibility that metamorphism began in the schist belt during the Tyennan Orogeny in the Upper Cambrian.

STRUCTURE AND STRUCTURAL RELATIONSHIPS

The structure of the Dundas Group is the result of two orogenies, the Tyennan in the Cambrian, and the Tabberabberan in the Lower and Middle Devonian (see fig. 5).
At Sticht Range, Dundas, Lodder's Point near Ulverstone, and at Deloraine, the Dundas Group rests unconformably on older rocks, which at the Sticht Range show pre-Dundas folds. At the Sticht Range the basal bed of the Dundas Group contains boulders similar to the underlying rock, and in higher formations in the same area the same types of rock fragments occur as boulders. The Precambrian rocks of the Sticht Range are part of the Precambrian complex of the Tyennan Block (Carey, 1953). It seems then, that this block may have provided sediment during deposition of the Dundas Group, and it would then be a geanticline. Additional evidence on this point is the overlap of the basal formation at Deloraine by higher ones towards the Tyennan Anticlinorium. It is proposed therefore, to refer to it as the Tyennan Geanticline. The unconformity at the Sticht Range has been called the Stichtan Unconformity by Carey and Banks (1954). It represents two or more orogenic movements with intervening periods of deposition or erosion. The time interval covered by this unconformity cannot yet be estimated.

The idea of cycles of sedimentation in the Dundas Group was first proposed by Carey (1950), developed in terms of volcanic cycles by Elliston (1954), and further developed as due to orogenic movements by Carey and Banks (1954). At Dundas, there is evidence, as shown earlier, of at least eight cycles, and of at least eleven in the Huskisson River section. There are gradational contacts between several of the cycles at Dundas, but Elliston (1954) showed one of them to be sharp. Actual angular unconformities may occur at the Hercules and Rosebery Mines, and at Mount Farrell (see Hall et al., 1953). Bradley's inferred discordance in the Lynch Creek section at Queenstown (1954, p. 221) is not supported by later work by Solomon. The contact between the conglomerate and the underlying argillite in the author's section in the Leven Gorge is not regular, and may be an unconformity, but this is certainly not proven.

The structure of Tasmania proposed by Carey (1953, fig. 3) is dominantly the result of the Tabberabberan Orogeny. As the Tabberabberan structures have affected the Junee (Ordovician) and Eldon (Silurian and Lower Devonian) Groups, the effect of this orogeny on the Dundas Group can be estimated where it is overlain by the Junee or Eldon Groups, and, by levelling the dips of the Junee and Eldon Group sediments, the pre-Ordovician dip of the Dundas Group can be found.
The movement which terminated the Dundas sedimentation has been termed the Jukesian Movement (Carey and Banks, 1954, p. 265). Places where this movement is represented by an unconformity are shown in figure 4, and will all be seen to lie within the trough marginal to the Tyennan Geanticline. Where possible, the structure of the Dundas Group, when deposition began in the Lower Ordovician, has been estimated. West of Mount Sorell, there would have been an anticline overturned to the east, and at Mount Darwin, a complicated, overfolded structure. At Walford's Peak, the Dundas Group would have a low dip to the west, and in the Red Hills area, would be vertical and overfolded to the east. At Zeehan and along both limbs of the Huskisson Synclinal Basin, the residual dips would be low. At Gunn's Plains, dips of up to 30° to the northeast would have been present, and at Deloraine, there would have been an anticline with dips of 23° to the southwest and 40° to the northeast. A low dip to the east would have been present at Adamsfield. The results given above are as yet only fair approximations and far more information is necessary before Tyennan structures can adequately be deduced. There does, however, appear to have been a zone of close folding approximately along the present position of the West Coast Range with more open folding elsewhere. Bradley (1954, comment on Mount Owen sheet) deduced a faulted monocline with upthrow and northerly movement on the west side in this position which he considered was formed during the Upper Cambrian as an east-facing scarp. He also considered that the Lyell Monocline was part of this structure, and that this line was a line of intrusion and movement in the Upper Cambrian and again in the Devonian.

PALAEOGEOGRAPHY

Insufficient information is available on which to base a detailed palaeogeography. Many more sections need to be measured in detail and more fossils found to provide accurate correlations. The remarks which follow are thus only conjectural.

At some time prior to the Ptychagnostus gibbus Zone of the Middle Cambrian, the pre-Dundas rocks of Tasmania were folded and eroded, perhaps several times, before fold movements produced the Tyennan, and probably the Rocky Cape Anticlinoria with their intervening trough. The sea spread into the trough and sands, silts and gravels, probably
produced by erosion of the Precambrian schists, gneisses and quartzites of these anticlinoria, were deposited rapidly in it. As shown earlier, it is probable that the anticlinoria acted as sources of sediment during deposition of the Dundas Group, and could be regarded as geanticlines. Deposition of the Dundas Group took place on the floor of this trough which sank rapidly as shown by the abundance of sub-greywackes and greywackes in the group. Widespread conditions of poor circulation are shown by the occurrence of black, pyritic slates on several horizons and in many places. Volcanic eruptions, many of them submarine, occurred in many parts of the trough, but there was probably a chain of volcanic islands along what is now the West Coast Range. Vulcanism usually occurred during deposition of the finer-grained sediments towards the end of the orogenic cycle. It is thought that uplift of the geanticlines, or of the volcanic islands which formed in the trough, occurred many times, and resulted in the cycles of sedimentation which occurred. Possibly mountain glaciers existed on the geanticline in the Middle Cambrian. Trilobites, brachiopods, dendroids, cystoids and worms lived in the sea filling the trough. At some time during the Upper Cambrian, basic and ultrabasic rocks were intruded through the Precambrian as dykes to spread out as somewhat transgressive sills into the Dundas Group, as at Adamsfield and Dundas. Also during the Upper Cambrian some granite was intruded into, or developed in, the Dundas Group at Mount Darwin. The Dundas Group and its associated extrusive and intrusive rocks were folded by the last, Jukesian, movement of the Tyennan Orogeny, which took place between the basal Franconian and the Middle Arenigian.

Conditions were probably similar in the Smithton and King Island areas, but insufficient information is available to make positive suggestions.

The Dundas Group is younger than the known Cambrian of South Australia, but contemporaneous with the Heathcotian of Victoria. It is possible that the movement which initiated deposition of the Dundas Group also initiated deposition of the Heathcotian and closed deposition in the Flinders Miogeosyncline. The association of a thick sequence of greywacke, sub-greywacke, chert, argillite and lavas and pyroclastics of the spilitic suite, with ultrabasic rocks, suggests that the trough in which the Dundas was deposited was part of a eugeosyncline.
MIDDLE AND UPPER CAMBRIAN IN TASMANIA

REFERENCES


BLAKE, F., 1931, Mines Dept. Tasm. unpub. rept.
—1936, District between Mainwaring and Wanderer Rivers: Mines Dept. Tasm. typewritten rept. (unpub.).

BLAKE, F., and HENDERSON, Q. J., 1939, Mines Dept. Tasm. typewritten rept. (unpub.).


—1953, Geology and Structure of Tasmania in Relation to Mineralization: Geology of Australian Ore Deposits; 5th Empire Mining Congress, vol. 1, p. 1108.


MAXWELL R. BANKS


GOULD, C., 1867, North-West Coast of Tasmania: Sec. Mines Rept. Tasm.


HUGHES, T., 1948, Mines Dept. Tasm. typewritten rept. (unpub.).

—1950, Mines Dept. Tasm. typewritten rept. (unpub.).

—1953a, Mines Dept. Tasm. typewritten rept. (unpub.).


NYE, P. B., 1927, Mines Dept. Tasm. typewritten rept. (unpub.).


MIDDLE AND UPPER CAMBRIAN IN TASMANIA


—1919b, Mines Dept. Tasm. typewritten rept. (unpub.).


—1954b, Mines Dept. Tasm. typewritten rept. (unpub.).

—1954c, Mines Dept. Tasm. typewritten rept. (unpub.).


—1905, Mines Dept. Tasm. unpub. rept.
—1911, Mines Dept. Tasm. unpub. rept.


—1911, Mines Dept. Tasm.


### MIDDLE AND UPPER CAMBRIAN IN TASMANIA

#### LOCALITY INDEX

<table>
<thead>
<tr>
<th>Location</th>
<th>Latitude South</th>
<th>Longitude East</th>
</tr>
</thead>
<tbody>
<tr>
<td>Adamsfield</td>
<td>42° 47'</td>
<td>146° 20'</td>
</tr>
<tr>
<td>Anthony Creek</td>
<td>41° 42'</td>
<td>145° 36'</td>
</tr>
<tr>
<td>Arthur River</td>
<td>41° 28'</td>
<td>145° 27'</td>
</tr>
<tr>
<td>Asbestos Point</td>
<td>42° 22'</td>
<td>145° 26'</td>
</tr>
<tr>
<td>Basin Lake</td>
<td>41° 59'</td>
<td>145° 32'</td>
</tr>
<tr>
<td>Beaconsfield</td>
<td>41° 11'</td>
<td>146° 45'</td>
</tr>
<tr>
<td>Blythe</td>
<td>41° 05'</td>
<td>146° 00'</td>
</tr>
<tr>
<td>Burnie</td>
<td>41° 03'</td>
<td>145° 55'</td>
</tr>
<tr>
<td>Cressy</td>
<td>41° 40'</td>
<td>147° 08'</td>
</tr>
<tr>
<td>Deloraine</td>
<td>41° 31'</td>
<td>145° 40'</td>
</tr>
<tr>
<td>Devonport</td>
<td>41° 11'</td>
<td>146° 22'</td>
</tr>
<tr>
<td>Dial Range</td>
<td>41° 11'</td>
<td>146° 01'</td>
</tr>
<tr>
<td>Double Cove</td>
<td>42° 20'</td>
<td>145° 20'</td>
</tr>
<tr>
<td>Dundas</td>
<td>41° 53'</td>
<td>145° 24'</td>
</tr>
<tr>
<td>Farrell Junction</td>
<td>41° 43'</td>
<td>145° 34'</td>
</tr>
<tr>
<td>Gawler</td>
<td>41° 12'</td>
<td>146° 10'</td>
</tr>
<tr>
<td>Gunns's Plains</td>
<td>41° 18'</td>
<td>146° 01'</td>
</tr>
<tr>
<td>Hatfield Plains</td>
<td>41° 40'</td>
<td>145° 34'</td>
</tr>
<tr>
<td>Huskisson River</td>
<td>41° 39'</td>
<td>145° 27'</td>
</tr>
<tr>
<td>King Island</td>
<td>40° 00'</td>
<td>144° 00'</td>
</tr>
<tr>
<td>Lake Dora</td>
<td>41° 58'</td>
<td>145° 39'</td>
</tr>
<tr>
<td>Langdon River</td>
<td>41° 59'</td>
<td>145° 31'</td>
</tr>
<tr>
<td>Leven Gorge</td>
<td>41° 15'</td>
<td>146° 05'</td>
</tr>
<tr>
<td>Linda Creek</td>
<td>42° 04'</td>
<td>145° 37'</td>
</tr>
<tr>
<td>Lodder's Point</td>
<td>41° 07'</td>
<td>146° 08'</td>
</tr>
<tr>
<td>Lonah Point (= Lodder's Point)</td>
<td>41° 35'</td>
<td>146° 07'</td>
</tr>
<tr>
<td>Lorina</td>
<td>41° 35'</td>
<td>146° 07'</td>
</tr>
<tr>
<td>Lynch Creek</td>
<td>42° 07'</td>
<td>145° 33'</td>
</tr>
<tr>
<td>Macquarie Harbour</td>
<td>42° 15'</td>
<td>145° 25'</td>
</tr>
<tr>
<td>Mainwaring River</td>
<td>42° 49'</td>
<td>145° 32'</td>
</tr>
<tr>
<td>Moina</td>
<td>41° 28'</td>
<td>146° 04'</td>
</tr>
<tr>
<td>Mount Claude</td>
<td>41° 30'</td>
<td>146° 12'</td>
</tr>
<tr>
<td>Mount Cleveland</td>
<td>41° 28'</td>
<td>145° 23'</td>
</tr>
<tr>
<td>Mount Darwin</td>
<td>42° 16'</td>
<td>145° 36'</td>
</tr>
<tr>
<td>Mount Farrell</td>
<td>41° 44'</td>
<td>145° 34'</td>
</tr>
<tr>
<td>Mount Lyell</td>
<td>42° 03'</td>
<td>145° 37'</td>
</tr>
<tr>
<td>Mount Murchison</td>
<td>41° 50'</td>
<td>145° 36'</td>
</tr>
<tr>
<td>Mount Ramsay</td>
<td>41° 36'</td>
<td>145° 27'</td>
</tr>
<tr>
<td>Mount Sedgwick</td>
<td>42° 00'</td>
<td>145° 35'</td>
</tr>
<tr>
<td>Mount Sorell</td>
<td>42° 15'</td>
<td>145° 32'</td>
</tr>
<tr>
<td>Natone</td>
<td>41° 10'</td>
<td>145° 55'</td>
</tr>
<tr>
<td>New River Lagoon</td>
<td>43° 27'</td>
<td>146° 35'</td>
</tr>
<tr>
<td>Nietta</td>
<td>41° 22'</td>
<td>146° 04'</td>
</tr>
<tr>
<td>Paloonha</td>
<td>41° 16'</td>
<td>146° 15'</td>
</tr>
<tr>
<td>Place Name</td>
<td>Latitude South</td>
<td>Longitude East</td>
</tr>
<tr>
<td>------------------------</td>
<td>---------------</td>
<td>---------------</td>
</tr>
<tr>
<td>Penguin</td>
<td>41°07'</td>
<td>146°04'</td>
</tr>
<tr>
<td>Pieman River</td>
<td>41°40'</td>
<td>145°02'</td>
</tr>
<tr>
<td>Que River</td>
<td>41°36'</td>
<td>145°31'</td>
</tr>
<tr>
<td>Queenstown</td>
<td>42°05'</td>
<td>145°33'</td>
</tr>
<tr>
<td>Red Hills</td>
<td>41°52'</td>
<td>145°35'</td>
</tr>
<tr>
<td>Renison Bell</td>
<td>41°48'</td>
<td>145°25'</td>
</tr>
<tr>
<td>Ring River</td>
<td>41°48'</td>
<td>145°27'</td>
</tr>
<tr>
<td>Rocky Boat Harbour</td>
<td>43°42'</td>
<td>146°40'</td>
</tr>
<tr>
<td>Rosebery</td>
<td>41°47'</td>
<td>145°31'</td>
</tr>
<tr>
<td>Sheffield</td>
<td>41°23'</td>
<td>146°21'</td>
</tr>
<tr>
<td>Smithton</td>
<td>40°50'</td>
<td>145°07'</td>
</tr>
<tr>
<td>Snake Spur</td>
<td>41°13'</td>
<td>145°35'</td>
</tr>
<tr>
<td>Spero River</td>
<td>42°38'</td>
<td>145°21'</td>
</tr>
<tr>
<td>Stanley River</td>
<td>41°48'</td>
<td>145°13'</td>
</tr>
<tr>
<td>Sticht Range</td>
<td>41°52'</td>
<td>145°38'</td>
</tr>
<tr>
<td>Stowport</td>
<td>41°07'</td>
<td>145°56'</td>
</tr>
<tr>
<td>The Pinnacles</td>
<td>41°40'</td>
<td>145°29'</td>
</tr>
<tr>
<td>Trial Harbour</td>
<td>41°55'</td>
<td>145°09'</td>
</tr>
<tr>
<td>Tullah</td>
<td>41°43'</td>
<td>145°35'</td>
</tr>
<tr>
<td>Tyndall Range</td>
<td>41°57'</td>
<td>145°34'</td>
</tr>
<tr>
<td>Walford's Peak</td>
<td>41°56'</td>
<td>145°36'</td>
</tr>
<tr>
<td>Wanderer River</td>
<td>42°43'</td>
<td>145°25'</td>
</tr>
<tr>
<td>Waratah</td>
<td>41°26'</td>
<td>145°31'</td>
</tr>
<tr>
<td>West Coast Range</td>
<td>41°44'</td>
<td>145°33'</td>
</tr>
<tr>
<td></td>
<td>42°18'</td>
<td>145°38'</td>
</tr>
<tr>
<td>Williamsford</td>
<td>41°50'</td>
<td>145°29'</td>
</tr>
<tr>
<td>Wilson River</td>
<td>41°45'</td>
<td>145°22'</td>
</tr>
<tr>
<td>Zeehan</td>
<td>41°53'</td>
<td>145°17'</td>
</tr>
</tbody>
</table>
Cambrian Succession in West Tasmania

Campana, King and McKenna (1960) have suggested in this Journal that the Mt. Read Volcanics (or porphyroids of Campana et alii and many earlier writers) are older than the Dundas Group and separated from it by an angular unconformity. They support their view by contrasting the deformation and metamorphism of the Volcanics and the overlying rocks.

The critical exposure (in a railway cutting north of Bulgobac) shows that there was erosion of the Mt. Read Volcanics during deposition of the overlying sediments but there is no evidence of angular discordance; while admitting local disconformity we question the "angular unconformity". Moreover, although there may be a difference in tectonic style we suggest that there is no marked difference in degree of deformation or metamorphism.

The correlation of the overlying sediments with the Dundas Group is apparently made on lithological similarity and the presence of (?) Hurdia davidi, as was done by et alii (1956); however, recent work on the Cambrian rocks of Tasmania indicates that the only valid basis for stratigraphical correlation is palaeontological and that the specimen named (?) Hurdia davidi by Chapman (1926) is too poor to be diagnostic. The age and stratigraphical position of the sediments above the Volcanics at Bulgobac Siding are at present unknown.

However, even if the correlation is correct, the disconformity (?) and the felspar grains in the Dundas rocks may be satisfactorily explained by assuming a volcanic accumulation near the margins of the sedimentary basin during part or all of Dundas deposition and erosion of volcanic material penecontemporaneously with vulcanism and sedimentation (see Carey, 1953; Campana et alii, 1958).

Crystal tuffs and lavas, both in the Dundas Group at Dundas and interbedded with fossiliferous Middle and Upper Cambrian rocks near Beaconsfield and Ulverstone demonstrate volcanic activity during Dundas deposition.

Although Campana et alii have put forward an interesting thesis, in our opinion the evidence is insufficient to show an orogeny between the formation of the Mt. Read Volcanics and the deposition of the Dundas Group.

Campana et alii explain the different structural relations at the base of the Owen Conglomerate at Red Hills and at Zeehan (Mt. Misery?) in terms of an orogeny between the Volcanics and the Dundas Group, but we suggest that the contrasting degrees of discordance at these localities can best be accounted for by assuming lateral differences in intensity of deformation of the pre-Owen beds during Jukesian movement (see Banks 1956, Solomon 1960).

M. R. BANKS, M. SOLOMON.

University of Tasmania, Hobart.
18 November 1960.

References


The Proterozoic-Upper Cambrian Succession in West Tasmania

Having mapped for two years the regional geology of the Zeehan Quadrangle, we welcome the recent contribution by Campana, King and McKenna (1960) as an attempt to unravel the complicated Cambrian succession of the West Coast. Although our work is incomplete, we must question one of their major conclusions.

We agree that the name 'Dundas Group' should be restricted to the Middle-Upper Cambrian sequence (Ptychagnostus gibbus, Glyptagnostus reticulatus Zones) and to rocks which can be correlated, for example the 'Huskisson Group' of Taylor (1954). However, we consider that in the Pieman-Zeehan-Dundas area the Group follows conformably on a sequence which ranges from Lower to Middle Cambrian, and not unconformably on Lower Cambrian as postulated by Campana et alii.

(1) Stratigraphical Sequence

Elliston (1954) defined the Carbine Group and the Dundas Group at Dundas, while between 1951 and 1954 B. L. Taylor and D. Burger mapped a considerable area round the Pieman River and Renison Bell. We
have continued this work, studying the Proterozoic-Cambrian succession over 350 square miles, and our mapping shows that overlying the Older Proterozoic there are two different series. The older sequence, probably ranging from Upper Proterozoic to Lower Cambrian, comprises pale grey saccharoidal quartzites, muscovite-bearing grey siltstones and fine quartzites, with grey or greenish-grey shales or slates. The beds are usually riddled with quartz veins, and schistosity or cleavage is locally well developed. The sequence includes the Oonah Quartzite and Slate (Spry, 1958) which apparently passes up into the finer Carbine Group, though the latter may be only a facies variant. We suggest that this sequence is at least 7,000 feet thick.

The Oonah or Carbine quartzites and slates are overlain by a thick series of argillites, greywacke and conglomerates, conspicuous by their purple, red, green and grey colours, which have long been referred to the Dundas Group. However, Taylor (1954) showed that below the fossiliferous Dundas Group in the Pieman River-Huskisson River region there is an important thickness of argillites, slates and greywacke included by Ward (1909), Waterhouse (1914) and Conder (1918) in the Dundas Group, which he named the Crimson Creek Argillite. This sequence, which may be up to 10,000 feet thick, and which we propose to term a Formation because subdivision may be possible later, is composed of generally finer sediments than the overlying Dundas Group.

We agree with Campana et alii that the Success Creek Group is equivalent to the Carbine Group, and that it is of Lower Cambrian or possibly Upper Proterozoic age. However, we support Taylor's conclusion that the Crimson Creek Formation is Lower to Middle Cambrian, and that the Dundas Group, as defined, succeeds it conformably.

The Dundas Group has been described in detail by Elliston (1954). The beds closely resemble those in the Crimson Creek Formation, but also include a number of massive greywacke-conglomerates separated by fossiliferous shales or siltstones. The Glyptagnostus reticulatus Zone has been found only on the Huskisson River.

(2) LOCALITIES

The succession in different districts is briefly described below:

(i) Pieman River-Huskisson River

The Oonah Quartzite and Slate is probably unconformable on Older Proterozoic and passes up into the finer Carbine Group. Taylor commented on the incoming of 'pyroclastic' material (greywacke) in the upper part of the Carbine Group. Such bands are common in the Crimson Creek Formation and the Dundas Group. On structural and lithological evidence we support Taylor's opinion that the Carbine Group passes up into the Crimson Creek Formation near the mouth of the Wilson River, and that on the Huskisson River the fossiliferous Dundas Group follows conformably.

(ii) Renison Bell

Micaceous saccharoidal quartzites, siltstones and shales resembling those in the Carbine Group form a structural high and pass up into greywacke, conglomerate and argillite typical of the Crimson Creek Formation with no evidence of unconformity. In this area there are many sills of gabbro and serpentinite. The Dundas Group as defined has not yet been identified and may be absent.

(iii) Dundas

The Carbine Group probably rests unconformably on Older Proterozoic schists. Elliston's conclusion that the Dundas Group is unconformable on the Carbine Group was based on doubtful evidence and our work so far indicates the presence of the Crimson Creek Formation beneath the Dundas Group. For example, north of Mt. Dundas the Carbine Group passes eastwards up into purple slates and greywacke resembling those in the Crimson Creek Formation elsewhere. Again, in Mariposa Creek on the west flank of Mt. Dundas west-dipping Carbine Group quartzites and slates are overlain by greywacke and conglomerate which we assign to the Crimson Creek Formation. In each locality strikes and dips are compatible with a passage up from the Carbine Group.

(iv) Zeehan District

The Oonah Quartzite and Slate can be traced for many miles north and north-west of Mt. Zeehan. The Carbine facies occurs near Queen Hill, Zeehan and on the Trial Harbour road. We consider that the Crimson Creek Formation is represented by part of the 'Keratophyric Tuff' of Twelvetrees and Ward (1910) which appears to follow the Carbine Group conformably east of Queen Hill and in the Austral Valley. Although the contact is frequently obscured by complex faulting and deep weathering, structural trends do not indicate a major unconformity. Part of the 'Keratophyric Tuff' which yielded Diplognostus sp. was correlated by Opik (1951) with the Hodge Slate (Dundas Group).

(v) East of Trial Harbour

The quartzites and siltstones resemble those of the Carbine Group. Southwards across the Little Henty River they are succeeded by dark purplish cherts, argillites and greywacke which, on lithological grounds, we correlate with the Crimson Creek Formation. Once again comparable structures
indicate that there is no unconformity. About two miles south-east of Trial Harbour part of a trilobite was found by D. Groves; it has not yet been identified but is probably a species from the Dundas Group.

A. H. BLISSETT, A. B. GULLINE.

Department of Mines, Zeehan, Tasmania.
16 December 1960.

References

Comment on the Note of Banks and Solomon

The statement of Banks and Solomon that 'the only valid basis of stratigraphic correlations is palaeontological', appears little dogmatic. Significantly it has been disregarded by them in treating the Tasmanian Cambrian stratigraphy. Indeed, nine out of 13 sections have been assigned by Banks (1957, pp. 178-187) to the Dundas Group 'on lithological and structural grounds'. Should these be regarded as of unknown age and stratigraphic position?

The sediments of the Queenstown area that have been correlated with the Dundas Group by Wade and Solomon (1958, p. 374) are, in the author's words 'unfossiliferous, but similar lithologies in the type area ... contain tribolites and dendroids of Middle and Upper Cambrian age'. Is this correlation invalid? I do not know whether Banks and Solomon would now apply such a rigorous principle to their own stratigraphic conclusions, but surely all over the world stratigraphers are legitimately using other criteria in correlating unfossiliferous formations.

Questions of method apart, the correlation with the Dundas Group of the sequence overlying the Mt. Read Volcanics in the Bulgobac-Que River area has not been based merely on lithological grounds. Besides the presence of Hurdia davi, where specific determination was not questioned by Banks in his previous publications, six distinctive members of the Bulgobac-Que River sequence are also found, in identical order of succession, in the fossiliferous Dundas beds of the Huskisson River, 12 miles south. Among these members there is a horizon of light-coloured siliceous conglomerates, very similar in facies to the Owen Conglomerate, which appears to form an unmistakable marker bed.

That the general presence of felspathic fragments and lava pebbles in the Dundas Group may be satisfactorily explained by assuming erosion of a volcanic accumulation near the margin of the basin, is precisely our conclusion. It follows that the Mt. Read Volcanics are older than the Dundas sediments. We have postulated an angular unconformity between these two groups of rocks not only 'by contrasting the deformation and metamorphism', but also on specific stratigraphic evidence.

Thus, in the Mt. Murchison-red Hill area the Owen Conglomerate-Jukes Breccia formations rest on the Mt. Read Volcanics with a right-angle unconformity, and contain abundant pebbles and boulders of metamorphosed Volcanics. In the Mt. Misery area this conglomerate shows not only conformable relations but also lithological gradations with the Mt. Misery Conglomerate forming the top of the Dundas Group. This would prove that the Mt. Read Volcanics were already metamorphosed and steeply folded at the time of deposition of the Jukes Breccia-Lower Owen Conglomerate, while undisturbed sedimentary conditions prevailed in the adjoining Dundas Trough (Mt. Misery area, Huskisson Syncline). The inference that the orogenic movements and related metamorphism that affected the Mt. Read Volcanics pre-date the Dundas sedimentation appears, therefore, stratigraphically justified.

Banks and Solomon suggest (but do not prove) 'that there is no marked difference in degree of deformation or metamorphism between the Mt. Read Volcanics and the overlying sediments of the Bulgobac-Que River area'. But McKenna, who mapped this zone for the first time, has shown that the sedimentary succession is folded in a regular syncline, the limbs of which have a general dip of 47°. Shearing, schistosity or other metamorphic effects in the sediments are entirely absent, the succession being, in fact, largely formed of shales, greywacke and felspathic sandstones. By contrast, the position of the underlying Volcanics is subvertical throughout in spite of their more competent nature, and their metamorphism is so widespread that one cannot but agree with the view of Carey that 'the abundant igneous rocks of the district ... all fall into that varied group of sheared acid and subacid porphyries which have gone under the name of porphyroids ... or schistose quartz-felspar porphyries, and where the alteration was most extreme, sericite schists' (Carey, 1945, p. 22; 1953, p. 1118). Similar alterations have not been described so far in the sediments of the Dundas Group of the area, nor have any been observed by us.
Comment on the Note of Bisset and Gulline

The unconformity between the Dundas Group and the Carbine-Success Creek Group questioned by Bisset and Gulline, was accepted by us on the basis of regional mapping in the Dundas-Renison Bell area, in agreement with previous authors. But our work was not then completed, and the problem can hardly be fully discussed before the various new maps and reports are published.

As for the stratigraphic position of the Crimson Creek argillites, there is indeed evidence that they conformably underlie the Ptychagnostus gibbus-Glyptagnostus reticulatus zones, as suggested by Blissett and Gulline. But our observations were not quite conclusive in this respect, so we preferred to consider the argillites as part of the Dundas Group, following a personal communication by Opik who is inclined to regard them as a lateral facies of the fossiliferous Dundas beds. In addition, their local developments, paucity of outcrops and vertical gradation to the Dundas beds make them an ill-defined mapping unit. However, in sections and palaeoprofiles illustrating a work now in press we represent the argillites (and interbedded black shales and cherts) as conformably underlying the Ptychagnostus gibbus-Glyptagnostus reticulatus zones. They would represent the initial euxinic facies of the geosynclinal cycle, followed by the greywacke-conglomeratic sequence of the Dundas Group (Flysch facies).

B. Campana.
Rio Tinto (Southern) Pty Ltd.,
Pty., Ltd.,
Melbourne, Victoria.

References
II

CAMBRIAN SYSTEM

By MAXWELL R. BANKS

with contributions by H. A. BARTLETT, K. L. BURNS, B. CAMPANA,
I. B. JENNINGS, D. KING, A. A. ÖPIK AND B. SCOTT

An historical review of work on the Cambrian rocks was included in a recent comprehensive paper (Banks, 1956). Later work has resulted in extension of their known distribution, discovery of significant fossils at several new localities, recognition of the activity of turbidity currents during deposition, reassessment of the age of the ultrabasic rocks and some of the volcanics and reconsideration of the tectonic history.

STRATIGRAPHY

The rocks of the West Coast Range, particularly around Dundas (five miles east of Zeehan) have been used as a local standard of reference for the Cambrian System. Three main lithological assemblages have been recognized:

(1) The Crimson Creek Argillite and Success Creek Group (Campana et al., 1960; Blissett and Gulline, 1961a) which may be of early Cambrian age.

(2) Mt. Read Volcanics which may be of early Cambrian age.

(3) The Dundas Group and its correlates, the most widespread and best known of the Cambrian rocks, ranging through the Middle and Upper Cambrian...

(?) EARLY CAMBRIAN SEDIMENTS

Campana and King state: "Successions of quartzite, slate, dolomite, dolomitic conglomerate and possibly pyroclastic deposits, e.g. Carbine Group, Success Creek Group, occur at Dundas (Elliston, 1954), along the Pieman River (Taylor, 1954), and at Moore's Pimple, etc. These units underlie the Mt. Read Volcanics which in turn antedate beds of the P. gibbus-G. reticulatus zones and are pre-Middle Cambrian in age (Campana et al., 1960). It is inferred that they
Fig. 8. Distribution of the Cambrian System (compiled by Banks).
Fig. 9. Geological map of the Mt. Lyell-Zeehan-Rosebery area (compiled by Campana and King).

represent early Cambrian deposits as they contain pyroclastic members manifestly related to the Cambrian volcanism.”

Elliston (1954) and Spry (Chapter I) consider the Carbine Group to be Precambrian. Little is known of the Success Creek Group and its reputed volcanics or of the Crimson Creek Argillite (Taylor, 1954; Campana et al., 1960;
Fig. 10. Cambrian System in the West Coast area (compiled by Campana, King, et al.).
Blissett and Gulline, 1961a) and in the absence of palaeontological evidence their exact age is debatable.

MT. READ VOLCANICS

Campana and King state: “This formation is a thick volcanic pile, the type section of which is exposed from east of the summit of Mt. Read west to the Hercules Mine and from west of the summit of Mt. Read east to Red Hills. This pile includes large bodies of keratophyre, quartz porphyry and quartz feldspar porphyry associated with massive or schistose pyroclastic rocks which may represent welded tuffs (Spry, Chapter I). Tuffaceous slates and ash beds, showing, in places, characteristic volcanic balls and steep cross-bedding are also found at intervals. The Mt. Read Volcanics are at least 8000 feet thick (Fig. 10, sections 4-7). The formation includes the Massive Pyroclastic Formation (Hall et al., 1953) and the ‘Porphyroids’ of early investigators and has been described lithologically by Twelvetrees and Petterd (1899), Hills (1914c), Finucane (1932) and Carey (1947a).”

“The Mt. Read Volcanics rest on and appear to grade downwards to the early Cambrian succession discussed above, and are unconformably overlain by sediments correlated with the Dundas Group on palaeontological and structural grounds (Campana et al., 1960). Because of difficulties of exposure, vegetation, relief, etc., the writers have regarded palaeotectonic and environmental evidence as important for the elucidation of the Lower Palaeozoic history. The contact is interpreted as an erosion surface on which transgressed the Middle Cambrian sea. This surface would mark an old volcanic belt (Mt. Read Volcanic Arc) developed in pre-Gibbon time at the margin of the Tyennan Geanticline, and from which much of the feldspathic detritus of the Dundas sedimentary succession was derived.

“The Mt. Read Volcanics (and their metamorphic derivatives) are related to a system of subsidence fractures developed along this arc. The large proportion of welded tuffs believed to be represented in the Volcanics would point to a long-lasting process of ash flows erupted from meridional fissures and filling what must have been at some stage in pre-Dundas time, a graben-like volcanotectonic depression occupying a large portion of the West Coast Range.”

The age of the Mt. Read Volcanics is not clear. They have been regarded as essentially younger than the Dundas Group (Campana et al., 1958), more-or-less contemporaneous with the Dundas Group (Carey, 1953; Banks and Solomon, 1961) and older than the Dundas Group (Campana et al., 1960; Campana, 1961a and above). They are clearly pre-Ordovician as they are overlain unconformably by Ordovician rocks. They are older than a slate at Hatfield Plains (145°39'E., 41°33'S.) containing (?) Hurdia davidii but this fossil is not suitable for detailed age determination. Thus the slate at Hatfield Plains may be older than, equivalent to some part of, or younger than the Dundas Group. No fossils have been found in the Mt. Read Volcanics. Structural and other arguments advanced by Campana et al. (1960) and Campana (1961a) all admit of several interpretations and are thus not critical for age determination.
DUNDAS GROUP

The Dundas Group was defined by Elliston (1954); and an amended succession is as follows:

<table>
<thead>
<tr>
<th>Formation</th>
<th>Thickness (ft.)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mt. Zeehan Conglomerate</td>
<td>(Ordovician)</td>
</tr>
<tr>
<td>Misery Conglomerate</td>
<td>500</td>
</tr>
<tr>
<td>Climie Siltstone and Greywacke</td>
<td>2000</td>
</tr>
<tr>
<td>Fernflow Greywacke and Conglomerate</td>
<td>470</td>
</tr>
<tr>
<td>Comet Siltstone and Greywacke</td>
<td>1050</td>
</tr>
<tr>
<td>Fernfields Greywacke and Conglomerate</td>
<td>470</td>
</tr>
<tr>
<td>Brewery Junction Slate and Tuff</td>
<td>2450</td>
</tr>
<tr>
<td>Razorback Conglomerate</td>
<td>250</td>
</tr>
<tr>
<td>Hodge Slate</td>
<td>600</td>
</tr>
<tr>
<td>Greywacke Conglomerate contact with serpentinite</td>
<td>400 = ?</td>
</tr>
</tbody>
</table>

Section Misery Hill to Mt. Razorback:

The Judith Formation contains *Peronopsis*, *Ptychagnostus*, *Pagetia* and other trilobites indicating correlation with the *Ptychagnostus gibbus* Zone (Fig. 11 and Öpik, 1956, p. 251). *Archaeolafoea serialis*, *Archaeocryptolaria skeatsi*, other “dendroids”, trilobites and cystoids occur in the Hodge Slate and indicate correlation with the upper part of the *P. atavus* Zone or the *P. punctuosus* Zone (Öpik in Banks, 1956, p. 191). Agnostids, other trilobites and cystoids occur in the Brewery Junction Formation. The Comet Formation contains agnostids including *Oidalagnostus* and many other trilobites including numerous “Blackwelderia cf. biloba” and these indicate Lower Dresbachian age.

Basic lavas occur in the Hodge, Brewery Junction, Comet and Climie Formations (Elliston, 1954).

North-east of Mt. Dundas near Zeehan and on the Huskisson River (145°27'E., 41°39'S.), Crimson Creek Argillite which may be the lateral equivalent of the lower part of the Dundas Group (Campana, 1961b), conformably follows the Carbine Group (Blissett and Gulline, 1961a, p. 338). The Dundas Group has also been regarded as unconformable on the Carbine Group (Elliston, 1954, pp. 174-5).

Mt. Zeehan Conglomerate (pre-Middle Arenigian but Ordovician) is concordant with the Misery Conglomerate (Elliston, 1954, p. 173; Bradley, 1954, p. 218; Campana *et al.*, 1960 and Fig. 21 herein) at Misery Hill and elsewhere around the Zeehan Basin. Fossils near the top of the Comet Formation (Blissett and Gulline, 1961b, f.37) are Lower Dresbachian. Between the Comet Slate and Mt. Zeehan Conglomerate only 3000 feet of sediment, some of it greywacke conglomerate, represents most of the Upper Cambrian. It seems likely that a
major interval of non-deposition or of erosion occurs within the succession between these formations.

In the Zeehan area, slates, shales, greywackes, quartzose sandstone, greywacke conglomerate, felsite, keratophyric pyroclastic rocks and spilitic volcanic and pyroclastic rocks occur (Elliston, 1954, p. 175). *Diplagnostus* and cystoids occur in the "Keratophyric Tuff" and suggest correlation with the Hodge Slate fauna (Opik, 1951). Part of the "Keratophyric Tuff" may be correlated with the Crimson Creek Argillite (Blissett and Gulline, 1961a). The Zeehan Tillite formerly considered Precambrian or Cambrian is probably Permian (Campana and King, 1958; Spry, 1958a, pp. 96-99).

Along the Huskisson River and along the Pieman River downstream from the Huskisson, the Success Creek Group of Precambrian or Lower Cambrian age (Campana *et al.*, 1960; Blissett and Gulline, 1961a) is followed concordantly by the Crimson Creek Argillite, 10,000 feet of distinctively coloured argillites with minor greywackes and conglomerates, which is in turn overlain concordantly by the Huskisson Group (Taylor, 1955, p. 106; Blissett and Gulline, 1961a). This last group consists of over 6000 feet of shales, slates, greywacke, sandstone, conglomerate, chert breccia and possibly pyroclastic rocks. The group contains *Protospongia*, *Protorthis*, *Otusia?*, *Glyptagnostus reticulatus*, *Sphenoecium* and *Archaeolafoea*, the fossils indicating horizons from the *P. punctuosus* Zone to the *Glyptagnostus reticulatus* Zone (details in Banks, 1956, pp. 179-181).

Dark-grey argillites, greywacke conglomerates, thinly bedded limestone and dolomite and quartz feldspar-porphyry occur in railway cuttings near the mouth of the King River. From Mt. Darwin to Mt. Murchison Ordovician rocks unconformably overlie a succession of siltstone, argillite, slate, greywacke, quartzose sandstone, greywacke conglomerate, pyroclastic rocks and potash-rhyolite, rhyolite, keratophyre, augite-trachyte, andesite, and albitized pyroxene basalt (Solomon, 1960, pp. 33-38). Near Mt. Darwin, Queenstown, Lake Dora and Red Hills some of these rocks have been altered to schists containing quartz, chlorite and sericite. South of Mt. Sedgwick (near Queenstown) the succession contains equal proportions of sedimentary and volcanic material but further north the volcanic component increases (Solomon, 1960, p. 33). Intrusions or volcanic centres have been tentatively identified in several places (*ibid.*, pp. 34-36). A zone of acid to basic, but dominantly acid, volcanic rocks flanks the Tyennan Geanticline with a zone of basic lavas further west (*ibid.*, p. 41).

The succession is at least 2500 ft. thick just south of Queenstown but thicknesses are probably much greater (*ibid.*, p. 46). Near Lake Dora it is at least 4600 ft. thick and is only 20 per cent. lava (Banks, 1956, p. 177).

**FAR NORTH-WEST COAST**

Sediments similar to those in the Huskisson River and at Dundas are associated with basalts, spilites and pyroclastic rocks near Waratah. Chert occurs at Mt. Cleveland, just west of Waratah, and near Mt. Ramsay, south of Waratah (Banks, 1956, p. 183). An arthropod trail, *Tasmanadia twelvetreesi*
GEOLOGY OF TASMANIA

(Glaessner, 1957, p. 103) has been found at Kirkup's Quarry on the Arthur River, north-west of Waratah.

Gulline (1959) considered that Cambrian rocks at Smithton overlie Precambrian dolomite conformably. The basal unit was thought to be a fossiliferous siltstone, followed by a conglomerate of quartzite and chert pebbles in a tuffaceous matrix, then tuffs, siltstone, greywackes, breccias and basic lavas with an aggregate thickness near Smithton of 5000 feet. Fossils were discovered in the basal siltstone at Christmas Hills, about eight miles south-west of Smithton, by A. B. Gulline in 1956. These include Centropleura aff. loveni, Nepea, Ptychagnostus, Oedorhachis and Proamypyx and indicate correlation with the Lejopyge laevigata II Zone at the top of the Middle Cambrian (Opik, letter, 1959).

KING ISLAND

Bartlett states: “About 1000 feet of spilitic lavas (Scott, 1951), including pillow lavas and pyroclastic rocks with subordinate dolomite and slate outcrop at City of Melbourne Bay, about five miles north of Grassy. The succession at Bold Head, near Grassy, which commences with about 700 feet of basalt, then about 1200 feet of tuff, conglomerate and some basalt flows, a gap of about 150 feet and finally about 1150 feet of basalt with minor pyroclastic rocks and conglomerate, probably overlies the rocks at City of Melbourne Bay. No pillow lavas occur in this succession. The total thickness is a little more than 4000 feet.”

NORTH-WEST COAST

Burns states: “The Cambrian rocks in the Dial Range, near Ulverstone, occupy a steep-walled meridional trough, containing two basement wedges which outcrop at the northern end. The succession is

- Top Westbank Beds
  - Tea Tree Point Megabreccia
  - Radfords Creek Formation with Lejopyge
  - Motton Spilite
  - Barrington Chert
  - Hardstaff Unconformity
  - Kateena Formation with Dorypyge
  - Lobster Creek Volcanics

“The Lobster Creek Volcanics are acid tuffs and lavas forming a central belt in the trough and extending south-east as the core of the Wilmot Anticline. Conformably overlying the volcanics in the centre of the trough are greywacke siltstones and sandstones of the Kateena Formation, which directly overlies Precambrian rocks on the eastern margin. This formation contains a thick purple claystone conglomerate and a persistent horizon of lavas and volcanic sediments. At the mouth of the Gawler River this formation contains ‘dendroids’, Peronopsis, Dorypyge and other trilobites which indicate an age about the zone of P. punctuosus or P. nathorsti (Opik, pers. comm., 1959). Near Isandula it may contain Nepea, Acrothele, and a dolichometopid (ibid.). At Mt. Young, the Kateena Formation is faulted against the Lobster Creek Volcanics, the contact being transgressed by the Barrington Chert. The thicknesses of the Kateena Formation under the chert range from 50 feet to over 1500 feet. The
chert transgresses the whole of the Kateena Formation to rest on Lobster Creek Volcanics in many places. The surface at the base of the chert is termed the Hardstaff Unconformity, and represents at least a period of faulting and erosion. The Barrington Chert varies from 100 to over 1500 feet thick, thickening southwards and towards the centre of the trough. It is conformally overlain by the Motton Spilite, which occurs as a lens up to 1000 feet thick lying just east of the maximum thickness of the chert. The spilite thins rapidly westwards, so that on Mt. Young there is a conformable passage from the Barrington Chert into the Radfords Creek Formation. The Radfords Creek Formation is dominantly greywacke sandstone and siltstone, resembling the Kateena Formation but differentiated by fossils. It contains a persistent band of keratophyre and pyroclastics about 200 feet above the base. At the south end of the trough, it contains three intercalated conglomerate tongues closely resembling the Ordovician (Owen) conglomerate. These unite westward to form a persistent conglomerate horizon. The Radfords Creek Formation contains Clavagnostus and other fossils beneath the keratophyre, Lejopyge laevigata above it and Kormagnostus, didelophalids and other fossils even higher (Banks, 1956, pp. 184-185) in the Leven Gorge below Gunns Plains. At Riana this formation contains Clavagnostus. The formation is thus Upper Middle Cambrian and basal Dresbachian. At the north end of the trough the Motton Spilite is overlain by the Tea Tree Point Megabreccia, which consists of extremely large fragments of chert, calcareous siltstone, and cuneiform breccias which have slid from the west into normal greywacke sediments of the Radfords Creek Formation. The unconformity at Penguin between the Rocky Cape Group and the Megabreccia is a steep contact representing a contemporaneous escarpment. This escarpment can be mapped for several miles to the south-west, forming a fault-controlled western margin to the trough. The Westbank Beds lie on the spilite at Penguin east of the Megabreccia and directly overlie Precambrian rocks in the Westbank Chaos at Ulverstone. The rocks are limestone boulder beds at the base, massive limestone with chert bands, bedded limestones, mudstones and sandstones, and a well-sorted, well-rounded conglomerate at the top. The Hardstaff Unconformity (Upper Middle Cambrian) and the Tea Tree Point Megabreccia and Unconformity (Lower Dresbachian) indicate two important movements of the Tyennan Orogeny.

Beds probably belonging to the highest part of the Cambrian succession of the Dial Range unconformably overly the Rocky Cape Group at the Iron Cliffs Mine, Penguin (Burns, 1961b, pp. 119, 122).

Jennings states: "South-east of the Dial Range in the Sheffield and Middlesex districts the Cambrian succession begins with the Barrington Chert. This unit, comprising cream, grey and black cherts, finely bedded in many places and showing contemporaneous microfaulting and slumping, may reach 3000 feet in thickness. The base is not exposed.

Deposition of the chert seems to have been interrupted by uplift along the centre of the basin accompanied by widespread volcanic activity and all formations above the chert contain fragments of chert. The volcanic activity though widespread seems to have been related to local centres. Thus in the north-west the chert is overlain by about 1500 feet of Motton Spilite with some
tuffs and cherty breccia. In the Barrington district it is overlain by chert-pebble conglomerate at the base of the Gog Range Greywacke and by the Bott Conglomerate. It is overlain in the south-east by up to 1500 feet of Beulah Formation, basaltic lavas, tuffs, agglomerates and some greywackes. North and north-east of the Barrington Ridge, near Barrington, the chert is succeeded by the Bott Conglomerate, about 700 feet of greywacke conglomerate consisting of pebbles of quartzite, dolomite and various schists in a quartzose matrix. The Motton Spilite, Beulah Formation and Bott Conglomerate have restricted distributions but the Gog Range Greywacke is widespread.

"The Gog Range Greywacke is typically about 2000 feet thick and consists of argillites, greywackes, and greywacke siltstones containing some conglomerate members and, locally, bands of volcanic material and keratophyric lavas. Where it overlies the chert directly, the formation is somewhat cherty and the basal stages consist of abundant chert pebble conglomerates with disrupted frameworks. During 1960, W. L. Matthews collected from the Mersey River above Weegena, near Sheffield, slate with *Pseudagnostus*, other agnostids and trilobites which suggest an Upper Cambrian age (Opik, pers. comm., 1960). Although the specimens were not in situ they could have come only from this formation.

"The Gog Range Greywacke grades up into the Minnow Keratophyre, several thousand feet of acid lavas, soda rhyolites and keratophyres with some greywacke bands.

"The sequence above the Minnow Keratophyre is broken and the relationship of it to the two following formations is not clear. The Lorinna Greywacke is considered to be the uppermost Cambrian formation and to be underlain in turn by the Bull Creek Formation and the Minnow Keratophyre. The Bull Creek Formation may, however, be equivalent to one of the formations discussed above.

"The Bull Creek Formation consists of three members, Lower Porphyry Member (300 feet of acid porphyritic rocks), Geale’s Bridge Member (500 feet of greywacke, conglomerate, siltstone, chert and porphyry) and the Upper Porphyry Member (700 feet of acid porphyritic rocks) (Burns, 1961a, p. 35).

"The Lorinna Greywacke consists of greywacke, often highly sheared, and quartz chlorite schist. It is probably under 1000 feet in thickness. It appears to overlap other Cambrian rocks south of Lorinna and near the Dove Gorge rests on Precambrian rocks of the Tyennan Geanticline with angular unconformity."

Siltstones in cuttings on the Exeter Highway immediately west of the Franklin Rivulet and carbonaceous pyritic shale at Branch Creek may be Cambrian. The latter are associated with well- and poorly-sorted micaceous feldspathic sandstone, greywacke and a basic lava with chloritised and sericitised plagioclase. The Cambrian age is ascribed on lithological grounds only.

Almost 7000 feet of argillite, sub-greywacke, greywacke, greywacke conglomerate, pyritic slate, keratophyre, spilite and spilitic breccia occur unconformably on Precambrian rocks and unconformably below Ordovician rocks south of Deloraine (Wells, 1957). The sub-greywackes, greywackes and greywacke conglomerate are poorly-sorted, have a disrupted framework and show graded bedding and “slumping”. No fossils have been found but the lithology,
Cambrian and igneous associations and structural relationships suggest that these rocks are Cambrian. Slates, phyllites and sheared tuffs near O'Connor's Peak, south-west of Cressy, are lithologically like Cambrian rocks elsewhere (Voisey, 1949b).

Beaconsfield

The Dallys Siltstone, 1100-2000 feet thick, consists of slate with fine-grained greywacke conglomerate, overlain by greywacke, siltstone, impure quartz sandstone, greywacke with Dresbachia, micaceous phyllite, and greywacke siltstone with fragmentary trilobites (Green, 1959). A keratophyre seems to occupy the position of the quartz sandstone in places. Dresbachia indicates an Upper Middle Cambrian or Lower Dresbachian age.

The Ilfracombe Slate occurs west of Beaconsfield. This formation of black slate and greywacke is about 1600 feet thick. A picrite basalt may also occur in this formation. Still further west between the Precambrian rocks and the ultrabasic rocks there is about 250 feet of black slate with impure sandstone, greywacke and perhaps tuff. These rocks and the Ilfracombe Slate are considered Cambrian on lithological grounds only (Green, 1959).

Adamsfield and the South Coast

Slate, siltstone, chert and greywacke breccia in the valley of the Adam River west of Adamsfield may be considered Cambrian on lithological and structural grounds:

- Conglomerates, sands and silts composed of serpentinite detritus overlie serpentinite on the Sawback Range east of Adamsfield. These ancient placer deposits contain chromite and osmiridium (Carey and Banks, 1954). The siltstones contain inarticulate and articulate brachiopods, gastropods (Scaevogyra) and trilobites. After examining abundant material collected by S. W. Carey, Opik states: "The age of the Adamsfield fauna is Upper Dresbachian to Lower Franconian. This fauna is unknown elsewhere in Tasmania, and is, therefore, younger than the Lower Dresbachian Glyptagnostus reticulatus. It contains among other forms, Eoorthis, Billingsella and a new genus of nepeid trilobites, a combination found also on the Burke River, north of Chatsworth in Queensland, in the lower part of the Chatsworth Limestone, for which a Lower Franconian age is evident. These faunas cannot be compared as yet on the specific level and the correlation is, therefore, tentative."

- Slates, cherts and breccias have been recorded from near Rocky Boat Harbour just east of New River Lagoon. Recent field work by the author in this area has established that Precambrian dolomite is unconformably overlain by several thousand feet of conglomerate, siltstone and sandstone, the coarser rocks containing fragments of dolomite, serpentinite and other ultrabasic rocks and siliceous rocks. The sandstones show graded bedding and some of the conglomerates have a disrupted framework. Turbidity current deposition is inferred for them. Many sedimentary cycles from conglomerate to claystone occur. Worm casts and Protospongia-like spicules are the only fossils yet found. These rocks are overlain, probably unconformably, by Ordovician Caroline
Creek Sandstone at Prettys Point. By analogy with the rocks at the Sawback Range, these serpentinite-bearing sediments are thought to be Cambrian.

Ordovician conglomerate rests unconformably on gritty sandstone and conglomerate, shales and greywacke with graded bedding, slumps and load casts, quartz sandstone and shale and conglomerate on the Ironbound Range, west of New River Lagoon (Jennings, 1961). These rocks are considered Cambrian because of similarity in texture and sedimentary structure to Cambrian rocks elsewhere in Tasmania (Jenning, 1961, p. 182).

SOUTH-WEST TASMANIA

B. Scott states: “South of Macquarie Harbour rocks correlated with the Dundas Group on lithological and structural grounds can be broadly divided into two assemblages, one of which can be subdivided. The first assemblage (A) consists of a sedimentary and a volcanic association. The sedimentary association contains chert, shale and mudstone (calcareous in most places), greywacke and greywacke conglomerate, quartzite and rare thin beds of dolomitic limestone. The volcanic association consists of basalt, andesite, spilite, shale, tuff, greywacke and greywacke conglomerate. On a regional scale the two associations appear to be interbedded but the sedimentary association, which is widespread, is better developed in the south and central area rather than in the north. Basic lavas occur in this association along the coastline south of Point Hibbs. The volcanic association outcrops on the south-west shore of Macquarie Harbour. The second assemblage (B) contains quartzite, with subordinate greywacke and shale but consists predominantly of siliceous rocks with angular quartz and feldspar porphyroblasts up to 2 mm. long in a fine matrix of quartz and sericite. Most porphyroblasts postdate shearing. This assemblage occurs south and east of a line from Green Point through Wart Hill, Mt. Osmund and Hazell Hill. Pale quartzite, siltstone and quartz sericite schist predominate south of the Lewis River. Assemblages A and B appear to be largely coeval.

“The estimated thickness south of the Wanderer River is not less than 3000 feet.

“These rocks are commonly altered probably deuterically, to sericite, epidote, chlorite and secondary quartz. Localized, but intense, chlorite-epidote alteration occurs at the contact of assemblages A and B at Green Point. Some of the chert is considered to have resulted from silicification of lutite. The quartz sericite chlorite schists occur close to zones of shearing.”

Conglomerates, sandstones, siltstones, greywackes and greywacke conglomerate outcrop near Bathurst Harbour (Jennings, 1961). The basal Rugby Conglomerate (1000 ft. thick) consists of siliceous conglomerate and sandstone both with a closed framework. The McKenzie Conglomerate is a formation 2000 feet thick of siliceous conglomerate with a disrupted framework interbedded with siltstone and sandstone. The top formation, Long Bay Shale, consists of 1000 feet of mudstone with intercalated greywacke and conglomerate showing graded bedding, disrupted framework and flow casts. No fossils have been found in these formations. They are regarded as Cambrian because they rest unconformably on rocks of a type generally regarded as Precambrian in
Fig. 11. Cambrian correlations (Banks).
Tasmania, because they are similar in texture and sedimentary structure to dated Cambrian rocks elsewhere in Tasmania and because similar rocks on the Iron-bound Range unconformably underlie tubicolar sandstones thought to be Lower Ordovician.

CORRELATION

Correlation of the seven fossiliferous sections is shown in Fig. 11. The lowest fauna is that in the Judith Slate at Dundas of the P. gibbus Zone (Opik, 1956, p. 253). Later than this is the “dendroid” fauna of the Hodge Slate at Dundas and in the Huskisson succession and Diplagnostus from Zeehan regarded by Opik as of upper P. atavus to P. punctuosus age. The Kateena Formation near Ulverstone with “dendroids”, Peronopsis and Dorypyge may be a little younger, i.e. P. punctuosus or G. nathorsti Zone. The beds at Christmas Hills with Centroleura, Nepea, Oedorhachis are probably equivalent to the Laeavigata II Zone in Queensland (Opik, 1960, p. 104). The Clavagnostus and L. laeavigata and L. laeavigata armata faunas from the Leven Formation near Ulverstone are probably correlates of the Laeavigata III Zone in Queensland (ibid., p. 104). The Kormagnostus bed in the Radford Creek Formation and the Dresbachia bed at Beaconsfield are basal Dresbachian (Opik in Banks, 1956, p. 185 and herein) and may be equivalent to the fauna in the Mungerebar Limestone in Queensland (Opik, 1960, p. 106). The Blackwelderia fauna of the Comet Slate, Dundas, may be correlated with the fauna in the lower part of the O’Hara Shale in Queensland (Opik, 1960, p. 106) and as such should be followed by the Glyptagnostus reticulatus fauna of the Huskisson section, equivalent roughly to the lower zones in the Georgina Limestone (ibid., p. 106). The highest zone recognised is that with Eoorthis and Billingsella at Adamsfield correlated by Opik with the lower part of the Chatsworth Limestone of basal Franconian age (Opik, 1960, p. 105).

“No Cambrian trilobites or brachiopods from Tasmania have been described as yet, and it may be expected that some of the determinations as given above will ultimately be replaced by others. The correlation, however, as concluded from the preliminary study of the collections, is in no need of substantial revision” (pers. comm., A. A. Opik).

PALAEOCLIMATOLOGY

There is no clear evidence on the climate here during the Cambrian. Earlier some dubious evidence of a cool climate has been presented (Banks, 1956, pp. 193-4; Opik, 1956, pp. 264-266). The Zeehan Tillite, then considered possibly Cambrian, has been demonstrated to be Permian (Campana and King, 1958; Spry, 1958a, pp. 96-99). This leaves only the tillite at City of Melbourne Bay as possibly Lower Palaeozoic but its age is not clear. Lack of limestone and dolomite has been taken as indicative of cold climate (Opik, 1956, pp. 259,
IGNEOUS ACTIVITY

Volcanic rocks from picrite basalt to potash rhyolite and including albite-rich rocks such as spilite and keratophyre occur (Banks, 1956; Bradley, 1957; Solomon, 1960; and other authors herein Chapter VIII).

The dominantly acid Mt. Read Volcanics may be early Middle Cambrian or Lower Cambrian, but this is not proved. Acid lavas occur mainly in a zone bordering the Tyennan Geanticline on the west and north but occur over twenty miles from this structure at Zeehan, near Ulverstone and at Beaconsfield. Where the acid lavas and pyroclastic rocks occur in fossiliferous successions at Zeehan, Dundas, near Ulverstone and at Beaconsfield they are mainly, if not entirely, Middle Cambrian. Basic volcanic rocks appear to be more common further from the Tyennan Geanticline especially south of Point Hibbs, near Waratah, Ulverstone, Smithton and on King Island. They are Middle Cambrian near Ulverstone and probably also near Smithton. Volcanic rocks appear mainly in the siltstone part of the sedimentary cycles.

The part played by vulcanism in the Cambrian System in Tasmania requires careful assessment. The Mt. Read Volcanics appear to be predominantly volcanic. High proportions of volcanic material in successions south of Point Hibbs, along the West Coast Range, at Smithton and on King Island have been reported but at Dundas, in the Huskisson River area, near Ulverstone, at Beaconsfield and Deloraine, where the stratigraphy is reasonably well known, the proportion is lower, probably less than 25 per cent. No volcanic rocks are known in the thick succession near New River Lagoon.

Hypabyssal rocks are rare but show a wide range of composition. Granites, probably Upper Cambrian, occur at Mt. Darwin (Solomon, 1960) and in the Murchison Gorge south of Mt. Farrell (Bradley, 1957). Basic and ultrabasic rocks ranging in composition from quartz mica gabbro to dunites, but mainly pyroxenites, occur as slightly transgressive sills and rarely as dykes in Cambrian and Precambrian rocks (Taylor, 1955, pp. 106-7). These intrusions appear to be concentrated near the contact between Precambrian and Cambrian rocks along the eastern margins of structural highs, e.g. south of Macquarie Harbour, along the Wilson River, north of Zeehan, at Bald Hill, near Waratah, Beaconsfield and Adamsfield (Fig. 8; Banks, 1959). Chromite grains in Lower Ordovician rocks at Beaconsfield (Green, 1959, p. 14) and Queenstown (Wade and Solomon, 1958, p. 389) support earlier suggestions (Carey, 1953) of a pre-Ordovician age for the ultrabasic rocks. The serpentinite at the Sawback Range, Adamsfield, is older than the Lower Franconian sediments there. The ultrabasic rocks at Dundas appear to transgress rocks up to the Lower Dresbachian Fernflow Conglomerate (Elliston, 1954, p. 172; Taylor, 1955) and at Beaconsfield intrude rocks considered to be Cambrian (Green, 1959, p. 14; Baker, 1959). If all the ultrabasic intrusions are contemporaneous, they are Dresbachian. However, the contacts with the Cambrian may be due to tectonic reintrusion and the ultrabasic rocks could then be older than Middle Cambrian.
GEOL0GY OF TASMANDA

METAMORPHISM

Cherts, which may be silicified argillites or primary siliceous oozes, occur south of Macquarie Harbour, from Waratah to south-east of Ulverstone, near Adamsfield and New River Lagoon (Banks, 1956, p. 200).

Chlorite, quartz chlorite, quartz sericite and sericite schists occur between Nye Bay and the Que River and in the Lorimna area (see Structural Map this volume; Bradley, 1954, 1957; Scott, 1954; Banks, 1956, pp. 202-203). The schisting of the Cambrian rocks has generally been considered to be Devonian but may be partly Cambrian because the Roland Conglomerate (Lower Ordovician) immediately above an unconformity with Cambrian rocks at Cethana between Sheffield and Lorimna contains pebbles of sheared porphyry (Jennings, 1958, pp. 25-30). Scattered fragments of schistose porphyry are reported from unmetamorphosed Lower Ordovician Jukes and Owen Conglomerates and even from unmetamorphosed sediments of the Dundas Group (Campana and King, herein). If this last observation is verified it would support a pre-Dundas Group age for the Mt. Read Volcanics and a pre-Dundas period of movement as suggested by Campana et al. (1960 and earlier in this chapter).

STRUCTURAL RELATIONS

Cambrian rocks rest unconformably on pre-Dundas Group rocks at the Sticht Range (145°38'E., 41°52'S.), near Penguin, Deloraine, Beaconsfield and New River Lagoon. Rocks considered to be Cambrian rest conformably on older rocks at Dundas, Renison Bell, in the Pieman River area, at Waratah, Smithton and King Island (Carey and Banks, 1954; Burns, 1961b; Green, 1959; Blissett and Gulline, 1961a; Solomon, herein; Gulline, 1959). The conformity is in every case with rocks considered as younger Precambrian (Chapter I) or Lower Cambrian. The unconformities at Penguin and New River Lagoon are with younger Precambrian rocks but those elsewhere are with older Precambrian rocks. Cambrian rocks are absent from the Tyennan Geanticline (Fig. 8) and in early Ordovician time this feature was a land area. Lack of Cambrian rocks on it may indicate that it was also a land area during the Cambrian or that Cambrian rocks were deposited on it but eroded before the Lower Ordovician. This latter is possible but unlikely and it is thought that the Tyennan Geanticline was uplifted early in the Middle Cambrian (Banks, 1956, p. 204). Spry (Chapter I) suggests that the Geanticline may have formed in late Precambrian times.

Eight cycles of sedimentation have been suggested in the Dundas Group and eleven in the Huskisson Group (Carey and Banks, 1954; Banks, 1956, p. 204). A tectonic control of these cycles has been postulated and the epochs of tectonic activity might have resulted in local unconformities in the Middle and early Upper Cambrian. These have not been demonstrated unless the contact at Bulgobac, north of Rosebery (Campana et al., 1960; Campana, 1961a) and contacts in the Hercules and Rosebery Mines and at Mt. Farrell (Hall et al., 1953) are such. Shearing of the Mt. Read Volcanics may have occurred in one
or more of the epochs of tectonic activity and resulted in the schistose porphyry fragments reported from the Dundas Group (Campana and King, Chap. III).

Although faulting during formation of the Mt. Read Volcanics has been postulated by Bradley (1957, p. 116) and Campana et al. (1958, p. 52 and herein) this has not been demonstrated in the West Coast area. However, near Ulverstone faulting occurred during upper Middle Cambrian time and again in early Dresbachian time (Burns, herein).

The unconformity on the Sawback Range, Adamsfield, between serpentinite and serpentinite-bearing sediments suggests uplift either during or after intrusion and later erosion. If the serpentinite is Dresbachian (see above) considerable uplift of that age in the Adamsfield area is implied.

Ordovician rocks rest unconformably on Cambrian rocks at a number of places (Fig. 13, and Carey and Banks, 1954), but are concordant at others, e.g. Misery Hill near Zeehan (Fig. 21) and Beaconsfield (Green, 1959). These relationships and the nature of the Lower Ordovician rocks suggest that the Tyennan Geanticline was rejuvenated late in the Cambrian or early in the Ordovician during the Jukesian Movement (Carey and Banks, 1954) producing a zone of steeply dipping Cambrian rocks along the western side of this geanticline (Banks, 1956, p. 205).

SUMMARY

At some time prior to the Ptychagnostus gibbus Zone of the Middle Cambrian the area of deposition of Upper Precambrian (or Lower Cambrian) well-sorted sands, silts and dolomite was affected by tectonic movements producing uplift of the Tyennan Geanticline and change in the shape of the depositional basin (Spry, Chapter I). Continued tectonic activity and more rapid sinking of the sea floor resulted in a change in sedimentary association from well-sorted sediments of the orthoquartzite-limestone suite to poorly sorted sediments of the greywacke suite. Initially siltstone was the main deposit in the Dundas, Huskisson River, Ulverstone, Deloraine and Beaconsfield areas and this has been likened to the initial euxinic phase of geosynclinal development elsewhere (Campana, 1961b).

Silt seems to have been the predominant normal deposit during the Middle and early Upper Cambrian, but siliceous oozes and some limestone were also formed. Carbonaceous, pyritic and calcareous silts were deposited. Interbedded with the silts are poorly-sorted greywackes and greywacke conglomerates with a disrupted framework and graded bedding. Banks and Jennings interpret these as mostly turbidity current deposits. The proportion of greywacke and conglomerate varies through the successions in a cyclic manner (Carey and Banks, 1954; Banks, 1956) such that a conglomerate-rich section is followed by a greywacke-rich section and this by a predominantly lutaceous section. These cycles may be interpreted as due to tectonic instability and variation in height of the source area. Faulting of Upper Middle Cambrian and Lower Dresbachian age has been demonstrated near Ulverstone. Campana and King state: “The proportion of coarse material increases upwards in the Dundas and Huskisson successions at least.”
<table>
<thead>
<tr>
<th>GROUP</th>
<th>FORMATIONS</th>
<th>FACIES</th>
<th>AGE</th>
</tr>
</thead>
<tbody>
<tr>
<td>JUNEE GROUP</td>
<td>GORDON LIMESTONE</td>
<td>MARINE TRANSGRESSION</td>
<td>LOWER TO</td>
</tr>
<tr>
<td></td>
<td>CAROLINE CREEK SANDSTONE</td>
<td></td>
<td>ORDOVICIAN</td>
</tr>
<tr>
<td>CONFORMITY (MISERY HILL)</td>
<td>OWEN CONGLOMENATE CONFORMITY AND LOCALLY DISCONFORMITY</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>JUKES BRECCIA DISCONFORMITY</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>(IN ZONES OF ORDOVICIAN FAULTING)</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>GREYWACKE, CONGLOMERATES, SLATES, SHALES AND PEBBLE BEDS</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>PURPLE, GREEN &amp; GREY SHALES</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>SANDSTONES AND TUFFS</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>CHERT</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>CRIMSON CREEK ARGILLITES</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>UNCONFORMITY</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>SLATES AND TUFFS</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>MAGMA FLOWS KERATOPIERES PORPHYRIES AND MASSIVE PYROCLASTICS</td>
<td>MARINE SUITES</td>
<td>MIDDLE TO UPPER CAMBRIAN</td>
</tr>
<tr>
<td></td>
<td>VOLCANIC AGGLOMERATE</td>
<td></td>
<td>MIDDLE TO UPPER CAMBRIAN (INF)</td>
</tr>
<tr>
<td></td>
<td>FELDSPATIC TUFF</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>TECTONIC ZONE SCHISTS OF MT LYELL, HERCULES AND ROSEBERY MINE AREAS</td>
<td>VOLCANIC SUITE</td>
<td>LATE LOWER CAMBRIAN TO MIDDLE CAMBRIAN (INF)</td>
</tr>
<tr>
<td></td>
<td>GREY AND BLACK LAMINATED SLATES</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>QUARTZITE, COMMONLY MICACEOUS</td>
<td>VOLCANIC SUITE:</td>
<td></td>
</tr>
<tr>
<td></td>
<td>DOLOMITE BREA B CONGLOMERATE</td>
<td>VOLCANIC SUITE:</td>
<td></td>
</tr>
<tr>
<td></td>
<td>DOLOMITE AND DOLOMITE SILTSTONE</td>
<td>VOLCANIC SUITE:</td>
<td></td>
</tr>
<tr>
<td></td>
<td>PURPLE AND GREEN SLATES AND SILTSTONES</td>
<td>ROCKS IN UPPER</td>
<td></td>
</tr>
<tr>
<td></td>
<td>UNCONFORMITY</td>
<td>PORTION</td>
<td></td>
</tr>
<tr>
<td></td>
<td>QUARTZITES AND SLATES</td>
<td>QUARTZITES WITH VOLCANIC</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>SUITE IN UPPER</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>PRECAMBRIAN</td>
<td></td>
</tr>
</tbody>
</table>

Fig. 12. Stratigraphic and facies succession of Early Palaeozoic rocks of the Zeehan-West Coast Range area (Campana and King).
Turbidity currents brought fragments of grey, red, black and banded cherts, banded slate, quartzite, basalt and golden mica (this last presumably from breakdown of Precambrian mica schist) to the Dundas area. In view of the known distribution of chert in western Tasmania a westerly or north-westerly source is likely. Turbidity currents deposited fragments of chert, claystone, quartzite, slate, greywacke, quartz mica schist, chloritised basic lava and spilite in the Deloraine area indicating a source area with Precambrian rocks and earlier Cambrian sediments and lavas. Near Rocky Boat Harbour the source area contained dolomite, ultrabasic rocks, granite, and Precambrian quartzites and schists.

A difference between the fauna in the silts and in the greywackes is evident in the Hodge Slate at Dundas and the Kateena Formation near Ulverstone at least. The “dendroids” in the Hodge Slate are in the siltstone and the fragmentary trilobites and cystoids in the greywacke. This suggests that the fossils in the greywackes are thanatocoenotic as might be expected and introduces the possibility of *remanent* fossils and of shallow water fauna intercalated with deeper water fauna. The bathymetric conditions suggested by Hills and Thomas (1954) for the Cambrian of Victoria may thus not be applicable to Tasmania.

Deposition was also interrupted from time to time by lava flows, some of them, at least, submarine. The Mt. Read Volcanics may be Lower Cambrian but acid and basic lavas and pyroclastic rocks are interbedded with or overlie Middle and Upper Cambrian sediments at Zeehan, Dundas, Ulverstone, Smithton and Beaconsfield. Acid volcanic rocks are commoner near the Tyennan Geanticline and basic rocks further away. Possibly during the Dresbachian ultrabasic rocks were intruded as sheets and dykes into Precambrian and earlier Cambrian rocks and by Franconian time were exposed to erosion at Adamsfield.

Deposition may have commenced later at Smithton (Upper Middle Cambrian), Beaconsfield (Lower Dresbachian) and Adamsfield (Lower Franconian) than at Dundas (Lower Middle Cambrian).

_Campana and King_ express the thoughts of Bradley (1957, pp. 114-115) and the author when they state: “The Dundas Group reflects a eugeosynclinal cyclic sedimentation under unstable tectonic conditions. The group is no doubt a synorogenic suite comparable with the Flysch as it was deposited in the narrow subsiding Dundas Trough which developed along the Mt. Read Volcanic Arc, and which is similar to the present deeps of archipelago areas. Such a comparison is enhanced by the succeeding Ordovician conglomerates and sandstones, comparable in some respects with the molassic deposits which displaced the Flysch sedimentation in the Pre-Alpine troughs (Fig. 12).”

The Cambrian rocks were folded or tilted at least along the western and northern margin of the Tyennan Geanticline and near New River Lagoon, the Tyennan Geanticline was rejuvenated, the Asbestos Range Geanticline raised and the highland areas near Ulverstone and Zeehan uplifted late in the Cambrian or very early in the Ordovician.
On Hurdia ? davidii Chapman from the Cambrian of Tasmania

Chapman (1926) described a marking in slate from Hatfield Plains, near Rosebery in western Tasmania, as a fossil which he doubtfully ascribed to the genus Hurdia Walcott, a form occurring in the Middle Cambrian of British Columbia. This determination has subsequently been used without further examination of the specimen to indicate a Middle Cambrian or Cambrian age for the Hatfield Plains Slate (David, 1932, p. 37; Nye and Blake, 1938, p. 35; Banks, 1956, p. 182), and has played an important part in the recent controversy on the age of the Mount Read Volcanics Campana et al., 1960; Banks and Solomon, 1961; Campana, 1961).

Chapman's specimen was located recently in the National Museum of Victoria and kindly made available for study by the Curator of Fossils, Mr. E. D. Gill. The holotype is numbered P13505 in the collection of the National Museum.

The specimen is in a dark-grey, micaceous argillite which is thinly bedded (beds less than 5 mm. thick). It is a slightly convex brownish-grey mark with a relatively smooth, iron-stained area around the presumed dorsal margin and it is almost but not quite on a bedding plane. The prolonged posterior extremity such as Hurdia would have is not revealed in the specimen, but in the place indicated for this structure is a line of mica flakes, with the cleavage planes at a high angle to the bedding. This line of mica flakes is nearly parallel to the main joint splitting the specimen and to other joints and lineations in the fossil and outside it (see Chapman, 1926, Pl. X). The wrinkling of the dorsal margin mentioned by Chapman is not clear. The irregularities present along this margin are due to the intersection of a planar structure (?) cleavage) and the bedding. The undulatory folds on the surface are very small folds and joints and are parallel to

and in some cases continuous with lineations such as the intersection of joints and bedding, in the body of the rock away from the marking. Chapman's hypothetical reconstruction does not show these undulatory folds correctly. There is no sign of any organic material attributable to a carapace. The surface of the marking and the joints in the body of the rock are all iron-stained.

Chapman assigned an organic origin to the marking on the basis of the dorsal wrinkling but it seems more probable, because of the parallelism of the wrinkles and the undulations with the lineations in the argillite outside the marking, that the wrinkles and undulations are of tectonic origin. There is no unequivocal evidence of an organic origin for the marking. The marking may well have been some type of sole marking distorted by later compression and shearing. No evidence of the facing of the specimen could be seen. Even if the marking were organic in origin, allocation of it to Hurdia, even 'with some reservation' seems to be unjustified and the use of the specimen to suggest a Middle Cambrian age should be discontinued.

I wish to acknowledge helpful comments from Professor D. Hill, University of Queensland, and Mr. E. D. Gill.

University of Tasmania,
Hobart.
6 September 1962.

M. R. BANKS.

References
Plate Tectonics and the Lower Palaeozoic of Tasmania

Solomon and Griffiths¹ have applied a plate tectonics model to the Tasmanian part of the Tasman Orogenic Zone in the Lower Palaeozoic. Although this new interpretation of the Cambrian tectonics of Tasmania is timely and stimulating, we find that there are difficulties in fitting the facts to the model, and that the evidence suggests that other explanations are possible if not, indeed, necessary.

The present distribution of tectonic elements of the Cambrian and Lower Ordovician is shown in Fig. 1. We focus attention on the Dundas Trough, which lies between Precambrian blocks and is filled with greywackes, conglomerates, siltstones, cherts, and black shales interbedded with acid to basic volcanics. Exposed basement fragments of Precambrian metasediments occur within the trough, which must therefore be at least partly en-sialic. Deposition lasted from at least as early as the Ptychagnostus gibbus Zone of the Middle Cambrian to the late Franconian. Within the trough, and commonly close to its western margin, are ophiolite complexes of the marginal basin type². Only one of these complexes is adequately dated, that near Dundas; this is pre-Ptychagnostus nathorsti in age (M. J. Rubenach, personal communication).
Acid and intermediate volcanics are concentrated in a belt bordering the Tyennan Geanticline and called the Mt Read Volcanic Arc. These volcanics are mostly pre-Late Mesial Cambrian in age\(^34\), but the age of the base and of the top is unknown. The age relationships of the Mt Read Volcanics and the ophiolite complexes are thus not clear, but it is probable that they overlap (contra Solomon and Griffiths).

Fig. 1 Map showing distribution of tectonic elements in the Lower Palaeozoic of Tasmania.

Continuation of the Mt Read Volcanics around the northern and northeastern sides of the Tyennan Geanticline is indicated by regional mapping\(^5\), by petrological similarity and by association with sub-volcanic granites (Fig. 1). This bending of the volcanic arc around the geanticline was not considered by Solomon and Griffiths (inset, Fig. 1). The Dundas Trough seems also to continue through this area, and possible equivalents of the Dundas ultramafic belt are represented by basic intrusives and/or volcanics at Sheffield, Deloraine and Con-
norville associated with positive gravity anomalies interpreted as sub-surface ultramafic complexes.

The Adamsfield Trough, which lies at the exposed eastern margin of the Tyennan Geanticline, began to fill possibly as early as Upper Precambrian, and certainly by the upper part of the Mesial Cambrian a thick pile of greywacke, argillite and chert had been deposited. Initiation of the Adamsfield Trough was therefore not the result of a post-Mesial Cambrian collision between a crustal plate and the Mt Read Arc as suggested by Solomon and Griffiths. The Adamsfield ultramafic body which is a diapiric Alpine-type (A. V. Brown personal communication), was being eroded in the late Mesial Cambrian and further thick deposition accompanied by further tectonic intrusion of the ultramafics occurred in the Late Cambrian. But the Late Cambrian faulting in the trough appears to have been tensional and not thrust-faulting (contra Solomon and Griffiths).

Acid and intermediate volcanic rocks similar to the Mt Read Volcanics occur near the exposed eastern side of the Adamsfield Trough, and although continuity of these rocks with the Mt Read Arc cannot be demonstrated because of later cover, it is clear that petrologically similar rocks were erupted both east and west of the Tyennan Geanticline in the Cambrian. Poorly known Cambrian rocks, including ultramafics, also occur further south at New River (Fig. 1), suggesting there may have been an almost continuous Cambrian belt around the Tyennan nucleus.

We can find no evidence for the Middle Cambrian subduction zone and ocean postulated by Solomon and Griffiths between the Mt Read Volcanic Arc and the Tyennan Geanticline (Fig. 1). The Mt Read Volcanics rest on and are interbedded with a thin, west-facing succession of sandstone and argillite, with a basal conglomerate, in the Sticht Range area (Fig. 1). This pre-volcanic succession is in contact with Precambrian metasediments along a steep fault, but the basal conglomerate contains clasts derived from Precambrian rocks like the immediately adjacent metasediments. There is no sign of complex folding or thrusting. Further north, porphyry dykes similar to the Mt Read Volcanics occur within the Precambrian metasediments, and could well have been feeders to the immediately adjacent volcanic pile. These lines of evidence suggest original proximity of the Mt Read Arc and the Tyennan Geanticline. No detritus from sediments such as might have accumulated in the postulated Middle Cambrian ocean has been found in the Jukes Breccia or the Owen Conglomerate which directly overlie the volcanics along the western margin of the Tyennan Geanticline unless it be the chert fragments in the Owen Conglomerate.
We conclude that it is difficult to support the Solomon and Griffiths plate tectonics model because there is no evidence for the postulated trench or ocean east of the Mt Read Volcanic Arc; the theory does not explain the bending of the Mt Read Arc around the geanticline and it does not satisfactorily explain the Adamsfield Trough east of the geanticline. It might be argued that the bend of the Mt Read Arc represents a later impressed strain, for example, a meridional dextral shear operating on an originally linear trough could have produced an

![Diagram of plate models](image)

**Fig. 2** Cross-sections illustrating some possible models explaining the distribution of Lower Palaeozoic tectonic elements in Tasmania.

S-shaped pattern in northern Tasmania, but the structural evidence is against such a stress system\(^{10}\), and the other objections are still not satisfied.

Two other variations on the plate tectonics theme may be considered, the first involving a subduction zone west of the Mt Read Arc, and the second having the Adamsfield Trough as the subduction zone (Fig. 2). In the first case the deformed trench zone would now lie within the Dundas Trough, a distinct possibility, but again it is difficult to explain the bend in

---

\(^{10}\) Reference to a specific page number or citation is necessary for the S-shaped pattern.
the arc and the presence of the Adamsfield Trough. In the second case the subduction zone plunges west under the Tyennan Geanticline, the volcanic arc develops at the western margin of the geanticline, and the Dundas Trough develops as a back-arc marginal sea in the manner suggested by Packham and Falvey. Again, however, the shape of the arc and of the Dundas Trough are difficult to explain, although it is perhaps possible to see the northern belt developing on cross-fractures through the Tyennan Block, and the trench zone continuing north through Beaconsfield.

We believe that the classical model, which does not involve plate tectonics but envisages stretching of sialic blocks with minor creation of new crust (represented by the ultramafics) and acid volcanism along rifts fringing the major blocks (Fig. 2), seems to fit the facts equally well at this stage, although the origin of the Mt Read Volcanics remains a problem.

K. D. CORBETT

Geological Survey,
Mines Department,
Hobart, Tasmania

M. R. BANKS

University of Tasmania

J. B. JAGO

South Australian Institute of Technology,
Adelaide, South Australia

Received August 2, 1972.

5 Department of Mines, Tasmania, *Geol. Atlas*, 1-mile series, Sheffield, Middlesex and Quamby Sheets.
ORDOVICIAN SYSTEM

By MAXWELL R. BANKS

ADELAIDE
SOUTH AUSTRALIA
1962
III

ORDOVICIAN SYSTEM

By MAXWELL R. BANKS

with contributions by A. H. BLISSETT, K. L. BURNS, B. CAMPAANA,
R. G. ELMS, I. B. JENNINGS, D. KING AND M. SOLOMON.

The Ordovician rocks of Tasmania are known as the Junee Group which may be defined as consisting of the following formations or their correlates—

“Fenestella Shale”, at the top,
Gordon Limestone (Lower to Upper Ordovician),
Florentine Valley Mudstone,
Caroline Creek Sandstone,
Owen Conglomerate,
Jukes Conglomerate.

The group rests unconformably on Precambrian or Cambrian rocks except at Beaconsfield, Misery Hill (near Zeehan) and perhaps Adamsfield where it is concordant with Cambrian rocks. It is overlain concordantly by the Eldon Group and Mathinna Beds but may be disconformable with the latter. The maximum thickness is about 7500 feet. The type area is near Maydena and might be considered as including the Tim Shea and Florentine Valley sections. The group is widespread (Figs. 13, 22) but is not known in the far north-west, nor in the eastern part of the State. Some of the Mathinna Beds may be Ordovician (Chapter IV).

Terms synonymous with “Junee Group” are Junee Series (Lewis, 1940; Thomas, 1948), Junee System (Carey, 1947), and Junee Group (Hills and Carey, 1949; Bradley, 1954, and others) and terms probably synonymous include Gordon Beds (Gould, 1866), Gordon River Group (Johnston, 1888), Cabbage Tree Hill Series (Montgomery, 1891; Hughes, 1953), Gordon River Series (Montgomery, 1895) and Beaconsfield Series (Twelvetrees, 1903a, 1917).
Fig. 13. Distribution of Lower Ordovician conglomerates (Banks).
JUKES CONGLOMERATE AND CORRELATES

The Jukes Conglomerate, Wade and Solomon (1958, p. 376), may be defined as that formation dominantly composed of conglomerate and breccia consisting of fragments of lava and other Cambrian rocks exposed in the cliffs near Lake Jukes (3623.8060). It rests on Cambrian rocks and is overlain conformably by Owen Conglomerate. It is up to 300 feet thick and is probably Lower Ordovician.

The conglomerate consists of angular, sub-angular or sub-rounded fragments up to four feet long, of the underlying sediments and lavas, haematite and haematitic sandstone with rare quartz and quartzite fragments (Hills, 1914a, p. 42). Distinct stratification is uncommon. Overlap of this unit by Owen Conglomerate (Fig. 15) suggests an initial restricted distribution. It thins at a maximum rate of one in ten. The Sorell Conglomerate and Dora Conglomerate are correlates of the Jukes.

The Sorell Conglomerate rests unconformably on pre-Ordovician sediments, lavas and granite and is overlain by siliceous conglomerate in an area east of Mt. Sorell (Fig. 19). It merges south along the strike into siliceous conglomerate and contains fragments of haematite, magnetite, Darwin Granite and quartz-chlorite rock (Hills, 1914a, p. 3; Bradley, 1954, p. 216). The granite boulders decrease in grainsize from Mt. Darwin (Fig. 15) westwards. The formation is 300 feet thick at Mt. Sorell (M. Solomon, pers. comm.).

The 1000 ft. thick Dora Conglomerate (Bradley, 1954, p. 210) is another correlate of the Jukes Conglomerate. Campana and King state: “It is an unsorted, crudely stratified greywacke breccia-conglomerate with pebbles and boulders of porphyritic and pyroclastic material and fragments of quartz, quartzite, and haematite dispersed in a grey or dark, micaceous feldspathic matrix. High angle unconformities beneath the unit occur at Red Hills and half a mile east-north-east of the northern shore of Lake Westwood (363.843) but at Lake Dora the lower limit is indefinite (Carey and Banks, 1954; Fraser, 1958). This local apparent gradation (Fig. 14) from the Mt. Read Volcanics to the Jukes Breccia cannot be regarded as showing stratigraphic continuity, as there are high-angle unconformities at this level just to the north. The view that gradation is due to permeation of the feldspathic greywacke conglomerate by feldspathising solution during a period of post-Ordovician progressive metamorphism (Bradley, 1957) must be rejected as scattered fragments of schistose porphyries, keratophyres and pyroclastic rocks occur in unmetamorphosed sediments of the Dundas Group, and in unaltered layers of the Jukes Breccia and Lower Owen Conglomerate. The apparent gradation is due to the exfoliation and disintegration of the underlying volcanic and pyroclastic material with little or no transport of material.

“However, sharp and unconformable relations are also seen near Lake Dora, where haematite veins in the Mt. Read Volcanics are truncated by the unconformity plane.”
CUMMAR 
JURASSIC 
PERMIAN 
SILL'S!

MT. MURCHISON 
MIDDLE OWEN CONGLOMERATE 
JURA, DRECCIA 
ANGULAR UNCONFORMITY 
SANDSTONES & PYROCLASTICS 
SLATES, TUFFS. QUARTZ 
DOLOMITE 
PRE TAMPA/ANN 
FAULT SMEAR

The Jukes Conglomerate thins laterally at a rate of one in ten, its equivalent at Mt. Tyndall at one in nine (1400 ft. to zero in 2 miles, Campana et al., 1959b, p. 200) and at Mt. Lyell at one in six. The Jukes, Sorell and Dora Conglomerates are similar in gross lithology (all contain fragments of local derivation), in texture, structure and stratigraphical position. Because of overlap of these formations by higher units of the Ordovician, the approximate limits of each at the time of deposition can be inferred (Fig. 15). The Sorell Conglomerate was deposited on both sides of a meridional ridge along the line of the Great Lyell Fault Zone, the Jukes Conglomerate as a body bifurcating to the east and lying on the Fault Zone and the Dora Conglomerate as an almost meridional belt about three miles east of the Great Lyell Fault Zone. The conglomerates were probably discrete bodies at the time of formation.

Fig. 14. Sections across the West Coast Range between Mt. Murchison and Mt. Sedgwick (Campana).

Fragments in the Sorell Conglomerate were derived from the meridional ridge and probably from the Precambrian rocks to the east (Hills, 1914a; Bradley, 1954; Solomon, 1957b, p. 48). Transgression of siliceous conglomerate northward over the Sorell Conglomerate (Hills, 1914a, pp. 43-44) and overlap onto the meridional ridge (Solomon, pers. comm.) were explained by Hills (1914a, p. 45) as due to rise in sea-level but may be due to progressive encroachment northward of alluvial flood-plain gravels of easterly derivation at the expense of fanglomerate of northerly derivation.

The distribution, variations in thickness and lithology of the Jukes Conglomerate support its indentification as a fanglomerate (Hills, 1914, p. 45) deposited on a piedmont fronting a mountain range. "Fanglomerate . . . should
Fig. 15. Distribution of Jukes and Owen Conglomerates (Banks, based on mapping by Solomon).
be considered possible under any strongly marked seasonal system of precipitation, provided an adequate break of slope is provided by the topography" (Krynine, 1950, p. 155). None of the characters of the Jukes Conglomerate or its correlates requires deposition under arid or semi-arid conditions as postulated by Hills (1914, p. 45) and Campana et al. (1958). Nor are its characters concordant with a littoral environment (Carey and Banks, 1954, p. 265). Bradley (1954, p. 211) considered the Jukes and Dora Conglomerates to be deposits flanking and derived from the coasts of a strait (the Jukes Trough) separating the Dundas Ridge from the Tyennan Geanticline. Under this hypothesis, the Jukes Conglomerate would have to be a talus deposit formed below wave base at the foot of steeply-cliffed coasts and steep submarine slopes. Uplift of the Tyennan Geanticline bordering the strait on the east initiated deposition of Owen Conglomerate according to this view and maximum thickness and main distribution of Owen Conglomerate east of the Jukes and Sorell Conglomerate would be expected. This is not in accordance with known thicknesses and distributions (Fig. 15). Some fanglomerates of westerly derivation might be expected under the "rift valley" hypothesis (Campana et al., 1958, F. 4, stage 3) but have not been identified.

Reconstruction of conditions during formation of the Jukes Conglomerate and correlates must be tentative in view of the small amount of information available. The soundest reconstruction is that they are fanglomerates of predominantly easterly derivation. The sections provided by Campana and King (Fig. 16) represent the writer's view except that there seems no evidence for any fanglomerate of westerly derivation. There is little information on the height of the Dundas Ridge (Bradley, 1954, p. 210) during early Lower Ordovician time. This reconstruction suggests that the main tectonic event immediately prior to deposition of the fanglomerates was uplift of the Tyennan Geanticline, the most intense movement being in a zone a few miles wide bordering the geanticline. Within this zone Cambrian rocks were steeply tilted. The conglomerates were then deposited as fanglomerates (derived from a veneer of Cambrian rocks on the western slope of the geanticline) on the eroded, upturned edges of the Cambrian rocks producing Jukesian unconformities. This reconstruction is somewhat similar to that of Hall and Cottle (1959, p. 128).

Campana et al. (1958, 1959a, 1959b) suggest that the Jukes was deposited against the western scarp of the "Owen Rift Valley" apparently on the evidence of the "abrupt decrease in thickness" (1959a, p. 200). However, the slope on the upper surface of the Jukes Conglomerate at the time of deposition appears to be less than 10° which would be normal in a fanglomerate. The thickness variations given by Scott (1959), Hall and Cottle (1959) and Campana et al. (ibid.) do not support the presence of nor the need for a confining scarp to the west.

Other correlates of the Jukes Conglomerate occur at Mt. Fincham (McLeod, 1955; Scott, 1960a, p. 104), Warnes Lookout (Wells, 1955), Denison Range (Twelvetrees, 1908a, p. 30), Tim Shea (Carey and Banks, 1954, p. 267) and Beaconsfield (Blyths Creek Formation, Green, 1959).

The Jukes Conglomerate and correlates have not yielded fossils. They underlie siliceous conglomerates which are overlain by Middle and Upper
Fig. 16. Palaeoprofiles showing the deposition of the Jukes and Owen Conglomerates at the eastern edge of the Owen Rift Valley (Campana). (1) Late Cambrian faulting. (2) Terrestrial deposition of Jukes Conglomerate as the reworked products of the Mt. Read Volcanics. (3) Terrestrial deposition of the Owen Conglomerate as scree and fanglomerate derived from Precambrian quartzites. (4) Marine transgression, deposition of Gordon Limestone. (5) Devonian folding, as reflected in present profile.

Arenigian sediments near Maydena, Devonport and Beaconsfield. Middle Ordovician limestone on the Andrew River is separated by a siliceous conglomerate, sandstones and siltstones from the Jukes Conglomerate. Thus the Jukes Conglomerate and correlates are older than Middle Ordovician and probably older than Middle Arenigian. The Sorell, Jukes and Dora Conglomerates uncon-
formably overlie the Mt. Read Volcanics considered by Banks (1956) as Middle and Upper Cambrian but by Campana et al. (1960) as pre-Middle Cambrian. Because of their unconformable relationship with the older rocks and their conformity with Ordovician sediments, these conglomerates are considered to be Lower Ordovician.

**OWEN CONGLOMERATES AND CORRELATES**

**West Coast Range**

The Owen Conglomerate is that formation of siliceous conglomerate and quartz sandstone which outcrops on Mt. Owen and nearby mountains near Queenstown. It rests conformably or disconformably on Jukes Conglomerate and correlates and overlaps onto older rocks unconformably. It underlies the Caroline Creek Sandstone and correlates. In the type section on the northern face of Mt. Owen it is 1180 feet thick. It is Lower Ordovician.

Observations on this unit have been made from time to time since 1862 (see Smith, 1959). Recent detailed work near Queenstown (Wade and Solomon, 1958) allows selection of a type section, which, although faulted, is the best one known close to Mt. Owen (Solomon, 1957b, table 5):—

Central part of Owen Spur—
Upper Owen: 720 ft.

Middle Owen:
- 40 ft. yellow, medium-grained, thickly bedded siliceous conglomerate.
- 200 ft. red sandstone.
- 240 ft.

Below summit of Mount Owen—

Middle Owen:
- 160 ft. cross-bedded, red sandstone with pebble bands, becoming more conglomeratic upwards.
- 40 ft. dark, medium-grained conglomerate, mainly yellow siliceous pebbles in haematitic matrix.
- 50 ft. red sandstone.
- 250 ft.

Lower Owen:
- 340 ft. coarse-grained, grey, siliceous conglomerate with red sandstone beds mostly less than 2 feet thick; sandstones commoner in upper part of unit than in lower; pebbles mainly banded quartzite, vein quartz; quartzite, chert, etc.
- 40 ft. very coarse-grained conglomerate, boulders up to 2 feet long.
- 350 ft. yellow grey, coarse-grained siliceous conglomerate with lenticular sandy beds.
- 200 ft. pink-grey, very coarse-grained, siliceous conglomerate with thin sandstone beds; pink sandy matrix.
- 930 ft.
As used in this chapter “Owen Conglomerate” includes “Stages” 1-3 (Hills, 1914), Lower and Middle Series and Razorback Beds (Conolly, 1947; Alexander, 1953) and the Lower and Middle Owen (Wade and Solomon, 1958). Higher units previously included in the Owen as the “Upper Owen” of Wade and Solomon (1958) are marine and are here considered to be correlates of the Caroline Creek Sandstone. If this is so, the “Upper-Middle-Lower” terminology can no longer be used. It is therefore proposed to refer to the Lower Owen of Wade and Solomon as “Member A” and the Middle Owen as “Member B”.

Fig. 17. Owen Conglomerate near Queenstown (compiled by Banks from Wade and Solomon, 1958).
The formation is dominantly siliceous with fragments of vein quartz, quartzite, quartz schist, chert and rarely other rock types in a matrix of quartz grains with a siliceous and/or ferruginous cement. The colour varies from white or grey to purple or greenish. The larger fragments, with a maximum length of about two feet in Member A are characteristically well-rounded but the sand grains in the matrix are angular or sub-angular. Most of the larger fragments have a fairly high sphericity, varying somewhat with rock type, and in a few beds almost discoidal particles occur. The grains in the matrix have a high sphericity. Sorting is good both in the conglomerates and sandstones and the framework is closed. Member A is poorly-bedded, no cross-bedding has been recorded, but imbrication may be present. Member B is more clearly bedded than Member A and shows cross-bedding and cut-and-fill structure (Wade and Solomon, 1958, p. 387). The beds, especially those of conglomerate, tend to be lenticular.

The maps and panel diagrams (Figs. 15, 17, 18) show the distribution and thickness of the Owen Conglomerate members along the West Coast Range. Member A occurs in a north-north-westerly trending belt overlapping and lying...
west of the belt of Dora Conglomerate between Mt. Sedgwick and Mt. Huxley. This member also occurs east of the Jukes Conglomerate near Mt. Jukes. Another area of deposition lay on the meridional ridge near Mt. Darwin.

The Owen Conglomerate was almost certainly derived from the Precambrian rocks of the Tyennan Geanticline to the east. A high area seems to have been present near Little Owen during deposition of Member A judging from decrease in the ratio of conglomerate to lutite plus arenite north and north-west of this area based on work by Wade and Solomon (1958) and Campana, King and Atkinson (Fig. 19). Along the length of Mt. Lyell, Member A thins at between one in three and one in six.

Member B is more widespread than the older part of the Junee Group. Where the eastern margin can be delineated it lies east of, or at the same place as, the eastern margin of Member A and the western margin is west of those of the Dora Conglomerate and Member A. Local unconformities occur in or at the base of Member B (Fig. 15) south-east of Mt. Jukes (Solomon, 1957b). Thickness variations are shown in Figs. 15, 17, 18, 19.

Solomon states: “Trails, probably of merostomaceous origin, occur on the track from Gormanston to Lynchford (327.8188) close to the top of Member B.”

Two main hypotheses have been advanced for the conditions of deposition of the Owen Conglomerate and similar Lower Ordovician conglomerates elsewhere in Tasmania. Twelvetrees (1903b, p. 2) and most later authors regarded these rocks as littoral deposits. The grounds advanced are: well-rounded pebbles, good sorting, regularity of stratification, nature and form of pebbles, regularity of linear extension, disposition of the pebbles, regular grading of individual members and rapid thinning. None of these characters, singly or in combination, is absolutely diagnostic of littoral deposits and some are mutually contradictory. Confusion probably arose because dissimilar units, e.g. Member A and the “Upper Owen Conglomerate” were grouped in a single formation. The “Upper Owen Conglomerate” contains marine fossils.

Hills (1915, pp. 34, 36) suggested an origin as continental alluvial fans, flood-plains or playas because of the alternation from conglomerate to sandstone and shale, cross-bedding in the sandstone and the sporadic occurrence of sandstone in conglomerate. His palaeogeographic reconstruction of a plain overlying Cambrian rocks with piedmont deposits against a highland of Precambrian rocks to the east, is essentially that postulated herein.

Campana et al. (1958) returned to Hills' earlier ideas on the basis of the narrow, elongate distribution, rapid lateral variations in thickness, the coarse-grained, unstratified, unsorted nature of the lower portion, the “red beds” in the succession, violent lateral and vertical variation in lithology, interfingering of beds, local angular unconformities, cut-and-fill structures, steep cross-bedding and the absence of claystone and limestone. They postulated a piedmont and valley-flat deposition in a rapidly subsiding land-locked graben, probably under a dry climate. Campana and King state: “The Jukes and Owen Conglomerates have a wedge-shaped distribution characteristic of coalescing aprons and fans and described from various grabens throughout the world (Fig. 20).”

The present author follows Hills' reconstruction (1915) except that the “Upper Owen” and part of Member B are considered marine and he differs
Fig. 19. Ordovician System along the West Coast Range (Banks).
Fig. 20. Geological evolution of the West Coast region in Lower to Middle Palaeozoic times (Campana).
from Campana et al. (1958) mainly in that he does not consider a graben necessary nor proven during deposition of the Owen Conglomerate. The red colour is not diagnostic of aridity (Solomon, 1959). The relief of the Dundas Ridge (Bradley, 1954; Wade and Solomon, 1958) during deposition of this conglomerate is not known.

After deposition of the fanglomerates (Jukes Conglomerate and correlates) close to the steep western slope of the Tyennan Geanticline, erosion of the uplifted block continued and streams cut into the Precambrian rocks. Streams draining the geanticline carried a load of siliceous sand and gravel, debouched onto the lowland and deposited their load as alluvial fans and sandy plains. During deposition of Member B the relief of the source area decreased on the whole but minor uplifts (or increased rainfall) increased competence of the streams flowing over the sandy plains and caused formation of the interbedded conglomerates. The sea then encroached over the sandy lowlands, as shown by the merostome tracks, and onto the highland area which was by then greatly reduced in relief.

Siliceous conglomerate occurs in a number of isolated outcrops (Fig. 13) which, in view of the lithological features and thickness variations of the conglomerate, were probably never continuous. Because of the probably discontinuous original distribution, a separate name for them in each area of outcrop has been used.

**Tyennan Geanticline**

The Tim Shea Conglomerate (Twelvetree, 1908a, p. 27) consists of 200 ft. of siliceous conglomerate and pebble breccia with thin cross-bedded sandstones resembling Member B or the Caroline Creek Sandstone. At Tim Shea it overlies 70 ft. of red siltstone with thin sandstone beds and lenses of fine conglomerate which in turn rest on a dolomitic breccia which is correlated with the Jukes Conglomerate.

The conglomerate becomes thinner and finer-grained to the south towards Maydena and to the south-west; it thickens and becomes coarser at the Thumbs near Adamsfield. It becomes thinner to the north along the Denison Range. Chromite in the conglomerate at Tim Shea and the other evidence above suggests a source just north of Adamsfield, mainly in Precambrian rocks of the eastern part of the Tyennan Geanticline but with some contribution from the Adamsfield serpentinites and transport from this source north, east and south.

Siliceous conglomerates occur across the southern part of the Tyennan Geanticline. Conglomerate occurs at Warnes Lookout (900 ft., Wells, 1955), Calder Pass (Ward, 1908b, 1909a; Wells, 1955) and at Mt. Arrowsmith (Ward, 1909a) but is missing between the Precambrian and Caroline Creek Sandstone at the Olga River and Elliot Range and is very thin along the Engineer Range (8 to 84 ft., Mather, 1955).

The section near Hazel Hill is very thick. Elms states: “A total thickness of 5900 ft. of Owen Conglomerate is composed of 900 ft. of basal pebble conglomerate followed by 900 ft. of quartz sandstone and minor conglomerate, then 1250 ft. of micaceous quartz sandstone with a little shale and thin conglomerate.
ORDOVICIAN

This is overlain by 800 ft. of thick-bedded pebble conglomerate, then 550 ft. of quartz sandstone with a little conglomerate, 700 ft. of pebble conglomerate, then 500 ft. of fine conglomerate.

"The section north of Thirkell Hill is about 2500 ft. thick and consists of 1300 ft. of conglomerate overlain by micaceous sandstones with shales increasing in importance towards the top."

Zeehan-Mt. Farrell Area

Waller (1904a) named the Mt. Zeehan Conglomerate and described it as a regularly bedded, coarse- to fine-grained conglomerate composed mainly of quartz boulders in a siliceous ferruginous matrix. Blissett and Gulline state: "The thickness of conglomerate at Mt. Zeehan is 1500 ft. It thins to the north-west and overlaps onto the Precambrian at Duck Creek."

Bradley (1954) suggested that the formation thinned north from Mt. Zeehan and Elliston (1954, pp. 175, 177) considered that it was overlapped by the Gordon Limestone which rested directly on Cambrian strata. Blissett states: "The contact between the Cambrian rocks and the limestone is due to faulting and small fault blocks of Caroline Creek Sandstone occur in the fault zone."

A high area from Misery Hill to just north of Zeehan and one just south of Duck Creek is suggested by the overlap in these areas of conglomerate by younger beds (Fig. 21). The conglomerate seems to thin from Mount Zeehan south-west, south-east, east and north and a source area for the Mt. Zeehan Conglomerate in Precambrian rocks near there may be tentatively postulated.

The conglomerate at Mt. Farrell reaches 700 ft. in thickness at the south end of the mountain and thins to the north and south (Ward, 1908a, p. 23; Bradley, 1954, p. 212). It is overlapped to the east by Caroline Creek Sandstone. An eastern origin from the western flank of the Tyennan Geanticline seems likely.

North-West Coast

Jennings states: "The Roland Conglomerate exposed on the mountain ranges from Mt. Gog past Mt. Roland to Black Bluff is indistinguishable from the Owen Conglomerate. It rests on Cambrian rocks with an unconformity which is clear at Tin Spur and Cethana and which is indistinct along the Gog Range. The Conglomerate contains boulders up to 18 inches long including Cambrian volcanics, cherts and greywackes. The maximum thickness of the Roland Conglomerate is about 800 ft. It thins rapidly to the south where it rests on the Precambrian rocks of the Tyennan Geanticline by overlap not by thinning of individual beds. The thinner unit contains fewer pebbles."

The conglomerate is missing where Caroline Creek Sandstone rests directly on pre-Ordovician rocks south of Lorinna, on Mt. Stormont, north of Liena, near Wilmot (Reid, 1919a, p. 26; Jennings, 1958, 1959a) and at Bonds Peak (Twelve-trees, 1913a, p. 20). Lack of conglomerate suggests Lower Ordovician topographic high areas or low areas not reached by the gravels. From Round Mount the conglomerate thins south at about one in seven for the first mile and about
Fig. 21. Zeehan-Misery Hill area (Campana and King).
1 in 200 for the next four miles (Jennings, 1958, p. 30; and above). The source of the conglomerate is possibly the Tyennan Geanticline to the south.

Burns states: "Ordovician conglomerate occurs as a meridional belt in the Dial Range near Ulverstone where it is about 400 ft. thick. Most of the pebbles are chert with some micaceous haematite, clear quartz and rare fragments of Cambrian volcanic rocks and argillites. It is significant that the pebbles consist almost entirely of Cambrian fragments, in contrast to the normal Owen and Roland Conglomerates which are composed mainly of Precambrian rock fragments. The conglomerate occupies a channel cut into the Cambrian rocks, mainly cherts. The pebbles in the conglomerate east of the Dial Range consist mostly of Precambrian quartzites and as the Cambrian conglomerates show a similar variation in the type of pebble, it is suggested that no major change in provenance occurred between the Lower Dresbachian and Lower Ordovician. Imbricate structure indicates currents of roughly northerly derivation.

"The conglomerate thins to the east and is 50 to 100 ft. thick at Kindred and Palooa but absent just east of the Forth River. It thins to the south, being 100 ft. thick at Gunns Plains and is absent at Eardley Tor. It also thins to the west being very thin at Penguin and Sulphur Creek (Carey and Banks, 1954)."

Beaconsfield

The Cabbage Tree Conglomerate forms a meridional lenticular body which varies from 20 to 2900 ft. in thickness and resembles the Owen Conglomerate and rests on a correlate of the Jukes Conglomerate (Green, 1959). Tubicolar structures in sandstones near the top indicate that part of the formation should be correlated with the Caroline Creek Sandstone. Chromite grains near the base suggest derivation from the west as ultrabasic rocks occur at Andersons Creek.

Summary

The outcrops are all close to areas of Precambrian rocks in geanticlinal areas, e.g. Tyennan, Rocky Cape, Ulverstone and Asbestos Range Geanticlines, which had considerable relief at the time, probably due to uplift associated with the Jukesian Movement. Evidence of the existence of the Adamsfield Rift Valley (Campana et al., 1958, pp. 58-59) at this time is inconclusive.

The conglomerates occupy a stratigraphic position consistently below marine sandstone (Caroline Creek) but there is no real evidence of their contemporaneity or relative age. The Owen Conglomerate is considerably older than Middle Ordovician limestone in the Andrew River. The Mount Zeehan conglomerate conformably underlies at some distance Lower Trentonian limestone at the Oceana Mine (Hill, 1955) and near Misery Hill concordantly overlies rocks at the top of the Dundas Group which are younger than Lower Dresbachian. The Roland Conglomerate conformably underlies Upper Arenigian Caroline Creek Sandstone and cannot be much older than it. The conglomerate on the Dial Range overlies Lower Dresbachian rocks in the Leven Gorge and conformably underlies Caroline Creek Sandstone. The Cabbage Tree Conglomerate is younger than Lower Dresbachian rocks and underlies
<table>
<thead>
<tr>
<th>AREA</th>
<th>FLORENTINE VALLEY MAYDENA</th>
<th>IDA BAY</th>
<th>WEST COAST RANGE</th>
<th>ZEEHAN</th>
<th>BEACONSFIELD</th>
<th>RAILTON-MELROSE</th>
<th>MOLE CREEK</th>
</tr>
</thead>
<tbody>
<tr>
<td>OVERLYING BEDS</td>
<td>Eldon Group, Sharp</td>
<td>Permian</td>
<td>Eldon Group</td>
<td>Eldon Group</td>
<td>Mathinna Beds</td>
<td>Permian</td>
<td>Eldon Group</td>
</tr>
<tr>
<td>conformity</td>
<td>(Unconformity)</td>
<td>(Gradation)</td>
<td>(Gradation)</td>
<td>(Gradation)</td>
<td>(Gradation)</td>
<td>(Unconformity)</td>
<td>(Gradation)</td>
</tr>
<tr>
<td>Cincinnatian Series</td>
<td>Gordon Lime-</td>
<td>Gordon</td>
<td>Fredonia</td>
<td>Gordon</td>
<td>Limestone</td>
<td>Gordon Lime-</td>
<td>Gordon</td>
</tr>
<tr>
<td>Stone, Catenipora,</td>
<td>Stone, Trilobite,</td>
<td>Limestone with Tryplasma</td>
<td>Limestone with Tryplasma</td>
<td>Limestone</td>
<td>Limestone</td>
<td>Limestone with Tryplasma</td>
<td>Limestone with Tryplasma</td>
</tr>
<tr>
<td>Escifera, Palaeofavosites</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Trentonian Series</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Blackriveran Series</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Maclurites, Girvanella</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Orthoptychoceratids</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Phyllograptus</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Canadian Series</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Manchuroceras-Pilo-</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>ceras Fauna</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Florentine Valley Mud-</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Stone with</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Trilophus, Locasopira</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Asplanchna, Didymograptus</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>gracilis, SANDSTONE with</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Trilophus, Tubicolar bodies</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>TIM SHEA CON-</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>GLOMERULATE, SILTSTONE</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Dolomitic Breccia</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>American Stage names after Kay 1960.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Caroline Creek Sandstone of Upper Arenigian age near Beaconsfield. Tim Shea Conglomerate overlies Lower Franconian sediments near Adamsfield and is overlain conformably by Caroline Creek Sandstone and then Florentine Valley Mudstone of Middle Arenigian age.

Thus the ages of the siliceous conglomerates of the Junee Group must be between Franconian and Lower Arenigian. Because of their unconformable relationship with Cambrian rocks in many places and conformity with Lower Ordovician rocks they are generally considered to be Lower Ordovician.

The Owen Conglomerate is thought to be dominantly a terrestrial alluvial fan deposit and the conglomerate on the Dial Range a channel filling but conditions of deposition of the other conglomerates are not clear through lack of textural and structural information.

CAROLINE CREEK SANDSTONE AND CORRELATES

The Caroline Creek Sandstone is a formation of sandstone with minor microbreccia and siltstone which conformably overlies Roland Conglomerate and equivalent formations and passes gradationally up into Florentine Valley Mudstone or Gordon Limestone. It is about 1000 feet thick in the Melrose-Railton area just south of Devonport. It contains Etheridgaspis, Tasmanocephalus, Asaphellus lewisi, Carolinites bulbosa, Prosopiscus? subquadratus, gastropods, brachiopods and worm castings and burrows and is Arenigian.

First noted by Strzelecki (1845) this unit was subsequently described by Johnston (1888) and many others. It has been referred to as Magog Group, Moina Sandstone, Beaconsfield Beds and Engineer Quartzite (see Smith, 1959).

The underlying conglomerates contain sandstone beds and this formation contains conglomeratic beds. For the present the lowest sandstone bed in the Junee Group containing marine fossils, especially “tubicolar” organisms, might be taken as the base of this formation as a practical means of separation.

Jennings et al. (1958, 1959a) have used the term Moina Sandstone to refer to rocks considered identical with the Caroline Creek Sandstone. Jennings states: “This step has been necessary because (1) the unit used is the only one mappable regionally on a scale of 1 inch to the mile, (2) the terms ‘Tubicolar Sandstones’ and ‘Discoidal Series’ are unacceptable, (3) the Caroline Creek beds are not strictly defined and (4) the Florentine Valley Mudstone has not yet been recognised widely enough to rank as a separate formation for regional mapping.”

North-West Coast

The Caroline Creek Sandstone in the Sheffield and Middlesex areas is variable in lithology. Near Round Mount it consists largely of dense quartzites, sandstones, fine conglomerates, and rare shales. Near Railton quartzite occurs but the dominant rock types are ferruginous sandstone and siltstone. To the north and north-west the formation appears to be more conglomeratic.

° The relative merits of Banks’ use of Caroline Creek Sandstone and Jennings’ Moina Sandstone for the same formation are not discussed here but as such duplication is unwise in a volume such as this, the term, Caroline Creek Sandstone, has been substituted in Jennings’ contribution. A.S., Ed.
Fig. 22. Caroline Creek Sandstone and Gordon Limestone (Banks).
A bed rich in haematite occurs in the Caroline Creek Sandstone at Mount Claude (Burns, 1959a, p. 58). Two thin bands of spherulitic quartzite have been found near Round Mount. The spherulites are pyritic, but the pyrite may be a replacement (Jennings, 1958, p. 31).

The Caroline Creek Sandstone is generally about 1000 ft. thick. It contains brachiopods, gastropods and trilobites and thus is marine. Tubicolar casts are abundant on some horizons as worm burrows or casts and as branching tubes along the bedding. The Sandstone overlaps the Roland Conglomerate to rest directly on older rocks, particularly on the Tyennan Geanticline.

Burns states: "The Caroline Creek Sandstone at the Dial Range is composed of about 400 ft. of well-bedded sandstone, shale and laminated siltstone overlying conglomerate. The middle part at the Denny Gorge contains gastropods." The lower part contains strophomenids, euomphalids and trilobites.

The thickness in the Denny Gorge is estimated at 1000 feet and a similar thickness has been suggested near Railton (Reid, 1924, p. 19). At Caroline Creek the ferruginous sandstone contain Scolithus tasmanicus, an orthid probably Tritoechia, euomphalid gastropods, Asaphellus lewisi, Carolinites bulbosa, Etheridgaspis carolinensis, and Tasmanocephalus stephensi and are Lower Ordovician (Kobayashi, 1940b). "Pliomerops sub quadratus and Pseudobasilicus lewisi occur as well as those trilobites noted by Kobayashi and the fauna indicates an Upper Arenigian age, zone of D. hirundo (O. P. Singleton, pers. comm.). These beds extend south-east to Railton where they contain an euomphalid (Twelvetrees, 1909, p. 36).

The top of this formation on the south-western end of Standard Tier contains algal markings, tubicolar burrows, Lecanospira and other gastropods. At Alum Cliffs this sandstone has worm burrows and castings, euomphalids and strongly costate brachiopods and near Chudleigh contains Tritoechia.

South of Deloraine on Stockers Plain, friable, siliceous sandstone 1000 feet thick overlies siliceous conglomerate and contains Tritoechia? careyi, cephalopods and gastropods.

Beaconsfield

Siltstones, sandstones, chloritic spherulitic siltstone and shale reaching 750 ft. in thickness and overlying the Cabbage Tree Conglomerate are correlated with the Caroline Creek Sandstone (Green, 1959). Fossils are common on some horizons and include fucoids, annelid castings, brachiopods (Johnston, 1888, pp. 59-61), including Tritoechia and Paurorthis, trilobites such as Tasmanaspis lewisi, Prosopiscus? subquadratus, cystoid plates and hyolithids.

Maydena

Siliceous sandstone with thin beds of conglomerate and siliceous siltstone overlie the conglomerate at Tim Shea and occur at and near Sunshine Spur two miles north of Maydena and on the railway line west of Maydena. The sandstone is well-sorted and shows cross-bedding and ripple-marking. Fossils include worm burrows and castings, Tritoechia at the 2¼ mile post on the Florentine
Road, *Lecanospira* and other gastropods, cephalopods and trilobites (Kobayashi, 1940a).

Near Adamsfield sandstones containing euomphalids overlie the conglomerate and are 1300 ft. thick (Nye, 1929, pp. 11-12). Just west of Clarke's Workings, Adamsfield, a cavernous sandstone contains trilobites and other fossils.

**South Coast**

Sandstone with a bed of conglomerate unconformably overlies Cambrian rocks at Prettys Point (Twelvetrees, 1915, p. 12 and author). The sandstone is at least 400 feet thick. At the western end of Prion Bay beach, siliceous conglomerate with worm castings overlies quartzite (Twelvetrees, 1915, p. 15).

**Tyennan Geanticline**

Tubicolar sandstone rests unconformably on Precambrian rocks west of the Olga River, 5400 yards south-south-west by south of the junction of the Olga and Gordon Rivers. Above this are sandstones with worm burrows, orthids, gastropods, pelecypods, and pliomerid trilobites. The total thickness of these sandstones is about 1000 feet. White quartzite and subordinate pebble conglomerate are overlain by highly calcareous trilobitic sandstone along and north of the Gordon River (Carey and Banks, 1954, f.6, p. 254) beneath the Gordon Limestone. Tubicolar Caroline Creek Sandstone occurs in the Calder Pass area in the Loddon Syncline (Ward, 1909a). *Mather* states: "Caroline Creek Sandstone ranges from 1550 ft. on the north end of the Engineer Range, to 750 ft. in the centre and 1000 ft. at the south."

**West Coast Range**

Correlation of the "Upper Owen" of earlier authors with the Caroline Creek Sandstone is suggested by lithological similarity, abundance of worm castings and burrows in both, the occurrence in both of coarsely costate brachiopods and euomphalid gastropods, and the conformable succession from both through passage beds to the Gordon Limestone. Exact contemporaneity is not claimed but both are probably Lower Ordovician.

In the central part of Owen Spur the formation is at least 720 feet thick and the succession is as follows (Solomon, 1957b, table 5):

**Top**

- G. 20 feet alternating shale, sandstone, tubicolar sandstone and granule conglomerate.
- F. 40 feet yellowish conglomerate, haematitic at base, with pebbles of brown iron oxide and much chromite in the matrix.
- E. 60 feet of haematitic tubicolar sandstone.
- D. 250 feet of pink, grey or purple thinly bedded sandstone with shale and haematitic bands.
- C. 140 feet of grey, fine, breccia-conglomerate with a few quartzite bands.
- B. 110 feet of purple thin-bedded sandstone, red to pink pebbly sandstone and shaly beds.
- A. 100 feet grey quartzite, fine yellow conglomerate and grey-green shale.
This formation covered the whole of the West Coast Range area (Fig. 15) and has been commented on by Hills (1914a, p. 48), Conolly (1947, p. 3) and Bradley (1954). Both Conolly and Bradley refer to an unconformity at the base of the "Tubicolar Sandstone" representing a contemporaneous fault scarp. This is the Haulage Unconformity between the Chocolate Sandstone and the Pioneer Beds (units F, G.) (Wade and Solomon, 1958). Sandstone dykes occupy fissures produced in Member B of the Owen Conglomerate by this movement (ibid., 1958). The upper 1200 feet of the Thirkell Hill section (Elms, above) might well be Caroline Creek Sandstone. Sandstone, pebbly grits and "tubicolar sandstone" occur in the Mt. Farrell area and contain costate brachiopods (Ward, 1908a, p. 28; Bradley, 1954, p. 212). Maximum thickness in the area is 300 feet. Blissett and Gulline state: "Tubicolar Caroline Creek Sandstone overlies Mt. Zeehan Conglomerate in the Zeehan area and reaches about 1200 ft. in thickness." Blissett (1960) states that the lowermost 40 ft. of conglomerate and quartzite at Duck Creek may be the Caroline Creek Sandstone.

Summary

Caroline Creek Sandstone is widespread in Tasmania (Fig. 22). It rests conformably on Owen Conglomerate and correlates, or unconformably on older rocks. It overlaps the Owen Conglomerate onto the western, northern and eastern margins of the Tyennan Geanticline, onto a high area north of Zeehan and south of Duck Creek and it rests on Cambrian rocks near Queenstown, Wilmot and Prettys Point.

The formation consists mainly of well-sorted, siliceous sandstones, coloured white, yellow, pink, red, chocolate, brown or more rarely greenish. The fresh rock is greenish grey at Beaconsfield, but weathers white or reddish and the haematitic cement which is common elsewhere may be due to weathering of pyritic or sideritic cement. The cavernous nature of the sandstone in many places suggests a carbonate cement.

Fossils are common and include fucoidal bodies, costate orthids, strophomenids, euomphalid and other gastropods, cephalopods, annelid worms, trilobites, cystoids and hyolithids. Shallow water deposition is suggested by the fucoidal bodies, and numerous annelids and the textural and structural characters of the sediment are accordant with this. The formation is Lower Ordovician at Caroline Creek, Mole Creek and Chudleigh, Deloraine, Beaconsfield and Maydena as shown by fossils. The Caroline Creek trilobitic fauna is considered by O. P. Singleton (pers. comm.) to be Upper Arenigian (Zone of D. hirundo). The overlying formation at Frodshams' Gap is Middle Arenigian (Zone of D. extensus) and this suggests that the Caroline Creek Sandstone is a diachronous formation (O. P. Singleton, pers. comm.).

FLORENTINE VALLEY MUDSTONE AND CORRELATES

Beds transitional from the Caroline Creek Sandstone to the Gordon Limestone are sufficiently significant to warrant formational status in some places.

The Florentine Valley Mudstone is a formation about 300 feet thick of siltstone, calcareous siltstone and calcareous sandstone outcropping in road
cuttings on the Florentine Road near Frodsham's Gap (44352.7418). It conformably overlies a sandstone correlated with the Caroline Creek Sandstone and underlies Gordon Limestone. It contains *Tritoechia lewisi*, *T? careyi*, *Syntrophopsis karmbergi*, *Lecanospira*, *Tentaculites*, *Asaphopsis florentinensis*, *Tasmanaspis lewisi*, *Pliomerops subquadratus*, *Dictyonema*, *Clonograptus*, *Tetragraptus*, *Didymograptus gracilis* and *Didymograptus of the mundus type*. The brachiopods indicate a middle Lower Ordovician age, about the top of the Bendigonian or low in the Chewtonian (Brown, 1948). The trilobites show a Middle Arenigian age (Zone of *D. extensus*, O.P. Singleton, pers. comm.) and the graptolites a Lower Ordovician age (Thomas, 1960). In Victoria *D. gracilis* occurs in the Chewtonian and Castlemainian stages.

Similar siltstone occurs near Maydena and from railway cuttings west of that town *Tritoechia? careyi*, *Syntrophopsis karmbergi*, *Lecanospira tasmaniensis*, *Asaphopsis juneensis*, *A. gracicostatus*, *Tasmanaspis lewisi* and *T. longus* have been recorded (Brown, 1948; Kobayashi, 1940b).

On the eastern side of Prion Bay a small outcrop of grey siliceous siltstone contains costate brachiopods, *Ampyx*, and a cryptolithid close to *Eirelithus*. Although lithologically like the Florentine Valley Mudstone, the rock is probably Middle Ordovician.

Thin sandy and clayey beds are transitional between “Upper Owen” rocks and Gordon Limestone at Harris’ Reward, south of Ten Mile Hill on the Kelly Basin Line (Solomon, 1957, p. 59), and at Lake Margaret (Bradley, 1954), all in the West Coast Range area.

The Florentine Valley Mudstone is probably represented by siltstone with pelecypods overlying Caroline Creek Sandstone on the Mersey Forestry Road south of Liena, possibly by “calcareous sandstones and sandy limestones more than 100 feet thick between the Caroline Creek Sandstone and Gordon Limestone in the Mersey River above Liena” (Jennings), by a carbonaceous shale with chert seams, siltstone breccias and strongly ribbed brachiopods (Burns, 1958, p. 75) between Caroline Creek Sandstone and Gordon Limestone at Bell Mount, by shale at the top of the Caroline Creek Sandstone, Stormont Bismuth Mine (Burns, 1959c, p. 39), and by siltstones overlying sandstones with *Tritoechia* just north-west of Chudleigh.

Siltstones with brachiopods and trilobites overly Caroline Creek Sandstone on the west bank of the Don River half a mile above Eugenana.

Claystone, sandstone and clay “slates” occur immediately below Gordon Limestone at Blenkhorn’s Quarry, Rainlot (Twelvetrees, 1909, p. 36). The uppermost claystone contains *Tritoechia* and *Tasmanocephalus stephensi* and these units occupy the stratigraphic position of the Florentine Valley Mudstone.

The Leonardsburg Siltstone at Beaconsfield (Green, 1959), 950 feet of black and dark grey micaceous siltstone, overlies the Caroline Creek Sandstone and underlies limestone. No fossils have been found in it.

GORDON LIMESTONE

Nomenclature of this formation has been dealt with by Smith (1959, pp. 72-74) and the history of ideas concerning its age by the same author and by Thomas (1948).
The Gordon Limestone is a formation, 5000 feet thick, of limestone conformably overlying the Florentine Valley Mudstone on the western slopes of Wherrets Lookout and conformably or disconformably overlain by the Eldon Group in the Tiger Range, ranging in age from Upper Canadian to Upper Ordovician.

The Gordon Limestone is a pure limestone although argillaceous and arenaceous beds occur near the base and top and these clastic sediments may be more widely distributed through the limestone on the West Coast and near Beaconsfield. The modal calcium carbonate content of the limestone, based on 200 analyses (Hughes, 1957, pp. 22-28), is 93%. Dolomite is present (up to 22% MgO) as irregular, yellow to buff, sandy-looking patches. Other impurities are silica, iron and aluminium oxides, traces of phosphates, titania, manganese and sulphur. The silica may occur as sponge spicules (Noakes et al., 1954, pp. 89-90) but more generally occurs as chert nodules showing joint and bedding control. Nodules and spherulites of pyrite are found and chalcopyrite occurs in the Florentine Valley, and at Blenkhorn's Quarry (Railton) where it is associated with sphalerite. Both of these areas are some miles from known areas of mineralisation and the sulphides may be syngenetic. The limestone has a foetid, bituminous odour when struck, probably due to the presence of tarry substances as reported by Wells (1957, p. 7). Much of the organic matter is in the stylolites. The limestone is light to dark grey and rarely pink. Limestones reported as bluish are medium grey according to the standard colour chart.

Most of the limestone is calcilutite with some calcarenite and a few beds of boulder calcirudite (Banks, 1957, p. 44). Sorting is good. Oolites may be present in the Florentine Valley and at Mayberry.

The limestone has beds from less than a centimetre to several feet thick. Ripple marking occurs rarely and cross-bedding has been recognised at Bubbs Hill, Mole Creek and Mayberry. Stylolites are everywhere present and are so common in places that they intersect to produce "nodular" limestones. Dolomitization preceded stylolitization in the Maclurites-Girvanella bed in the Florentine Valley and stylolitization occurred prior to folding in most areas.

The limestone has a subdued topography in most areas but a karst topography in others.

The formation is thickest in the Florentine Valley area (Fig. 22) and the thickness decreases south of Maydena, east and west of a line from Maydena to Mole Creek and north from Zeehan. The proportion of clastic beds in the limestone appears to increase on the West Coast especially near to and north of Zeehan and a source of clastic material west or north-west of Zeehan is tentatively suggested. Facies change from limestone near Maydena to siltstone at Prion Bay is suggested by recent age determinations and to sandstone at Caroline Creek from determinations by Singleton (above). From Flowery Gully to Beaconsfield the proportion of interbedded clastic material increases and the limestone is not known further east. It may be represented by the lutite association of the Mathinna Beds (Green, 1959, p. 8; Banks, Chapter IV).

At Zeehan and possibly Queenstown the limestone grades up into calcareous siltstone but in the Florentine Valley, Mole Creek and Gunns Plains areas the
contact with the basal sandstone of the Eldon Group appears to be sharp. At Flowery Gully normal faulting and erosion are thought to intervene between deposition of the limestone and the Mathinna Beds (Noakes et al., 1954, p. 93). At Beaconsfield siltstones of the Grubb Beds follow the limestone conformably (Green, 1959).

The fauna is a typical Ordovician shelly fauna with sponges, stromatoporoids, tabulate and rugose corals, polyzoa, brachiopods, a few pelecypods, numerous gastropods, cephalopods, trilobites, ostracodes, and echinoderms. Graptolites (*Phyllograptus*) are known from a cutting in the Florentine Valley road in the Florentine Valley. No coral reefs have been found. The fauna contrasts strongly with the graptolitic fauna of Victoria. The faunal relationship is with New South Wales, Eastern Asia, North America and the Baltic.

The base of the limestone is Upper Canadian at Adamsfield and may be Middle Ordovician at Zeehan, Mole Creek and Railton (Banks, 1957, p. 54). The limestones include some Upper Ordovician beds, but except possibly for some fossils of unknown provenance from the Gordon River, no Silurian fossils have been found in it. Wherever recent collections have been made from the top of the limestone, no Silurian fossils have been recognised (Table II).

Some of the limestone was deposited in a shallow sea as shown by the calcareous algae. The richness of the fauna and especially the assemblages of large coral colonies suggest warm water. The presence of sulphides and bituminous matter suggest slightly reducing conditions close to the depositional interface.

**Gordon River Area**

The limestone in the type area is part of an extensive belt between Maydena and the Florentine Valleys. The formation reaches 5000 ft. in thickness near Benjamin (Jennings, 1955, p. 173).

Impure nodular beds near the base contain *Tritoechia*. Possibly a little higher are impure limestones with *Phyllograptus*. Higher beds include one with *Maclurites florentinensis* and *Girvanella* which is probably Chazyan (Banks and Johnson, 1957). The topmost beds exposed on the Adamsfield Track and the Gordon Bend Track where these tracks flank the Tiger Range contain *Eofletcheria* spp., *Catenipora*, *Palaeofavosites*, *Favosites* and are probably Upper Ordovician. Just west of Adamsfield the basal beds contain silicified sponges, gastropods and cephalopods including *Manchuroceras*, *Suecoceras*, *Piloceras*, *Utoceras*, and *Allocotoceras* (Teichert and Glenister, 1953) indicating an Upper Canadian age.

Limestone occurs in the area drained by the Gordon River and its tributaries below the Maxwell River (Carey and Banks, 1954, p. 254; Blake, 1957a, p. 117, f.17). It is about 4900 feet thick three miles up the Olga River from the Gordon River where it contains *Lichenaria* and other fossils. Fossils occur in the limestone along the Gordon and Franklin Rivers (listed, Banks, 1957, p. 46) and include several Ordovician species. *Entelophyllum*, *Phaulactis shearsbyi*
ORDOVICIAN  

and *Gasconsoceras insperatum* may indicate that the limestone ranged into the Silurian (Hill, 1943, p. 58; Teichert and Glenister, 1953) or that limestone lenses occur in the Eldon Group upstream from the mouth of the Olga River or between Limekiln Reach and Macquarie Harbour.

**West Coast Range**

Gordon Limestone occurs on both flanks of the West Coast Range. The limestone is impure or interbedded with shales and sandstone near the base at the 5 mile post in the Kelly Basin Line, in the Clark Valley (Hills, 1914a, p. 54), on the Nora River (Bradley, 1954, p. 203), near Linda and at the head of Lake Margaret (Bradley, 1954, p. 203). Limestone is interbedded with siltstone in the Andrew River near the Darwin Road and at the Smelters Quarry, Queenstown. An aulacerid and *Rhinidictya* occur in limestone at the Darwin Quarry and *Cryptophragmus* and *Saffordophyllum* on the Andrew River below the road bridge indicate a Middle Ordovician age. The limestone in the Smelters Quarry, Queenstown, contains many corals and cephalopods (list, Banks, 1957, p. 47) of which the corals indicate an age between Trentonian and Richmondian (Hill, 1955).

Limestone at Bubbs Hill is at least 800 feet thick and contains many fossils which indicate an Upper Ordovician age for part of the limestone (Hill, 1942, 1955).

Limestone occurs from Zeehan south almost to the Henty River (Gill and Banks, 1950, p. 262; Banks, 1957, p. 48; Hughes, 1957a, p. 186) and includes Trentonian and older beds at the Oceana Mine (Hill, 1955) and Trentonian or younger beds at the Smelters Quarry (Hill, 1955; Teichert and Glenister, 1953). Thin beds of shale and sandstone occur in the limestone at the Smelters Quarry and the limestone here appears to pass up into calcareous, carbonaceous siltstone. Hills (1914a, p. 55) noted that the limestone is represented by "black pug" in the Darwin area. Similar pugs occur in the Zeehan area.

The limestone is thin (300 ft.) at Duck Creek and is represented by calcareous siltstones and impure limestones. It is only about 100 ft. thick near Heazlewood (Twelvetrees, 1900b, p. 39; Reid, 1921, p. 47; Nye, 1923, pp. 32, 33). *Favosites grandipora* occurs in one of these units (Etheridge, 1896).

**North-West Coast**

*Jennings* states: "The full thickness of the Gordon Limestone is preserved at Mole Creek and Gunns Plains where there is between 2000 and 3000 ft." The section in the Mole Creek area shows more complete exposure than that in the Florentine Valley area.

*Girvanella* has been described at Loongana (Banks, 1957, p. 50). A richly coralline zone above the Gunns Plains Caves is probably Upper Ordovician (Banks, 1957, p. 50). The limestone section at Eugenana includes a bed with *Maclurites* and *Girvanella*, possibly of Chazyan age (*ibid.*, p. 51). The limestone at Ralton is richly fossiliferous. Cephalopods at Blenkhorn's Quarry and
cephalopods, gastropods and sponges at the Goliath Cement Company quarry suggest a Middle Ordovician age (ibid., p. 51).

South and east of Standard Hill, Caroline Creek Sandstone with *Lecanospira* passes gradationally up into limestone with large stromatoporoids and *Lichenaria*. A bed with *Maclurites* and *Girvanella* occurs within a few hundred feet of the base at Sassafras Creek and about 300 feet above the base near Grunter Hill. Near Liena limestones with *Favistella cerioides*, *Favosites marginatus*, *Plasmoporella* cf. *convexotabulata* and *Falsicatenipora chillagoensis* are probably Upper Ordovician (Hill, 1942, 1943; Hamada, 1958, p. 421). The top of the limestone at The Den is a coralline calcirudite containing favositids, heliolitids, *Favistella*, *Tryplasma*, *Streptelasma* and many other corals. It is possibly Upper Ordovician. Near Chudleigh the upper beds of the limestone contain *Catenipora* cf. *gracilis*, aulacerid hydrozoans, *Tryplasma cerioides* and many other fossils. The limestone is about 3000 feet thick and ranges here from Middle or perhaps Lower Ordovician into the Upper Ordovician.

At Flowery Gully, just south of Beaconsfield, more than 1700 feet of limestone rest on sandstone, siltstone and shaly beds and are overlain by Mathinna Beds (Noakes et al., 1954). Unidentified fossils occur in the limestone (Banks, 1957, pp. 52-53) and correlation with Gordon Limestone is on lithological grounds.

**Southern Tasmania**

Limestone occurs at Ida Bay (Everard, 1957, p. 52), east of Prettys Point (Twelvetrees, 1915, p. 12), and near New River Lagoon (Johnston, 1888, pp. 50, 63) (Twelvetrees, 1915; Blake, 1957b). The oldest beds at Ida Bay are those with *Trocholitoceras idaense* which may be Upper Canadian (Teichert and Glenister, 1953, p. 13). Possibly younger are the basal beds on the old Lune River Tram (see Everard, 1957, p. 52) with *Tetradium* cf. *syringoporoides*. Limestone on the eastern end of Prion Bay Beach contains sponges, corals, strophomenids, euomphalids and trilobites. The narrow bands of black slates (Blake, 1957b, pp. 182-184) are stylolites.

"FENESTELLA SHALE"

A formation of siltstone overlies Gordon Limestone and underlies Crotty Quartzite in the Linda Valley, east of Queenstown. It is a few feet to a few tens of feet thick and contains fenestrate trepostomes, probably *Phylleporina*, at the old Linda Cemetery and on the Princess River (Solomon, 1957, p. 61). It may be the "Fenestella Shale" of Gregory (1905).

East of the Smelters Quarry, Zeehan, on the western slope of Smelters Hill, the limestone appears to grade up through calcareous, carbonaceous siltstone into the Crotty Quartzite. The fossils in the siltstone include *Tetradium*, *Stictopora*, *Beloitoceras kirtoni*, *Trocholitoceras* and *Cheirurus*, and suggest an Upper Ordovician age.

A siltstone occurs between Gordon Limestone and the Eldon Group on the Mersey Forestry Road just south of Liena.
GENERAL COMMENTS ON THE JUNEE GROUP

The Junee Group is one major cycle of sedimentation covering most if not all of the Ordovician Period.

In areas bordering the Tyennan Geanticline and near Beaconsfield, Deloraine, Penguin and Surprise River Bay the Ordovician rests unconformably on older rocks. Where the older rocks are Precambrian the angular discordance is considerable but where they are Cambrian, the discordance is less except along the western and northern margin of the Tyennan Geanticline. Away from the geanticlinal areas the Ordovician is commonly concordant with the Cambrian, but the Ordovician rests on Cambrian rocks of different age and where information is available, a big time-break can reasonably be inferred. Paraconformity or disconformity is then, probably the relationship.

The Jukes and Owen Conglomerates and their correlates are the products of erosion of highland areas. Many parts of the Tyennan Geanticline were high areas early in the Ordovician as also were areas west of Zeehan, near Ulverstone and the Asbestos Range Geanticline. Erosion during early Lower Ordovician time reduced these highlands and in the Arenigian Epoch the sea flooded the reduced remnants of the high areas. During this epoch movement occurred along the Great Lyell Fault Zone near Queenstown and produced or rejuvenated a high area west of Queenstown called the Dundas Ridge, later inundated by seas in which limestone was deposited.

An overall reduction in grainsize upwards through the Junee Group indicates decreasing competence of currents moving material to the depositional area. The decreasing competence could represent decrease in grade of the streams supplying the sediment and therefore a gradual erosional lowering of the source land, a rise in sea-level or both. By Upper Ordovician time the sea had probably reached its maximum extent and the source land had been reduced to low plains almost at sea-level. Subsequent rejuvenation, perhaps associated with the Benambran Orogeny, increased stream grade so that silt and then, late in the Ordovician or early in the Silurian, sands and some pebbles could be brought to the depositional area.

The well-washed, well-sorted sediments of the Junee Group, except for Jukes Conglomerate, contrast strongly in texture, structure and fauna with the Ordovician sediments of Victoria. Turbidity current effects are not known in the Junee Group but are common in Victoria (Hills and Thomas, 1954). The shelly fauna of the Tasmanian Ordovician has little in common with the Victorian graptolitic fauna. Correlation with the shelly faunas of eastern Asia and North America will probably be more accurate than with the graptolitic fauna of Victoria. The fauna of the Junee Group shows relationship, at least on the generic level, with faunas from Orange, New South Wales, from Central Australia, eastern Asia, North America and northern Europe.

The Junee Group ranges from Middle Arenigian at least into the Upper Ordovician. Although Silurian fossils have been recorded their provenance is doubtful. No Silurian genera have been recognised from beds demonstrably at the top of the Junee Group.
Deposition of over 6000 feet of predominantly shallow water sediments over this period indicates a slowly sinking shelf area possibly near the margin of the Tasman Geosyncline. Carey (1953, Table I) suggested deposition on the cratonic edge of a miogeosyncline.

The Junee Group is concordant with the overlying sediments but the contact varies from gradational to sharp and even disconformable.
ORDOVICIAN STRATIGRAPHY OF THE FLORENTINE SYNCLINORIUM, SOUTHWEST TASMANIA.

by K.D. Corbett
Department of Mines, Hobart, formerly University of Tasmania

and M.R. Banks
Department of Geology, University of Tasmania

ABSTRACT

The Florentine Synclinorium constitutes the type area of the Ordovician Junee Group in Tasmania, and the group is herein re-defined according to the formations present in this area. The base on the western side is formed by the Reeds Conglomerate, a unit of siliceous fanglomerate up to 1,560 m thick lying conformably above a thick Upper Cambrian sequence on the Denison Range. The laterally-equivalent sandstone unit on the southeastern side is also given formation status (Tim Shea Sandstone). The overlying sequence of marine sandstone and siltstone is designated the Florentine Valley Formation, and is of Late Tremadocian-Arenigian age. A sub-unit of siltstone and limestone occurs in the middle part of the formation in some areas, but is not given formal status pending further mapping.

The "Gordon Limestone", subdivided into three formations, becomes the Gordon Limestone Sub-Group. The basal Karmberg Limestone, of Upper Canadian -?- Chazyan age, includes a mappable chert-rich unit which forms chert-covered ridges and is designated Wherretts Chert Member. The Cashions Creek Limestone, corresponding to the "Maciastites-Girvanella zone" of earlier reports, succeeds the Karmberg Limestone. Above this, and forming the bulk of the sequence, is the Benjamin Limestone, consisting of three members, viz. Lower Limestone Member, Lords Siltstone Member, Upper Limestone Member. A characteristic coral fauna with Favorites and cateniporines occurs near the top of the latter member, and includes conodonts which suggest an age not younger than Maysvillian.

Above the limestone sequence and transitional with the overlying Eldon Group sandstone is a unit of siltstone and fine sandstone designated Westfield Beds. These contain a fauna correlated with the Richmondian, and the fauna in the overlying sandstone also appears to be Late Ordovician.

INTRODUCTION

This paper presents details of the stratigraphy of the Ordovician succession in the Florentine Valley - Adamsfield area, regarded as the type area of the Junee Group in Tasmania. The Gordon Limestone sequence is subdivided for the first time, into three formations, and a new unit above the limestone, the Westfield Beds, is introduced. Some new palaeontological data are given, including work which indicates that the top of the limestone sequence is probably of Maysvillian age. It is hoped that the sequence established will provide a good basis for detailed correlation throughout the State.

The work is based mainly on mapping done by the senior author in the Florentine Valley in 1962-63 for a B.Sc. Honours project at the University of Tasmania, and on later mapping (partly reconnaissance) of the remainder of the area as part of a Ph.D. project in 1966-69. The sections on palaeontology have been written by Banks, with a contribution on conodonts by Mr. C.F. Burrett. The palaeontological work must be regarded as mainly of a reconnaissance nature and determinations of the macrofossils as preliminary. Many of the forms, especially of brachiopods and trilobites, probably belong to new genera and the names given suggest the closest affinities only. Excit-
Or dovician Stratigraphy of the Florentine Synclinous

ing palaeontological work in stratigraphically well controlled collections is indicated for the future. Fossil collections are held at the Geology Department, University of Tasmania. The work has been supported by research funds from the University of Tasmania and a grant from the Australian Research Grants Committee. Australian Newsprint Mills Ltd. provided accommodation and assisted with transport and we are indebted to Mr. D. Kitchener and Mr. D. Frankcombe and their staff for many courtesies.

GEOL OGI CAL SETTING

The Florentine Synclinous (Corbett 1970) is the name given to the large synclinal structure occupied by Ordovician and Siluro-Devonian rocks in the Florentine Valley area, its deepest part underlying the Tiger and Gordon Ranges. Its western and southern limits are defined by the ridges of Lower Ordovician conglomerate and sandstone extending from Battlement Hills in the north to the Saw Back Range in the south and thence east to Tim Shea (fig. 1). The northern and eastern margins are overlapped by, or faulted against sub-horizontal Permian-Triassic sediments and Jurassic dolomite, along an escarpment extending from Wylds Craig along the Misery Range to St. Field West and Florentine Peak.

The synclinous lies at the eastern margin of a large basement block of metamorphosed Precambrian quartzites and schists known as the Tyennan Geanticline, and is one of a series of large synclinal structures fringing this geanticline and produced during the Middle Devonian Tabberabberan Orogeny. A separate basement block, composed mainly of unmetamorphosed Precambrian dolomite, quartzite and argillite and called the Jubilee Block (Corbett 1970), plunges north under the southern end of the synclinous.

A series of broad open folds comprise the synclinous, the major one being the Tiger Syncline, which has a thick core of Siluro-Devonian rocks. Flanking this to the east are the Tim Shea Anticline, Westfield Syncline and Parker Anticline, and to the west the Adamsfield Anticline and Eve Creek Syncline. Most of the folds are oversteepened from the west, with dips up to nearly vertical, and have axes which are either subhorizontal or plunge gently north. The Westfield Syncline has a shallow core of Eldon Group rocks at its southern end. The Misery Range Fault (Jennings 1955), which forms the contact with the younger rocks to the east in some places, possibly follows the southerly continuation of the axis of the Parker Anticline.

The synclinous overlaps to a large extent an earlier eugeosynclinal trough of Cambrian rocks, called the Adamsfield Trough (Corbett 1970). Part of this trough is exposed between the western edge of the synclinous and the adjacent Tyennan Geanticline, and in a smaller area against the Jubilee Block near Mt. Mueller. The Cambrian rocks consist of two main groups, viz. (i) an older, apparently unfossiliferous, sequence of greywacke, argillite, chert and conglomerate, with minor acid and basic volcanics, and a number of mafic and ultramafic intrusives, and (ii) a younger fossiliferous sequence, chiefly Upper Cambrian in age, which consists mainly of conglomerate, sandstone and siltstone and has a maximum thickness of about 1300 m on the Denison Range. The younger sequence is everywhere unconformable on the older rocks but is conformable and gradational with the Ordovician in most areas.

A thick unit of essentially non-marine conglomerate and sandstone occupies a transitional position between the fossiliferous Upper Cambrian and Lower Ordovician marine sequences, and is herein called the Reeds Conglomerate. This formation and its correlates, the Owen Conglomerate etc., have traditionally been included with the overlying marine Ordovician formations in the "Junee Group", largely because in many areas there is an unconformity between the conglomerate and the underlying Cambrian or Precambrian rocks. However, more recent work, including that on the Denison Range, has shown that the conglomerate is transitional to Upper Cambrian sediments in some areas, and that its palaeogeographic and tectonic affinities are as much with the geosynclinal Cambrian rocks as with the Ordovician shelf-type sequences. Despite this,
FIG. 1. - Geological map of the Florentine Synclinorium and environs (modified after Corbett 1970).
Ordovician Stratigraphy of the Florentine Synclinorium

it appears preferable at this stage to retain the conglomerate within the Junee Group rather than isolate it as a separate unit or include it in a Cambrian group, since it extends geographically well beyond the limits of the Upper Cambrian sequences and overlaps unconformably onto older rocks, while retaining its conformity with the overlying formations.

The Ordovician marine succession, which consists largely of limestone, is discussed in detail in this paper. It passes conformably upwards into a thick sequence of sandstone and shale which comprises the Eldon Group and has generally been considered to be of Siluro-Devonian age. More recent work discussed in this paper indicates that the limestone-sandstone transition occurs in the Upper Ordovician.

The Parmeener Supergroup (Banks 1973) rests unconformably on the folded Ordovician - Devonian sequences, and except where affected by major faults, against which the beds may be dragged into a sub-vertical attitude (e.g. against the Misery Range Fault), tend to be sub-horizontal. Outliers of these rocks occur on Mt. Mueller and probably also on Mt. Wedge. Faulted sections are exposed in road cuttings along the Misery Range where the total thickness is of the order of 500 m. The Supergroup here includes Permian and Triassic rocks.

A thick sill of Jurassic dolerite overlies the Parmeener Supergroup, and caps most of the eastern peaks. The base of the sill is near the Permo-Triassic boundary along the Misery Range but transgresses steeply upwards at the southern end of Mt. Field West.

Pleistocene till-like deposits occur at Lawrence Rivulet, near The Needles - Tim Shea Saddle, on the valley floor west of The Needles, along the Denison Range and on the valley floor northwest of Battlement Hills. Glaciﬂuvial gravels form an extensive blanket down the Rasselas Valley and also occur in the Florentine Valley, downstream of Lawrence Rivulet bridge. Tilted gravel and carbonaceous clay beds, possibly of Pleistocene or earlier age, are exposed on the Gordon Road one km east of the old Needles heliport. These and other high-level occurrences of alluvial deposits at about the 450 m (1500 ft) level possibly represent remnants of a valley floor formed when the Florentine River flowed west into the Gordon, prior to its capture by the Derwent (Jennings 1955; Corbett 1963).

A small area of Tertiary basalt is being quarried for road metal on Parker Road at the northern end of the Misery Range, and there is another small basalt area about two km northeast of this. The presence of the (?) plug of basalt mapped by Jennings (1955) near the old Benjamin settlement in the Florentine Valley has not been confirmed, and the basalt and dolerite float, and limonitic material, which occur in this area could be remnants of an old valley surface.

PREVIOUS STUDIES

Although the Ordovician succession in the Florentine area has figured prominently in discussions of Tasmanian stratigraphy for many decades, the area was not mapped in any detail until the senior author's work in 1963. Limestone was first reported from the area in 1850 (Proc. R. Soc. V.D.L. June 12, 1850) and later in the same year Akers reported siliceo-ferruginous conglomerate from the Great Bend of the Gordon River (ibid., Dec. 12, 1850). Gould reported limestone in the area in 1861 (footnote). Some trilobites collected by T. Stephens from Tim Shea were described by Etheridge (1904), but little was known of the geology until Twelvetrees' exploration in 1908. He recognized the major synclinal structure of the area, assigning the limestones to the Lower Silurian (i.e. Ordovician) and the conglomerates of The Thumbs, Denison Range etc. to the Cambrian. Those at Tim Shea he called Permo-Carboniferous. Hills (1921) clarified the stratigraphic relations somewhat, and recognized the Silurian sandstone sequence of the Tiger and Gordon Range.

Nye's (1929) account of the osmiridium field at Adamsfield gave a reasonably
K.D. Corbett and M.R. Banks

accurate interpretation of the general structure and the relationships of the major formations, and included a useful sketch map of the area. He recognized the "Cambro-Ordovician" slates and cherts west of Adamsfield, and the unconformable relationship with the overlying conglomerates. He correlated these with the "West Coast Range Conglomerate Series", and the overlying limestone with the "Gordon River Limestone Series", then thought to be Silurian.

The work of Lewis (1940) in the Tim Shea - Maydena (Tyenna) area is important in that he proposed the "Junee Series", and, in conjunction with the palaeontological work of Kobayashi (1940), established its Ordovician age.

The next important work was that of Carey and Banks (1954) in which Lower Palaeozoic unconformities at Adamsfield and Tim Shea were described, with sketch maps showing the generalized structure and stratigraphy of these areas. They clarified the structural relations at The Needles, which had been mis-interpreted by Lewis (1940), and defined the Tyennan Unconformity between the conglomerate on Tim Shea and the underlying Precambrian dolomites. The unconformity on the serpentinite at Adamsfield was mis-interpreted, however, since the overlying rocks, which they correlated with the Owen Conglomerate, actually belong to an Upper Cambrian (Opik, in Banks 1962 b, p. 137) sequence below the conglomerate.

The northern sections of the Florentine Valley and Gordon Range were mapped on a regional scale by I.B. Jennings (1955). Slight revision of some of this mapping has been necessary. Banks (1957) reviewed the state of knowledge of the Ordovician System to that date, summarizing the palaeontological contributions of Kobayashi (1940 a,b), Brown (1948), Opik (1951), Teichert and Glenister (1953) and Banks and Johnston (1957) from the Florentine area, and listing some new fossils from the Gordon Limestone in the area. In a later, more comprehensive review, Banks (1962 a) redefined the Junee Group, Florentine Valley Mudstone, and Gordon Limestone in the Florentine area, and condensed new palaeontological data from Singleton (unpub. pers. comm.) and Thomas (1960).

The major part of the Florentine Valley was mapped in some detail by Corbett (1963). A significant result of this work was the first subdivision of the Gordon Limestone into six more or less mappable units. The revised stratigraphy of the limestones proposed herein is based on that work. In 1966-69 the major remaining part of the synclinorium was mapped, including the inaccessible Denison Range area (Corbett 1970). An appendix to that work included a revised Ordovician stratigraphy, upon which the present stratigraphy is based.

ORDOVICIAN TERMINOLOGY

Background

The terminology applied to the Tasmanian Ordovician rocks has been a matter of considerable confusion and debate since the rocks were first described in the latter part of the last century, and some anomalies still persist. Prior to about 1948 it was thought that there were probably two distinct conglomerate-sandstone-limestone sequences within the Lower Palaeozoic of the state, one being Cambrian or Ordovician, the other Silurian.

This arose from two basic errors. The first was made by Charles Gould (1862) when he correlated limestone near the mouth of the Gordon River and considered by him to be above the Eldon Group with limestone at the Great Bend (near The Thumbs). Limestones occur on many horizons near the mouth of the Gordon River, several in the Eldon Group (Gee et al. 1969) and one in the Junee Group. Gould himself corrected this mistake in 1866 and wrote of the Gordon Limestone as occupying the stratigraphic position now assigned to it and as being Lower Silurian (Ordovician in the modern sense). The second basic error arose when Etheridge (1896) assigned a Silurian age to a collection from rocks, including limestone, above conglomerates at Zeehan. He correctly recognized the Ordovician affin-
Ordovician Stratigraphy of the Florentine Synclinorium

Ities of others but because the field stratigraphy by Montgomery in an admittedly very complex area was not good enough, assumed that the collection came from essentially one horizon and was therefore probably Silurian. The collection is now known to have come from both Junee and Eldon Groups. From this and subsequent events arose the concept that there were two sequences, conglomerate to limestone, in the Lower Palaeozoic. This development was fully summarized by Thomas (1948), who supported the concept.

Carey (1947) strongly opposed the two-sequence concept, and further field work established that the major formations were of Ordovician age and could be correlated throughout the state. Hills and Carey (1949) proposed the term "Junee Group" for this generalized sequence, following the work of Lewis (1940) in the Tyenna area, and defined it as consisting of five formations, viz. Jukes Breccia and correlates at the base, followed by West Coast Range Conglomerate, Caroline Creek Sandstones and Shales, Gordon River Limestone, and Crotty Sandstones at the top.

The Crotty Formation has since been shown to include Silurian beds and is now assigned to the Eldon Group, but the remainder of the succession, with only slight modification, is still quoted, and the "Junee Group" is still used in this way for some purposes. Thus Banks (1962 a, p. 147), in a review of the Ordovician, states: "The Ordovician rocks of Tasmania are known as the Junee Group, which may be defined as consisting of the following formations or their correlates: Fenestella Shale at the top, Gordon Limestone (Lower to Upper Ordovician), Florentine Valley Mudstone, Caroline Creek Sandstone, Owen Conglomerate, Jukes Breccia."

It should be noted that only two of the type formations (Gordon Limestone and Florentine Valley Mudstone) are from the type area of the "Junee Group" (i.e. Florentine - Maydena area), the others being from the west coast and north-western areas. The lack of a single complete Ordovician section in which all the formations were named and defined has been a major factor in the nomenclatural disagreements.

The Tasmanian Geological Survey has had to adopt a somewhat different policy with respect to Ordovician nomenclature in their regional mapping programme in recent years. Recognizing the variations in the formations, particularly the lower ones, and the fact that deposition of these units may not have been continuous either spatially or temporally from one area to another, there has been a tendency to use local names for formations and groups in each area or basin, e.g. Magog Group with Roland Conglomerate and Moina Sandstone, overlain by Gordon Limestone in the Sheffield area (Jennings 1963). (Banks 1962 a (fig. 13 and text) adopted this practice when dealing with conglomerates in the lower part of the Group). Thus Williams (in Jennings et al. 1967) regards the term "Junee Group" as applying only to the Florentine Valley sequence. It is appropriate at this stage to re-define the "Junee Group" in terms of the formations which are present in the Junee (now Maydena) area.

The recent mapping of the Florentine Synclinorium, which may be considered as including the type area of the original "Junee Series" of Lewis (1940), indicates that the Ordovician section in this area is more complete and probably better exposed than most of the other sections in Tasmania, and should thus provide a good basis for detailed correlation throughout the state. A new and expanded terminology is proposed which incorporates those elements of the old terminology which are still applicable.

Revised Terminology

In the revised terminology (fig. 2) the basal conglomerate of the Denison Range etc. is given formation status (Reeds Conglomerate), and the laterally-equivalent sandstone unit around the southern side of the synclinorium is made a separate formation (Tim Shea Sandstone). The reasons for this are given below. The overlying sequence of fossiliferous sandstone and siltstone is also given formation status (Florentine Valley Formation). Since the limestone is subdivisible, it is given sub-group status: (Gordon Limestone Sub-group), the sub-group consisting of three formations
FIG. 2. - Revised terminology of Junee Group.

(Karmberg Limestone at base, Cashions Creek Limestone, Benjamin Limestone). A unit of chert-rich limestone is distinguished at the top of the Karmberg Limestone, and is called the Wherretts Chert Member. The Benjamin Limestone constitutes the bulk of the sequence, and in places can be subdivided into three members, viz. the Lower Limestone Member, the Lords Siltstone Member and the Upper Limestone Member. At the top of the Junee Group is placed the Westfield Beds, a sequence of siltstone and sandstone occupying a transitional position between the limestone and the overlying Eldon Group. The Westfield Beds - Eldon Group contact has not yet been clearly defined.

The decision to have two laterally equivalent formations at the base of the group was made because, although the term "Tim Shea Conglomerate" (Opik 1951; Banks 1962 a) has precedence, it was considered that the section at Tim Shea was not typical
Ordovician Stratigraphy of the Florentine Synclinorium

of the formation elsewhere, and that there were sufficient lithological and palaeo-
geographic differences to warrant two formations being established. The Reeds Con-
glomerate consists typically of non-marine conglomerate, whereas the Tim Shea Sand-
stone consists mainly of marine and non-marine sandstones. The two formations appear
to interfinger to some extent, but pending detailed mapping the contact between the
two is taken as the fault at Frodsham's Pass (fig. 1).

A coarse, locally-derived breccia occurs in places beneath the Reeds Conglomerate
and Tim Shea Sandstone, and is probably equivalent to the "Jukes Breccia" of other
areas. It has not been given any formal status in this area, partly because it is
not sufficiently continuous but also because it appears to be developed on a trans-
gressive surface which continues below the Upper Cambrian sequence where the latter
is developed.

DEFINITIVE AND DESCRIPTIVE STRATIGRAPHY

In this section the various rock units are described and defined according to
the Australian Code of Stratigraphic Nomenclature, and preliminary palaeontological
data are given.

Junee Group

Synonomy: Junee Series - Lewis 1940; Junee System - Carey 1947; Junee Group -
Hills and Carey 1949; Banks 1962 a; Older terms are given by Banks (1962 a) and
Smith (1957).
Derivation: The old township of Junee, now incorporated in Maydena.
Type area: Florentine Synclinorium, including Denison Range, Tim Shea and Florentine
Valley sections.
Thickness: Maximum of the order of 4200 m (14000 ft) in the Denison Range - Rasselas
Valley area.
Age and relationships: Upper Cambrian (probably) to Upper Ordovician; mostly con-
formable on Upper Cambrian sequences but otherwise unconformable on older rocks;
apparently conformable and transitional with the Siluro-Devonian Eldon Group.
Elements: see fig. 2.

Reeds Conglomerate (nov.)

Definition: That formation of quartzose conglomerate and conglomeratic sandstone,
usually red to purplish in colour, occurring on the crest and eastern slopes of the
Denison Range. It has a maximum thickness of about 1560 m (5200 ft), and is laterally
equivalent to the Tim Shea Sandstone. It transitinally overlies Upper Cambrian sedi-
ments on the Denison Range and adjacent areas, but is unconformable on Precambrian
rocks west of Battlement Hills. It has an upper sandstone unit in most areas which
is transitional with the sandstone at the base of the overlying Florentine Valley
Formation; the base of that formation in such areas is taken as the first appearance
of flat-beded sandstone with worm burrows. It is named for Reeds Peak, highest
point on the Denison Range, and may be largely Upper Cambrian in age.

Description: The Reeds Conglomerate is a mountain-forming unit of siliceous conglom-
erate which extends from the Battlement Hills in the north to the Saw Back Range in
the south. It varies greatly in thickness, reaching a maximum of over 1500 m near
Reeds Peak. It occurs essentially as four great wedges, one centred on Battlement
Hills, one on the Denison Range, one in the Clear Hill - Thumbs - Stepped Hills area,
and one at the Ragged Range - Saw Back Range (figs. 1, 3).

The contact with the Upper Cambrian sediments is conformable in most areas. The
upper contact with the marine Florentine Valley Formation is transitional and
probably interfingering. Intercalations of marine sandstone with abundant worm
burrows occur in the middle part of the sequence at Clear Hill and The Thumbs. The
top of the formation in most areas is a sandstone or conglomeratic sandstone unit, up
to about 100 m thick, which varies from red to grey in colour and usually shows
abundant trough cross-bedding.
The bulk of
the formation is
red to brown to
purplish in col-
our, and consists
of pebble to boul-
der grade silice-
ous conglomerate,
with an abundant
sandy matrix,
interbedded with
conglomeratic
sandstone. With-
in the mega-wedges
there appears to
be a second-order
arrangement of
large lenses of
conglomerate, up
to 100 m or so
thick, separated
by sandstone (fig.
3). Third-order
lensing on the
scale of beds or
groups of beds can
be seen in most
outcrops. The
sandstones show
abundant trough
cross-bedding,
while the finer
conglomerates are
characterized by
abundant scour-
and-fill structures,
rapid inter-
lensing of sand
and gravel, rare
large-scale tabular
cross-bedding, and
fairly numerous
channel structures
up to 10 m across.
The coarse conglom-
erates tend to be
thick bedded to
massive, but large
channel structures
and large-scale
heterogeneous
cross-bedding oc-
cur in places.
Imbrication of
tabular clasts is
apparent in a few
sections.

The majority
of clasts consist

FIG. 3. - Block diagram showing distribution of Reeds Conglomerate
and Tim Shea Sandstone. Cross-bedding measurements shown.
of either quartzite or quartz-schist, and the only other common types are vein quartz, chert and quartz sandstone. Igneous rock fragments are apparently absent, as is feldspar. Most of the clasts are well rounded to very well rounded, with moderate to high sphericity, while the sand-grade material is mostly sub-angular to sub-rounded. The bulk of the material appears to have been derived from the Precambrian rocks of the adjacent Tyennan Geanticline, with possibly a small contribution (mostly chert) from the Cambrian rocks in the southern part of the area. Palaeocurrent evidence to date also indicates derivation from the Tyennan Geanticline (fig. 3).

The prevailing red colour of the sediments, the abundance of cross-bedding and channel structures, the pronounced lateral variability of the sequence, the rounding and imbrication of the clasts, the bimodal nature of the conglomerates, the absence of very fine-grained material, and the absence of fauna except for worm burrows in the rare marine intercalations, indicate deposition by powerful streams under non-marine conditions. The features coincide closely with those of modern alluvial fan complexes on which deposition is mainly by shallow braided streams (e.g. Denny 1965; Bull 1963; McKee 1957; Blissenbach 1954; Gregory 1915; Trowbridge 1911), and with ancient deposits interpreted as fanglomerates of this type (e.g. Allen 1965; Bluck 1965; Potter 1955; Krynine 1950). There is little evidence to support their interpretation as littoral deposits as suggested by several authors (Twelvetrees 1903; Bradley 1954; Carey and Banks 1954), although there is interfingering with marine sandstone in places, indicating proximity to the shoreline. The formation and its equivalents in western and northwestern Tasmania (Owen Conglomerate etc.) would appear to be one of the most extensive and best developed examples of alluvial fan deposition in the geological record. Such an interpretation was first suggested by Hills (1915) and later supported by Banks (1962 a).

Tim Shea Sandstone
Definition: That formation of red to grey quartzose sandstone with minor conglomerate and red siltstone exposed on the crest and northern slopes of Tim Shea and on the cuesta ridges to the southwest. It has a locally derived breccia at the base in some areas, and at Tim Shea this rests unconformably on Precambrian dolomite. The thickness is variable, with a maximum of the order of 300 m (1000 ft) at Tim Shea. It is laterally equivalent to the Reeds Conglomerate, and conformable with the overlying Florentine Valley Formation. The presence of Clonograptus rigidus (Lancefieldian) in beds only a hundred metres or so above the top (Quilty 1971) at The Needles suggests the age may be largely Upper Cambrian. It is synonymous with the "Tim Shea Conglomerate" of Banks (1962 a, p. 160).

Description: This formation rests unconformably on the Precambrian rocks around the eastern flank of the synclinorium. It consists mainly of quartzose sandstone and conglomeratic sandstone with lesser pebble conglomerate and some basal breccia and chocolate shale in places. It shows considerable lateral variations in thickness (fig. 3).

The base of the formation at Tim Shea is a very irregular unconformity on the Precambrian dolomite (Tyennan Unconformity of Carey and Banks 1954), with at least one channel-like feature up to 60 m (200 ft) deep. The channel is filled with dolomitic breccia, and this is overlain by poorly exposed dolomitic sandstone followed by about 12 m (40 ft) of red shale containing abundant small tube-like structures. Rather similar red shales occur in the upper part of the Upper Cambrian sequence at Adamsfield and on the Ragged Range, and it is possible that those at Tim Shea are correlates of the Upper Cambrian sequences.

The main part of the formation consists of alternating zones, up to 100 m or so thick, of red cross-bedded sandstone and grey flat-bedded bioturbated sandstone. Red sandstone with abundant trough cross-bedding predominates at Tim Shea, but near Mt. Mueller the sequence is mostly grey. Poorly-preserved gastropods occur in grey sandstone near the base of the sequence in the latter area, and the grey horizons in all areas appear to be marine. The red association on the other hand, appears to be un-
fossiliferous and is probably non-marine. The presence of sub-angular chert fragments in many beds, and of disseminated chromite grains in some places, suggests partial derivation from Cambrian rocks, although the bulk of the material is of Precambrian derivation.

Fifty-three current directions measured at Tim Shea (fig. 3) show two pronounced modes at right angles, possibly reflecting both littoral and fluvial currents. The environment envisaged is a flat coastal plain at the seaward edge of the major alluvial fans of the Reeds Conglomerate, with shallow marine conditions alternating with alluvial floodplain deposition.

The base of the formation in most areas consists of coarse-grained pink to grey quartzose sandstone containing numerous worm casts and gastropods, usually exposed on the lower dip slopes of the ridges formed by the underlying formation. At Tim Shea these basal beds grade up into grey silty quartzite with interbedded siltstone, followed by thin-bedded siltstone with bands rich in fossils. Further west, on the Gordon Road, the basal rocks include white sandstone with worm casts and gastropods, and interbedded glauconitic shale. At the southern end of the Ragged Range, in a cutting on the Sam Back track to Adamsfield, a thin-bedded white quartzose sandstone near the base of the formation contains an abundant gastropod fauna, with forms similar to *Ophileta* sp. and *Raphistoma* spp.. In the Denison Range area the base is transitional with the upper sandstone unit of the Reeds Conglomerate, and consists of thick-bedded gritty sandstone grading up into thin-bedded white sandstone with abundant gastropods. Ripple marks, load casts and longitudinal furrow structures occur in the thin-bedded white sandstone at Battlement Hills.

The middle part of the formation in The Needles - Tim Shea area includes about 100 m of interbedded calcareous siltstone and impure nodular limestone. These are particularly well exposed in cuttings on the Gordon Road just northwest of The Needles (near the 12 mile peg). A similar unit occurs at The Gap and in the logging area at the end of 5 Road (fig. 4). This part of the sequence is richly fossiliferous, with brachiopods, trilobites, gastropods and dendroids. Quilty (1971) identified *Clonograptus rigidus* from this unit near The Needles, indicating a Lancefieldian age. The unit has not been identified west of The Needles or in the Saw Back Range - Thumbs area, but a similar unit occurs further north in the Denison Range - Battlement Hills area. Here it is of the order of 150 m thick and consists mainly of grey calcareous siltstone grading to nodular impure limestone, with lesser quartzose sandstone and micaceous siltstone. Weathering of the calcareous nodules in the limestone produces a yellowish clay and gives the rock a characteristic pock-marked appearance.

The upper part of the formation around Tim Shea consists of interbedded micaceous and calcareous siltstone, quartzose sandstone, impure limestone and chert. The chert forms a residual gravel capping on low ridges in places, and is used for road metal. This part of the sequence is exposed on the ridge traversed by 8 Road East (fig. 4), along 5 Road and the old HEC Road (fig. 4), and on the Gordon Road east of the Little
FIG. 4. - Geological map of the Florentine Valley (modified after Corbett 1963).
Florentine River. At The Gap, this part of the formation appears to be represented by the zone of interbedded siltstone and chert at the old gravel loading chute. A thin section of a chert band from here shows it to consist largely of monaxon sponge spicules (Corbett 1963). In the Denison Range area, the upper part of the formation forms a broad low ridge (Timbs Ridge) and consists of about 300 m of quartzose sandstone interbedded with siltstone and glauconitic sandstone. The sandstones show trough cross-bedding in places. North of Battlement Hills this unit forms a sharp-crested ridge and consists mainly of thinly-interbedded sandstone and siltstone showing ripple marks and wavy bedding. This unit is only sparsely fossiliferous in this area.

Palaeontology: The Florentine Valley Formation has a rich shelly fauna dominated by trilobites and brachiopods but including also worms, gastropods, bivalves, "cystoids", and rare beds of graptolites. The known occurrences may be summarized as below:

<table>
<thead>
<tr>
<th>Localities</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
</tr>
</thead>
<tbody>
<tr>
<td>Taxa:</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Tritoechia lewisi</td>
<td></td>
<td>x</td>
<td></td>
<td></td>
<td></td>
<td>x</td>
</tr>
<tr>
<td>T. cf. planulata</td>
<td></td>
<td></td>
<td></td>
<td>x</td>
<td></td>
<td></td>
</tr>
<tr>
<td>? T. careyi</td>
<td></td>
<td>x</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>cf. Schmidites</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>x</td>
<td></td>
</tr>
<tr>
<td>inarticulates</td>
<td>x</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Finkelnburgia cf. bellatula</td>
<td>x</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>worms</td>
<td></td>
<td>x</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Nuculites (Cleidophorus)</td>
<td></td>
<td></td>
<td>x</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>cf. planulatus</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Eomastacis tasmanensis</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>x</td>
<td></td>
</tr>
<tr>
<td>Hystricurus cf. genulatus</td>
<td></td>
<td></td>
<td></td>
<td>x</td>
<td></td>
<td></td>
</tr>
<tr>
<td>H. paragenulatus</td>
<td></td>
<td></td>
<td></td>
<td>x</td>
<td></td>
<td></td>
</tr>
<tr>
<td>cf. Parahystricurus sp.</td>
<td></td>
<td></td>
<td></td>
<td>x</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pseudohystricurus sp.</td>
<td></td>
<td></td>
<td></td>
<td>x</td>
<td></td>
<td></td>
</tr>
<tr>
<td>&quot;Asaphopsis&quot; florentinensis</td>
<td></td>
<td></td>
<td></td>
<td>x</td>
<td></td>
<td></td>
</tr>
<tr>
<td>&quot;Asaphopsis&quot; juneensis</td>
<td></td>
<td>x</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cybelospira sp.</td>
<td></td>
<td>x</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Tasmanaspis lewisi</td>
<td></td>
<td>x</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>cystoids</td>
<td></td>
<td></td>
<td>x</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Clonograptus rigidus</td>
<td></td>
<td></td>
<td></td>
<td>x</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Clonograptus sp.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>x</td>
<td></td>
</tr>
<tr>
<td>Tetrograptus sp.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>x</td>
<td></td>
</tr>
<tr>
<td>Didymograptus gracilis</td>
<td></td>
<td></td>
<td></td>
<td>x</td>
<td></td>
<td></td>
</tr>
<tr>
<td>cf. mundus</td>
<td></td>
<td></td>
<td></td>
<td>x</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Tentaculites</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>x</td>
</tr>
</tbody>
</table>

Localities are:
1. Gordon Road at 12 mile post
2. 400 metres south of end of 5 Road
3. 5 Road (co-ordinates 440,400 E. 742,500 N)
4. Cuttings on A.N.M. road at The Gap
5. Currawong Gully (near The Gap)
6. Near The Gap (Etheridge 1904)

Locality 1 is close to the base of the formation and was considered Lancefieldian by Quilty (1971) and if the range given by Thomas (1960, p. 16) for C. rigidus applies, the rocks there may be correlated with La 2 or La 3 of the Victorian succession, and may thus be Late Tremadocian or Early Arenigian (Strachan 1972, pp. 11-12).

Localities 4, 5 and 6 are all close to the top of the formation and the graptolite
fauna (D. gracilis and D. cf. mundus) suggests correlation with the Chewtonian or lower Castlemainian of Victoria and in turn an Arenigian age (Zone of D. nitidus or early part of I. gibberulus zone in Great Britain). These ages are supported by ages based on the brachiopods (Brown 1948) and trilobites (Singleton, in Banks 1962 a, p. 170), ages with which occurrence of hystricurids and Cybelopsis are also consistent. The Cybelopsis species is close to the species illustrated by Hinze (1952, pl. xxv, f. 1-4) but very much smaller. Closer correlations must await detailed study of the rich and well-preserved brachiopod and trilobite faunas.

Several associations may be recognized. On some bedding planes are intense concentrations of Tricocochita and orthids or of Pinkeinburgia. Quilty (1971, p. 183) noted two other associations, one of inarticulate brachiopods such as Westonia, the other of very abundant dendroids. The dendroid-graptoloid association at The Gap has few other fossils in it but is not as rich in dendroids as that near the 12 mile post on the Gordon Road. Other beds contain almost exclusively trilobites, especially hystricurids (both in siltstone at The Gap and in sandstone on the Gordon Road), or "Asaphopsis". The "cystoids" usually occur as dispersed plates associated with trilobites but one specimen with plates in association has been found in siltstone at The Gap.

Gordon Limestone Sub-group
Definition: That sequence of marine limestone with lesser siltstone and sandstone lying conformably between the Florentine Valley Formation below and the Westfield Beds above. The type area may be taken as the southern Florentine Valley, where three formations are mappable (fig. 4), viz. Karmberg Limestone at base, Cashions Creek Limestone, and Benjamin Limestone. A composite stratigraphic section is shown in fig. 5. The thickness reaches a maximum of the order of 2100 m (7000 ft) in the northern Rasselas Valley, and is 1200 - 1800 m (4000 - 6000 ft) in the Florentine Valley. A thick sandstone unit occurs near the base of the sequence in the Battlement Hills area (fig. 1). The sub-group ranges in age from Lower to Upper Ordovician, and is synonymous with the "Gordon Limestone" of previous authors (e.g. Banks 1962 a).

Remarks: Because of their high solubility the Ordovician limestones characteristically form broad, flat-floored, poorly drained solution valleys usually covered with extensive superficial gravels. The Vale of Rasselas (fig. 1) is a typical example. The lack of outcrop under such conditions usually makes stratigraphy difficult or impossible. Exposure is better than normal in the Florentine Valley because the old drainage pattern has been disrupted by river capture, and the present Florentine River and tributaries have dissected much of the limestone surface and removed much of the superficial cover.

The major units mapped by Corbett (1963) in the Florentine have since been traced into the southern part of the Vale of Rasselas (Myrtle Creek drainage area), but over most of this valley there is very little outcrop except in stream beds. A thick sequence of coarse quartzose sandstone forms a low ridge on the valley floor north of Battlement Hills, and it is apparent that much of the lower half of the sequence is non-calcareous in this area. A narrower continuation of this sandstone ridge extends south down the main part of the Vale of Rasselas.

Karmberg Limestone (nov.)
Definition: That formation of impure limestone and chert-rich limestone lying between the Florentine Valley Formation below and the Cashions Creek Limestone above. Best exposures are on the lower northern slopes of Wherrett's Lookout and along 9 Road from its junction with the main Florentine Road (fig. 4), but no single complete type section is yet known. It is of the order of 450 m (1500 ft) thick, and possibly ranges in age from Upper Canadian to Chazyan (fig. 5). It is named for Karmberg's Track, an old track leading from The Gap around the eastern side of the valley. The upper 150 m or so consists of chert-rich limestone in the Florentine area, and is designated the Wherrett's Chert Member. The proportion of chert apparently decreases
markedly to the west, however, and the member is not recognizable in the southern Rasselas area.

Description: The lower part of the formation consists mainly of impure nodular limestone and calcareous siltstone such as exposed at 9 Road junction, and is richly fossiliferous in places. Large spherulites of pyrite, commonly oxidized to limonite, occur within this rock and may be found scattered over the surface in places. The correlate of this part of the sequence west of Adamsfield contains an Upper Canadian cephalopod fauna. The upper part of the formation is poorly fossiliferous and constitutes the Wherretts Chert Member.

Palaeontology: The fauna at the 9 Road junction (loc. 7) is rich in a new plectambonitid species, Geragnostus and Trinodus, Cybelopsis and other pliomerids, Tasmanoocephalus stephensi, and a new species close to Platillaena. Several ostracodes including Eoleperditia, a "cystoid" close to Leptocystis and rare graptolites, Phylograptus anna, P. iliicifolius also have been recognized. Although some taxa present in the underlying Florentine Valley Formation were still present, new ones had appeared. Phylograptus iliicifolius occurs in the Chewtonian of Victoria (Thomas 1960) and a form close to P. anna in the G. austrodentatus zone of the Darriwillian (Harris 1935). P. anna also occurs in the Pitman Formation in Canberra in beds regarded by Opik (1958, pp. 15, 86) as Darriwillian. The two species occur together also in the Garden City Formation and Phi Kappa Formations in the Basin Ranges (Ross and Berry 1963, pp. 81-83) within the Zones of Tetragnostus fruticosus and D. protobifidus considered by Ross and Berry as late Arenigian. Thus, in the terms of Berry (1968, p. 24) it is Late Canadian and of Cassinian age (Whittington 1968, p. 51). The lithological correlation with the cephalopod bearing beds at Adamsfield mentioned above is supported by the palaeontological evidence as Teichert and Glenister (1953, p. 9) regarded the Adamsfield fauna also as Upper Canadian.

Wherretts Chert Member (nov.)

Definition: That unit of dark grey limestone, containing up to 50% chert, occurring on the lower northwestern slopes of Wherretts Lookout and forming low ridges capped with chert gravel around the southern Florentine Valley (fig. 4). It is about 180 m thick and probably of Chazyan age.

Description: This member forms cliffs and steep slopes east of 4 and 6 Roads, but elsewhere its presence is mainly indicated by low strike ridges covered with residual chert gravel. The ridges carry a distinctive vegetation and hence the unit is a good mapping horizon. The chert gravel is quarried for road metal in several places, e.g. the Westfield Road turnoff. The chert occurs mostly as very irregular beds up to 15 cm thick, but irregular lenses, patches and nodules are also common. The percentage of chert varies between beds from 5% to 50%, with 10 - 20% being about average. The proportion of chert decreases upwards.

Palaeontology: Fossils occur in this member, usually silicified internal and external moulds. They are not, however, common, and few have been collected. Just north of Wherretts Lookout (loc. 8) Nybyoceras cf. pauicubatulatum has been identified, suggesting (after Teichert and Glenister 1953, p. 13) a Champlainian age.

Cashions Creek Limestone (nov.)

Definition: That formation of thick-bedded dolomitic limestone containing abundant Girvanella colonies which forms a prominent strike ridge in many areas and is well exposed where Cashions Creek is crossed by an easterly branch road from Lawrence Creek Road, and for several miles north of this (fig. 4). It is of the order of 150 m (500 ft) thick and is probably of Chazyan age (fig. 5).

Description: This formation crops out more strongly than any other unit within the limestone sequence, probably because the high proportion of dolomite renders it less soluble and the thick bedding makes it less prone to disintegration. Small sub-spherical colonies of Girvanella occur in profusion throughout most of the unit, and
Ordovician Stratigraphy of the Florentine Synclinorium

FIG. 5. - Composite section of Gordon Limestone Sub-Group and Westfield Beds.
the large flat-bottomed gastropod *Maclurites* is a common associate. The rock is mostly a fine calcarenite, non-stylolitic, and weathers to an off-white colour. The formation forms a discontinuous, low strike ridge, a section of which can be traced almost continuously from Cashions Creek to a point several kilometres north of Dawson Road (fig. 4).

Palaeontology: The fauna is dominated by *Girvanella* spp. and *Maclurites florentinensis*, but a stromatoporoid close to *Stromatocerium rugosum*, strophomenid brachiopods, rare illaenids and some cephalopods, *Orthonybyoceras tasmaniens*, also occur. The *Maclurites* species is closest to *M. magnus* from the Narmor Stage (Cooper 1956).

Benjamin Limestone (nov.)

Definition: That formation of limestone and minor siltstone lying between the Cashions Creek Limestone below and the siltstones and sandstones of the Westfield Beds above (fig. 4). No single complete type section is yet known, but the formation is well exposed in the area between the old Benjamin Settlement and the lower slopes of Mt. Field West (fig. 4). It is of the order of 900 - 1200 m (3000 - 4000 ft) thick and probably ranges in age from Middle to Upper Ordovician (fig. 5). The Lords Siltstone Member divides the unit into two parts which for convenience are called the Lower Limestone Member and the Upper Limestone Member.

Lower Limestone Member: This is of the order of 480 m (1600 ft) thick, and in 1963 was best exposed immediately west of the Cashions Creek Limestone in the vicinity of 16 Road (fig. 4). Rapid variations in lithology, particularly in the dolomite content and in the number and form of stylolites, is characteristic. Most of the lower half consists of unfossiliferous stylolitic and dolomitic limestone, with fossils occurring in narrow, isolated bands. Beds of brown to black limonitic limestone occur in places, and there are several thin horizons of chert nodules. The limestone varies from micrite to very coarse calcarenite, but the fine-grained types predominate. Most of the limestone is considered to be sub-standard for economic purposes. Thin horizons rich in *Tetradium cf. bowanense* occur in a number of places, with *Thamnobeatricia* also present in some.

The most distinctive horizon is a 45 metre (150 ft) unit of thick-bedded, richly fossiliferous crinoidal calcarenite which occurs about 330 m above the base, and forms a narrow strike ridge fronted by low cliffs just west of the end of 16 Road (loc. 9). The rock is characterized by the presence of numerous large silicified colonies of a tabulate coral similar to *Foerstephyllum halli*, and other corals, stromatoporoids, sponges, cephalopods, brachiopods, gastropods and *Thamnobeatricia* also occur. This unit is exposed again about 100 m southwest of the junction of Eden Creek Road and Lawrence Creek Road (loc. 10). The rock is composed largely of fossil fragments and dolomite.

Palaeontology: The fauna from the known fossiliferous horizons is dominated by sessile benthos such as the dasycladacean *Ischadites* ("Receptaculites" of earlier reports), stromatoporoids comparable to *Thamnobeatricia*, rugose corals such as *Foerstephyllum* close to *F. halli* and tabulates, predominantly chaetetids. These last include a *Lichenaria* close to *ramosa* and another species of *Lichenaria*, and several species of *Tetradium*, e.g. *T. bowanense*, *T. dendroides*, *T. cf. duplex* *T. (?) cruciforme* *Webby & Semeniuk*, *T. apertum* *Webby & Semeniuk*, *T. compactum*, *T. ? cribiforme* and *Billingsaria* is also present. Other taxa recognized include *Solenopora*, large diameter colonies of *Girvanella*, *? Acidolites* and *Trochiscolithus*, orthid brachiopods, gastropods, *Ctenodonta*, *Heatoxonia longinquum* and a trilobite close to *Bumastus*, this last in a crinoidal biocalcarenite. The faunal association suggests deposition on a shallow floor beneath a clear sea and the crinoidal biocalcarenite indicates more competent currents than were present at most times during deposition of this unit. The overall aspect of the fauna is Champlainian but more detailed palaeontological work is necessary. The *Tetradium* association suggests correlation with Fauna 1 of *Webby & Semeniuk* (1971) of Gisbornian age (i.e. approximately Costerfield or Wilderness, *Webby* 1969).
Lords Siltstone Member (nov.)

Definition: That unit of buff-coloured micaceous siltstone and fine sandstone, about 15 m (50 ft) thick, exposed on the main Florentine Road 200 m east of the Florentine River bridge (fig. 4). It is probably of Middle Ordovician age, and is named for Lords Road (fig. 4).

Description: This member is generally poorly exposed, and could not be traced for more than about 3 km from the type area. A small outcrop of siltstone on a track connecting Lords Road to a branch road from Florentine Road to the north-west is considered to represent this member on the eastern limb of the Westfield Syncline (fig. 4). The unit has not been seen on the western limb of the Tim Shea Anticline. It is fossiliferous in the type area (loc. 11) and contains numerous bryozoans as well as trilobites, brachiopods, cystoids and ostracodes.

Palaeontology: Stictoporellids form the commonest element in this fauna, but being preserved only as moulds, are not readily identifiable. A phylloporine is also commonly present. Brachiopods and trilobites are approximately equally abundant and form the rest of the fauna. Both orthid and rhynchonellid brachiopods occur but identification has not proceeded further. The trilobites are particularly characteristic and include Homotelus sp., an ogygiocaridine, a form close to "Asaphellus" lewisi, fragments of a form tentatively identified as Ampyx, Pliomerina and another pliomerid, Ectenotus, and a trilobite of the Tetralichas group within Amphilichas. An ostracode close to Eoleperditia and beyrichiids are also present.

The characteristic fossils are the stictoporellids and Pliomerina. The overall aspect of the fauna is Champlainian and perhaps early Trentonian.

Upper Limestone Member: This unit is probably of the order of 600 - 700 m (2000 - 2500 ft) thick, but no single complete section between the underlying and overlying siltstone units has yet been found. Most of the unit was exposed in the core of the Westfield Syncline in the triangle between the northern end of Cashions Creek, Lords Road and the Florentine Road (fig. 4) in 1963, but the area may be heavily overgrown now. The upper part of the formation is exposed near the base of the Permian at the southern end of the Westfield Syncline, about 500 m southeast of the large sandstone quarry, and also near the Adamsfield Track at the southern end of the Tiger Range.

The lithology is very variable, with many dolomitic and stylolitic horizons and at least six zones of very impure brownish-black limonitic limestone. Fossils appear to be more common and more evenly distributed than in the lower member, but again there is a marked concentration into zones, particularly of the corals. Zones with Bajgota and "Lichenaria ramoea", are common towards the base, with stromatoporoids, cephalopods, gastropods, brachiopods and other small corals, also present. The white-weathering corals are distinctive against the brown-weathering limestone in many places.

Near the top of the Lords section is a distinctive zone about 18 m thick of fossiliferous limestone rich in corals, particularly a heliolitid, a form like Nyctopora, and a stromatoporoid. Bajgota and other corals, as well as many gastropods, brachiopods and a few cephalopods, are also present.

Within a hundred metres of the top of the member at the southern ends of the Westfield and Tiger Synclines (Banks 1957) is a richly fossiliferous horizon with a characteristic fauna dominated by halyssid, Favosites, Palaeofavosites, Eofavosites and stromatoporoids, with other corals, brachiopods, trilobites, and cephalopods also present.

Palaeontology: Horizons low in the Upper Limestone Member contain corals which also occur in the Lower Limestone Member such as Lichenaria cf. ramoea, Tetradium cf. duplex and Poerestephyllum but also contain others not known from the Lower Member,
Near the top of the Upper Member is a micrite containing *Eobronteus* (loc. 12).

The uppermost and richly coralline horizon contains an *Aulacera* species up to 5 cm in diameter, also recognised at The Den, Mole Creek, *Palaeophyllum? crassum*, Webby, *Favistina*, ? *Calapoecia*, ? *Acidolites*, *Propora*, favositids, *Eofletcheria* and halyssidts near the road metal quarry at the southern end of the Westfield Syncline. Trepostomes and a cephalopod probably *Beloitoceras* also occur at this locality (loc. 13). In the same horizon at the southern end of the Tiger Range (loc. 14) occur *Solenopora*, a stromatoporoid like *Clathrodictyon*, *Favistina* cf. *stellata* Hall, and other species of *Favistina*, *Cystaphylloides*, *Favosites* sp., *Palaeofavosites* sp., *Eofletcheria* subparallela and *E. irregularis*, and *Falsicatenipora chillagoensis* (Etheridge). The generic composition of this uppermost fauna is more like that of Webby's (1972, p. 150) fauna IV than older faunas especially in containing favositids and cateniporines. Fauna IV was thought (Webby 1972, p. 150) to be Bolindian and the occurrence of *Falsicatenipora chillagoensis* in the Gordon Limestone was assigned a similar age by Webby and Semeniuk (1969). This places it as Maysvillian or Richmondian as noted by these authors. The presence of *Diplopora* in correlates of the horizon at Mole Creek might suggest correlation with the uppermost Ordovician of Estonia (Porkuni Beds) but the example of a Middle Ordovician *Halysettes* in New South Wales (Webby and Semeniuk 1969) prompts caution.

Recent identification by C.F. Burrett of conodonts from the uppermost limestone beds at the southern end of the Westfield Syncline, in the beds containing *Aulacera*, favositids and cateniporines suggest that they are no younger than Early Maysvillian.

Burrett (pers. comm.) reports that "The conodont fauna is lacking in diversity, consisting mainly of *?anderoitids* and *Belodina compressa* and *Phragmodus undatus*. The problematical p. sphatic helmet-shaped objects, covered in regularly disposed nodes (very similar to those described by Ethington and Clark, 1965, from the Lower Ordovician of Alberta) are twice as abundant as the conodonts. Scolecodonts are rare. Crinoid columnals are present. Apart from one gigantic conodont the fauna is diminutive.

The large conodont compares very closely with *Cyrtoniodus sinicairi* which is found in Faunas 11 and 12 of Sweet et al. (1971). The multi-element species *Belodina compressa* does not range above Lower Maysvillian in the U.S.A. (= lower part of Fauna II). The form species *Phragmodus undatus* is not very common and this ranges from Fauna 8 to Fauna 12 (i.e. Upper Blackriveran - Richmondian).

An obvious absentee is *Bryantodina abrupta* which occurs abundantly at Mole Creek (in its correct relative position) but does not occur in this sample. This ranges up to the top of Fauna 10 (Edenian) in the U.S.A., as do fibrous conodonts which are also abundant at Mole Creek.

This fauna compares most closely with that from the top of the Mole Creek section, and with Fauna 11 in the U.S.A. An Edenian - Early Maysvillian age is suggested."

The *Favosites*-cateniporine fauna recognized in the Florentine Valley in both the Westfield and Tiger Synclines is widespread in Tasmania, having been noted on Bubbs Hill, in the Olga - Hardwood Saddle, and in the Mole Creek Synclinorium. Despite the richness in corals the uppermost limestone in the Florentine Valley and elsewhere is not biohermal as far as is known. The corals, some of them colonies over 50 cm in diameter, are rolled and fragmented, and none have yet been seen in growth position.
Westfield Beds

Definition: That unit of buff-coloured siltstone and fine sandstone, with some coarse sandstone, exposed on the Westfield Road about 2½ km east of the Florentine Road, in the core of the Westfield Syncline (fig. 4). Sandstone which may belong to this unit, or to the overlying Eldon Group, is exposed in a large road metal quarry on the ridge south of Westfield Road (fig. 4). The base of the unit has not been seen, and its upper contact with the Eldon Group is not yet clearly defined. The unit is also exposed on the Adamsfield Track 100 m southeast of the Myrtle Creek bridge, and on the bombardier track just north of this. The thickness of the unit has not yet been determined, but is probably of the order of 150 metres. Its age is Upper Ordovician.

Description: Thin-bedded micaceous siltstone and quartzose fine sandstone are poorly exposed in road cuttings from about 300 m east of the sassafras landing on Westfield Road, and on branch roads and tracks in this area. The sequence becomes coarser-grained upwards, and quartzose sandstone and partly silicified buff-coloured sandstone are well exposed in the large gravel quarry at the top of the ridge south of Westfield Road. The rocks are fossiliferous on many horizons, with bryozoans, pelecypods, small brachiopods, trilobites and crinoid columns being present in the siltstones, while large brachiopods are common in the sandstones, as well as rare trilobites and solitary corals.

Palaeontology: Within the Westfield Beds there are some richly fossiliferous horizons. Near the base on Westfield Road (loc. 15) siltstones contain trepostomes, stictopor-ellids, Lepidocyclas, Pterinea cf. damsea, Neseuretus cf. birmanicus, and other trilobites and ostracodes. Somewhat further up in the succession just west of the axis of the Westfield Syncline (loc. 16), are siltstones with inarticulate brachiopods, Orthodesma, Pterinea, a ctenodont, ? Bemastus, Neseuretus and Ninkiangolithus. A graptolite, possible Glossograptus, is also present at locality 16. The close similarity of the Pterinea to an Upper Ordovician (Richmondian) species from North America, the presence of Neseuretus and of Ninkiangolithus all support an Ordovician age for the faunas. Some of the species present are similar to Richmondian forms and such an age would be consistent with the stratigraphic position of the Westfield Beds.

Eldon Group

Above the siltstone and fine sandstones of the Westfield Beds and in and near the road metal quarry in the axial region of the Westfield Syncline are rather coarser sandstones which also include interbedded fine sandstones and siltstones. These higher rather coarser beds occur not only in the Westfield Syncline but also around the southern end of the Tiger Range. The finer beds have quite well preserved moulds, especially of brachiopods, but also of other fossils.

Palaeontology: The coarse beds in road cuts below the quarry contain simple cuneiform corals of several sorts, perhaps belonging to Dalmanophyllum and Holophragma, and poorly preserved brachiopods close to Onniala and Kjerulfina. In road cuttings on the eastern side of the quarry and in the quarry itself (loc. 18) are beds replete with trepostomes and rich in brachiopods close to "Onniala" and Kjerulfina but also containing some Encrinurus and other trilobites. "Onniala" also occurs in all the fossil localities shown in the Westfield Beds and the basal Eldon Group on the Tiger Range (loc. 19 - 23).

The generic composition of the faunas suggests an Upper Ordovician rather than a Silurian age for these localities and it is likely that the Ordovician - Silurian boundary occurs further up in the Eldon Group on the Tiger Range.

GENERAL FAUNAL SUCCESSION

A gastropod fauna from the Ragged Range may be the oldest fauna in the Junee Group but its age is uncertain. The oldest recognized Ordovician fauna, that with
Clonograptus rigidus, occurs not far above the base of the Florentine Valley Formation and is Lancefieldian (Late Tremadocian or Early Arenigian) in age. The next highest fauna is that with Finkelnburgia, Nystriciurae, "Asaphopita" fauna which continues almost to the top of the formation. The hystricurid fauna of the Florentine Valley Mudstone suggests correlation with the Datsonian Stage of Jones et al. (1971) in Queensland. At the very top of the formation is the graptolite fauna at The Gap with Clonograptus, Tetragraptus and Didymograptus of Arenigian age.

The graptolite fauna is followed by beds which at Adamsfield contain a Piloceras - Manchuroceras fauna not yet recognized in the Florentine Valley but probably a little older than or coeval with the plectambonitid fauna including Phylograptus species at the 9 Road Junction. This latter fauna is Late Arenigian.

A relatively unfossiliferous interval follows but one which does contain Nybyoceras cf. pauciothiculatum, a species recorded by Teichert and Glenister (1953) from beds at the base of the Gordon Limestone at Railton.

The next fauna is very rich in numbers and is dominated by Maclurites, Girvanella and Stromatoecurium and is probably Marmorian.

Above the Maclurites beds are limestones with many species of Tetradium, with Foerstephyllum, Iechadites, "Thamnobeatricea", Lichenaria and many other fossils. This fauna correlates well with faunas of Gisbornian age in New South Wales.

Limestone deposition was later interrupted by an influx of silt which supported a fauna containing stictoporellids and Pliomerina as the commonest elements.

Above the siltstone Palaeophyllum and Bajgolia enter the coralline faunas which higher in the succession lose Lichenaria and Tetradium. After these genera disappeared from the area, Eobronteus entered and flourished for a short time. Later again, probably late in the Edenian or early in the Maysvillian, Favistina, Plasmoporella, favositids and cateniporines such as Falsicatenipora entered or developed in the area. Later influx of silt probably caused the migration or destruction of the fauna of colonial corals and the fauna in the silt is dominated by brachiopods and trilobites, the latter including Neseuretus and Ninkiangolithus. This fauna is Upper Ordovician, perhaps Richmondian.

Higher in the succession is a trepostome - dalmanellid strophomenid fauna containing "Onniella", cf. Kjerulfina and Enocrinurus, probably also Late Ordovician.

REFERENCES


Ordovician Stratigraphy of the Florentine Synclinorium


———, 1940 b: Lower Ordovician fossils from Caroline Creek, near Latrobe, Mersey River district, Tasmania. *Ibid.*, 67-76.


ILLUSTRATIONS OF THE ORDOVICIAN FAUNA OF THE FLORENTINE SYMCLINORIUM
PLATE 1

Figs 1-9.
Brachiopods from the Florentine Valley Formation; Early Ordovician; locality 2 (text-fig. 4), 400 m south of the end of 5 Road.
Figs 1-7,9,10: *Finkelburgia* cf. *bellatula*.
1: rubber cast of interior of pedicle valve (UTGD 81302), x 2.
2: rubber cast of exterior of pedicle valve, counterpart of UTGD 81302 (UTGD 81307), x 2.
3,4: rubber cast (x2), and internal mould of pedicle valve (x1) (UTGD 81306).
5: internal mould of brachial valve, with internal mould of brachial valve of *Apheoorthis* sp. (UTGD 81303), x 2.
6: internal moulds, pedicle and brachial valves (UTGD 81304), x 2.
7: internal moulds of pedicle and brachial valves (UTGD 81305), x 2.
9: rubber cast of pedicle valve interior, with external and internal cast of *Apheoorthis* sp. (UTGD 81306), x 2.
10: internal mould, brachial valve, original of fig. 1., x 1.
Fig 8: *Apheoorthis* sp., internal cast of pedicle valve (UTGD 81305), x 2.
Figs 11-16, 18-27. Brachiopods and trilobites from the Florentine Valley Formation, Early Ordovician; locality 3 (text-fig. 4).
11: *Nanorthis* sp., internal mould of pedicle valves (UTGD 80998), x 2.
12: *Nanorthis* cf. *hamburgensis*, internal moulds of both valves, with hypostoma, probably of *"Asaphopsis" juneensis* (UTGD 80977), x 2.
14,15: *"Asaphopsis" juneensis*, pygidia (UTGD 80993), x 1: (UTGD 80992), x 2.
16: *Hystricurus paragemulatus*, distorted external mould of a cranidium (UTGD 81056), x 2.
18: *"Asaphopsis" juneensis*, small cranidia (UTGD 81007), x 2.
19: librigenae of hystricurids (UTGD 81037), x 1.
20: *Hystricurus paragemulatus*, internal mould of cranidium (UTGD 81046), x 2.
21: *Hystricurus* sp., internal mould of cranidium (UTGD 81063), x 2.
22: *"Asaphopsis" juneensis*, distorted cranidium (UTGD 81015), x 1.
23: *"A." juneensis*, ventral surface of librigenae (UTGD 81001), x 1/4.
24: hypostoma, probably of *"A." juneensis* (UTGD 80979), x 2.
25: *Hystricurus*, cranidium (UTGD 81055), x 1.
26: *Hystricurus*, librigena (UTGD 81061), x 1.
27: *Hystricurus*, cranidium (UTGD 81052), x 2.
Fig 17. Trilobite, Florentine Valley Formation, Early Ordovician; The Gap (loc. 4, text-fig. 4).
17: *"Asaphopsis" juneensis*, distorted cranidium and broken pygidium (UTGD 81093), x 1.

Numbers UTGD ...... refer to specimens in the collection of the Department of Geology, University of Tasmania.
Plate 2

Figs 1-16.
Brachiopods, gastropod, trilobites from the Florentine Valley Formation, Early Ordovician; The Gap (loc. 4, text-fig. 4); see also Plate 1, fig. 17.
1: Nanorthis sp., internal moulds of pedicle and brachial valves (UTGD 81110), x 2.
2: Nanorthis sp, internal mould of brachial valve (UTGD 81110), x 2.
3: Apheloorthis cf. meeki, internal mould of brachial valve (UTGD 81117), x 2.
4: Apheloorthis cf. emmonsi, internal mould of pedicle valve (UTGD 81117), x 2.
5: Nanorthis sp, and other brachiopods (UTGD 81110), x 2.
6(?) Tritoechia careyi, internal mould of brachial valve (UTGD 81092), x 2.
7-8: Lecanospira tasmanensis; 7: Z152 Tasm. Mus., x1 approx.; 8: rubber cast from Z152, x 1.
9: "Asaphopsis" juneensis, pygidium (UTGD 81074), x 1.
10: "Asaphellus" lewisi, pygidium (UTGD 81116) x 2 approx.
11: Hystriocephalus paragenulatus, distorted cranidium (UTGD 81106), x 2.
12: Hystriocephalus sp., pygidium (UTGD 81113), x 1.
13: cf. Schmidtites (UTGD 81117), x 2.
14: Hystriocephalus cf. paragenulatus, external mould of cranidium, (UTGD 81093), x 1.
15: Cybelopsis sp. and "cystoid" plate (UTGD 81073), x 5.
16: Cybelopsis sp., partial cranidium (UTGD 81085), x 2.

Figs 17-24.
Brachiopods, trilobites, cystoid, graptolite from the Karmberg Limestone; Early Ordovician; 9 Road junction (loc. 7, text-fig. 4).
17: cf. Platilloenas sp., and TasmanocephaZus stephensi, part of librigenae (UTGD 81287), x 2.
18: Phyllograptus anna (UTGD 81335), x 2.
19: TasmanocephaZus stephensi, external mould of cranidium (UTGD 81329), x 1.
20: Trinodus sp., pygidium (UTGD 81319), x 10.
21-23: Spanodonta cf. hoskingiae, internal moulds of pedicle valves (21, 22 - UTGD 81333), and brachial valve (23 - UTGD 81331), all x 2.
24: "cystoid" plate (UTGD 81284), x 2.
25: cf. Eoleperditia (UTGD 81333), x 5 approx.

Fig. 26.
Cephalopod, Wherretts Chert Member, Early Ordovician; loc. 8 (text-fig. 4), just north of Wherretts Lookout.
26: Nybyoceras cf. paucicubiculatum (UTGD 81137), x ½.

Figs 27-8.
Gastropod, Cashions Creek Limestone, Marmorian.
27: Macurites, florentinensis, section showing flat base and depressed apex (UTGD 25033), x ½; Cashions Creek.
28: M. florentinensis, view of base (UTGD 21718), x ½; near The Settlement.
PLATE 3

Figs 1-4.
Stromatoporoid, tabulates and trilobite; Lower Limestone Member of the Benjamin Limestone, Mesial Ordovician; figs 1-3 - loc. 9 (text-fig. 4), near end of 16 Road; fig. 4 - near location of Eden Creek Road and Lawrence Creek Road.

1: *Tetradium apertum* (UTGD 81660), x 1.
3: *Tetradium tenue* (UTGD 81655), x 1.
4: *Bumastus* sp. (UTGD 81248), x 2.

Figs 5-17.
Polyzoa, trilobites, and echinoderm; Lords Siltstone Member of the Benjamin Limestone, (?) Early Trentonian; type section, Florentine Road.

5: (?) *Stictoporella* sp. and an encrinurid trilobite (UTGD 81340), x 2.
6: *Eotenotus*, pygidium (UTGD 81357), x 3.
7: *Camarocystites*, external mould (UTGD 81356), x 2.
8-11: *Pliomera* cf. *sulatifrons*, pygidia and cranidia; 8: UTGD 81338, x 5; 9: UTGD 81345, x 2; 10: UTGD 81340, x 2; 11: UTGD 81359, x 2.
12: (?) *Homotelus* sp., thorax and pygidium (UTGD 81347), x 1.
13-14: *Amphilichas* (*Tetralichas*), internal mould of cranidium and part of counterpart thereof (UTGD 81272, UTGD 81271), x 2 approx.
15: phylioporine cryptостome (UTGD 81274), x 2.
16: (?) *Ampyx* sp., partly broken cranidium (UTGD 81353), x 2.
17: (?) *Stictoporella* and a trepostome (UTGD 81351), x 3.

Figs 18-21.
Corals and trilobites, Upper Limestone Member of Benjamin Limestone, Late Ordovician.

18: *Hillophyllum* sp. (UTGD 81316), x 2; locality north of Lords Road.
19: *Billingsaria* sp. (UTGD 81129), x 5; in *Eobronteus* bed, on Adamsfield Track about one km west of bridge over Florentine River (loc. 12, text-fig. 4).
20-21: *Eobronteus* sp, pygidium and cranidium (UTGD 81136, x 2; UTGD 81124, x 1); locality and horizon as fig. 19.
Figs 1-5.
Corals and trilobite from coralline horizon at top of Upper Limestone Member, Benjamin Limestone, Late Ordovician; loc. 14 (text-fig. 4), except Fig. 1.
1: *Falsicatenipora* sp., (UTGD 81483), x 1; The Den, Mole Creek.
2: *Falsicatenipora chillagoensis* (UTGD 22078), x 2.
3-4: *Palaeofavosites* sp., (UTGD 22150), x 2½.
5: *Favistina* sp., (UTGD 22136), x 2.

Figs 6-8.
Trilobites, Westfield Beds, Late Ordovician.
6: *Ninkiangolithus* sp., (UTGD 81399), x 4; loc. 16 (text-fig. 4).
7-8: *Neseuretus* cf. *birmanicus*, internal and external moulds of cranidia (UTGD 81374, x 2; UTGD 81378, x 4); loc. 15 (text-fig. 4).

Fig 9.
Trilobite, coralline horizon at top of Upper Limestone Member, Benjamin Limestone, loc. 14 (text-fig. 4).
9: *Cervartinus* sp., cranidium (UTGD 22110), x 2.

PLATE 4.
K. D. Corbett and M. R. Banks
on

Reprinted with original pagination, from
THE PAPERS AND PROCEEDINGS OF
The Royal Society of Tasmania

Edited by M. R. Banks and published by the Society

Hobart, Tasmania
December 1975

Volume 109

T. J. Hughes, Government Printer, Tasmania
REVISED TERMINOLOGY OF THE LATE CAMBRIAN-ORDOVICIAN SEQUENCE
OF THE FLORENTINE-DENISON RANGE AREA, AND THE SIGNIFICANCE OF THE "JUNEE GROUP"

by K.D. Corbett, Department of Mines, Hobart, and
Maxwell R. Banks, University of Tasmania.

(with one text-figure)

ABSTRACT

The area of Lewis's original "Junee Series" is unsuitable as a basis for definitive stratigraphy and correlation, even with units in adjacent areas. A review of the various usages and concepts associated with the "Junee Group" indicates considerable diversity in meaning and application of the term, and suggests that the sequences are better considered in terms of a lower clastic unit and an upper limestone unit rather than as a single group. Accordingly, the Late Cambrian-Ordovician sequence in the Florentine Synclinorium is defined in terms of the Denison Subgroup, comprising four formations between the basal unconformity on the Denison Range and the base of the limestone, and the Gordon Subgroup, comprising three limestone formations and the Westfield Beds. These two Subgroups together approximate to the "Junee Group".

INTRODUCTION

The contribution by Brown et al. (this volume), on the basal beds of the Junee Group, raises many questions as to the terminology applied to the Early Palaeozoic sequences in Tasmania. A previous definition proposed by us (Corbett and Banks 1974) for the Junee Group is criticized on the grounds that, by including the Reeds Conglomerate (from the Denison Range) as well as the Tim Shea Sandstone in the definition, we have introduced a questionable correlation and have contravened the Australian Code of Stratigraphic Nomenclature with respect to the location of type sections and the validation of terms by later workers.

We accept that the correlation is not provable and that any possible ambiguity should be removed. Our definition was influenced by our firm view that Lewis's (1940) area of the "Junee Series" is unsuitable as a basis for definitive stratigraphy and for regional correlations, and that to define the group from strictly within that area would make for an impracticable term. That view we still hold.

Because it was originally poorly defined, the "Junee Group" has been used in different ways by different authors, depending on their concept of its regional significance. We review these usages and concepts in the light of new information and the arguments of Brown et al., and conclude that the usefulness of the "Junee Group" is limited in either a generalized form or as designated by Lewis in the Junee area. A terminology based on a lower clastic unit and an upper limestone unit seems more useful, and our earlier terminology for the Florentine-Denison area is revised accordingly.

USAGE OF THE "JUNEE GROUP"

Although Lewis (1940) originally defined the "Junee Series" from the Tyenna Valley area (including The Needles, Tim Shea, Wherrett's Lookout, and the Junee - now Maydena - area) he did not specify any type sections or give formation names.

Hills and Carey (1949) borrowed the term for their "Junee Group", comprising formations from widely-separated areas of Tasmania, and this generalized usage was
Revised Terminology and Significance of "Junee Group"

continued by Banks (1962), who defined the group in terms of the Jukes Conglomerate, Owen Conglomerate, Caroline Creek Sandstone, Florentine Valley Mudstone, Gordon Limestone and "Fenestella Shale". This generalized term has been used in discussions of the Tasmanian sequence for many years, and is still used by some people.

The present authors (1974), in redefining the group in the Florentine Synclinorium, attempted to amalgamate the generalized "Junee Group" usage with the ill-defined "Junee Series" by using only formations which could be defined in the general Tim Shea - Florentine - Denison Range area. We did not feel obliged to restrict the definition entirely to within the area of Lewis's "Junee Series" because: (a) there was a long historical precedent for using the term outside that area; (b) the area selected was adjacent to and physically continuous with that of Lewis; (c) there were serious problems due to the lack of exposure of Lewis's area, as discussed below; and (d) there were well-established precedents for not using the first-designated area to define an important group if the area was unsuitable or impracticable. For example, the Dundas Group was first designated by Waller (1905) as the sequence on the NE Dundas Tram but was redefined by Elliston (1954) on the Dundas Rivulet; and the Eldon Group of Gould (1866) from the inaccessible Eldon River area was redefined by Gill and Banks (1950) near Zeehan. Both these terms are accepted and in general use.

Williams, (in Jennings et al. 1967) referred the term "Junee Group" to the Maydena - Tim Shea area, and the Geological Survey of Tasmania in recent years has referred to sequences elsewhere as "Junee Group correlates" without specifying the composition or origin of the "Junee Group" referred to (e.g. Williams and Turner 1974). It is unfortunate that the Survey's assessment of the validity or otherwise of the "Junee Group" usage of Banks (1962) and others, was not made clear at an earlier date, since by inference Brown et al. (this volume) would regard this usage as invalid.

CONCEPTS ASSOCIATED WITH THE "JUNEE GROUP"

Several concepts have been associated with the "Junee Group" and have influenced the application of the term over the years, but need re-evaluation in the light of new information. The idea of the group as a single major cycle of sedimentation, from non-marine conglomerate to limestone, was put forward by Carey (1947) and has been fairly generally applied since then (e.g. Banks 1962). Together with this has been the idea that the group encompassed most or all of the Ordovician Period, since the lowermost fossils were of Early Ordovician age and the uppermost probably Late Ordovician. Thus "Junee Group" and "Ordovician System" have been used almost synonomously (e.g. Banks 1962; Williams and Turner 1974). The recent discovery by one of us of middle Late Cambrian fossils in a marine facies of the lower part of the Owen Conglomerate correlate on the Tyndall Range (Corbett in press) indicates that the "Junee Group" (sensu Banks) can contain an earlier marine cycle and that the lower part may include much of the Late Cambrian Series. This is also demonstrated by the Denison Range sequence (Corbett this volume).

The concept that the "Junee Group" marks the beginning of deposition of siliceous clastics, following the greywacke sedimentation typical of the Cambrian, has been expressed more recently (e.g. Williams, Solomon and Green 1975). However, in some areas at least, considerable amounts of siliceous conglomerate and sandstone were deposited in Middle or Late Cambrian sequences which must be regarded as pre-"Junee Group", e.g. in the Strahan area (Baillie et al. in press), and in the Trial Ridge area (A.V. Brown and N.J. Turner, pers. comm.; Corbett this volume).

Because of the varying usages and concepts, the meaning of the "Junee Group" in regional correlations and discussions has become confused, and its value as a widely usable term is doubtful. Another means of considering the Late Cambrian-Ordovician sequences of Tasmania has emerged in recent years. This involves splitting the sequence into a lower clastic unit of mainly conglomerate and sandstone, and an upper limestone
K.D. Corbett and Maxwell R. Banks

This two-fold division has been used on recent Geological Survey one mile maps (e.g. Barton et al. 1966; Barton et al. 1969), with the clastic sequence being generally referred to as "correlates of Owen Conglomerate", and the limestone sequence as "correlate of Gordon Limestone". The same subdivision is being used on the recent 1:250,000 scale compilations (e.g. Williams and Turner 1974), and on the 1:500,000 geological map of Tasmania (in preparation).

We believe that this two-fold subdivision reflects a fundamental character of the sequence, and is therefore likely to be of more future benefit than a single group term. The terminology of the Denison-Florentine sequence has accordingly been designated in terms of two subgroups, one for the lower clastic sequence, which is best developed in the Denison Range area, and one for the limestone sequence of the Florentine Valley. These two subgroups approximate to the old "Junee Group", but are designed so that they can be used independently, with the aim of eventually raising them to group status if the usage of "Junee Group" becomes impracticable.

THE LOWER CLASTIC SEQUENCE (DENISON SUBGROUP)

On the Denison Range the clastic sequence is some 3390 metres thick (fig. 1) and comprises four formations (Singing Creek Formation; Great Dome Sandstone; Reeds Conglomerate; Squirrel Creek Formation) defined as the Denison Subgroup (Corbett this volume). The Squirrel Creek Formation is a correlate of the Florentine Valley Formation and is of Early Ordovician age. The basal Singing Creek Formation comprises siltstone, quartzwacke and siliceous conglomerate, and contains middle Late Cambrian (Franconian) fossils. It rests with angular unconformity on Middle Cambrian beds, and this unconformity can be traced south through the Ragged Range to Frodshams Pass (Corbett 1970; Corbett and Banks 1974). East of this, the area of the unconformity is covered by dense forest, but the siliceous sandstone-conglomerate sequence transgresses various Precambrian and Cambrian rock types and structural features, and the unconformity is again exposed at Tim Shea (fig. 1).

The clastic sequence at Tim Shea, which is in the area mapped by Lewis as "Junee Series", is only some 750 m thick (fig. 1) and comprises the poorly fossiliferous Tim Shea Sandstone and the fossiliferous Florentine Valley Formation (Corbett and Banks 1974). The basal unconformity is on Precambrian dolomite on the south flank of the peak, although Lewis did not recognise it here (see Carey and Banks 1954). The Tim Shea Sandstone probably corresponds to the lower unit of Lewis's "Junee Series", the "quartzites with conglomerates and breccias interbedded", and the Florentine Valley Formation to Lewis's second unit, the "yellow mudstones with trilobites and other fossils of lower ordovician age".

The area first mentioned by Lewis (1940) as "Junee Series" is that around Junee (now Maydena) and Sunshine Spur, the latter some 8 km southeast of Tim Shea. Here he recognised a lower quartzite unit overlain by yellow fossiliferous mudstone followed by limestone. This relationship was also mapped by Everard and Hughes (in Hughes 1957, fig. 47) and has since been confirmed by R.K. Whyte (pers. comm.). Dense vegetation precludes tracing of the lower units between here and Tim Shea, although Lewis's correlation to Tim Shea is probably correct. The basal part of the sequence is exposed only at Sunshine Spur, where poor exposures suggest unconformity between basal conglomeratic beds and an underlying sandstone-siltstone sequence of unknown age.

The Denison Range section has many advantages over those at Tim Shea and Sunshine Spur as the basis for definition of the lower clastic sequence, as for example:

(i) The Tim Shea Sandstone is atypical in that it lacks the coarse conglomerates which occur along the whole western part of the synclinorium. These conglomerates reach their maximum development (1560 m) on the Denison Range (Corbett and Banks 1974).
(ii) Use of the Tim Shea or Sunshine Spur sections would leave doubt as to whether the Singing Creek Formation, which does not appear to be represented in the latter areas, should or should not be regarded as part of the group or subgroup.
Revised Terminology and Significance of "Junee Group"

Similarly it would be arguable if the Great Dome Sandstone (fig. 1) should be included, as evidenced by the discussion of Brown et al. (this volume).

(iii) Since the Tim Shea sequence sets directly on Precambrian rocks, the relationship to Cambrian sequences is difficult to specify. On the Denison Range, however, the unconformity is on fossiliferous Cambrian beds, and its significance and time range are more readily apparent.

(iv) There is no control on the age of the base at Tim Shea or Sunshine Spur, whereas on the Denison Range the beds above the unconformity contain a well-preserved and dated fauna (Corbett this volume).

(v) The Sunshine Spur section is poorly exposed.

It was for these reasons that we earlier decided that a Junee Group defined either at Tim Shea or in the Junee area would be of little value, and accordingly defined an alternative base for the group in the Denison Range section (Corbett and Banks 1974). We selected the base of the Reeds Conglomerate for what we then considered were several good reasons: (a) we wished to exclude the fossiliferous Late Cambrian beds since these did not appear to be present at Tim Shea and their inclusion would create problems of correlation to western Tasmania; (b) the use of a conglomerate as the base agreed with previous usage (e.g., Banks 1962); (c) we were influenced by the cycle of sedimentation concept; and (d) we regarded the Reeds and Tim Shea Formations as equivalents (fig. 1), although realizing that this was probably not provable.

Several arguments indicate that the Junee Group should not be defined in this way. Firstly, as pointed out by Brown et al. (this volume), there is a questionable correlation involved in the definition which makes it confusing. Secondly, there is the question of extending the type area beyond that of Lewis's original "Junee Series", and while we believe there is good precedent for doing this, there is little point if users of the term object. Thirdly, there is recent geological evidence to indicate that the base of the Reeds Conglomerate is not the most logical place for the base of the group. In particular, the discovery of a fossiliferous Late Cambrian marine facies...
in the lower part of the Owen Conglomerate indicates that the Junee Group (sensu Banks 1962) can include equivalents of the Singing Creek Formation.

The unconformity which occurs below the Singing Creek Formation, and which almost certainly corresponds to that in Lewis's type area, is the logical place for the base of the clastic sequence, just as the Denison Range is the logical place to define the sequence. The Denison Subgroup has been established accordingly, and while it is not defined as being part of the Junee Group (sensu stricto) it may be regarded as approximating the pre-limestone part of that group.

**THE LIMESTONE SEQUENCE (GORDON SUBGROUP)**

Conformably overlying the lower clastic sequence is a thick limestone succession with some minor siltstone-sandstone units. The limestone is poorly exposed in the Denison Range area because of the cover of superficial gravels, but is well exposed in the Florentine Valley. We used sections in the latter area to define our Gordon Limestone Subgroup (comprising three formations) and an overlying passage unit of siltstone and sandstone called the Westfield Beds.

The limestone sequence of the Florentine Valley is partly the same unit as Lewis's "blue Junee limestone" of the "Junee Series", but is outside his area. The basal limestone formation can be traced (Whyte, pers. comm.) from Junee into the Florentine Valley where it has been named Karmberg Limestone (Corbett and Banks 1974). Where mapped by Lewis, the limestone sequence is truncated unconformably by the Permocarboniferous beds, and to define the unit here would leave doubt as to the constitution of the upper part of the sequence and the relationship with the Siluro-Devonian sequence (Eldon Group correlates). This relationship is well shown in the Florentine Valley, however, and the exposures of limestone there are much better.

It is clearly preferable to use the Florentine Valley sections to define the limestone sequence, but there could be argument as to whether the sequence here corresponds precisely to that of the "Junee Series". We therefore do not define the Junee Group as containing this sequence, but regard it as approximating the "Junee limestone" of Lewis.

For convenience of correlation, we hereby slightly amend our earlier terminology in order that all the units below the Eldon Group correlates, and above the lower clastic sequence, be included in a single subgroup. We define the Gordon Subgroup as including the Westfield Beds at the top as well as the three limestone formations, i.e. the Karmberg Limestone at the base, the Cashions Creek Limestone, and the Benjamin Limestone. All units have previously been defined by Corbett and Banks (1974). The base of the Subgroup can be traced, as far as outcrop allows, from the Junee area to the valley of the Gordon River east of the Denison Range, where the Gordon Subgroup rests conformably on the Denison Subgroup.

**REFERENCES**


Revised Terminology and Significance of "Junee Group"


ACKNOWLEDGEMENTS

The authors acknowledge with thanks discussions with and comments from Dr. E. Williams, Mr. A.V. Brown, Mr. M.J. Clarke, Mr. I.B. Jennings and Mr. N.J. Turner of the Tasmanian Department of Mines.
MACLURITES AND GIRVANELLA IN THE GORDON RIVER LIMESTONE (ORDOVICIAN) OF TASMANIA

BY

MAXWELL R. BANKS AND J. HARLAN JOHNSON

Reprinted from
JOURNAL OF PALEONTOLOGY
Vol. 31, No. 3, May, 1957
MACLURITES AND GIRVANELLA IN THE GORDON RIVER LIMESTONE (ORDOVICIAN) OF TASMANIA

BY
MAXWELL R. BANKS AND J. HARLAN JOHNSON

Reprinted from
JOURNAL OF PALEONTOLOGY
Vol. 31, No. 3, May, 1957
MACLURITES AND GIRVANELLA IN THE GORDON RIVER LIMESTONE (ORDOVICIAN) OF TASMANIA

MAXWELL R. BANKS AND J. HARLAN JOHNSON
University of Tasmania, and Colorado School of Mines

ABSTRACT—Maclurites fiorentinensis, n. sp., and Maclurites spp. are associated with Girvanella problematica, G. tasmaniaensis, n. sp., and G. grandis, n. sp., in several places in Tasmania in a bed, probably Chazyan, within the Gordon River Limestone (Ordovician).

INTRODUCTION

Maclurites and Girvanella have not previously been described from Tasmania, but Maclurites was noted some years ago by Dr. I. A. Browne, University of Sydney, in a collection sent to her from the Geological Survey of Tasmania, and remarked upon in her letter to the Director of Mines. Early in 1950 Professor S. W. Carey, University of Tasmania, and I. B. Jennings collected a suite of specimens, including Maclurites, from the Gordon River Limestone near Benjamin, a small settlement about 20 miles from Maydena in the central part of Tasmania.

The authors wish to acknowledge the ready assistance of the Australian Newsprint Mills and especially that of Mr. J. Wylie of that organization, of the Goliath Cement Company, and particularly of Mr. R. Best, and of the Eugenana Lime Quarries. Professor Carey assisted with collections and helpful criticism, and Professor G. W. Bain of Amherst College, Massachusetts, kindly made available facilities in his department. Dr. E. Yochelson, U. S. Geological Survey, and Dr. H. B. Whittington, Museum of Comparative Zoology, Harvard, made specimens of Maclurites available for comparison.

STRATIGRAPHY

The Ordovician stratigraphy of Tasmania can be summarized as follows:

Junee Group
Gordon River limestone
Caroline Creek sandstone and shale
Owen conglomerate
Jukes breccia

It will be sufficient for the purposes of this discussion to consider the age limits of the Gordon River Limestone only. In the Florentine Valley area it is underlain by calcareous shales with Tritoechia spp. and Syntrophopsis sp. (Brown, 1947), trilobites such as Asaphopsis, Tasmanaspis, etc. (Kobayashi, 1940), and graptolites such as Dictyonema and Didymograptus spp., all of which indicate an horizon about the Didymograptus nitidus zone or in the Upper Canadian. Just west of the Florentine Valley, the base of the limestone contains Manchuroceras, Suecoceras, Piloceras and Allococeras (Teichert, 1947, and Teichert & Glenister, 1953), which also indicate an Upper Canadian age. The limestone with Maclurites and Girvanella occurs some hundreds of feet above the base in this area, in which the Gordon River limestone is about 6,000 feet thick. The top of the Gordon River limestone is not so well dated, but in this area contains Eofletcheria. Elsewhere, the limestone contains cephalopods such as Beloitoceras and Trocholitoceras (Teichert & Glenister, 1953), and corals such as Protaraea and Acidolites etc. (Hill, 1955), which indicate that it extends at least into the Richmondian and perhaps into the Lower Silurian.

OCCURRENCES

Localities mentioned below are shown in text-fig. 1.

Florentine Valley area.—The best exposure of limestone with the two genera in association is near Cashions Creek on the main logging road along the valley, where about 300 feet of limestone contains abundant specimens of both. Girvanella forms up to 40% of the rock in places, and on one piece of limestone 60 colonies more than 1 inch in diameter were counted in an area of 9 square inches. The specimens of Maclurites usually occur flat side down-
TASMANIAN MACLURITES AND GIRVANELLA

633 yards, and in several cases were seen to be encrusted by a stromatoporoid. Other fossils are rare but include strophomenid brachiopods and orthoconic cephalopods. The limestone with *Maclurites* overlies a white, stylolitic, somewhat impure limestone with asaphids and brachiopods. It is overlain by a fine-grained lithoidal limestone. The *Maclurites* limestone is markedly dolomitic and numerous rhombs of dolomite can be seen in section. It contains rare grains of pyrite and is stylolitic.

On the Adamsfield Track, one-half mile east-north-east by east of the bridge over the Florentine River, a small outcrop of limestone contains large specimens of *Maclurites* and some *Girvanella*.

Just east of Benjamin beside the old Dawson Road there are several hills showing outcrops of dolomitic limestone with *Maclurites* and *Girvanella*, showing the same orientation of the gasteropods as at Cashons Creek. Associated with the two genera are a *Receptaculites*, brachiopods, a *Scolerophontid*, a tall-spired gasteropod (pl. 74, fig. 7), a genus resembling *Maclurites* except for the nuceloconch which is not shown on the flat surface, and an actinoceroid. On the flanks of the Misery Range, several hundreds of feet stratigraphically below the *Maclurites—Girvanella* zone, is an impure limestone with *Tristoechia*. The total thickness of the limestone here is over 5,000 feet.

On the north side of Wherrets Lookout, cutting Karmberg's Track, are outcrops of limestone with *Maclurites* and *Girvanella* overlying a limestone with gasteropods and brachiopods, and overlain by a dolomitic rilobicite limestone.

The *Maclurites—Girvanella* association occurs again on the hill-slope immediately above the entrance to the Junee Caves on the Junee River about 2 miles from Maydena, and here is associated with *Orthonyctoceras tasmaniense* (Teichert and Glenister, 1953).

About a mile south of Maydena in a doline leading to the entrance to Pillingers Creek Caves *Maclurites* and *Girvanella* again occur in association and with them are other gasteropods and some cephalopods.

*Ida Bay.*—The association occurs also in the limestone at Ida Bay where a bed of limestone less than 10 feet thick contains both genera. This bed is several hundreds of feet above the base of the formation, which locally contains a *Tetradium* with the growth form of *T. syringoporoides*. Only sections of *Maclurites* were obtainable. Immediately below the *Maclurites—Girvanella* bed is one with *Tetradium* and *Catenipora* and about 100 feet above it is a richly coralline zone which is probably Richmondian (Hill, 1955). It is possible that this occurrence of *Maclurites* and *Girvanella* is not contemporaneous with those in the Florentine Valley but represents a later recurrence of similar ecological conditions.

*Gordon River.*—Cross sections of *Maclurites* occur in cliffs on the south bank of the Gordon River 3 miles below the mouth of the Franklin River. In the brief time available to examine this limestone *Girvanella* was not seen.

*Loongana.*—*Girvanella* occurs profusely
in a zone 30 feet thick in medium grey limestone exposed in the cliffs on the south bank of the Leven River about half a mile upstream from Hell's Gates, Loongana. It is associated with a stromatoporoid but despite close search by three people no *Maclurites* was seen.

**Eugenana.** —*Maclurites* and *Eugirvanella* are found associated with a stromatoporoid in a stylolitic, dolomitic limestone at the southern end of the limestone quarry. The zone, here 30 feet thick, overlies unfossiliferous limestone.

**Raillton.** —In the main quarry of the Goliath Cement Works at Raillton, a bed of limestone 20 feet thick contains numerous opercula of *Maclurites* and some shells. The limestone is sheared, stylolitic and pyritic. *Zittelella* and bellerophontids occur in the same quarry but no definite *Girvanella* was seen. The limestone in the quarry overlies with some gap the cephalopod beds at Blenkhorns Quarry with *Nybyoceras* spp. (Teichert & Glenister, 1953), which in turn is about 300 feet above the shales of the Caroline Creek sandstone and shale which here contain *Triocochia*.

As shown later, *Maclurites florentinensis* appears to be most closely related to *M. Magnus*, so that its age is probably Chazyan. Such an age is not inconsistent with the stratigraphic evidence in the Florentine Valley—Maydena area and at Raillton, but more detailed work is needed to establish this age.

**SYSTEMATIC PALAEONTOLOGY**

**Algae**

**Chlorophyta**

**Genus **Girvanella **Nicholson & Etheridge, 1880.**

The plants consist of tubular filaments which form loose irregular masses or more commonly small compact rounded nodular or bean-shaped bodies. Normally, the tubes have thick well defined walls, and are circular in cross section. Branching is rare in some species, fairly common in others. The sporangia are unknown. Species have been separated on the basis of the tube diameter. The thickness of the wall also appears to be a rather constant specific characteristic. Possibly the angle of branching is also.

The genus has a known geologic range from Lower Cambrian to Late Jurassic.

Our study was based on 25 slides (petrographic thin sections) of limestones rich in *Girvanella*. Several hundred tubes were measured. It is interesting to note that all fell into three groups without any intermediate specimens. Hence, they are considered to represent three species. These are described below.

Localities: Florentine Valley, Junee Caves, Pillingers Creek Caves, Ida Bay, Loongana and Eugenana.

**Girvanella problematica** Nicholson & Etheridge

**Pl. 73, fig. 1,4**

*Girvanella problematica* Nicholson & Etheridge, 1880, p. 23, pl. 9, fig. 24.

*Girvanella problematica* N. & E., Høeg, O. A., 1933, p. 64–65, pl. 1, fig. 4–6.

**Description.** —Tube diameter 14–17 μ, commonly 16–17 μ, wall thickness 3–4 μ, commonly 4 μ. Branching occurs, but not frequently, at an angle of about 30°. The tubes occur abundantly, often closely packed to form coatings, and small nodular masses. Tubes not parallel, seldom straight for more than short distances. They twist and turn.

**Remarks.** —In the tube diameter, growth habit, and appearance this form resembles Nicholson & Etheridge's type, and specimens attributed to the same species found at a number of widely scattered localities in several continents. Unfortunately, none of the previous writers have given wall thicknesses.

Chapman (1907, p. 76) describes a form of similar tube dimensions from the Silurian of Victoria which he named *G. confera*. However, he specifies that it differs from *G. problematica* "in having the tubes in bundles lying side by side, and in being segmented by transverse or oblique partition walls, at which place the tube is generally constricted." Neither of these features were observed in the specimens from Tasmania being discussed.

**Occurrence and types.** —Figured specimen U.T.G.D. 25945a: Gordon River Limestone, Ordovician; Cashions Creek, Florentine Valley, near Maydena, Tasmania. U.T.G.D. 21221 (a & b): Gordon River Limestone, Ordovician; on hill slope above mouth of Junee Caves, Junee River, about 2 miles north of Maydena, Tasmania.
TASMANIAN MACLURITES AND GIRVANELLA

635

U.T.G.D. 25039a, 25043b, 25046b, 25081b, 25084b, 25086, 25088: all from Cashions Creek, Florentine Valley, Tasmania.

GIRVANELLA TASMANIAENSIS Banks & Johnson, n. sp.

Pl. 73, fig. 3.

Description.—Tube diameter 21–23 μ, wall thickness 4–5 μ, commonly 5 μ. Tubers twisted, loosely packed in more or less parallel bundles. Branching moderately abundant, commonly at an angle of 45° to 60°. They form small pellets, or irregular masses or coatings. Some occur in same slide with G. problematica.

Remarks.—Høeg (1933, p. 64–65) described a Girvanella from the Ordovician of Norway as G. problematica forms moniliformis which closely resembles G. tasmaniensis in tube diameter and growth habit. However, his species has a somewhat greater range of tube size (20–26 [30] μ), and branches frequently at a considerably wider angle (commonly about 90°).


GIRVANELLA GRANDIS Banks & Johnson, n. sp.

Pl. 73, fig. 2,4.

Description.—Tube diameter 31–33 μ, commonly 32 μ. Wall thickness 5–7 μ, normally 6 μ. Tubers twist, loosely packed, in nearly parallel groups of 2 to 4. Branching rare or absent. A few observed cases of apparent branching suggest bifurcation at an angle of about 90°.

Remarks.—This species has the largest tubes of any recorded Ordovician Girvanella. Pia mentions a form G. brainerdi (Seeley) having a tube diameter of 50–100 μ. However, an examination of Seeley's original plates and material from his type locality indicate an alga of the Sphaerocodium type rather than a Girvanella.

This species occurs in loose masses and in thick coatings and nodular masses associated with Girvanella problematica. It is much less common in the Tasmanian collection than the two species previously described.

Occurrence and types.—Holotype: U.T.G.D. 25043a: Gordon River Limestone, Ordovician; Cashions Creek, Florentine Valley, near Maydena, Tasmania.


Phylum MOLLUSCA
Class GASTEROPODA
Superfamily MACLURITACEA
Genus MACLURITES Lesueur, 1818.

MACLURITES FLORENTINENSIS
Banks & Johnson, n. sp.

Pl. 74, fig. 1,2,4,5,10.

Diagnosis.—Large, hyperstrophic shells with all whorls visible on flat lower side and a deep, often wide umbilicus on convex upper side; operculum a heavy, horn-shaped or flattened plate, which if horn-shaped has rugose projections on inner side for muscle attachment; ornamentation growth-lines and in some species revolving striae or grooves (Knight et al., 1944).

This genus is very widespread in the Ordovician system. It occurs in the Baltic, the British Isles, the Arctic, North America, Argentina, China, the northern Shan States, and Australia. It was recorded for the first time from Australia by Opik (Stevens, 1952), who noted its presence in limestones from Cleifden Caves, near Orange, New South Wales, where it is associated with a rich shelly fauna. It is also known from Tasmania.

MACLURITES FLORENTINENSIS
Banks & Johnson, n. sp.

Pl. 74, fig. 1,2,4,5,10.

Diagnosis.—Maculurites with a rate of increase corresponding to a tangential angle of 83°, approximately a trapezoidal whorl section, fine radial ornament only, and an apical angle of about 332°.

Description.—The holotype is a partial internal mould, the depressed apex being filled with limestone, the upper surface being an internal mould and the lower surface retaining some of the shelly material recrystallized. The specimen is 9.16 cm. in maximum diameter, and 2.90 cm. in maximum height. The shell is 0.26 cm. thick at the periphery close to the aperture.

The lower surface is slightly convex, the umbilical angle being approximately 184°. On this surface the whors are almost flat, the sutures being very slightly impressed.
An ornament of very fine lines of growth occurs on this surface, the lines being very low and close together and making no impression on the internal mould which is smooth. The growth lines sweep back toward the apex from the inner suture of the whorl and then cross the main body of the whorl in a line which is gently concave to the aperture. One of the syntypes (U.T.G.D. 25707, pl. 74, fig. 2) shows that this ornament continues over the upper surface of the whorl at least to the edge of the apical depression.

There are six whorls, of which four are readily visible on the lower surface and, when the central part is moistened and examined closely, two more are revealed. The nucleoconch is 1 mm. in diameter.

Measurements were made of the radii of successive whorls along two radial lines approximately at right angles, with the following results:

(a) 0.05 0.09 0.17
(b) 0.05 0.06(?) 0.11
(c) 0.05 0.09 0.13
(d) 0.05 0.07 0.23

The measurements were made in 1/128th inches and converted to millimetres. The radii of the outside whorl are all a little less than the true radii because some or all of the outside wall is missing. It will be noticed that there are anomalies in these measurements, due to difficulties of measuring near the nucleoconch and to slight shearing.

From these measurements, the ratio $r_{x+1}/r_x$, where $r_x$ is the radius of whorl number $x$, and $r_{x+1}$ the radius of whorl number $x+1$ measured along the same line, was calculated for as many whorls as possible. The mean of these ratios was then found according to the formula

$$m = \frac{\sum V}{n}$$

where $m$ is the mean, $f$ is the number of ratios falling in a class with the median value of $V$, and $n$ the total number of ratios, and found to be 2.205. For any one set of measurements along a radius of the shell, successive radii plotted on logarithmic scale against whorl number on arithmetic scale fell on approximately straight lines (text-fig. 2b), thus showing the rate of increase to be logarithmic and the spiral an equiangular one (see Darcy Thompson, 1942, Chapt. XI). As the umbilical angle of the holotype is 184° (i.e., the semi-angle of the enveloping cone is 88°), the angle of the spiral can be determined (see Thompson, 1952, p. 771) from the formula

$$\cot \alpha = \frac{\log 2.205}{2 \pi \sin 88° \log e}$$

and is found to be approximately 82° 58'.

The whorl section of the holotype cannot be determined with any accuracy but the syntypes show that it is essentially a trapezohedron with the corners considerably rounded. The angle between the parallel sides and the flat base of the whorl is 46° (approximately) in the holotype, but varies from 44° to 56° in the syntypes. The fourth side of the trapezohedron, the upper and inner side, is not revealed in the holotype, but is shown in the syntypes to be from 14° to 16° from vertical. In the outer whorls the uppermost corner of the trapezohedron is more angular than in the younger whorls and forms a rather sharp shoulder to the apical depression.

Although the apical depression ("umbilicus" of authors) cannot be observed in...
TEXT-FIG. 2—Graph of whorl radius against whorl number in: (a) types of *Maclurites magnus*; (b) types of *M. florentinensis*; (c) types of *M. logani*.
the holotype, syntypes reveal that it is comparatively narrow and that within it the sutures are initially quite deeply impressed, later becoming deeply channeled. The apical angle could be measured in four of the syntypes and was found to be about 332°, so that the apical depression is quite narrow. Wherever it could be observed, the nucleoconch lies at the base of the apical depression and forms part of the lower surface.

From these figures it will be seen that M. florentinensis may have a slightly lower rate of increase than M. magnus, but there are hardly enough measurements of either to determine this finally. Similarly, M. logani seems to increase still more rapidly than M. magnus, but again more measurements are needed. American specimens of M. bigsbyi are quite close to M. magnus as far as coiling is concerned, but the Chinese specimens (Endo, 1932) seem distinctly different.

The ornament of M. florentinensis is very similar to that of M. magnus and a number of other species but differs markedly from that of M. manitobensis and somewhat from that of M. bigsbyi, which has fine revolving lines. Because the umbilical angle of M. magnus varies from 177° to 199° and that of most species is between 180° and 190° this character cannot be considered diagnostic. Another character used by some authors to distinguish species is whorl section. In this M. florentinensis is closest to M. magnus and M. bigsbyi, and in peripheral whorl profile sometimes approaches M. cuneata although it differs in overall whorl profile.
Table 1—Measurements of Syntypes of Macrurites florentinensis

<table>
<thead>
<tr>
<th>Diameter (cms.)</th>
<th>Height Diameter</th>
<th>Radii (cms.)</th>
<th>$r_{x+1}/r_x$</th>
<th>Umbilical angle</th>
<th>$\rho$</th>
<th>$\beta$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Holotype: 9.16</td>
<td>0.319</td>
<td></td>
<td></td>
<td>184°</td>
<td>46°</td>
<td></td>
</tr>
<tr>
<td>Syntypes: 8.02</td>
<td></td>
<td></td>
<td></td>
<td>189°</td>
<td>45°</td>
<td>166°</td>
</tr>
<tr>
<td></td>
<td>0.461</td>
<td>1.07 2.42 4.84</td>
<td>2.26</td>
<td>45°</td>
<td>166°</td>
<td></td>
</tr>
<tr>
<td></td>
<td>0.73 1.27</td>
<td>1.73</td>
<td>2.82</td>
<td>56°</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>0.32 0.89 1.98</td>
<td>2.22</td>
<td></td>
<td>167°</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3.93</td>
<td>0.50</td>
<td></td>
<td></td>
<td>186°</td>
<td>45°</td>
<td>166°</td>
</tr>
<tr>
<td>4.72</td>
<td>0.521</td>
<td>0.42 0.79 1.41</td>
<td>1.90</td>
<td>194°</td>
<td>49°</td>
<td>166°</td>
</tr>
<tr>
<td>3.83</td>
<td>0.524</td>
<td>0.18 0.41 0.73 1.11</td>
<td>1.98</td>
<td>54°</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

$r_{x+1}/r_x =$ radii of successive whorls; $\rho =$ angle between flat lower surface and parallel sides of trapezoidal whorl section; and $\beta =$ half of apical angle.

Thus, as far as rate of increase and whorl profile are concerned the Tasmanian syntypes could be either *M. magnus* or *M. bigsbyi*, but in one important respect, the apical angle, they differ from both species. In those specimens or illustrations of *M. magnus* which show this feature, the angle was found to be 304°, 319°, and 308°, each of which is somewhat less than the angle shown by *M. florentinensis*; in *M. bigsbyi*, angles of 306°, 316° and 295° were measured. In respect to this character only *M. acuminata* (328°), *M. manitobensis* (326°) and *M. cuneata* (355° and 336°) are at all close to *M. florentinensis*, most of the others being similar to, or less than *M. magnus*.

Thus, in summary, *M. florentinensis* resembles *M. magnus* more than any other species but differs from it in having the apical angle about 20° greater and perhaps also in the slightly smaller rate of increase.

**Occurrence and types.**—Holotype: U.T.G.D. 21718: Gordon River Limestone, Gordovician; Benjamin, Florentine Valley, Tasmania; Pl. 74, fig. 1. Paratypes, U.T.G.D. 25033: Gordon River Limestone, Gordovician; Cashions Creek, Florentine Valley, Tasmania; Pl. 74, fig. 3. U.T.G.D. 26906: Same locality as holotype; unfigured; U.T.G.D. 26909: same locality as holotype; unfigured; U.T.G.D. 26909; same locality as holotype; unfigured.

**Macrurites sp.**

Although sections of *Macrurites* have been seen in a number of places as detailed earlier, only at Railton could specimens be collected. One of these (U.T.G.D. 25334) consists of a piece of blue-grey limestone broken in two. The fossil shows the pseudo-sinistral coiling and a deep, rather wide apical depression. The upper edge of the whorl is sharply angulated and the angle is distinctly sharper than in *M. florentinensis*. Unfortunately, insufficient characters are shown to allow a specific determination. The other specimens collected at Railton are the opercula illustrated (pl. 74, fig. 3,6,8,9). Two, U.T.G.D. 26910 (pl. 74, fig. 6,8) and U.T.G.D. 26911 (pl. 74, fig. 9), are horn-shaped. Specimen U.T.G.D. 26910 has a more or less triangular section, 3.06 cm. in length and 1.75 cm. in width; the horn is 2.32 cm. in length, with the longest side of the horn being 4.11 cm., the apex being situated almost at one side of the horn. There is no sign of coiling in the main body of the operculum, but this may be due to the beekatisation of the specimen. The abapical surface is somewhat hollowed. On this surface is a ridge for muscular attachment, which arises from the rim of the operculum at one end of the shortest side, and, coiling dextrally, rises rapidly to its...
highest point, 0.77 cm. above the surface (pl. 74, fig. 6), and then falls slowly towards the shortest side. No rugosites are present on it. The other hornshaped operculum (U.T.G.D. 26911) is incomplete and shows only a slight sign of the ridge for muscle attachment (at the angle between the two arms in pl. 74, fig. 9).

Also from Railton is a flat operculum (U.T.G.D. 25331, pl. 74, fig. 3). This was not completely exposed by acid treatment which revealed part of the flat base of a Maculures in the same piece of limestone. The preserved part is 4.54 cm. long and about 2.60 cm. wide. The apex, which lies slightly outside the plane of the rim and overlaps the margin of it considerably, has a slight sinistral twist when viewed from above. The most prominent feature of the operculum is the projection for muscular attachment, which from within the angle under the apex rises rapidly to a ridge 0.77 cm. above the plane of the rim, and then slopes downward towards the centre of the operculum. The highest preserved part of this ridge is 0.78 cm. long and 0.42 cm. wide, and oval in section. There are no rugosites preserved. Insufficient features were available to allow specific identification, and although in flatness it resembles M. logani, its other features are dissimilar.

REFERENCES


REED, F. R. C., 1915, Supplementary memoir on new Ordovician and Silurian fossils from the Northern Shan States: Pal. Indica Mem. G. S. Ind. vol. VI, mem. 1, p. 21, pl. IV, fig. 8.


TEICHERT, C., 1937, Ordovician and Silurian faunas from Arctic Canada: Rept. Fifth Thule Expedition, 1921-24, v. 1, no. 5, Mollusca, p. 70-100.


THOMPSON, D. W., 1942, On growth and form: Cambridge Univ. Press, Chapt. XI.


ULRICH, E. O., & SCHOFIELD, 1897: see bibliog- raphy in Bassler, 1915.

MANUSCRIPT RECEIVED AUGUST 13, 1956
Graptolite from the Mathinna Beds, north-eastern Tasmania

During a reconnaissance survey in the Back Creek area east of Lefroy in north-eastern Tasmania, two graptolites were found in a block on the dump at the Australasian Slate Quarry (49°6.9 E. 94°4.3 N., Pipers River sheet, Geological Survey, Department of Mines, Tasmania), just south-west of Turquoise Bluff. The graptolites occur in cleaved siltstones contorted by herring-crested folds of a few cm. amplitude and wavelength, and containing irregular cavities now occupied by friable, sand-grade material. Such siltstones are commonly exposed in the quarries and there is no reason to suspect that the graptolitic block is other than local. The siltstones are part of the 'lutite association' of the Mathinna Beds (Banks, 1962, 182).

The Mathinna Beds consist of at least two associations, the 'lutite association' from which no fossils have previously been recorded and an 'arenite-lutite association' containing psilopsid plants. Chondrites and fragmental shelly fossils suggesting a Lower Devonian age for the fossiliferous parts (Banks, 1967, Table 2). Following a suggestion by Green (1959), Banks (1962, p. 187) suggested that the lutite association may be Ordovician. 'Diplograpsus' was recorded by Thureau (1882) from slates presumably part of the Mathinna Beds at Lisle some miles south-east of Turquoise Bluff but the record was subsequently rejected by Hall (1902) and Thomas (1945).

The graptolites are preserved as somewhat distorted impressions. One (top right, Figure 1) has 14 stipes which at least three are uniramous and shows dichotomous branching, probably up to the fourth order. Thecae are poorly preserved but parts of two stipes give counts of about 20 thecae/cm. The other specimen (middle left, and obverse, bottom right, Figure 1) shows evidence of 15 stipes, some of which show dichotomous branching. In both specimens there is a strong tendency to bilateral symmetry and concentration of the dichotomy close to the initial part of the rhabdosome. The number of stipes and the character of the branching suggest that both specimens belong to Loganograptus and the stipe thickness and general characters suggest allocation to Llogan. However, the thecal count, based though it is on poorly preserved thecae, is too high for this species, indeed for most Loganograptus species.

The presence of Loganograptus suggests an Arenigian or Llanvirnian age (Thomas 1960, p. 16) for the host rock. The presence of two specimens of Loganograptus and no other graptolite suggests the possibility that...
the rock can be correlated with the upper part of the Castlemainian (Ca 3, Subzone of *D. nitidus*, Arenigian) of Victoria when *L. logani* (Hall) became abundant (Thomas, 1960, p. 9).

The Lower Ordovician age for these sediments poses stratigraphical and structural problems by their proximity to the 'arenite-lutite association' about a hundred metres to the east. The nature of the contact between the associations in this area is uncertain. If conformable, some parts of the 'arenite-lutite association' may be older than the Siluro-Devonian age normally postulated for them. If the 'arenite-lutite association' is Siluro-Devonian either the Ordovician succession is remarkably condensed or the contact is an unconformity or a fault. The cleavage at the slate quarry dips at only 11° (shallower than bedding), and this suggests recumbent folds quite different in style from those exposed in the 'arenite-lutite association' at The Sidling, Weymouth, and elsewhere (see Launceston, Pipers River and Nolands Bay geological sheets for fold style). Further detailed field work and intensive search for fossils is needed to solve the problems raised.

The cleavage has distorted the stipes such that the thickness of the stipe on the bedding plane is directly proportional to the angle between the cleavage and the axis of the stipe.

M. R. Banks,
University of Tasmania,
Hobart.

E. A. Smith,
Launceston Matriculation College,
Launceston, Tasmania.
1 April 1968.

References.

CLATHRODICTYON AND ECCLIMADICTYON (STROMATOPOROIDEA)

FROM THE ORDOVICIAN OF TASMANIA

by B.D. Webby, University of Sydney

and M.R. Banks, University of Tasmania

(with three plates)

ABSTRACT

Five species of late Ordovician clathrodictyid stromatoporoids are described and illustrated from Tasmania. Of these, three are new species of Clathrodictyon—C. molense, C. plicatum—and a fourth is a new species of Ecclimadictyon—E. latum. They come from localities in the Mole Creek, Ida Bay and Florentine Valley areas, from horizons towards the top of the Gordon Limestone Subgroup.

INTRODUCTION

Apart from the early record of the Ordovician stromatoporoid Stromatocerium sp., d. from west Tasmania (Biggsy 1868), there is virtually no further recognition of the group until Banks (1957), and Banks & Johnson (1957) drew attention to stromatoporoids in the 'Gordon Limestone' of the Florentine Valley area, Loongana, Moina and Genana. Subsequent records include Banks' (1962; 1965) identification of alicids, Cryptophragmuss and Thamnobeatricea-like forms from various localities in the Gordon Limestone, and Banks' (1971) reference to the 'Chazyani' association of Stromatocerium with Maclurites and Gymnactina. Webby (1971, p.13) also mentioned the presence of a lindsayiform having an Alleynodictyon-type structure, and Corbett and Banks (1974) listed 'Thamnobeatricea', a form close to Stromatocerium rugosum, Aulacera sp. and androdictyid-like form from the Florentine Valley area, together with providing the first illustration of an Ordovician stromatoporoid (cf. Thamnobeatricea) from Tasmania.

The majority of the stromatoporoids in the Gordon Limestone Subgroup of Tasmania are labechiids not clathrodictyids. Only five species of clathrodictyids—those described herein—have so far been recognized. The clathrodictyids are confined to the uppermost part of the Gordon Limestone Subgroup in the Mole Creek area and elsewhere. Clathrodictyon plicatum sp. nov., Clathrodictyon sp., and Ecclimadictyon latum sp. nov. occur at The Den, 3.5 km west-north-west of Mole Creek (Mersey 1:00,000 sheet 8114, edit. 1, series R661; Grid ref. DQ483010). C. plicatum and E. latum have also been found in the large working quarry farther west (Grid ref. 366027), and C. plicatum from west of the road leading to the quarry (Grid Ref. 365023). Another species, C. molense sp. nov., occurs together with E. undatum at locality on the north-east side of the road leading to the quarry (Grid ref. 365020). E. undatum also comes from the Benjiman Limestone (upper part of Gordon Limestone Subgroup) at a locality east of the Westfield Syncline, approximately 0.8 south-east of the Westfield Road (co-ordinates 444.650E, 751.350N). A fifth species, C. idense sp. nov., has been collected from the Gordon Limestone Subgroup nr Ida Bay. Unfortunately the precise horizon and location are unknown. It seems likely to have come from an horizon high in the limestone, possibly from the site of the main quarry on the north-east slopes of Marble Hill (Tasmania topographic series 1:31,680, Southport sheet no. 8211-II-S; Grid Ref. 764E, 650N).

Most of the Tasmanian species of Clathrodictyon and Ecclimadictyon are new, and
Ordovician Stromatoporoidea from Tasmania

are distinct from those described from the late Ordovician of New South Wales (Webby 1969). It is difficult therefore, on the basis of these faunas alone, to suggest a likely correlation between the Tasmanian clathrodictyid-bearing limestones and those of N.S.W. In N.S.W. the first clathrodictyids appear at the base of Fauna II and persist through Fauna III. It seems unlikely, however, from other faunal data and correlations that the occurrences, restricted to the top of the respective 'Gordon Limestone' sequences, come from horizons older than Fauna III. Differences between the Tasmanian and N.S.W. clathrodictyid faunas may be accounted for either (1) by the Tasmanian fauna being slightly younger than the N.S.W. Fauna III (perhaps being equivalent to the non-carbonate interval of the Malachi's Hill Beds between Faunas III and IV, or (2) by the differing tectono-environmental settings of the Tasmanian Shelf and the Macquarie Volcanic Belt (Webby 1976) during Fauna III time (i.e., late Eastonian-early Bolindian time).

SYSTEMATIC PALAEONTOLOGY

The registration numbers of specimens in the University of Tasmania, Department of Geology fossil collections have the prefix UTGD.

Family Clathrodictyidae Kuhn, 1939

Genus Clathrodictyon Nicholson & Murie, 1878

Type species. C. vesiculoseum Nicholson & Murie, 1878

Clathrodictyon idense sp. nov.

Pl. I, figs. 1-2

Material. Holotype (UTGD 58125) from Gordon Limestone Sub-group south-west of Ida Bay. Precise horizon and location near Ida Bay unknown.

Description. Fragment of massive, sheet-like coenosteum measuring 70 x 15 mm in cross and 50 mm in height. Laminae are regular, continuous, and only very gently undulating; spaced from 10-12 mm in 2 mm vertically; and of variable thickness, typically 0.03-0.1 mm. Pillars vertical, and cylindrical to spool shaped, usually extend across interlaminal space; rarely incomplete; only occasionally superposed; vary in diameter from 0.05-0.2 mm; spaced from 0.2-0.5 mm apart laterally. Galleries rounded to elongate, may be up to 0.2 mm high and 0.1-1.0 mm wide, but at certain levels in coenosteum of more closely spaced and thickened laminae, galleries may be constricted completely infilled; zones of thickening usually laterally continuous but not ways. Occasional thin, curved, inclined plates subdivide galleries; these are assepsiments, and they are especially conspicuous in tangential section showing as cuate lines linking pillars. Astrorhizae not observed. Microstructure compact.

Remarks. No other Australian Ordovician species of Clathrodictyon is closely similar to C. idense.

Clathrodictyon molense sp. nov.

Pl. I, figs. 3-6.

Material. Holotype (UTGD 94622) from upper part of the Gordon Limestone Sub-group north-east side of road to limestone quarry, 5 km WNW of Mole Creek.

Description. Coenosteum massive, low conical, 110 x 80 mm across and 40 mm in height; only weakly folded in some parts of this fine textured coenosteum. Laminae mutely crumpled and downwardly deflected at junctions with pillars; identity of individual layers laterally persistent but not individual laminae; spacing of laminae 14-18 per 2 mm vertically; thickness of laminae 0.03-0.05 mm. At base of coenosteum, first few rows of laminae notably irregular; also a few bands of more closely spaced laminae at intervals through coenosteum. Pillars cylindrical, confined to interlaminar space, not normally superposed; from 0.05-0.1 mm in diameter; spaced from 0.1-0.3 mm apart; isolated crossing galleries, but form incomplete
shes adjacent to contacts with laminae. Galleries rounded to elongate, up to 0.2 high; of variable length, usually 0.1 mm high and about 0.4-0.5 mm long; in extremes up to 1.3 mm long. No astrorhizae. In better preserved parts of coenos-

marks. C. molense, of Ordovician species of Clathrodictyon, is quite distinct. shows a resemblance to the Estonian Llandoveryan C. sullevi Nestor, 1964, but is much finer textured, having 14-18 laminae per 2 mm, as compared with 10-12 laminae per mm in C. sullevi. Also the Estonian species has small astrorhizae.

Clathrodictyon plicatum sp. nov.
Pl. II, figs. 1-5

Material. Four specimens (UTGD 94623-26) from locality west side of road leading to limestone quarry, 5 km WNW of Mole Creek. One specimen (UTGD 94627) from lime-
one quarry, 5.5 km WNW of Mole Creek. Four specimens (UTGD 94628-29, 94631-32) from The Den, 3.5 km WNW of Mole Creek. Holotype is UTGD 94626; other numbered specimens designated paratypes. All specimens from upper part of Gordon Limestone Sub-group.

Description. Laminar, sheet-like to encrusting; often showing intertonguing re-
tionships with surrounding sediment; largest specimen (UTGD 94624) measures 80 x 70 across and 60 mm high. Mamelons prominent, spaced from 2-7 mm apart; of variable size. Latilaminae also conspicuous, vary from 0.5-11 mm high; mamelons may be con-

nous through more than one latilamina. Latilaminae mainly regular and laterally con-

uous; folded evenly across mamelons; usually spaced from 9-14 in 2 mm vertically and vary from 0.02-0.07 mm thick; in a few areas of coenosteum where laminae are more widely spaced than normal, galleries become occupied by dissepiments (or secondary laminae). Within part of laminar, sheet-like coenosteum of UTGD 94631 (Pl. II, fig. there are mamelon-like upgrowths which exhibit an inner, axial core filled with ggzag, secondary laminar tissue and interspersed regular laminae - a Clathrodictyon-

form with vertical pillars confined to an interlaminar space in marginal areas. Possibly the inner, axial zone spread more rapidly than the flanking marginal areas. Pillars cylindrical, spindle-
d inverted conical; these latter spread upwards to meet laminae leaving a triangu-

r space between them; confined to one interlaminar space, rarely superposed; pillars mainly 0.05-0.1 mm in diameter; spaced 0.1-0.3 mm laterally. Occasional astrorhizal tubes associated with mamelons; diameter about 0.2 mm. Also a few rare foreign bodies or tubes, 0.7-1.0 mm across, in positions near base of latil-

inae, which have caused laminae to updome over them. Microstructure compact.

marks. C. pilatum has a similar morphology to C. aff. mammillatum (Schmidt) from the late Ordovician of New South Wales (Webby, 1969), but has narrower spacing laminae (9-14 in 2 mm as compared with 6-9 per 2 mm in C. aff. mammillatum). Compared with the second N.S.W. late Ordovician species, C.cf. microroundulatum Nestor, has a more markedly mammillated form, and the pillars, usually confined to a single interlaminar space, include inverted conical forms.

Clathrodictyon sp.
Pl. III, figs. 4-5

Material. Three specimens (UTGD 94633-35) from The Den, 3.5 km WNW of Mole Creek; per part of Gordon Limestone Sub-group.

Description. Coenosteum columnar, comprising a series of interconnected cylinders forming in tangential section branching to chain-like patterns with the sediment. Cylinders probably merely represent extended mamelon columns; spacing usually from 15-35mm laterally, measured between centres of cylinders. Largest specimen (UTGD 634) measures 100 x 80 mm across, and column at least 120 mm in height. Axial zone cylinders destroyed by recrystallization; calcite infilled. Commensal tubes
Ordovician Stromatoporoidea from Tasmania

Sturat through coenosteal tissue of middle-outler parts of cylinders; from 0.3-0.6 mm thick and with horizontal to slightly sagging tabulae (spaced about 7 per 2mm.

Stilaminae also frequently occur in outer parts of coenosteum; 1-6 mm wide. Laminae best variable; may be evenly spaced and regular at some levels within coenosteum, but others interlaminar spaces widen and become infilled with irregular, crumpled laminae (disseipments or secondary laminae); usually 11-15 per 2 mm vertically; thickness of laminae typically from 0.05-0.07 mm. Pillars normally confined to one interlaminar space, cylindrical to spindle shaped; occasionally with upwardly spreading form leaving space between forks and the overlying lamina; usually from 0.03-0.1 mm in diameter, and spaced about 0.1-0.2 mm apart. No astrorhizae seen, but may have been confined originally to centres of cylinders, now recrystallized and calcite filled. Microstructure compact.

Remarks. Although closely similar to C. pilatum, C. sp. exhibits a markedly different columnar growth form, and slightly more prominently crumpled or zigzagged laminae.

Genus Ecclimadictyon Nestor, 1964

Type species. Clathrodictyon fastigiatum Nicholson, 1886

Ecclimadictyon undatum sp. nov.

Pl. III, figs. 1-3

Material. Holotype (UTGD 94636) from north-east side of road to limestone quarry, 5.5 km WNW of Mole Creek; and paratype UTGD 90917 from the Den, 3.5 km WNW of Mole Creek, uppermost part of Gordon Limestone Sub-group. Holotype UTGD 94638 from locality off track, south-east of Westfield Rd. and east of Westfield Syncline, Florentine Valley area; and paratype UTGD 94637 from limestone quarry, 5.5 km WNW of Mole Creek.

Description. Coenosteum consists of latilaminate, irregularly undulating sheet-like masses, 130 x 110 mm across, and up to 70 mm in height. Preservation indifferent; structure of parts of coenosteum, especially interiors, has been obliterated, and all areas show tectonic distortion. Laminae zigzag shaped, evenly spaced, from 14 per 2 mm vertically; at base of latilaminae laminar tissue shows much irregularity; laminae usually about 0.05-0.08 mm thick. Pillars normally confined to interlaminar space; very rarely superposed; formed from downward inflexions of laminae; about 0.07-0.1 mm in diameter; in tangential sections, pillars appear as isolated dots, and with laminae as bars and open to closed meshes. No astrorhizae present. Compact microstructure exhibited in a few small areas of good preservation, but usually shows a secondary three-layered structure composed of a central, clear white with darker granular margins to either side.

Remarks. In comparison with Late Ordovician E. ammassensis (Khalfina 1960) from the upper part of the Clieffen Caves Limestone of central New South Wales (Webby 1969), E. undatum has less vertically continuous pillars, a closer spacing of laminae (12-14 per 2 mm, as contrasted with 8-12 in E. ammassensis), a more undulating, sheet-like, latilaminate form, and no astrorhizae. A second Ordovician species, E. nestor, also from the upper part of the Clieffen Caves Limestone, differs in being finer textured form (15-16 laminae in 2 mm) and showing bunchy astrorhizae. Another N.S.W. species, E. sp. nov. (Webby & Morris, in press) from a limestone breccia in the upper part of the Malongulli Formation, has similar spacing of laminae but differs in having more sharply zigzagged laminae with gaps in lateral continuity which suggest they may form, in part, rod-like, as well as sheet-like laminar tissue. Also the coenosteal tissue generally is slightly thicker in E. undatum than in this N.S.W. species. The widely distributed type species E. fastigiatum (Nicholson 1886) from the Silurian of Britain, Estonia, the Pechora Basin of the U.S.S.R. and North America bears closer similarities to E. undatum but it too can be distinguished by having slightly wider spacing of laminae (10-12 in 2mm) and less conspicuous pillars (Nestor, 1964).
ACKNOWLEDGEMENTS

The authors have been aided by funds from the Australian Research Grants Committee (R.G.C. Grants No. B65/15286 and E75/15102). Mr. D.G. Morris has assisted in preparation of material and photography.

REFERENCES


Ordovician Stromatoporoidea from Tasmania

EXPLANATION OF PLATES

PLATE I.

Figs. 1-2. *Clathrodictyon idense* sp. nov.; holotype (UTGD 58125) from Ida Bay, X10. 1, longitudinal section. 2, tangential section.

Figs. 3-6. *Clathrodictyon molense* sp. nov.; holotype (UTGD 94622) from locality on roadside leading to quarry, west of The Den, Mole Creek. 3-4, longitudinal sections X10. 5, longitudinal sections showing detail of part of fig. 4, X20. 6, tangential section, X10.

PLATE II.

Figs. 1-5. *Clathrodictyon plicatum* sp. nov. X10. 1, vertical section of paratype UTGD 94623. 2, vertical section of paratype UTGD 94631, showing latilaminae with closed spaced laminae. Note possible foreign body around which new laminae are draped in the upper part of coenosteum. 3, vertical section of holotype UTGD 94626. Note dissepiments in areas of coenosteum showing widely spaced laminae. 4, tangential section of holotype UTGD 94626. 5, vertical-oblique section of paratype UTGD 94631 exhibiting in axial part of 'bulge' a *Plexodictyon*-like structure. Figs. 1, 3 and 4 are from an area just off the road near quarry west of The Den, and Figs. 2 and 5, from The Den, Mole Creek area.

All figures X10.

PLATE III.

Figs. 1-3. *Eooolimadictyon undatum* sp. nov. 1-2, vertical and tangential sections of holotype UTGD 94636, off road near quarry, west of The Den, Mole Creek area. 3, vertical section of paratype UTGD 94638 south-east of Westfield Rd., Florentine Valley area. Note patches of coenosteum are destroyed or silicified.

Figs. 4-5. *Clathrodictyon* sp., vertical and tangential sections of UTGD 94633 from The Den, Mole Creek area. Note latilaminae and tabulated caunopore tubes.
Ordovician Stromatoporoidea from Tasmania

Plate II
Silurian and Devonian Stratigraphy of the Zeehan Area, Tasmania

By

EDMUND D. GILL
Palaeontologist, National Museum, Melbourne

and

M. R. BANKS
Lecturer in Geology, University of Tasmania

(Read 1st November, 1949)

WITH 2 TEXT FIGURES AND 3 PLATES

The renewed exploration of the Zeehan Mining Field in Western Tasmania has led to a more detailed study of the geological structure of the area, and the authors have investigated recently the Middle Palaeozoic sequence of sedimentary rocks. After spending a week on the Gordon River studying the Cordon River Limestone (a key formation in West Coast stratigraphy), the limestone and succeeding formations were studied in the Zeehan area.

PHOTO-GEOLGY

The stratigraphic work described in this paper was based on a geological map of the area prepared from aerial photographs by Professor S. Warren Carey of the University of Tasmania. He recommended that the stratigraphic studies be based on a comparatively undisturbed area south of Zeehan rather than on the very faulted Zeehan area. This suggestion was adopted and the stratigraphic succession was determined, but the extremely rough nature of the country made the work very difficult and placed limitations on the amount of palaeontological material which could be collected. This work was therefore supplemented by the study of railway cutting sections and sections in the cleared country around Zeehan.

Three great advantages accrued from the use of the photo-geological map and the aerial photographs—

1. The map provided beforehand an idea of the structure, thus making simpler the planning and execution of the field work.

2. The country is very rough, and the aerial photographs made it possible to save a great deal of time and physical effort by showing the most suitable routes for traverses.

3. In the past, difficulty has been experienced by field geologists in describing localities in rough country of this kind. References are found in the literature to such temporary features as tracks and blazed trees. However, localities can be pin-pointed from the aerial photographs, and either transferred to a map, or a reference given relative to the centre point of an officially numbered and published photograph. In Tasmania these are supplied by the Department of Lands and Surveys. An index to fossil localities will be found as Appendix B.
Fig. 1.—Stratigraphy and Diastrophism.
**GEOLOGICAL SEQUENCE**

The stratigraphical succession is represented in fig. 1. This series of sedimentary rocks on the whole is a highly arenaceous one, even the limestone having sandy horizons. The strata are strongly folded, and regional metamorphism is present as a function of the competence of the beds. An average of eighteen measured dips in the Eden area gave the figure of 50°, and this was used in calculating the thicknesses of the formations. As all the dips are high, this method is not inaccurate. The average dip in the Zeehan area was 70°, this being due to the highly folded nature of that district.

In 1949 Loftus Hills and Carey put forward a tentative classification of the Silurian and Devonian rocks, which is now slightly modified (fig. 2) with their agreement as far as possible, the names already proposed have been retained, and at the same time the new code now being accepted taken into account (Glaessner, et al., 1948). The name 'Drumlin' was dropped because it is the name of a geological feature, and so likely to be confusing. The new names are 'Amber', after the Amber Rivulet which crosses this formation, and 'Florence' after a ridge of that name near Zeehan (see Plates II and III) consisting of rocks of that formation. The type section for all the Eldon Group formations discussed in this paper is in the vicinity of Eden Siding (see State Map 4M) about 10 miles south of Zeehan on the Zeehan-Strahan railway. This area is uninhabited and does not provide sufficient geographical names for formational names. Eden Siding is on the Gordon River Limestone.

<table>
<thead>
<tr>
<th>Present Classification</th>
<th>Earlier Classification</th>
</tr>
</thead>
<tbody>
<tr>
<td>BELL SHALE ± 1400'</td>
<td>BELL SHALES</td>
</tr>
<tr>
<td>FLORENCE QUARTZITE 1600'</td>
<td>DRUMLIN SANDSTONES</td>
</tr>
<tr>
<td>KEEL QUARTZITE 400'</td>
<td>KEEL FORMATION</td>
</tr>
<tr>
<td>AMBER SLATE 800'</td>
<td></td>
</tr>
<tr>
<td>CROTTY QUARTZITE 1600'</td>
<td>CROTTY SANDSTONES</td>
</tr>
</tbody>
</table>

Fig. 2.—Silurian and Devonian Formations.
The West Coast Range Conglomerate and the Gordon River Limestone formations have not yet been formally defined, but this is being done elsewhere and so these are not included in the Eden sequence of definitions.

**West Coast Range Conglomerate**

This formation constitutes some of the most prominent features of West Tasmanian geomorphology, but at the point of the section it has been planated with the rest of the formations during the development of the Henty Peneplain (Gregory, 1903). The relationship of the conglomerate to the Gordon River Limestone in this area was recognized by Waller in 1904, and was studied by the writers at an abandoned mine (loc. 77) about half a mile SSE. of Greive Siding. The spoil heaps show the presence of—

1. A quartzite which is undoubtedly the uppermost member of the West Coast Range Conglomerate formation, forming passage beds from the conglomerate into the limestone.
2. Re-crystallized limestone of a light bluish colour with some ferruginous staining.
3. Ore containing galena and sphalerite.

In the considerable changes of strike attendant upon the strong pitch of many of the folds in this area, the West Coast Range Conglomerate always remains in the same relationship with the limestone, indicating that the two formations are conformable. This was confirmed by further observations near Zeehan. The thickness of the formation shown in fig. 2 is Loftus Hills' and Carey's estimate for Mt. Zeehan (1949, p. 26).

**Gordon River Limestone**

In addition to the abovementioned limestone locality, this formation was studied in a ballast quarry (loc. 58) about 50 chains NE. of Greive Siding. Argillaceous and arenaceous impurities were observed in some of the beds, and some appear to contain carbonaceous material. Calcite veins are common, and pyritic inclusions occasional. Certain horizons are considerably leached, while others remain compact. The limestone is often sheared. This locality is stratigraphically low in the formation as it is near the base of the scarp formed by the West Coast Range Conglomerate formation. The limestone has a characteristic physiographic expression as a lowland, and judging by this criterion it has a thickness of the order of 2000 feet. Outcrops are difficult to obtain, but the proving of limestone at the two localities mentioned shows that its lower extent is approximately coincident with the eastern wall of the valley, and no reason suggests itself why the western wall of the valley should not likewise mark the upper extent of the limestone.

Fossils were obtained from this formation at loc. 58, but preservation was generally poor. The fossils, which were far from numerous, included tabulate corals, trepostomatous and cryptostomatous bryozoans, with very poorly preserved brachiopods and pelecypods and some well preserved ostracods. The genera identified are set out below—

Coelenterata: Favosites.
Polyzoa: Rhinidietya.
Polygona.

The trepostomatous types found were difficult to identify and work is proceeding on these. The brachiopods included a strophomenid and a rhynchonellid, but insufficient details were preserved to warrant identification. Rhinidietya is
found at Zeehan in association with *Tetradium tasmaniense* Chapman and other fossils of Upper Ordovician age and its occurrence at Eden suggests a similar age for the limestone there. If this is true, the base of the limestone at Eden would be high in the Ordovician. More work is needed before the point can be finally resolved.

**Eldon Group**

The formations of this Group in the Zeehan area in order are the Crotty Quartzite (lowest), the Amber Slate, the Keel Quartzite, the Florence Quartzite, and the Bell Shale (highest). (See figs 1 and 2.) These lithological units are now formally defined and described. The quartzites are of impure types.

**Crotty Quartzite**

The Crotty Quartzite hereby defined as a formation of some 1600 feet of quartzitic sedimentary rocks as mapped in Plate III, underlain conformably by the Gordon River Limestone and overlain conformably by the Amber Slate. The formation consists mostly of quartzites, but includes a thick band of quartzitic grit which in places becomes a fine conglomerate. The Crotty Quartzite is usually of a light greyish colour which weathers white at the surface. In places it has a pinkish hue which is not altogether lost on weathering and is characteristic of the lithology of the formation. The rocks are sometimes sheared, and thin milky veins are frequent. Cross-bedding is common.

This formation is a typically unfossiliferous one. Near Eden Siding poorly preserved brachiopods, lamellibranchs, crinoid stems, and tubicolar structures were recognized, but even generic determinations were difficult. As the matrix preserves so little detail, it is easy to confuse various types of tube-like structures, and the following generalisations have proved useful in the field:

1. Tube structures at right angles to the bedding planes, straight, and unbranching are generally the tubes of marine worms. These are discussed in an accompanying palaeontological paper (Gill, 1950).
2. Tube structures parallel to the bedding planes, sometimes straight and sometimes curved, but unbranching, are generally pieces of crinoid stem. Sometimes there is enough structure preserved to make out the columnals.
3. Tube structures which are branched. These are usually polyzoa.

From experience so far it would appear that the tubicolar quartzite in the West Coast Range Conglomerate is usually (if not always) of the first type, whereas in the Crotty Quartzite all three types are present. As these two formations are so sparsely fossiliferous, such distinctions are helpful in field work. The West Coast Range Conglomerate, being older than the Ordovician Gordon River Limestone, is probably too old to have either crinoids or polyzoa.

The Crotty Quartzite constitutes the ridge at Zeehan on which the Smelters' works are built. As the ridge is bare, and is excavated in places, it provides an excellent opportunity for studying a cross-section of the formation. The majority of the strata yielded no fossils, but one highly fossiliferous band (loc. 17) was found occurring along the crest of the ridge under the median grit, and at the Smelters' sand quarry (loc. 19) large and distinctive crinoid columnals were noted. Similar columnals were noted at loc. 3. The quartzites on top of the Smelters' ridge have been strongly leached, and in some places so de-silicified as to permit of the rock being readily broken down for sand. There is a similar quarry at the south end of Manganese Hill in Crotty Quartzite.
The coarse grit band characteristic of this formation can be clearly seen on the Smelters' ridge, most of it being of remarkably open texture. The examination of fresh rock from a deep railway cutting near the 22-mile post and from mine workings, and of mineralised rock as at the Central Balstrup Mine, indicates that the grit and conglomerate contain pebbles of many different kinds of rocks and minerals, and the open texture of the leached horizons is due to the removal thence of clay, silt (siltstone pebbles were noted in the fresh rock), and soluble minerals. Mr. J. J. Jenkin of the National Museum, Melbourne, tested the percentage by volume of insoluble matter in rocks from various horizons. Fresh Crotty Quartzite from the deep railway cutting at loc. 49 showed 88 per cent insoluble matter, while specimens of the leached rock from Smelters' ridge were practically 100 per cent insoluble matter. The high rainfall of this area (90-100 inches) causes strong leaching of the surface rocks. Another lithological feature of importance is that the rocks are mixedstones, i.e., consisting of both roundstones and sharpstones, which is characteristic of rapidly eroded sediments in a geosynclinal trough.

Other results of interest from Mr. Jenkin's tests are that the sample of rock from beside the Central Balstrup Mine contained 0.57 per cent of heavy minerals, a sample of Florence Quartzite from loc. 15 contained 94 per cent insoluble matter, a sample of Amber Slate from loc. 42, 93.5 per cent, and a sample of Bell Shale from loc. 16 had 82.4 per cent.

Waterhouse (1916) described some rather unfossiliferous rocks from near Trial Harbour, on the coast west of Zeehan, in the following terms: The rocks are invariably very siliceous sediments, white in colour, the predominating members being sandstones and grits, although sometimes coarser pebbles occur, giving the rock more the features of a conglomerate. Although hard and usually silicified, there appears to have been no crushing of the sediments. Individual particles vary in shape from angular to rounded. It is worthy of note that in many of the finer sandstones, as well as in the coarser grits, although the bulk of the rock is made up of glassy quartz, there are softer fragments which show signs of kaolinisation.

The striking feature of the rocks is the occurrence of abundant cavities, many of which are strongly suggestive of fossil impressions, although no definite fossils were found. Some of the cavities are quite irregular in shape, and are doubtless caused by the weathering out of some of the softer constituents of the rock; others are approximately circular in plan, but of small thickness, while others again suggest the forms of brachiopods, although the impressions are not sharp. Some of the cavities are circular or slightly oval in shape, but one-quarter of an inch in diameter, and have a small circular central pillar, i.e., the cavities are cylindrical. These cavities are very suggestive of crinoid stems. Although they do not appear to be common, one loose fragment of white sandstone was obtained which showed on weathered surfaces some irregular tubular casts up to about one inch in length all lying parallel with the bedding plane of the specimen. In general form they resemble the so-called "pipe-stems" of the tubicolar sandstone which is associated with (and later than) the West Coast Range Conglomerate in various localities on the West Coast. These casts, however, are rather more indefinite than typical "pipe-stems," and lie horizontally, and not perpendicularly, with reference to the bedding planes. The above description fits the Crotty Quartzite precisely, both in lithology and content. The cavities with the central pillar are clearly crinoid columnals. The one inch tubular casts are probably coprolitic, and are reminiscent of some found non in situ east of Johnston's Flat, near Zeehan, by Mr. Bruce Webb.
Amber Slate

The Amber Slate is hereby defined as a formation consisting of some 800 feet of grey slates (see Plate III), underlain conformably by the Crotty Quartzite and overlain conformably by the Keel Quartzite. There is much fine silica in these slates, which shows that they were siltstones before their regional metamorphism rather than claystones. The slates are generally highly fissile, and on weathering turn to a yellowish-brown, sometimes with pinkish and purplish hues. The formation is very uniform in its lithology.

North of Greive Siding, at the 22-mile post, the railway passes from the Gordon River Limestone of the valley into a high cutting which traverses Crotty Quartzite. Fossils were found at 460 feet and 1157 feet north of the 22-mile post. The railway then passes through Amber Slate, following this formation for about 1.5 miles. Four fossil localities were discovered (locs. 38, 41, 42, 47), and at the first three of these the true dip was obtained from the lay of the fossiliferous material, viz., 57° N., 25° N., and 32° N. respectively. This shows that the beds, although now in the form of slate, are actually conformable with the underlying Crotty Quartzite.

Keel Quartzite

The Keel Quartzite is hereby defined as a formation consisting of some 400 feet of quartzite as mapped in Plate III. This formation is conformably underlain by the Amber Slate and conformably overlain by the Florence Quartzite. The rock is a grey quartzite, and quite bluish when fresh. It weathers like the other quartzites to a whitish colour.

In the railway section north of Greive Siding already partly described, Keel Quartzite was noted above the Amber Slate. Well-defined ripple marks were observed in one bed. In the railway section somewhat shaley quartzites occur at the top of the formation, and this accounts for the valley between the Keel hogbacks and the Florence ridges.

The Keel Quartzite is very poorly fossiliferous.

Florence Quartzite

The Florence Quartzite is hereby defined as a formation consisting of some 1600 feet of quartzite as mapped in Plate III. It is conformably underlain by the Keel Quartzite, and conformably overlain by the Bell Shale. The quartzite is usually light grey in colour, but not infrequently stained yellowish-brown with iron oxide. Like the other quartzites, it weathers to a whitish rock except that there is still often some of the iron stain left. This is the only formation in the Eldon Group in this area containing any quantity of iron stain, and this fact was found useful as accessory evidence in the field.

The strata of this formation are highly fossiliferous, so much so that the rock must have been a calcareous sandstone originally, and even a sandy-limestone in places. All the calcareous matter is now leached away, so that the fossils are preserved in the form of casts and moulds. An enormous amount of calcium compounds must have been carried away by vadose waters.

It is to be noted that both the Florence Quartzite and the contiguous Keel Quartzite are arenite formations, but each has a very distinctive physiographic expression. The Keel Quartzite forms hogbacks—sharp, keel-like ridges—and hence the name of the Ridge from which the formation takes its name. The upper beds of this formation are physiographically weaker, so that a valley is always
formed in them, thus separating the two quartzite formations. The Florence Quartzite forms rounded ridges across which branch streams cut back, with the result that a number of drumlin-shaped eminences are formed, and hence the name originally given to this formation.

Bell Shale

The Bell Shale is hereby defined as a formation of the order of 1400 feet of siltstones, commonly with shaley fracture, and with interbedded quartzitic bands. The formation is conformably underlain by the Florence Quartzite, but is terminated above by a regional unconformity brought about by the Middle Devonian orogeny. This diastrophism is responsible for the folding and emergence of the formations described in this paper, and apparently also for the injection of the metalliferous lodes which caused mining at Zeehan to be undertaken. In the present state of our knowledge, there appears to be more diversity of lithology and faunal assemblages in the Bell Shale than in any of the other Eldon Group formations. This is probably connected with the movements which brought sedimentation to a close in this part of the Tasman Geosyncline. A hint has been given of a possible higher formation than the Bell Shale (L. Hills and Carey, 1949, p. 28) having a thickness of at least 3000 feet, but the field work just completed has proved that there are no beds in the type area younger than the Bell Shale.

There is considerable variation in the amount of regional metamorphism in the strata of this formation in the faulted Zeehan area, where slates occur in the proximity of large faults. In such localities the sandstones are strongly sheared, and the quartzite bands are buckled and broken. Some of the quartzitic horizons are very finely banded due not to laminated bedding but alternate fine layers of lighter and darker sediment. This feature has not been seen in any other formation of the Eldon Group.

Appendix A provides a table for the ready recognition in the field of the Eldon Group formations described above.

**Permian System**

Rocks of this system outcrop in railway cuttings and on the prominent hills on either side of the railway line on the Strahan side of Eden. They are faulted against formations of the Jicneec and Eldon Groups. The Permian rocks with their possibility of coal have received some attention from geologists in the past. Voisey (1938, p. 322) mentions them but was simply recording passages from Johnston (1891) who was the last geologist to make ground observations on them. The area occupied by the Permian was delineated by Carey in his photographical map. Insufficient time was available to make the definition of formations possible, and so the following are notes on outcrops studied.

At Firewood Siding (loc. 72), brown to grey micaceous sandstones outcrop. The sandstone is finely bedded, of medium grain size and extremely micaceous, the mica being of a clear variety. Plant fragments, although present, are not common, but carbonaceous laminae are well developed, particularly in finer grained sandstones. Current bedding is present in these finer sandstones, and all are jointed, the jointing dipping to the east.

In the creek bed to the north-east of the siding (loc. 71), a grey grit is found, and this contains medium-grained fragments of quartz and argillaceous material with a few fragments of plants up to one-quarter of an inch long, surrounded by iron staining, especially in the weathered zone. White mica is again present.
A prominent homoclinal ridge can be seen further to the north-east of the siding (loc. 70), and this proved to be due to a bed of white conglomeratic grit dipping 230° at 35°. This rock, like those already described, has an argillaceous cement. It is of a glistening white colour, and is composed of poorly rounded quartz pebbles up to 5 cm in diameter in a matrix of smaller sub-angular quartz and occasional argillaceous fragments, again with fine-grained clear micas. There is a rough alternation of pebbly and non-pebbly bands. Current bedding is very common, and in the main dips to the south but not invariably so. No fossils were found.

In the railway cuttings (locs. 73, 74, 75, 76) to the east of Firewood Siding, the main rock type is a fluvio-glacial siltstone with angular, rounded, and faceted pebbles of many rock types in a fine-grained brown matrix. The latter consists of argillaceous material with, however, an appreciable amount of quartz and occasional very fine grains of mica. The pebbles occur in irregular bands and lenses, and close to the top of the siltstone carbonaceous bands become common. The pebbles include quartz (especially near the top of the siltstone), quartzite, schists, and grey granite, one boulder of which was eight inches in diameter and markedly faceted. Fossils were found in two localities in this rock, and are sufficient to establish its Permian age, viz.:—

**Locality 75:**
- Brachiopoda *Martiniopsis oviformis* McCoy.
- *Spirifer duodecimcostata* McCoy.

**Locality 76:**
- Polyzoa *Fenestrellina* spp.
- *Polypora* sp.
- *Stenopora* sp.

- Brachiopoda *Martiniopsis subradiata* Sowerby.
- Mollusca *Merismopteria macroptera* (Morris).
- *Platyschisma oculus* Sowerby.
- *Comatula inornata* Dana.

The matrix at loc. 76 is the rock type described above, while that at loc. 75 is much fresher and of greenish grey colour. Preservation is such that specific identification of the bryozoa was precluded.

Correlation of these strata with other Permian sequences in Tasmania is difficult. They are somewhat different from most other Permian rock types in the possession of abundant mica flakes; although these are recorded from Prider’s Bronte Facies of the Marlborough Series (Prider, 1947, p. 133). The fossils are not of very great value for correlation. One of us (M.R.E.) has noticed, however, that the molluscs recorded from this locality are more common in the lower formations in the Hobart area than they are in the higher ones. These strata may be equivalent to the Clanton Formation of Eastern Tasmania, but the evidence is not yet sufficient for definite correlations.

**Structure and Diastrophism**

The Eldon Group strata of the Zeehan area are strongly folded, with considerable pitching, by compressive forces operating in a S.W.-N.E. direction. In the comparatively undisturbed area south of Zeehan, the folds pitch to the north-west, and this strong pitching gives the beds a very sinuous outcrop (see Plate I). The bedrock is traversed by many faults of different types and amount of throw. The faulting of this area has been considered to be connected with the Middle
Devonian diastrophic and metallogenetic period (e.g., Twelvetrees and Ward, 1910, Ward, 1911, L. Hills, 1921), the ores being regarded as differentiates from the Heemskirk granite massif. However, it should be noted that—

1. The fault affecting the Permian rocks in the south of the area is definitely of later age, and
2. L. Hills and Carey (1949, p. 38) state that it is possible that the Heemskirk granite is of Lower Carboniferous age.

It would appear that there are fault systems of various ages. A. priori one would expect faults to be associated with the original epi-Eldon folding, with the intrusion of the doleritic sills (Edwards, 1942), and with the Tertiary faulting held responsible for some of the massive grabens of Tasmania.

We wish to record our indebtedness to Professor Carey for suggesting this area to us as one worthy of attention and to him and North Broken Hill Pty. Ltd. for making available to us their maps and aerial photographs of the area studied. These facilitated the work considerably. Help in the area was made available through the courtesy of Dr. M. D. Garretty, and Mr. B. P. Webb, B.Sc. assisted us in the field and helped us to check in the immediate vicinity of Zeehan the criteria we had established near Eden. Mr. Ramsay Ford was a willing worker with us at all times during our visit, and lightened the burden of fossils for us on many occasions. Assistance in compilation and drafting was given by Mr. Bruce Ellis.

REFERENCES

EDWARDS, A. B., 1942.—Differentiation of the dolerites of Tasmania. J. Geol. 50, 451-480, 579-610.
GILL, E. D., 1956.—Preliminary Account of the Palaeontology and Palaeoecology of the Eldon Group Formations of the Zeehan Area, Tasmania. This volume.
## Appendix A

**Table for Recognition of Formations in the Field**

<table>
<thead>
<tr>
<th>Types of Evidence</th>
<th>Crotty Quartzite</th>
<th>Amber Slate</th>
<th>Keel Quartzite</th>
<th>Florine Quartzite</th>
<th>Bell Shale</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Lithology</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(a) Fresh rock</td>
<td>Light-grey and sometimes pinkish quartzite with mixed-stone grit to fine conglomerate of mixed rock and mineral types</td>
<td>Grey slates</td>
<td>Blush, light-grey, and dark-grey quartzite</td>
<td>Light-grey and yellowish-brown quartzite</td>
<td></td>
</tr>
<tr>
<td>(b) Weathered rock</td>
<td>Whitish and sometimes pinkish porous-quartzite to freestone</td>
<td>Yellowish-brown slates sometimes with pinkish or purplish hue</td>
<td>Whitish porous quartzite</td>
<td>Whitish or, sometimes yellowish-brown porous quartzite</td>
<td>Light- or dark-grey, yellowish-brown to reddish siltstones with quartzitic horizons, some finely banded</td>
</tr>
<tr>
<td>(c) Metamorphism</td>
<td>Sheared in places</td>
<td>Fissile slates, Fissile slates across cleavage</td>
<td>Sheared in places</td>
<td>Sheared in places</td>
<td>Little alteration on weathering</td>
</tr>
<tr>
<td><strong>Physiography</strong></td>
<td>Rounded ridges</td>
<td>Low relief Tendency to dendritic stream pattern</td>
<td>Sharp keel-like ridges (Hogbacks)</td>
<td>Rounded ridges</td>
<td>Low relief with quartzitic bands standing out as low ridges</td>
</tr>
<tr>
<td><strong>Palaeontology</strong></td>
<td>Camarataechia, synchococea Gill, Annelid tubes</td>
<td>Iheuropesulairia, Ostracod zones, Slender crinoid columns</td>
<td>No fossils yet specifically associated with this formation, its physiographic expression is its chief characteristic</td>
<td>Notoschoenichidium floracensu Gill Eutonia-pleonecta Gill Large actinopterid Masses of crinoid columns c. 1&quot; diam. Maaeristrophidium-Protoeleptostrophe plutea association</td>
<td>Cloaetes ruddochensis Gill Eospirifer parab淠iens Gill Leptocodia polyspora Gill Meristella bellensis Gill Notoschoenichidium floracensu Gill Plectoconus bipartita (Chapman) Prenitus corynops (McCoy) Crinoid columns with scalloped margins Land plants</td>
</tr>
<tr>
<td>(a) Index fossils and assemblages</td>
<td>Poorly fossiliferous</td>
<td>Sparsely fossiliferous</td>
<td>Poorly fossiliferous</td>
<td>Richly fossiliferous</td>
<td>Poorly fossiliferous</td>
</tr>
<tr>
<td>(b) Relative abundance of fossils</td>
<td>Poorly fossiliferous</td>
<td>Sparsely fossiliferous</td>
<td>Poorly fossiliferous</td>
<td>Richly fossiliferous</td>
<td>Poorly fossiliferous</td>
</tr>
</tbody>
</table>
## Appendix B

### Index to Fossil Localities

<table>
<thead>
<tr>
<th>Loc.</th>
<th>Ruhl</th>
<th>Photo</th>
<th>Dist.</th>
<th>Bearing</th>
<th>Co-ordinates</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>5</td>
<td>21646</td>
<td>9-9</td>
<td>58</td>
<td>5,060</td>
<td>1,730</td>
</tr>
<tr>
<td>2</td>
<td>6</td>
<td>21644</td>
<td>9-3</td>
<td>104</td>
<td>5,070</td>
<td>1,039</td>
</tr>
<tr>
<td>3</td>
<td>7</td>
<td>8-4</td>
<td>105</td>
<td>4,970</td>
<td>900</td>
<td>1,270</td>
</tr>
<tr>
<td>4</td>
<td>8</td>
<td>9-35</td>
<td>118</td>
<td>4,950</td>
<td>900</td>
<td>2,095</td>
</tr>
<tr>
<td>5</td>
<td>9</td>
<td>21646</td>
<td>5-6</td>
<td>52</td>
<td>4,580</td>
<td>2,095</td>
</tr>
<tr>
<td>6</td>
<td>10</td>
<td>6-55</td>
<td>29</td>
<td>4,210</td>
<td>1,557</td>
<td>1,010</td>
</tr>
<tr>
<td>7</td>
<td>11</td>
<td>21644</td>
<td>1-8</td>
<td>73</td>
<td>3,950</td>
<td>381</td>
</tr>
<tr>
<td>8</td>
<td>12</td>
<td>1-14</td>
<td>94</td>
<td>3,960</td>
<td>540</td>
<td>1,010</td>
</tr>
<tr>
<td>9</td>
<td>13</td>
<td>3-5</td>
<td>165</td>
<td>3,760</td>
<td>1,010</td>
<td>1,010</td>
</tr>
<tr>
<td>10</td>
<td>14</td>
<td>4-9</td>
<td>339</td>
<td>4,100</td>
<td>1,770</td>
<td>1,790</td>
</tr>
<tr>
<td>11</td>
<td>15</td>
<td>5-65</td>
<td>336</td>
<td>3,340</td>
<td>1,790</td>
<td>1,790</td>
</tr>
<tr>
<td>12</td>
<td>16</td>
<td>5-36</td>
<td>323</td>
<td>3,030</td>
<td>1,790</td>
<td>1,790</td>
</tr>
<tr>
<td>13</td>
<td>17</td>
<td>6-15</td>
<td>316</td>
<td>2,583</td>
<td>1,750</td>
<td>1,750</td>
</tr>
<tr>
<td>14</td>
<td>18</td>
<td>9-4</td>
<td>129</td>
<td>1,938</td>
<td>2,330</td>
<td>2,330</td>
</tr>
<tr>
<td>15</td>
<td>19</td>
<td>9-2</td>
<td>140</td>
<td>1,729</td>
<td>2,530</td>
<td>2,530</td>
</tr>
<tr>
<td>20</td>
<td>20</td>
<td>9-15</td>
<td>76</td>
<td>3,990</td>
<td>1,211</td>
<td>1,211</td>
</tr>
<tr>
<td>21</td>
<td>21</td>
<td>8-85</td>
<td>78</td>
<td>3,219</td>
<td>1,425</td>
<td>1,425</td>
</tr>
<tr>
<td>22</td>
<td>22</td>
<td>9-3</td>
<td>85</td>
<td>3,160</td>
<td>1,730</td>
<td>1,730</td>
</tr>
<tr>
<td>23</td>
<td>23</td>
<td>8-6</td>
<td>77</td>
<td>2,360</td>
<td>1,470</td>
<td>1,470</td>
</tr>
<tr>
<td>24</td>
<td>24</td>
<td>21662</td>
<td>8-34</td>
<td>341</td>
<td>-2,465</td>
<td>2,520</td>
</tr>
<tr>
<td>25</td>
<td>25</td>
<td>7-6</td>
<td>335</td>
<td>-2,545</td>
<td>1,417</td>
<td>1,417</td>
</tr>
<tr>
<td>26</td>
<td>26</td>
<td>21533</td>
<td>11-3</td>
<td>281</td>
<td>-2,908</td>
<td>737</td>
</tr>
<tr>
<td>27</td>
<td>27</td>
<td>9-8</td>
<td>77</td>
<td>-3,066</td>
<td>121</td>
<td>121</td>
</tr>
<tr>
<td>28</td>
<td>28</td>
<td>9-15</td>
<td>76</td>
<td>-3,190</td>
<td>138</td>
<td>138</td>
</tr>
<tr>
<td>29</td>
<td>29</td>
<td>8-85</td>
<td>78</td>
<td>-3,219</td>
<td>179</td>
<td>179</td>
</tr>
<tr>
<td>30</td>
<td>30</td>
<td>9-3</td>
<td>85</td>
<td>-3,160</td>
<td>55</td>
<td>55</td>
</tr>
<tr>
<td>31</td>
<td>31</td>
<td>8-7</td>
<td>77</td>
<td>-3,260</td>
<td>147</td>
<td>147</td>
</tr>
<tr>
<td>32</td>
<td>32</td>
<td>8-8</td>
<td>80</td>
<td>-3,260</td>
<td>216</td>
<td>216</td>
</tr>
<tr>
<td>33</td>
<td>33</td>
<td>6-6</td>
<td>84</td>
<td>-3,655</td>
<td>329</td>
<td>329</td>
</tr>
<tr>
<td>34</td>
<td>34</td>
<td>9-7</td>
<td>56</td>
<td>-3,765</td>
<td>2,665</td>
<td>2,665</td>
</tr>
<tr>
<td>35</td>
<td>35</td>
<td>21562</td>
<td>10-4</td>
<td>234</td>
<td>-3,330</td>
<td>3,500</td>
</tr>
<tr>
<td>36</td>
<td>36</td>
<td>19-10</td>
<td>235</td>
<td>-3,360</td>
<td>3,590</td>
<td>3,590</td>
</tr>
<tr>
<td>37</td>
<td>37</td>
<td>21562</td>
<td>241</td>
<td>-3,385</td>
<td>3,550</td>
<td>3,550</td>
</tr>
<tr>
<td>38</td>
<td>38</td>
<td>21562</td>
<td>6-95</td>
<td>38</td>
<td>-3,350</td>
<td>2,465</td>
</tr>
<tr>
<td>39</td>
<td>39</td>
<td>21533</td>
<td>1-15</td>
<td>35</td>
<td>-4,889</td>
<td>156</td>
</tr>
<tr>
<td>40</td>
<td>40</td>
<td>1-2</td>
<td>30</td>
<td>-4,620</td>
<td>199</td>
<td>199</td>
</tr>
<tr>
<td>41</td>
<td>41</td>
<td>21533</td>
<td>8-9</td>
<td>231</td>
<td>-4,400</td>
<td>2,975</td>
</tr>
<tr>
<td>42</td>
<td>42</td>
<td>5-85</td>
<td>50</td>
<td>-3,450</td>
<td>2,300</td>
<td>2,300</td>
</tr>
<tr>
<td>43</td>
<td>43</td>
<td>21533</td>
<td>2-7</td>
<td>335</td>
<td>-4,890</td>
<td>-69</td>
</tr>
<tr>
<td>44</td>
<td>44</td>
<td>2-35</td>
<td>331</td>
<td>-4,800</td>
<td>-9</td>
<td>-9</td>
</tr>
<tr>
<td>Loc.</td>
<td>Run</td>
<td>Photo</td>
<td>Dist.</td>
<td>Bearing</td>
<td>Co-ordinates</td>
<td>Notes</td>
</tr>
<tr>
<td>------</td>
<td>-----</td>
<td>-------</td>
<td>-------</td>
<td>----------</td>
<td>--------------</td>
<td>-------</td>
</tr>
<tr>
<td>45</td>
<td>2</td>
<td>21533</td>
<td>1-95</td>
<td>334</td>
<td>-4,856</td>
<td>452</td>
</tr>
<tr>
<td>46</td>
<td>..</td>
<td>21530</td>
<td>6-65</td>
<td>356</td>
<td>-5,806</td>
<td>173</td>
</tr>
<tr>
<td>47</td>
<td>..</td>
<td>21530</td>
<td>6-55</td>
<td>346</td>
<td>-5,806</td>
<td>2,119</td>
</tr>
<tr>
<td>48</td>
<td>..</td>
<td>21530</td>
<td>6-55</td>
<td>346</td>
<td>-5,806</td>
<td>2,355</td>
</tr>
<tr>
<td>49</td>
<td>..</td>
<td>21530</td>
<td>5-59</td>
<td>331</td>
<td>-4,650</td>
<td>2,510</td>
</tr>
<tr>
<td>50</td>
<td>..</td>
<td>5-1</td>
<td>038</td>
<td>010</td>
<td>-5,510</td>
<td>2,640</td>
</tr>
<tr>
<td>51</td>
<td>..</td>
<td>21533</td>
<td>2-1</td>
<td>306</td>
<td>-5,790</td>
<td>-554</td>
</tr>
<tr>
<td>52</td>
<td>..</td>
<td>2-4</td>
<td>306</td>
<td>010</td>
<td>-5,770</td>
<td>-554</td>
</tr>
<tr>
<td>53</td>
<td>..</td>
<td>5-55</td>
<td>305</td>
<td>010</td>
<td>-5,800</td>
<td>-565</td>
</tr>
<tr>
<td>54</td>
<td>1</td>
<td>21436</td>
<td>12-14</td>
<td>120</td>
<td>-5,800</td>
<td>-510</td>
</tr>
<tr>
<td>55</td>
<td>2</td>
<td>21550</td>
<td>6-65</td>
<td>306</td>
<td>-5,920</td>
<td>2,395</td>
</tr>
<tr>
<td>56</td>
<td>1</td>
<td>21436</td>
<td>10-25</td>
<td>344</td>
<td>-6,240</td>
<td>-606</td>
</tr>
<tr>
<td>57</td>
<td>..</td>
<td>21436</td>
<td>7-15</td>
<td>57</td>
<td>-6,460</td>
<td>1,663</td>
</tr>
<tr>
<td>58</td>
<td>2</td>
<td>21530</td>
<td>2-1</td>
<td>216</td>
<td>-6,580</td>
<td>3,890</td>
</tr>
<tr>
<td>59</td>
<td>1</td>
<td>21436</td>
<td>7-9</td>
<td>119</td>
<td>-6,660</td>
<td>-1,218</td>
</tr>
<tr>
<td>60</td>
<td>..</td>
<td>5-65</td>
<td>103</td>
<td>103</td>
<td>-6,680</td>
<td>-1,546</td>
</tr>
<tr>
<td>61</td>
<td>..</td>
<td>3-6</td>
<td>117</td>
<td>218</td>
<td>-7,050</td>
<td>-1,460</td>
</tr>
<tr>
<td>62</td>
<td>..</td>
<td>5-8</td>
<td>144</td>
<td>144</td>
<td>-6,940</td>
<td>-1,060</td>
</tr>
<tr>
<td>63</td>
<td>..</td>
<td>21432</td>
<td>4-1</td>
<td>108</td>
<td>-6,850</td>
<td>2,456</td>
</tr>
<tr>
<td>64</td>
<td>..</td>
<td>4-15</td>
<td>129</td>
<td>129</td>
<td>-6,600</td>
<td>2,398</td>
</tr>
<tr>
<td>65</td>
<td>..</td>
<td>4-8</td>
<td>180</td>
<td>180</td>
<td>-7,160</td>
<td>2,340</td>
</tr>
<tr>
<td>66</td>
<td>..</td>
<td>4-8</td>
<td>180</td>
<td>180</td>
<td>-7,210</td>
<td>2,550</td>
</tr>
<tr>
<td>67</td>
<td>..</td>
<td>5-2</td>
<td>160</td>
<td>160</td>
<td>-7,260</td>
<td>3,609</td>
</tr>
<tr>
<td>68</td>
<td>..</td>
<td>5-4</td>
<td>166</td>
<td>166</td>
<td>-7,300</td>
<td>3,070</td>
</tr>
<tr>
<td>69</td>
<td>..</td>
<td>5-4</td>
<td>166</td>
<td>166</td>
<td>-7,350</td>
<td>3,055</td>
</tr>
<tr>
<td>70</td>
<td>..</td>
<td>21436</td>
<td>2-75</td>
<td>356</td>
<td>-7,650</td>
<td>-2,105</td>
</tr>
<tr>
<td>71</td>
<td>..</td>
<td>2-90</td>
<td>330</td>
<td>330</td>
<td>-7,850</td>
<td>-2,040</td>
</tr>
<tr>
<td>72</td>
<td>..</td>
<td>3-70</td>
<td>325</td>
<td>325</td>
<td>-7,950</td>
<td>-2,120</td>
</tr>
<tr>
<td>73</td>
<td>..</td>
<td>4-4</td>
<td>251</td>
<td>251</td>
<td>-7,500</td>
<td>-1,580</td>
</tr>
<tr>
<td>74</td>
<td>..</td>
<td>2-7</td>
<td>250</td>
<td>250</td>
<td>-7,900</td>
<td>-1,295</td>
</tr>
<tr>
<td>75</td>
<td>..</td>
<td>2-8</td>
<td>236</td>
<td>236</td>
<td>-8,000</td>
<td>-1,132</td>
</tr>
<tr>
<td>76</td>
<td>..</td>
<td>5-45</td>
<td>222</td>
<td>222</td>
<td>-8,100</td>
<td>-908</td>
</tr>
<tr>
<td>77</td>
<td>..</td>
<td>5-91</td>
<td>242</td>
<td>242</td>
<td>-8,150</td>
<td>3,745</td>
</tr>
</tbody>
</table>

* Loc. is locality number shown on Plates II and III. *
* Run refers to aerial survey photo runs. All runs are in the Zeehan Quadrangle. *
* Distance is measured from centre of photo quoted. *
* Bearing is taken from line joining centre of the photo quoted and the next photo west, and is measured in a clockwise sense. *
* Co-ordinates refer to Mt. Zeehan and North and East are taken as the positive directions and are measured in yards. *
PLATE I

Two aerial photographs of Zeehan Run 1, nos. 23431 (top), 23432 (bottom), to show the structure near Eden. Arranged for stereoscopy and published by courtesy of the Lands and Surveys Department, Hobart.

(Note.—The top of the page is east.)
SILURIAN AND DEVONIAN SYSTEMS
By MAXWELL R. BANKS

ADELAIDE
SOUTH AUSTRALIA
1962
IV

SILURIAN AND DEVONIAN SYSTEMS

By MAXWELL R. BANKS

with contributions from E. D. GILL and K. L. BURNS

The rocks of the Silurian and Devonian Systems may best be considered under four headings: the Eldon Group, the Mathinna Beds, the Spero Bay Group and the Eugenana Beds. These units differ in gross lithology, are not in contact and, except possibly for the first two, differ in age.

ELDON GROUP (E. D. GILL)

This group was recognised as an entity by Gould (1866) and defined by Gill and Banks (1950). The history of its nomenclature was considered by Smith (1959). It rests on the Junee Group with conformity (Gill and Banks, 1950) or disconformity (Bradley, 1954). The group occupies the axial region of synclines in central, western and north-western Tasmania (Fig. 23).

SUCCESSION

The six constituent formations are from the base upwards—Crotty Quartzite, Amber Slate, Keel Quartzite, Austral Creek Siltstone, Florence Quartzite and Bell Shale (Fig. 24). The rocks outcrop in high rainfall areas and deep leaching produces big differences between the lithology in outcrop and that at depth. Quartzites weather to sandstones at the surface.

Crotty Quartzite

This formation, 1600 feet thick near Zeehan, has the coarsest sediments of the group and consists of quartzite with some pebbly bands and some siltstones. The unwashed character of the coarsest sediments is shown by the inclusion of pieces of country rock (much of it kaolinized) and the admixture of angular and polycyclic rounded quartz grains. Cross-bedding is common. The commonest fossil found is the coarse-ribbed, heavy Camarotoechia synchoneua, a...
Fig. 23. Distribution of Middle Palaeozoic rocks (Banks).
# MIDDLE PALAEOZOIC CORRELATION TABLE

<table>
<thead>
<tr>
<th></th>
<th>ELDON GROUP 5800+ ft.</th>
<th>SPERO BAY GROUP 2000+ ft.</th>
<th>MATHINNA BEDS</th>
<th>EUGENANA Beds</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>DEVONIAN</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Famennian</td>
<td>Bell Shale (1400 ft.)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Frasnian</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Givetian</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Eifelian</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Emsian</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Siegenian</td>
<td>Clearwater Bay Sandstone (270 ft.)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Gedinnian</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

| **SILURIAN** |                        |                           |               |               |
| Ludlow | Austral Creek Sandstone (200 ft.) |               |               |               |
| Wenlock | Keel Quartzite (200 ft.) |               |               |               |
| Upper | Amber Slate (800 ft.) |               |               |               |
| Llandovery Middle | Crotty Quartzite (1600 ft.) |               |               |               |
| Lower |                        |                           |               |               |

Whitehorses Beach Sandstone (210 ft.)
Red Reef Cliff Sandstone (220 ft.)
Sanctuary Bay Sandstone (800 ft.)
Point Hibbs Limestone (570+ ft.)
Helicothyrion, Philosphistia, etc.
Clearwater Bay Sandstone (270 ft.)

Fig. 24. Correlation of Middle Palaeozoic rocks (Banks).
shell typical of a sandy environment. The sediments were deposited rapidly without much washing, and carry a benthos of sand shells and sand worms ("tubicolar sandstone").

Banks comments: "Crinoid columnals characteristic of the Crotty Quartzite at Zeehan (Gill, 1950, p. 240) have been recognised in a sandstone at Heazlewod and as discoidal impressions at Calders Pass (Ward, 1909). Available fossil evidence indicates a post-Ordovician and pre-Ludlow age. Opik (1951) considered it Lower and Middle Llandoverian as it underlies beds with Gillatia which he considered Upper Llandoverian. The overlying beds in the Loddon River area contain Cyrtograptus and are therefore Wenlockian. Thus a Llandoverian age is likely." Wells (1955) discovered Monograptus of the halli type in beds thought to be Crotty Quartzite at Thirkell Creek in the Loddon River area.

**Amber Slate**

In contrast with the underlying formation, this unit, 800 feet thick in the type area, consists of fine-grained sediments containing pelagic fossils which occur in vast numbers in narrow bands. *Tentaculites* and ostracods respectively constitute such bands. Opik (1951) recorded, from just south of the Smelters, Zeehan (close to the base of the formation, M.R.B.) *Gillatia* which he described from the Upper Llandoverian "Illaenus Band" at Heathcote, Victoria (Opik, 1953).

Limestones have been recorded from this formation at Queenstown (Banks, 1957) but Wade and Solomon (1958, p. 378) seem to place the limestones in the Keel Quartzite.

Strata near the Adam Range in the Loddon River area thought to be equivalent to the Amber Slate yielded to I. Threadgold a *Cyrtograptus* of Wenlockian age (Thomas, 1960, p. 15).

**Keel Quartzite**

This poorly fossiliferous formation, 200 ft. thick in the type area, originated as ripple-marked, shallow-water dirty sands. It forms characteristic hog-backs in western Tasmania (Gill and Banks, 1950). It underlies Lower Devonian beds and overlies Wenlockian beds and may be Upper Wenlockian or Ludlovian.

**Austral Creek Siltstone**

The term "Hill Shale" was used by Taylor (see Smith, 1957) for a shale formation 700 feet thick overlying the Keel Quartzite and underlying the Florence Quartzite in the Huskisson River area north-east of Zeehan. Gill and Banks (1950, p. 265) referred to this unit as "shaly quartzites" at the top of the Keel Quartzite and Blissett who named the unit "Austral Creek Siltstone" estimates its thickness south of Zeehan at 200 feet.

In referring to this unit south of Duck Creek, Blissett states: "The Austral Creek Siltstone consists of less than 50 feet of thinly-bedded pale grey and greenish quartzites and siltstones at the base, overlain after a stratigraphic gap
of 100 feet by similar rocks less than 250 feet thick and containing moulds of brachiopods." M. R. Banks discovered *Monograptus colonus* of Lower Ludlovian age (Thomas, 1960, p. 15) in fawn siltstones, on the Lyell Highway fifteen miles from Queenstown in a faulted area between the sandstone at Victoria Pass referred to the Crotty (Bradley, 1954) and the beds with the Florence fauna on the Lyell Highway (Gill, 1948b). The writer recognized *Nucleospira* s.s. in these beds. The stratigraphic position of these beds is not clear and they may correlate with either the Austral Creek Siltstone or the Amber Slate.

**Florence Sandstone**

This formation of arenaceous sediments, 1600 feet thick near Zeehan, is highly fossiliferous, abounding in impressions of brachiopods (which predominate), lamellibranchs and polyzoans. Masses of crinoid columnals and isolated calical plates at some horizons attest strong colonies of these organisms. The disruption of the crinoids indicates the presence of quite strong currents. Graded bedding in a sandstone with a closed framework has been recognised at the Silver Bell railway cutting south of Zeehan.

This formation is referred to the Devonian because it contains *Maorisphoria*, *Protoleptostrophia*, *Eatonia* and other Devonian genera. *Notoconchidium* (Gill, 1951), an index fossil for the formation, is also an index fossil in the Lower Devonian Mt. Ida beds (with *Pleurodictyum*, *Eatonia*, *Maorisphoria* and *Protoleptostrophia*) in the Heathcote district, Victoria (Thomas, 1937).

Beds on the Lyell Highway twelve miles from Queenstown (Gill, 1948b) referred to as the Florence Quartzite also contain *Pleurodictyum*, *Protoleptostrophia* and *Eatonia*. *Encrinurus* also occurs but the survival of this genus into the lowest Devonian has been recorded elsewhere. The Florence Quartzite probably belongs to the base of the Devonian, accepting the base of this system as the base of the Ludlow Bone Bed in the Welsh Borderland.

**Bell Shale**

Bands of silicified sandstone (quartzite in the broad sense used in this section) are interleaved with the shales of this formation and each rock type contains fossils typical of the facies. The formation is more than 1400 feet thick in the type area near Zeehan. The fauna, like that of the Florence, is mostly shelly but there are some trilobites, a few corals (*Pleurodictyum* and *Lindstroemia*), and land plants. These last occur at certain horizons as very numerous fragments of vascular plants accompanied by a few marine fossils. A river eroding a vegetated delta could account for this abundance of land plants in a marine bed.

The Bell Shale is classified as Devonian because it contains *Pleurodictyum*, not known in strata older than Devonian (Hill, 1957). *Australocoelia* (Boucot and Gill, 1956) a Lower Devonian genus known from South Africa, South America and Australia, *Notoleptaena* (Gill, 1951) known from the Lower Devonian of Australia and Europe (Kozlowski, 1929, pl. 3, figs. 24-26; Pajchlowa,
1957) and *Maoristrophia* (Allan, 1947) known also from the Lower Devonian of New Zealand and Victoria (Gill, 1952). The faunas of the Florence Quartzite and the Bell Shale have been compared with those of strata below the limestone at Lilydale, Victoria, the type area for the Yeringian stage.

**SEDIMENTATION**

Over 5000 ft. of sediments were deposited in Silurian and Lower Devonian time near Zeehan and over 12,000 ft. near Queenstown in a miogeosyncline (Gill, 1958). The sediments show a marked oscillation between sand and silt grade (Gill, 1950a, fig. 1) with a conglomerate member only in the lowest formation. The change from one formation to the next is distinct, so that the change in sedimentation was due to alteration in the environment, presumably by tectonic movements. The sediments consist of shelf-type deposits, the coarsest sediments belonging to disturbed near-shore and to moderately deep waters, and the finer sediments to deeper, quieter waters. In the Zeehan area arenaceous beds predominate, being about twice the thickness of the lutaceous beds. Due to incompetence of the latter, their present thickness is very different from the original thickness of sediment deposited.

**MATHINNA BEDS (M. R. BANKS)**

The terms, Mathinna Beds, is applied to all pre-Permian sediments in North-Eastern Tasmania. Gould (1864, p. 4) first gave a formal name, Fingal Schists, to these rocks and the name “Mathinna. Slates and Sandstones” was first used by Twelvetrees (1904, p. 2). From 1898 to 1938 they were generally regarded as Ordovician, partly by analogy with Victoria (Selwyn, 1855) but have also been considered as Precambrian (Nye, 1925), Cambrian (Nye and Lewis, 1928) and Siluro-Devonian (Carey, 1947a; Thomas, 1948; Gill, 1958).

**STRATIGRAPHY**

The Mathinna Beds consist of sandstone, siltstone and claystone, or their metamorphic equivalents and outcrop from Beaconsfield to the east coast and from the north coast to Maria Island (Fig. 23). The unit is at least 6000 feet thick but the total thickness is unknown.

Reports of limestone (Strzelecki, 1845), conglomerate (Johnston, 1888) and volcanic rocks (Twelvetrees, 1900; Reid, 1926; Reid and Henderson, 1929) have not been confirmed by later work and are open to doubt.

Two sedimentary associations may be recognised: (a) the lutite association, consisting dominantly of lutite, with a subordinate arenite component, (b) the arenite-lutite association, consisting of sandstone or coarse siltstone grading up into fine siltstone or claystone in most places, the latter being equal or subordinate in thickness to the former. The lutite association occurs between Nabowla and Lebrina, on the western side of the Lisle Valley, at Bangor, near the Mt. Barrow turn-off on the Tasman Highway and eastward to St. Patricks River and at Burns Creek. It has been referred to as Lisle Slate and Bangor
Slate. The arenite-lutite association occurs widely in north-eastern and eastern Tasmania (Fig. 23), and includes the Fingal Beds, Mathinna Slate and Quartzite, Scamander Slate and Quartzite and Grubb Beds.

No contact between the two associations has been found. On the Mt. Barrow Road structural considerations suggest that the lutite association is the older. In the Tasmania Mine, Beaconsfield, the Gordon Limestone is followed by about 200 ft. of black slightly micaceous shale and then by the Grubb Beds (Green, 1959, p. 7). If the shale can be correlated with the lutite association and the Grubb Beds with the arenite-lutite association, the former is the older. This discussion assumes that each association is a formation but they may well be interbedded with one another or facies equivalents. Only detailed structural and stratigraphic work will solve this problem.

In view of the uncertainties noted above and lack of type areas with defined top and bottom, it is considered better to refer to these rocks as “Beds” rather than as a formation or group as has been done earlier (see Smith, 1959).

SEDIMENTATION

The conditions of deposition of the arenite-lutite association have recently been described by Williams (1959) from exposures at Upper Scamander and similar conditions may be adduced for all occurrences of this association because outcrops at Weymouth, south of Lebrina, Lilydale, the Sidling, Telita Siding, Gladstone, Ormley, Mangana, Mathinna, Elephant Pass and Bicheno show similar rock types and sedimentary structures. Williams deduced that the normal deposits in the Upper Scamander area were clay and fine silts. Normal deposition was interrupted from time to time by turbidity currents from the south-west bringing in sand, silt, fragments of vascular plants and fragments of shallow water marine fossils. Observations elsewhere by Williams and others indicate that other current directions are also present. Gill (1958, p. 106) deduced from the absence of macroscopic benthos and lack of disturbance of the fine laminations, deposition in quiet, probably deep water. During deposition of the lutite association the source area was probably more stable than during formation of the arenite-lutite association, and the material available for transport finer grained.

FOSSILS AND AGE

Fossils have been found only in the arenite-lutite association. The earliest record is by Thureau (1882) of a graptolite from Lisle but this was rejected by Hall (1902). Johnson noted the presence of Anodonta and plant fragments near Fingal (1888, p. 67) but the specimens are missing and the locality has not been rediscovered. Blake discovered Hostimella and other vascular plants at Telita Siding near Branxholm in 1934 and these were described by Cookson (1937). Fragments of vascular plants have since been found at the Sidling, Ormley, Scamander, Upper Scamander, and Elephant Pass. At Weymouth a Chondrites-like organism occurs in the claystone portion of a sedimentary unit. Marine fossils were found at Scamander in 1949 and include ramose colonial
corals, probably favositids, polyzoa, brachiopods including strophomenids, and
crinoid columnals.

*Hostimella* occurs in lithologically-similar Silurian and Lower Devonian
rocks in Victoria, and similar plant fragments occur in the Eldon Group on the
Gordon River and in the Bell Shale near Zeehan. The marine fossils are frag-
mentary and identification is difficult, but they are not inconsistent with a
Silurian or Devonian age. At Beaconsfield and Flowery Gully just south of
Beaconsfield lithological correlates of the Mathinna Beds conformably (Green,
1959) or disconformably (Noakes *et al.*, 1954) overly the Gordon Limestone of
Ordovician age. Superposition of Mathinna Beds on the Jumna Group in this
area was first recognised by Nye (see Thomas, 1948). Thus several lines of
evidence suggest a Silurian or Devonian age for this formation and equivalence
with the Eldon Group (Thomas, 1948).

**SPERO BAY GROUP (M. R. BANKS)**

Gould (1866) assigned a limestone at Point Hibbs to the Gordon Limestone
as did Hills (1914b), who noted the association of other sediments with lime-
stone. Hill (1942) recorded Devonian corals from the limestone. Banks (1957)
suggested that the limestone might be a lens in the Bell Shale.

The limestone, Pt. Hibbs Limestone, is part of a succession, at least 2000
feet thick, composed dominantly of sandstone which outcrops along the shore-
line for several miles north of Point Hibbs and along the northern shore of
Spero Bay, east of Point Hibbs. The succession rests unconformably on Pre-
cambrian and Cambrian rocks and is faulted against Permian rocks. The
succession is younger than the Eldon Group and is probably late Lower
Devonian and early Middle Devonian.

A basal siliceous conglomerate, 20 feet thick, is overlain by about 50 feet
of well-sorted, quartz-rich sandstone showing torrential cross-bedding indicating
currents from just north of west. This sandstone unit is overlain by finer-
grained, cross-bedded sandstone and thinly bedded siltstone with a total thickness
of about 130 feet.

This sandstone formation is overlain by the Point Hibbs Limestone, a
formation at least 570 feet thick, composed mainly of limestone but containing
subordinate calcareous siltstone, dolomitic limestone and siliceous conglomerate.
At the northernmost outcrop the sandstone is overlain by 200 feet of limestone
including beds very rich in *Girvanella* and the limestone by a bed 20 feet thick
of pink to red siliceous conglomerate. This conglomerate also extends down
into the limestone as “dykes” which expand irregularly at their lower ends. The
“dykes” appear to be sandy gravel infillings of channels and caves eroded in the
recently deposited limestone. The conglomerate is overlain by less than 100
feet of limestone, faulted against Cambrian rocks. A little further south the
sandstone formation is overlain by about 200 feet of richly coraline limestone
at the top of which is a few feet of dolomitised limestone, then the red siliceous
conglomerate, here 40 feet thick. The conglomerate is overlain by about 100
feet of limestone faulted against Cambrian rocks. Just north of Point Hibbs the
limestone is faulted against Permian rocks. The lower 320 feet of limestone are richly coralline limestone lenses in calcareous siltstone. Near the base *Pseudoplexus* is common but higher favositids become the dominant corals. The favositids include *Favosites? bryani*, *F. goldfussi* (Hill, 1942), and *Thamnopolis*. The associated corals include large *Rhizophyllum*, *Radiophyllum*, *Tryplasma*, *Heliophyllum? chillagoense* (Hill, 1942), syringoporids and numerous *Aulopora* including one comparable to *conferta*. The associated fauna contains common trepostomatous polypoa, rare fenestellids, rhyynchonellids, strophomenids, spiriferids including *Atrypa*, *Cyrtina cf. hamiltonensis* and *Acrospirifer*, a few pectinaceans, rare gastropods, a few *Tentaculites*, actinoceroids, a few calymenids, lichadids, proetids and crinoid columnals. The coralline beds are overlain by 30 feet of light grey, fine-grained limestone, 32 feet of dolomitised limestone and 190 feet of light grey, thinly bedded limestone with *Girvanella*, stromatoporoids and turreted and eumphalid gastropods. The Point Hibbs Limestone is Devonian as suggested by Hill (1942) and is probably Upper Lower Devonian or Middle Devonian.

Above the limestone is a sandstone formation about 800 feet thick. The sandstone is well-sorted, cross-bedded and quartz rich. The formation contains subordinate siltstone and conglomerate beds. The cross-bedding indicates currents of easterly derivation in most cases but some from the south-west are also recorded. The only fossils present are fucoidal markings and worm-castings.

The next formation consists of 220 feet of red fine-grained sandstone with subordinate coarser red sandstone and red conglomerate. It outcrops on the northern shore of Spero Bay. The sediments occur in 29 complete or incomplete cycles, units of the cycles being in order of decreasing grainsize upwards. A number of the sandstone beds and rare conglomerate beds show cross-bedding of easterly derivation. The conglomerate contains fragments of Cambrian rocks. The top formation is at least 210 feet thick and consists of well-sorted, quartz-rich sandstone with subordinate siltstone and conglomerate. Cross-bedding in the sandstones is of easterly derivation. A fossiliferous bed near the top of the formation contains orthids and spiriferids, *Tentaculites* and orthoconic cephalopods.

**EUGENANA BEDS (M. R. BANKS AND K. L. BURNS)**

In 1953 K. G. Brill recognised cave deposits in the Gordon Limestone in the western quarry of the Hallet's Limeworks at Eugenana. The deposits consist of sandstones, carbonaceous siltstones and cave breccias and contain no macro-fossils.

Spore analysis indicates that the carbonaceous siltstone is Devonian, probably Upper Middle Devonian (Balme, 1960). The spores include *Punctatissporites*, *Apiculatisporis*, *Calamospora*, "Radiospora", cf. *Brochotriletes*, *Stenozonotriletes*, *Spinizonotriletes*, and cf. *Endosporites*.

Structures in the Eugenana quarries show that the Gordon Limestone had been subjected to three episodes of folding on two trends, uplifted and eroded prior to deposition of the Eugenana Beds. As the Eldon Group is concordant
with the Gordon Limestone all the folding must have occurred after deposition of the Bell Shale in Lower Devonian time. The cave deposits are almost horizontal and detailed work by Burns has revealed no evidence of tectonic folding although slump folding or convolute bedding is present.

SYNTHESIS (M. R. Banks)

Uplift of a source area in western or north-western Tasmania is indicated by the change from limestone deposition in the Ordovician to sandstone and pebbly sandstone deposition in the Lower Silurian. This uplift may be associated with the Benambran Orogeny and the Crotty Quartzite regarded as a distal orogenic formation (Örik, 1951, p. 3). Rolled fragments of Gordon Limestone in the Crotty Quartzite at South Queenstown (Bradley, 1954, p. 201), the disconformity at Flowery Gully (Noakes et al., 1954) and the faulting associated with it suggest some tectonic activity in Upper Ordovician or Lower Silurian time with uplift of some part of the Asbestos Range Geanticline.

In western Tasmania deposition occurred on a mildly unstable shelf, close, at times, to the source area. The Crotty Quartzite appears to reach a maximum thickness south of Zeehan and south and east of this area the thickness decreases (Bradley, 1954, p. 202); thicknesses are: Duck Creek, 80 ft.; south of Zeehan, 1600 ft.; Queenstown, 1000 ft.; Crotty, 800 ft. Associated with this variation in thickness is a decrease in maximum grainsize from Duck Creek to Zeehan to Queenstown and Crotty. At Duck Creek conglomerate is common, at Zeehan and Queenstown it forms a small proportion of the section and is lacking at Crotty and is not reported east of Rosebery. Indeed, at Crotty the sandstones are calcareous and, on the Nelson River, further east, impure limestone occurs in the Crotty Quartzite (Bradley, 1954, pp. 200-201). These observations suggest a westerly or north-westerly source but Jennings (1955, p. 174) also reported gritty and conglomeratic bands in the basal formation near Maydena. The Amber Slate appears to thicken from Zeehan to Queenstown (south of Zeehan, 800 ft.; Queenstown, 900 ft.) and was formed in quieter, water than was the Crotty Quartzite as shown by the comparative lack of wave and current structures. This, with the decrease in grainsize, suggests either rise in sea-level or sinking of the sea floor. Subsequently the Keel Quartzite spread as a thin sandy sheet over an area at least from Duck Creek and the Huskisson River to Crotty and areas to the east. Increase in grainsize suggests uplift of the source area. Deposition of the Austral Creek Siltstone probably took place in relatively deep water during reduction in relief of the source area. The Florence Quartzite marks uplift of the depositional interface to shallower water where stronger current activity produced sands with cross-bedding, ripple marking, broken pelagic shells and disrupted crinoids. The Florence Quartzite grades up into the Bell Shale and the decrease in grainsize suggests slow sinking of the depositional interface. During deposition of the Bell Shale turbidity currents brought in slightly coarser sediment and shallower water shells from time to time as shown by the occurrence near Zeehan (loc. 6, Gill and Banks, 1950) of graded beds of the same type as seen in the Mathinna Beds at Upper
SILURIAN AND DEVONIAN

Scamander. There appears to be an overall increase in proportion of lutites in the group from Zeehan to Queenstown (compare thickness quoted by Gill and Banks (1950) with those of Wade and Solomon (1958)) again suggesting a westerly or north-westerly source. The Bell Shale east of Queenstown (King River Slate, Ward, 1908b) is very thick.

While the Eldon Group in western Tasmania was being deposited on a mildly unstable shelf the Mathinna Beds were being deposited in deeper water further offshore. The lutite association may be Ordovician as was suggested in principle by Green (1959, p. 8) and this would be consistent with the quiet deposition during the Ordovician as shown by the great thickness of almost pure Gordon Limestone. Increase in, or commencement of, instability late in the Ordovician or early in the Silurian is suggested by the succession at Flowery Gully and continuation of instability during the Silurian and Devonian is indicated by the frequency of turbidity current activity in the arenite-lutite association. Instability has also been suggested for the Eldon Group (Gill, 1950a).

Deposition of marine beds in western Tasmania continued well into the Lower Devonian and the Eldon Group and Mathinna Beds were folded prior to intrusion of Middle Devonian granite at Coles Bay (Riley, this volume) and Lower Carboniferous granite at Trial Harbour and Coles Bay (Evernden and Richards, 1962).

Late in the Lower Devonian a basin of deposition developed at Point Hibbs. Deposits in this basin are of shallow water origin throughout. The basal conglomerate indicates swift currents in shallow water, deriving their load from a nearby source in Precambrian rocks. The overlying sandstone was derived from the north-west. With reduction in relief of the source area or rise in sea-level siltstones and then limestones, including algal limestone, were formed. Subsequent emergence led to development of a wave-cut platform in the limestone and of chasms and submarine caves in the platform. A sheet of ferruginous siliceous gravel spread over the platform probably from the Precambrian rocks to the north, and filled the channels and caves in the platform. Subsequently rise in sea-level or sinking of the area allowed further deposition of limestone, formation of which was terminated by uplift of a source area including siliceous rocks. Sandstone with worm burrows and cross-bedding, mainly of easterly derivation, was then formed. Subsequently easterly currents brought red sediments including fragments of Cambrian rocks to the depositional area. Finally, siliceous material was deposited as sand and calcareous sand with some marine shells. The Spero Bay Group was then folded into an asymmetrical almost meridional syncline. If this folding affected all of Tasmania it occurred prior to deposition of the Eugenana Beds and was therefore probably Couvinian. Approximate correspondence to the Tabberabberan Orogeny in eastern Victoria might be suggested (Talent, 1958).
Devonian of Victoria and Tasmania

JOHN A. TALENT and M. R. BANKS

VICTORIA

JOHN A. TALENT

ABSTRACT

There are, broadly speaking, in the Devonian of Victoria, two provinces of differing sedimentary, igneous and tectonic history. In the central Victorian Province marine sedimentation was essentially continuous from Silurian into Lower Devonian times. In the eastern Victorian Province, on the other hand, marine sedimentation was successively interrupted in late Silurian times by orogenesis (Bowning orogeny) followed by widespread granitic emplacement, rapid de-roofing of the granitic intrusions, and a new cycle of rapid non-marine sedimentation, essentially acid volcanism with but minor marine incursions. This was followed later by block faulting and planation prior to the widespread late Emsian marine incursion that was connected with accumulation of the Buchan Group.

INTRODUCTION

There are, broadly speaking, two provinces of differing sedimentary, igneous and tectonic histories in the Devonian of Victoria: the central Victorian Province where marine sedimentation was essentially continuous from Silurian into Early Devonian time contrasts with the eastern Victorian Province where marine sedimentation was interrupted in late Silurian time successively by orogenesis (Bowning Orogeny), widespread granitic emplacement, rapid de-roofing of the granitic intrusions, a new cycle of rapid non-marine sedimentation, essentially acid volcanism with but minor marine incursions, followed later by block faulting and planation prior to the widespread late Emsian marine incursion connected with the accumulation of the Buchan Group (Table I). No sedimentary or igneous record is available for Givetian and possibly late Eifelian and early Frasnian times, during which interval an acme of deformation, the Tabberabberan orogeny, with associated intrusions of essentially meridionally aligned dyke swarms, affected the entire state. In eastern and western Victoria this deformation was followed by and, we may presume, connected with the rapid erosion and accumulation of vast thicknesses of non-marine Upper Devonian sediments over uneven surfaces. In central Victoria however, there was little sedimentation; vast, essentially acid, volcanic outpourings took place, in part at least from ring structures, to be intruded subsequently by their parent magmas at some time close to the Devono-Carboniferous boundary.
LOWER DEVONIAN

Central Victoria

The unravelling of the uppermost Silurian - Lower Devonian stratigraphy of central Victoria has been hampered by the dominance of poorly fossiliferous basin sediments over most of the area. There is an approach to near-shore sediments in the McIvor and Mt. Ida formations of the Heathcote-Redcastle-Puckapunyal area in late Ludlovian to Gedinnian times, an approach to shelf conditions in the Lilydale-Mooroolbark and Seville-Woori Yallock districts somewhat later with a true shelf environment clearly expressed in the Emsian Lilydale Limestone, the last indubitably marine Lower Devonian event in central Victoria. Regression of the late Lower Devonian sea and the change to non-marine conditions is graphically portrayed by the change from marine Walhalla Group to the non-marine Cathedral Beds in the Taggerty district. From such information it is impossible to determine shore lines at any time during the Early Devonian in central Victoria, though palaeoslope studies and the general coarsening of sediments persistently indicate a shore line an unknown distance to the west of Heathcote, to the north of Dookie, to the south-southeast of Wallan and to the southeast of Cape Liptrap (Schleiger, 1964b and unpublished; Clark, unpublished). There is, however, a gradual, possibly discontinuous, overall tendency for coarser sediments and more palably shelf-like conditions to migrate eastwards with time.

The primary framework for correlating across this area and tying in the various outcrop tracts is based on the widespread recognition of two graptolite horizons (zone of Monograptus nilssoni and local zone of M. thomasi-M. aequabilis), and a changing pattern in the brachiopod faunas, with the progressive incoming of new forms (Talent, 1965b and unpub.).

The first important sedimentary event close to the Silurian-Devonian boundary is the influx in the north-west in the Heathcote-Redcastle-Puckapunyal district of some 1,600 metres of sandstones with interbedded conglomerates, siltstones and minor claystones - the McIvor Formation - apparently thickening northwards from Redcastle. The base of the unit, however, can be fairly widely discriminated north of Melbourne, particularly to the east of Wallan, Kilmore and about Clonbinane, as a richly fossiliferous unit mapped as the Clonbinane Member and Mt. Phillipa Member of the Humevale Formation (Williams 1964). The faunas of this unit have been described for the Heathcote district (Talent 1965a) and have been listed for the Wallan-Clonbinane district (Williams 1964). In the Eildon district “Conchidium” and Mucophyllum occur within slumped units of otherwise poorly fossiliferous, presumably deep water equivalents of this formation within the Eildon Beds. Available evidence seems to indicate that the McIvor Formation spans the time interval from about the close of the Ludlovian into the Early Gedinnian. The Monograptus aequabilis horizon formerly visualized occurring within equivalents of the Eildon Beds at the 20 mile quarry, Yarra Track, and indicating an early Gedinnian age for that particular horizon (Jaeger, 1966), has been shown (Darragh & Talent unpub.) to be more widespread and essentially equivalent stratigraphically with the M. thomasi horizon and to lie within the Wilson's Creek Shale.

Sedimentation continued uninterrupted from the McIvor Formation into the Mt. Ida Formation in the Heathcote-Redcastle district, with the accumulation of at least 2,000 metres of sandstones with interbedded mudstones, shales and conglomerates. Similar sediments to those occurring at Redcastle and Heathcote crop out from the Moormbool Fault through Puckapunyal to the vicinity of the Goulburn River, where a rapid change occurs to graptolitic claystones and siltstones with frequent tongues of coarse conglomerates and sandstones, echoing the essentially coarser sedimentation to the west (Schleiger 1964a, b; Schleiger and Talent, unpub.). Part at least of the Mt. Ida Formation can be shown from this facies change to be equivalent to beds farther east containing Monograptus thomasi, the characteristic graptolite of the Wilson’s Creek Shale of the Eildon district. M. thomasi, together with its characteristic flora of vascular plants, Baragwanathia and other genera, occurs through more than 2,000 m. of strata (Lang & Cookson 1935), but to the east in the Yea-Molesworth district two horizons bearing M. thomasi occur 2,600 to 3,000 metres apart (Couper 1965). Yet in the Eildon area, still farther to the east, the Baragwanathia - M. thomasi beds have been shown by detailed mapping to have thinned to between 500
and 650 m. (Thomas 1947). These data would suggest broadly that the maximum rate of sedimentation during *M. thomasi* times took place in the vicinity of Yea and Molesworth.

Equivalents of the Wilson's Creek Shale in the Kinglake West district have not so far been shown to contain graptolites, but they are in fact a quasi-shelf development containing rich brachiopod-echinoderm-trilobite faunas, often with abundant plant material (Williams 1964). West of the Walhalla Synclinorium the Wilson's Creek Shale is overlain conformably by the Tanjil Formation, typically developed in the Matlock and Reefton districts (Harris & Thomas 1947; Moore 1965a) where the unit is about 1500 metres thick. The lower 1,000 metres of siltstones and fine sandy
siltstones have so far proved unfossiliferous, but the overlying Panenka-Nowakia-Styliolina-Striatostyliolina beds, normally 6-32 metres thick but some hundreds of metres thick south of the Triangle seem to be the approximate equivalents of the zone of Monograptus hercynicus; these in turn are overlain by siltstones and claystones 160-330 metres thick with minor bivalve-brachiopod-hyolithid faunas; the formation becomes more sandy towards the Eildon district where it is known as the Norton Gully Sandstone. To the south, in the Walhalla-Cooper's Creek and Tyers district, the highest beds of the Tanjil Formation contain locally rich faunas best known from the Tyers area, where they have been termed the Boola Beds (Philip 1962).

The Tanjil Formation is overlain by the Walhalla Group, best known from its development in the Walhalla Synclinorium (Whitelaw, 1916; Baragwanath, 1925; Thomas, 1942; Bell et al., 1961) where a widely discriminated conglomerate has facilitated mapping of its base. Such basal conglomerates have been identified to the west of the Walhalla synclinorium in the Eildon district (Thomas, 1947), but not yet in the East Warburton district (Moore, 1965a), or in the Taggerty district. The basal conglomerates are most conspicuous in the Cooper's Creek and Tyers areas south of Walhalla, where they contain prominent developments of limestones at differing horizons (Thomas, 1942) and have been termed the Cooper's Creek Formation. Despite detailed mapping (e.g. Kenny, 1937) and monographing of a large part of the faunas, principally at Tyers (e.g. Philip, 1960, 1962, 1965; Pedder 1967), it is still uncertain whether this sedimentologically important event involved a break in sedimentation, echoing the unconformity at Grinder Point, Waratah Bay, and at the base of the Wentworth Group at Tabberabbera, or whether there was continuous sedimentation from the Tanjil Formation (Boola Beds, Norton Gully Sandstone) into the Walhalla Group. Two recent assessments of the age of the Cooper's Creek Formation are in essential agreement: one based on conodonts from a locality at Tyers indicates an age in the range late Gedinnian-Siegenian (Philip, 1965); the other, based on regional stratigraphy, graptolites, tentaculitids and brachiopods, indicates a probably late Siegenian age (Talent, 1965b).

Lithological units underlying the Walhalla Group east of the Walhalla synclinorium have been mapped (e.g. Baragwanath, 1925), but the lithologies are so different from units west of the synclinorium that in the near absence of palaeontological evidence adequate matching of the units has been impossible.

Rare horizons of shelly fossils, correlating broadly with the rich faunas within the Kilgower Member of the Tabberabbera Formation at Tabberabbera on the one hand and with the highest faunas of the Ruddock Siltstone of the Lilydale-Mooroolbark district (Gill, 1942, 1965) on the other, indicate an Early Emsian age for horizons 500 to 800 metres above the base of the Walhalla Group. The Walhalla Group sediments are mostly fine grained, with a predominance of siltstones, claystones and fine sandstones, in places rhymically banded or with the development of pronounced grit bands. Vascular plant remains are more widely distributed than at most lower horizons, the most notable occurrence being in the Centennial Beds at Walhalla (Lang & Cookson, 1930).

In the Taggerty district, equivalents of the Walhalla Group pass gradually upwards with increase of sandstones, commonly ripple-marked, and claret coloured siltstones and claystones, into the Cathedral Beds. These beds crop out in a southeast-plunging synclinal structure and reappear to the southeast of the Cerberean Volcanics belt as a northwest-plunging lithologically similar body of strata mapped as the Koala Creek Beds (Bell et al., 1961). Here again they overlie Walhalla Group sediments and, despite poor outcrops and a faulted margin to the east, they are assumed to be in essence conformable with the Walhalla Group in the same way as the Cathedral Beds are. The poorly preserved flora, the absence of fauna, and the frequency of red beds are taken to represent non-marine sedimentation. The regression of the seas from central Victoria in late Lower Devonian time is thus graphically displayed in the passage from Walhalla Group to Cathedral Beds (Talent, 1965b).

Equivalents of the Walhalla Group and Tanjil Formation are not clearly defined within the Lilydale-Mooroolbark-Woori Yallock district where sedimentation appears to have continued without interruption from Late Silurian times. The Christmas Hills Formation, composed of about 1,750 metres of uniform, rarely fossiliferous siltstones and fine sandstones (Moore, 1965b) appears to span the Silurian-Devonian boundary. It is succeeded by the Ruddock Silt-
stone, a sequence of about 2,500 metres of claystones, siltstones and minor fine grained sandstones, sometimes rhythmically bedded, for the most part sparsely fossiliferous, but with intermittent developments of rich and varied brachiopod faunas with subordinate mollusces, trilobites and coelenterates (e.g. Gill, 1942). There is an almost total change in the specific composition of the brachiopod faunas through this unit, indicating that an appreciable length of time is involved embracing Early Emsian and much if not all of Siegenian time. The development of a true shelf environment with accumulation of 230 metres or more of organo-detritic limestones, the Lilydale Limestone, containing rich Emsian (possibly Lower Emsian) stromatoporoid, coral, and gastropod faunas with subordinate bivalves and brachiopods, represents the last adequately documented marine Devonian event in Central Victoria.

The Lilydale Limestone is overlain irregularly with an unconformity of about 15° by the Cave Hill Sandstone, a unit about 30 to 60 metres thick composed essentially of sands, clays, sandstones, and in one horizon sheared pebbles (Crohn, 1953). Hard secondarily silicified sandstones (quartzites) within the unit transgress the bedding. The eroded nature of the limestone surface prior to deposition of the sands is graphically displayed by pinnacles of limestone surrounded by sand. Because of the clearly unconformable relationships, this unit was excluded from the Yering Group (Talent, 1965b, Fig. 2), in line with the mandatory requirements of the Australian Code of Stratigraphic Nomenclature. The age of the unit has been a matter for some speculation; a few coarsely preserved spiriferid moulds are diagnostic neither of Silurian nor Devonian. All that can be safely presumed is based on its stratigraphic relationships: that its age is within the range latest Early Devonian to somewhere in the Late Devonian. The other hand mapping of the unit (Crohn, 1953) indicates that it roughly parallels the Lilydale Syncline, so that it would seem to have been folded during the Tabberabberan orogeny well prior to extrusion of the Dandenongs igneous complex. Could it be that this unit should be correlated with some part of the marine incursion responsible for deposition of the Bell Point Limestone unconformably across the Waratah Limestone to the southeast in the latest Early Devonian time?

The Lower to Middle Devonian succession of eastern Victoria contrasts in many respects with that of central Victoria, though some connection between the history of the two provinces can be seen in the sequences at Waratah Bay and on the Mitchell and Wentworth rivers.

The youngest Silurian horizons at present known in eastern Victoria are of early Ludlow age, thus setting a terminus post quem for the fold movements about the close of the Silurian or the beginning of the Lower Devonian (Bowning orogeny). This deformation was followed by the intrusion and deroofing of the Kosciusko batholith, followed by deposition of thick sequences of non-marine conglomerates, sandstones, siltstones and minor ignimbrites at least 1,600 metres thick, the Timbarra Formation, in the Buchan-Wulgulmerang district. Subsequently the Snowy River Volcanics complex of more than 3,300 metres of rhyodacites and tuffs, with subordinate rhyolites, andesites, keratophyres and basalts, accumulated over much of Victoria east of the Tambo River (Ringwood, 1955; Fletcher, 1963).

Evidence, best seen at Mt. Waterson, Bindi, shows that the Snowy River Volcanics were block-faulted prior to deposition of the Buchan Group, the lowest unit of which rests indiscriminately over the planed surfaces of blocks of Snowy River Volcanics and pre-Devonian Cowombat Group (Talent, 1965b). Subsidence of the more or less planar Buchan-Indi-Combienbar area in Emsian, probably late Emsian, time led to deposition of the richly fossiliferous Buchan Caves Limestone 220 to 260 metres thick, commencing typically with a basal sequence of dolomites, exceeding 65 metres southeast of Buchan. It is overlain by the Taravale Formation which is in facies relationship with the Murrindal Limestone north of Buchan. Faunas from low in the Taravale Formation at Buchan and from the top of the Buchan Caves Limestone at Bindi indicate an early Eifelian or possible late Emsian horizon. The great thickness of poorly fossiliferous Taravale Formation, particularly at Bindi where it exceeds 1,200 metres, indicates the possibility of the Buchan Group ascending even higher.

Two carbonate formations separated by an unconformity have been described at Waratah Bay (Talent 1965b). The
Table I. Suggested correlations of the Devonian in Tasmania
and Victoria after Talent (1965) and Banks.
Waratah Limestone rests with a clearly exposed unconformity directly on a Cambrian sequence; its rich faunas of stromatoporoids, corals and subordinate molluscs and brachiopods indicate correlation with the Cooper’s Creek Formation at the base of the Walhalla Group. It is overlain unconformably by the Bell Point Limestone which bears brachiopod faunas identical with those of the Buchan Caves Limestone, indicating connection with the marine incursion responsible for deposition of the Buchan Group to the northeast. The break in sedimentation between these two units correlates broadly with the period of block faulting and planation prior to deposition of the Buchan Group in eastern Victoria, to the possible interruption in sedimentation between the Kilgower and Roaring Mag members of the Tabberabbera Formation, and seemingly to the period of deposition of the Liptrap Formation immediately to the west of the Devonian limestones at Waratah Bay. During the accumulation of the Liptrap Formation, corals and lumps of limestone were eroded from the Waratah Limestone and incorporated, along with Cambrian detritus, in slumped units within the Liptrap Formation. The Liptrap Formation and the Waratah Limestone in many respects echo the sedimentation of the central Victorian Province. On the other hand, the Bell Point Limestone and the two unconformities reflect the tectonic and sedimentary history of the eastern Victorian province.

The Devonian succession on the Mitchell and Wentworth rivers (Talent 1963) consists of nearly 3,000 metres of essentially terrigenous sediments resting with marked angular unconformity on folded Upper Ordovician sediments. The lowest fossiliferous unit, the Wild Horse Formation, contains a poorly preserved and essentially undescribed fauna recalling that of the Cooper’s Creek Formation, indicating that the event responsible for the accumulation of limestones and conglomerates over such a wide area about the base of the Walhalla Group found similar expression at Tabberabbera. This event is to be compared with the contemporaneous subsidence and deposition of the Waratah Limestone unconformably over Cambrian greenstones at Waratah Bay. Higher in the succession within the Kilgower Member of the Tabberabbera Formation there occur faunas of Lower Emsian aspect more or less equivalent to horizons 500-800 metres above the base of the Walhalla Group.

**UPPER DEVONIAN**

Deformation of the Lower to early Middle Devonian sequences of Victoria took place principally at some time in the interval between the Eifelian and some time early in the Upper Devonian (Tabberabberan orogeny). The deformation was accompanied by the intrusion of syntectonic dyke swarms, notably the Woods Point (Hills, 1952) and Tabberabbera (Talent, 1963) swarms. These were followed by post-orogenic intrusions of granitic batholiths scattered more or less latitudinally across central Victoria, and by a few scattered granitic intrusions in eastern Victoria, and possibly in northeastern Victoria.

The pattern of plutonism, vulcanism and sedimentation in Victoria during Late Devonian times is complex. Broadly speaking three provinces can be discriminated: a western province with a basal sequence of rhyolitic lavas, pyroclastics and trachytes succeeded by a thick sequence of late Devonian to possibly early Carboniferous terrigenous sediments; a central province with but minor development of terrigenous sediments, but characterized by vast outpourings of predominantly acid lavas in part connected with cauldron collapses and intruded by the parent magmas; an eastern province where terrigenous sedimentation again predominates over rhyolitic and basaltic vulcanism.

**Western Victoria**

The tablelands west of the Grampians Ranges have extensive developments of two groups of Palaeozoic extrusives: a series of porphyritic rhyolites, tuffs and agglomerates, the Rocklands Rhyolites, and a series of trachytes located principally about Carapook. Localities with overlying Grampians Group sediments for the former (Spencer-Jones, 1964) and Permian glacials for the latter (Beavis, 1947) provide *termini ante quem* for these units; a Late Devonian age for the rhyolites rests on analogy with the Upper Devonian extrusives scattered across Central Victoria eastwards to the Mitchell River, and on an occurrence on the Hopkins River north of Wickliffe of Grampians Group sediments overlying about 70 metres of rhyolitic lavas and pyroclastics (Spencer-Jones, 1963).

The Grampians Group is a thick sequence exceeding 5,000 metres of sandstones, red siltstones and subordinate conglomerates and claystones, predominantly of non-marine
origin but in one unit, the Silverband Formation, bearing a meagre marine fauna diagnostic neither of Devonian nor Carboniferous (Talent & Spencer-Jones, 1963). A detailed account of the stratigraphy and structure of these sediments and their outliers has been given by Spencer-Jones (1963, 1964). The Grampians Group was folded into broad open structures and faulted during the Carboniferous, and intruded by a number of granitic bodies.

Central and Eastern Victoria

Two major cauldron collapse structures have been identified in the Eildon-Marysville-Healesville district, the northern or Cerberean ring-cauldron associated with a well-defined ring dyke of granodiorite, and the Acheron cauldron adjoining it to the southwest associated with larger bodies of parent granodiorite. The latter is composed predominantly of dacites following an initial outpouring of nevadite; the Cerberean structure is more complex, consisting of a basal conglomerate followed in turn by the Snob's Creek Volcanics (a sequence of acid lavas), the Taggerty Group (a succession of fossiliferous terrigenous sediments, basic and intermediate volcanics overlain by ignimbrites), the Cerberean Volcanics (nevadite grading up into toscanite, and overlain by rhyodacites and nevadite) (Thomas, 1947; Hills, 1958). A Late Devonian age is indicated by a small fish fauna from the Taggerty Group (Hills, 1931). Potassium-argon age determinations on rhyodacites from the Cerberean cauldron gave an age of about 350 million years, used by McDougall et al. (1966) as a means of approximate absolute age determination of the Devonian-Carboniferous boundary. Other bodies of Upper Devonian dacites and/or rhyodacites intruded by their parent plutons occur at Arthur's Seat (Baker, 1938); in the Macedon district (Skeats & Summers, 1912) where they are associated with 300 metres or more of conglomerates and sandstones, the Kerrie Conglomerates (Thomas, 1931); the Violet Town district, where a basal rhyolite 30 metres or so in thickness is overlain by about 500 metres of dacite (White, 1954); and the Dandenongs where a basal series of toscanites is overlain by a series of dacites, rhyodacites and pyroclastics (Edwards, 1956). A small Upper Devonian fish fauna has been recorded from the South Blue Range near Mansfield (Hills, 1935). Rhyo-
dacites and rhyolites similar to those of the Violet Town area occur to the east in the Tolmie Highlands (Brown, 1961, 1964), but to the SE in the watersheds of the Macalister, Avon and Mitchell rivers and their tributaries volcanics become subordinate to terrigenous sediments analogous to those of the Grampians Ranges. A succession of units, the Avon River Group, consisting of about 4,600 metres of non-marine conglomerates, sandstones and mudstones with interbedded rhyolites (the Wellington Rhyolites) and minor tuffs and basalts, has been identified by Neilson (1964 & unpub.), particularly in the watersheds of the Macalister and Avon rivers. The rhyolites thin eastwards, disappearing some distance east of the Mitchell River (Talent, 1963). Fish remains from sediments closely associated with these rhyolites have confirmed a Late Devonian age for at least part of the Avon River Group (Hills, 1931); more tenuous evidence from plant remains (McCoy, 1876) seems to indicate that much if not all of the higher part of this group is of late Devonian age. The sediments are broadly folded, their distribution in the Avon and Macalister watersheds being determined by two bounding faults.

Similar sediments at least 3,000 metres thick with a thin rhyolite low in the sequence crop out in the Mt. Tambo area between Benambra and Bindi and are in faulted contact with the Buchan Group and Snowy River Volcanics at Bindi. An adjacent area of conglomerates, sandstones and siltstones at Mt. Waterson, formerly thought to be Upper Devonian, has been shown to be Silurian (Talent, 1965b). Farther east Upper Devonian terrigenous sediments occur as four en echelon outliers between Club Terrace and the Genoa River (Spencer-Jones, unpub.). These can be construed as outliers of the Merrimbula Group of southeastern New South Wales, which at Eden include a marine intercalation containing a Late Devonian, probably late Frasnian, brachiopod fauna (Talent, unpub.).

At some time during the Carboniferous, probably Early Carboniferous, the Upper Devonian rocks of Victoria were broadly folded and faulted (Kanimblan "Orogeny"); they were subsequently intruded by granitic bodies, as in the Grampians (pre-Permian) and in the Benamba district (probably late Triassic).
Devonian rocks in Tasmania lie at the southern end of the Tasman geosynclinal zone. The Skalian to early Siegenian upper part of the Eldon Group of western Tasmania is thought to have been deposited on a rather shallow sea floor which slowly deepened, with turbidity currents occurring. These beds, and probably also the co-eval (?) off-shore deeper-water Mathinna Beds of northeastern Tasmania, were folded prior to the deposition of the Emsian to Eifelian Spero Bay Group that crops out on the southwest coast. The Spero Bay Group itself was folded prior to the deposition of the (probably) Givetian Eugenana Beds, cave deposits which are still horizontal. Thus, as in the case of the Tabberabberan Orogeny in Victoria, folding probably began in the Siegenian and was completed during or prior to the Givetian. Three main pulses have been suggested in Tasmania. Granitic rocks with radiometric ages ranging from 375 to 340 my. (late Siegenian to late Tournaisian) intrude the folded Devonian sediments.

INTRODUCTION

Devonian sedimentary rocks occupy the axial regions of synclines in central and western Tasmania and occur also in northeastern Tasmania and on adjacent islands (Fig. 1.). Devonian granites are widespread. Fossils now considered Devonian were first recognised by Gould (1866), first described by Etheridge (1896), and later authors (Cookson, 1937; Hill, 1942a; Gill, 1948, 1950, 1952; and Boucot and Gill, 1956) have made significant contributions. Separate formations were first delineated in western Tasmania in 1949 (Hills and Carey) with subsequent elaboration by Gill and Banks (1950), Banks (1962), and Pitt, Reid and Pike (unpublished). The succession in northeastern Tasmania is now being elucidated by the Geological Survey, and fossils from western Tasmania are under study by D. Hill, G. M. Philip and P. G. Quilty.

Regional Setting

Devonian rocks in Tasmania lie within the Molong Geosyncline (Swaminath, 1959; part of the Lachlan Geosyncline of Packham, 1960), at the southern end of the Tasman Geosynclinal Zone. The stratigraphy and structural relationships of Devonian rocks within Tasmania are summarised as Table I.

The Eldon Group (and probably the Mathinna Beds) were folded prior to deposition of the Spero Bay Group, itself folded prior to deposition of the Eugenana Beds. Folding probably began in the Siegenian and was completed during or prior to the Givetian. Faulting and folding, culminating in the Tabberabberan Orogeny, occurred during the same interval in Victoria.

The most detailed analysis of the development of stresses in Tasmania during this interval is that of Burns (1964), for northwestern Tasmania. He suggested three main movements. The first of these, the Eugenanan Movement, produced NNW - trending folds and thrusts and contemporaneous or later WNW dextral transcurrent faults. The next main phase, the Intermediate, produced meridional folds. The last main movement, the Loonganan Movement, produced initially folds trending 240°, then NNW transcurrent faults and finally WNW trending thrusts. The applicability of this scheme in other parts of Tasmania needs checking. The scheme may be too simple. Other authors (Carey, 1953; Bradley, 1956; Blissett, 1962; Solomon, 1962; Jennings, 1963; Solomon, 1965; Banks, 1965) have proposed simpler schemes. Most of these authors considered that folding parallel to pre-Devonian geanticlinal margins preceded the NNW folding of Burns’ Eugenanan Movement. Dextral meridional shear, sinistral latitudinal shear, or primary thrust followed by primary wrench regime have been proposed. (Fig. 2).

Granitic rocks intruded the folded Devonian sediments and both folded rocks and granite are overlain with angular unconformity or nonconformity by Permian sediments, or by sediments which are probably Upper Carboniferous.

STRATIGRAPHY

Eldon Group

LOWER DEVONIAN

The Eldon Group (see Table I) occurs in central, western and northwestern Tasmania. The Devonian part of this group commences with or within the Florence Sandstone. This formation consists of well-sorted, quartz-rich, original-
ly calcareous sandstone with few cross-bedded or ripple-marked units. Bands of granules are uncommon. Brachiopods are more numerous than other fossils which include corals, polyzoans, molluscs, trilobites and crinoids. *Notoconchidium* decreases in abundance both northwest and southeast from Zeehan. This formation is overlain gradationally by the Bell Shale, the lower part of which consists of alternating sandstone, with graded bedding and shale fragments, and carbonaceous siltstone. Vascular plants, *Pleurodictyum*, strophomenids and other brachiopods, homalonotid trilobites, ostracodes and ophiuroids occur in this transitional unit. The Bell Shale proper consists of carbonaceous pyritic siltstone with fossils abundant only in a limited number of horizons.

The Devonian part of the Eldon Group is thought to have been deposited on a rather shallow sea floor which slowly deepened during the Early Devonian. The shoreline probably lay in or not far west of northwestern Tasmania. Turbidity currents were active during deposition of the transitional formation.

**Mathinna Beds**

This unit includes a thick section of alternating sandstone and siltstone. The sandstone shows structures characteristic of deposition from turbidity currents of predominantly southwesterly derivation. The sandstones contain vascular plants in several places (Table II), and corals, brachiopods and crinoids at Scamander. The siltstones in the Scamander Formation were deposited in still water, below wave base in an extensive sea.

The Mathinna Beds are considered to be the offshore, deeper-water correlatives of the Eldon Group (Thomas, 1948; Green, 1959; Banks, 1962). There is some parallel with the contemporaneous facies change in Victoria from the Wilson Creek Shale to the McIvor Formation and Mt. Ida Beds (Talent, 1965b).

**LOWER and MIDDLE DEVONIAN**

**Spero Bay Group**

Deposition began in the Point Hibbs area with formation of reddish, cross-bedded, siliceous sandstones and siltstones of northwesterly derivation, from an area now covered by ocean. Subsequently, fossiliferous siltstone and then algal, coralline limestone were deposited. Deposition of limestone was interrupted by tilting, leading to exposure of the northern part of the basin and cutting of a shore platform and submarine caves in it, the caves being filled subsequently with red siliceous caves. Rise in sea-level led to deposition of algal-gastropod limestone. Uplift of the source areas later caused deposition of cross-bedded, ripple-marked, siliceous sands and gravels with abundant worm-castings. This uplift may have culminated in deposition of red gravels, sands and silts in rhythmic succession on a mud-flat or flood plain close to sea-level. Rise in sea-level followed, and blanketed the area with siliceous sands containing spiriferids, cephalopods and *Tentaculites*.

**MIDDLE DEVONIAN**

**Eugenana Beds**

Sub-aerial caves dissolved from folded and uplifted Ordovician limestone in the Eugenana area of northern Tasmania were filled with cave breccia, sand, silt and clay, the more finely grained sediments containing spores of probable Givetian age. The cave deposits contain fragments of foliated Ordovician limestone and therefore post-date folding of the Eldon Group, which is generally conformable with the limestone. The cave deposits are horizontal.

**BIOSTRATIGRAPHY and CORRELATION**

The biostratigraphy is summarised in Table II. *Notoconchidium florencensis* is the index fossil for the Florence Sandstone, in the upper half of which *Pleurodictyum megastoma* also occurs. *Eatonia* spp. and *Protoleptostrophia* occur only in this formation as far as is known. The transition beds at the base of the Bell Shale contain *Pleurodictyum megastoma*, *Notanoplia pherista*, *Plectodonta bipartita* and other fossils with Australian affinities, as well as the Malvinokaffric *Australocoelia polyspera*. "*Lindstroemia*", *Chonetes* and *Cypricardinia* appear with the beginning of the Bell Shale proper, and a number of earlier species persist. It is noticeable that *Notoconchidium*, *Pleurodictyum megastoma* and *Maoristrophia* enter the succession in the same order as in the upper McIvor Formation and the Mount Ida Formation (Talent, 1965a, p. 12) in the Heathcote district of Victoria. As an approximation it may be suggested that the lower part of the Florence Sandstone correlates with
### Table II. Faunal distribution chart.

Stratigraphic distribution of fossils within the Devonian System in Tasmania; letters and numbers within formations of the Eldon Group refer to letters and numbers on columns in Figure 2.

<table>
<thead>
<tr>
<th>Stratigraphic Unit</th>
<th>Vascular Plants</th>
<th>Additional Groups</th>
<th>Foraminiferida</th>
<th>Bryozoa</th>
<th>Copepoda</th>
<th>Crinoids</th>
<th>Corals</th>
<th>articulate brachiopods</th>
<th>articulate brachiopods</th>
<th>Belemnites</th>
<th>Belemnitidae</th>
<th>Bivalves</th>
<th>Bivalves</th>
<th>Brachiopoda</th>
<th>Brachiopoda</th>
<th>Brachiopoda</th>
<th>Brachiopoda</th>
<th>Brachiopoda</th>
<th>Brachiopoda</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>EUGENANA BEDS</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Whitehorses Beach Ss.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Red Reef Cliff Ss.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sanctuary Bay Ss.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Point Hibbs Ls.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Clearwater Bay Ss.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>SPERO BAY GROUP</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Scamander Silt., Ss.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Weymouth</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Siding</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Warrentina</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Peppers Hill, Mangana</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Elephant Pass, St. Marys</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>ELDON GROUP</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Shale</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>16</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>15</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>14</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>13</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>12</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>11</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>10</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>9</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>8</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>7</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Transition</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>16</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>15</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>14</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>13</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>12</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>11</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>10</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>9</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>8</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>7</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Austral Clc. Silt.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>G</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>F</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>E</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Note:** The table above represents the distribution of various fossil groups across different stratigraphic units in the Devonian System of Tasmania. Each letter and number correspond to specific locations and formations.
Errata

Table II (p. 158)

Letters and numbers within formations of the Eldon Group refer to letters and numbers on columns in fig. 3 except for K (quartzite and siltstone between 380 m. and 500 m. above the base of Florence Sandstone at Duck Creek, 30 km. north-west of Zeehan), L (a sandstone near St. Valentines Peak, 45 km. west of Eugenana) and M (a calcareous mudstone near St. Valentines Peak).
the upper part of the McIvor Formation, the upper Florence with Unit 1 of the Mount Ida Formation and the "transition" formation at the base of the Bell Shale with Unit 2 or Unit 3 of the Mount Ida Formation. Thus the "transition" formation is probably Lower Gedinnian but may be Upper (Talent, 1965a, p. 13). Boucot and Gill (1956) considered *Australocoelia polyspera*, from the "transition" formation, as middle Lower Devonian.

Hedeia, vascular plants, ?*Notanopia* and ?*Australocoelia* in the Scamander Formation suggest correlation with the "transition" formation and with the Wilson Creek Formation in Victoria.

The Point Hibbs Limestone contains *Favosites bryani*, *F. goldfussi*, *Rhizophyllum enorme*, *Radiophyllum*, *Keriophyllum chillagoense*, *Cyrtina cf. hamiltonensis*, and *Acros..."
<table>
<thead>
<tr>
<th>Carboniferous</th>
<th>Point Hibbs</th>
<th>Zeehan-Princess R.</th>
<th>Eugenana</th>
<th>Scamander-St. Marys</th>
</tr>
</thead>
<tbody>
<tr>
<td>Famennian</td>
<td>Permian</td>
<td>Upper Carboniferous-Permian</td>
<td>340 my Heemskirk Granite</td>
<td>Coast Range Granite 370 my</td>
</tr>
<tr>
<td>Frasnian</td>
<td></td>
<td>ANGULAR UNCONFORMITY, NONCONFORMITY</td>
<td>Dolcoath Granite 345 my Housetop Granite 365 my</td>
<td></td>
</tr>
<tr>
<td>Givetian</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Eifelian</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Emsian</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Siegenian</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Gedinnian</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Skalian</td>
<td>405 my</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Silurian</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table III. Summary of stratigraphic and structural relationships of Devonian rocks within Tasmania; radiometric ages after McDougall and Leggo, 1965.
These suggest correlation with the Garra Beds of New South Wales and the Mt. Etna Limestone of Queensland, and possibly with the Waratah or Bell Point Limestone, the Coopers Creek Formation, the Buchan Caves Limestone and the Murrindal Limestone of Victoria. These correlates are considered Emsian or Eifelian, and the most likely age on the present slight information is Late Emsian (Talent, 1965b; Strusz, 1965; Hill, 1942b).

The structurally complex *Spinozonotriletes* and cf. *Endosporites*, and the heavily ornamented *Apiculatisporites* and *Brochotriletes*, suggest an Eifelian or younger age, while the presence of *Radiospora* and *Spinozonotriletes* suggests a Late Devonian or older age for the Eugenana Beds (Balme, 1960). The assemblage is more like the Frasnian than the Famennian microfloras from Western Australia but is different even from the Frasnian, so that the most likely age is Givetian (Balme, 1960).

Correlations suggested by the fossils listed above are summarized in Table III.

### IGNEOUS ACTIVITY

Subsequent to the Tabberabberan folding, granitic rocks of Late Devonian and Early Carboniferous age intruded older rocks, causing local doming of the folded sediments in several places. The granitic rocks decrease in age from northeastern to western Tasmania (Fig. 1) (McDougall and Leggo, 1965). They seem to have been emplaced as small batholiths marginal to the Tyennan Geanticline, as larger batholiths marginal to the Rocky Cape Geanticline and possibly to the Heemskirk Anticlinorium, and in northeastern Tasmania in zones which may be anticlinorial (Carey, 1953) or marginal to the anticlinoria (Banks, 1957).

The main rock type is adamelite, but acid and basic differentiates are also present in the multiple intrusions which have cross-cutting, sharp contacts and narrow contact aureoles.

### ECONOMIC MINERAL DEPOSITS

The granitic rocks introduced tin, tungsten and gold which were emplaced as economically significant deposits in older rocks (Solomon, 1965). Lead, zinc, and copper ores were also probably emplaced during the granitic intrusions, but for some of the base-metal deposits a direct relationship has not been established. Devonian rocks are host rocks to minor lead-zinc deposits near Zeehan, and the tin-tungsten and gold deposits of northeastern Tasmania are emplaced in the Mathinna Beds.

### SUMMARY

During the earliest part of the Devonian, siltstones and some sandstones were deposited conformably on older rocks in shallow water in western Tasmania and in deeper water (partly as turbidity current deposits) in northeastern Tasmania. Folding of these rocks during the Early Devonian closed geosynclinal deposition in Tasmania. The main folds trend just west of north. Later a thin succession of shallow-water marine sediments was deposited at Pt. Hibbs, and then folded. Horizontal cave deposits of Givetian age, in folded Ordovician rocks at Eugenana, provide a younger limit for the age of the folding. Granitic rocks intruded during the Late Devonian and Early Carboniferous emplaced tin, tungsten, gold, lead, zinc and copper deposits.

### REFERENCES

Because of the large volume of palaeontological, stratigraphic and petrographic literature, only the more salient references have been cited in the text; most other literature of importance can be found in the larger list below.


Gill, E. D., 1942: On the thickness and age of the type Yeringian strata, Lilydale, Victoria. Ibid. 54: 21-52.


---, 1935: On a flora, including vascular land plants, associated with Monograptus in rocks of Silurian age, from Victoria, Australia. Ibid. 224: 421-449.

McCoy, F., 1876: Prodomus of the palaeontology of Victoria, Decade 4: 21-23.


---, 1967b: Lower Devonian steptelasmatid, lindstroemoid and possible amplexocarinoid corals from Victoria 81: 107-180. Ibid. 80 (1).


---, 1965: Lower Devonian conodonts from the Tyers area, Gippsland, Victoria. Ibid. 79: 95-117.


Tasmania


VICTORIA AND TASMANIA


MAXWELL R. BANKS,
University of Tasmania, Hobart, Tasmania.

JOHN A. TALENT,
Geological Survey, Mines Department, Melbourne, Australia.