PAPERS AND PROCEEDINGS OF THE ROYAL SOCIETY OF TASMANIA, VOLUME 88

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.

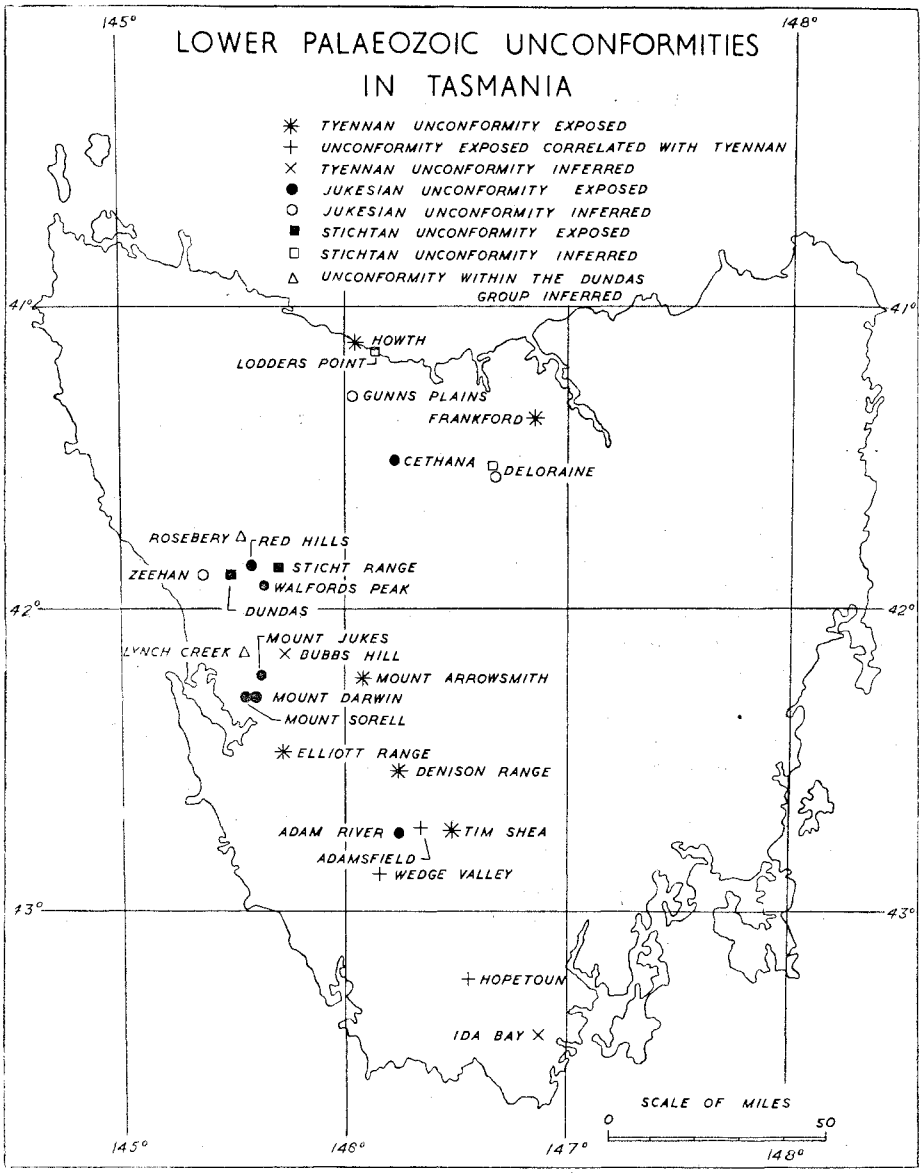

LOWER PALAEOZOIC UNCONFORMITIES
IN TASMANIA
TYENNAN UNCONFORMITY EXPOSED
UNCONFORMITY EXPOSED CORRELATED WITH TYENNAN
TYENNAN UNCONFORMITY INFERRED
JUKESIAN UNCONFORMITY EXPOSED
JUKESIAN UNCONFORMITY INFERRED
STICHTAN UNCONFORMITY EXPOSED
STICHTAN UNCONFORMITY INFERRED
UNCONFORMITY WITHIN THE DUNDAS GROUP INFERRED
145°
148°
41°
42°
43°
HOWTH
LODDERS POINT
GUNNS PLAINS
FRANKFORD
CETHANA
DELORAINE
ROSEBERY
RED HILLS
STICHT RANGE
ZEEHAN
WALFORDS PEAK
DUNDAS
MOUNT JUKES
LYNCH CREEK
BUBBS HILL
MOUNT ARROWSMITH
MOUNT DARWIN
MOUNT SORELL
ELLIOTT RANGE
DENISON RANGE
ADAM RIVER
TIM SHEA
ADAMSFIELD
WEDGE VALLEY
HOPETOUN
IDA BAY
SCALE OF MILES
0
50
145°
146°
147°
148°

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).

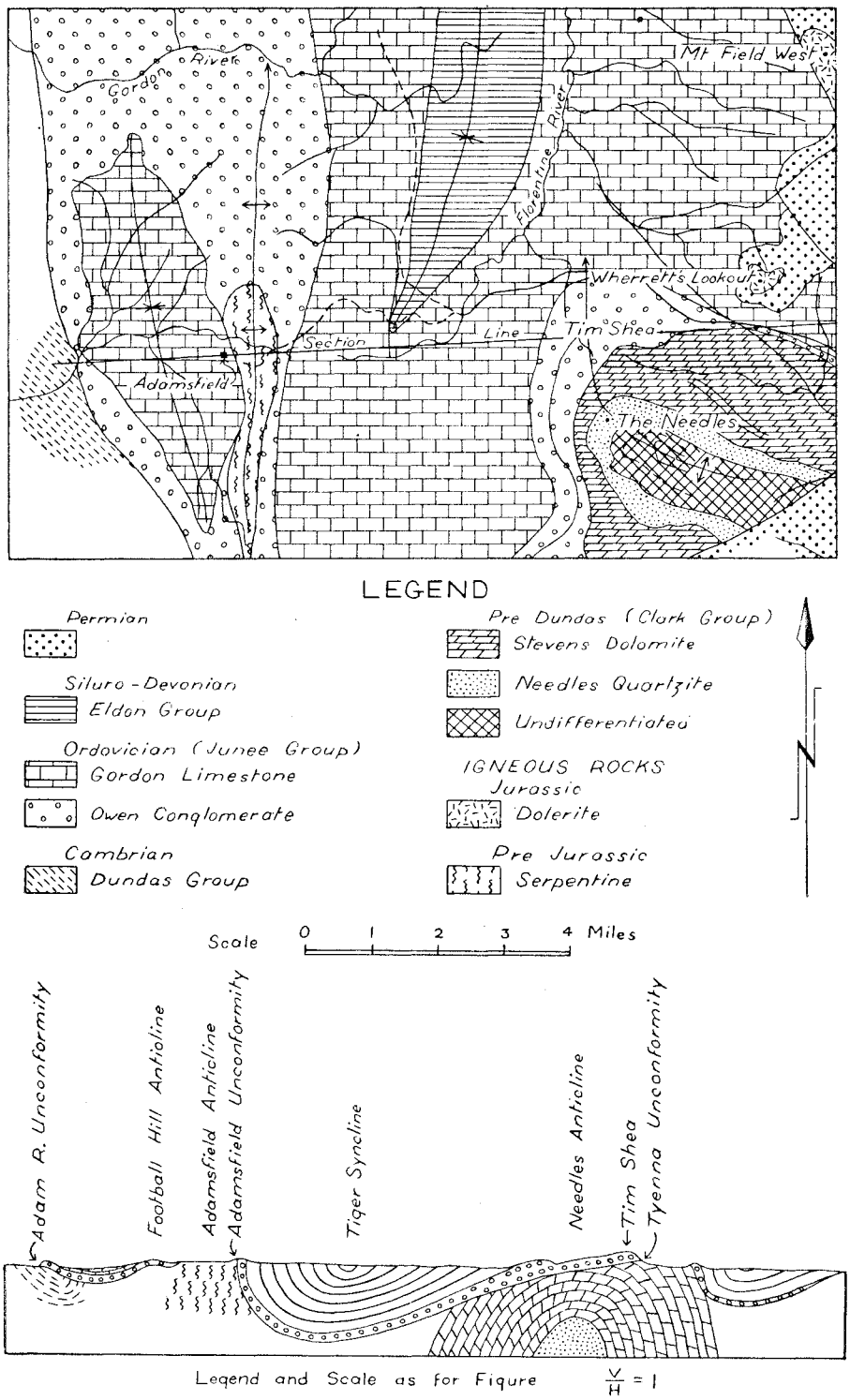
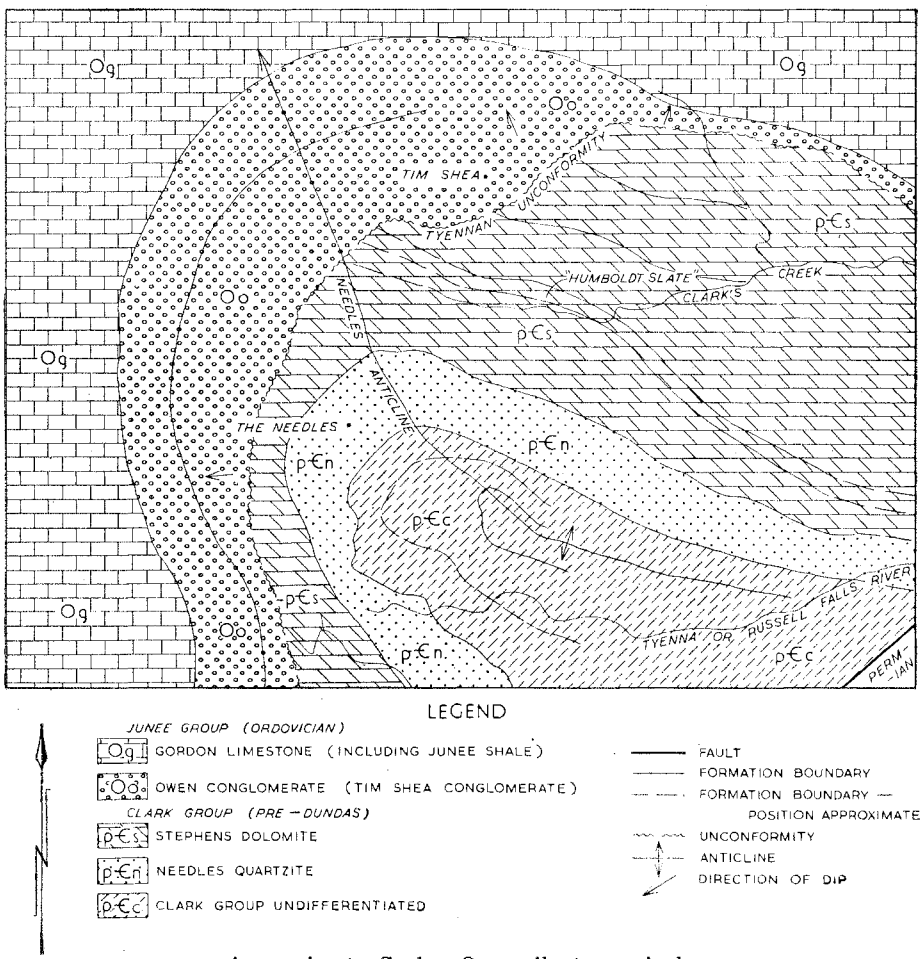


FIG. 2.—Geological Map of the Adamsfield-Tyenna area with section showing relations of Adam River, Adamsfield, and Tyenna unconformities.



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

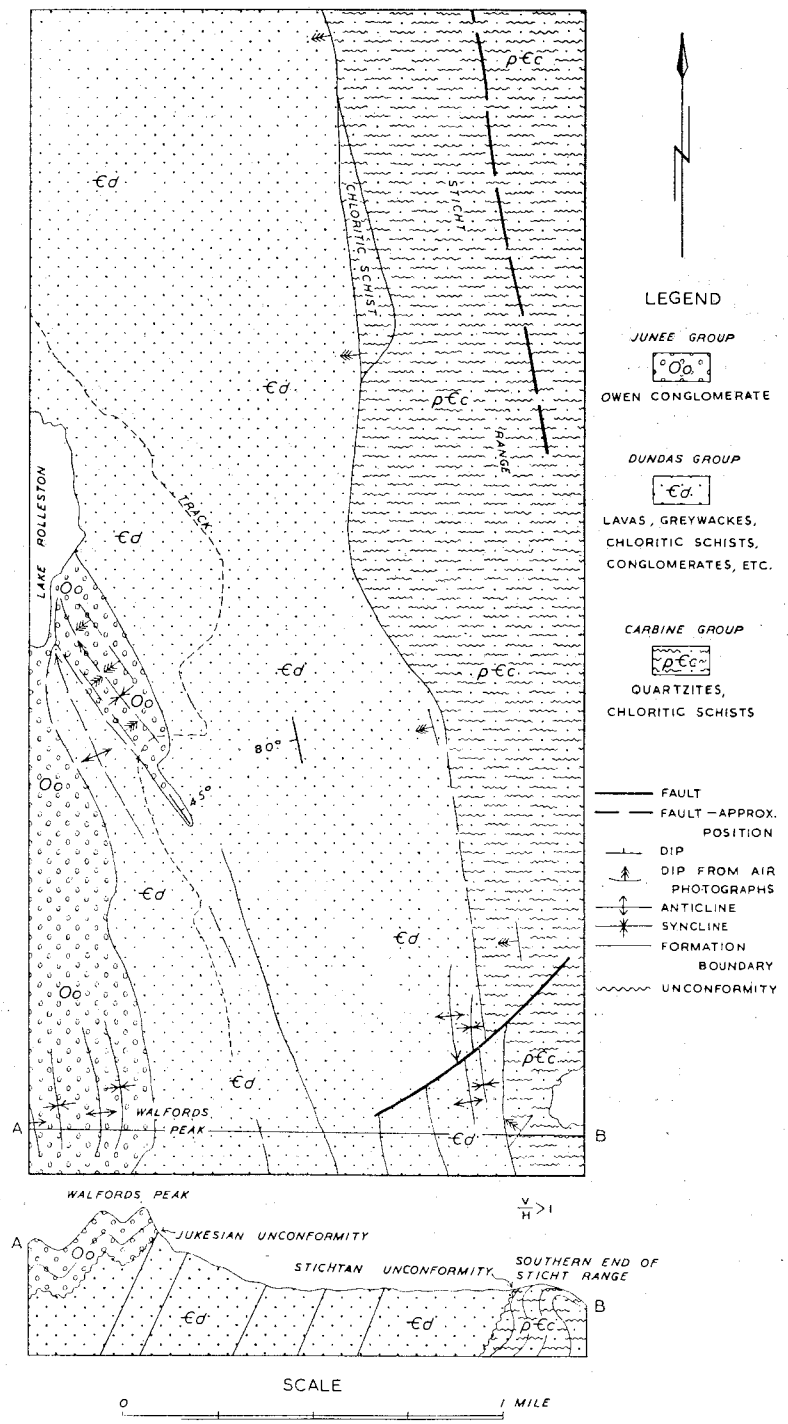


FIG. 4.—Geological map of the Walfords Peak and Sticht Range area, with section showing unconformities.

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-Dundas 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. 5 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-

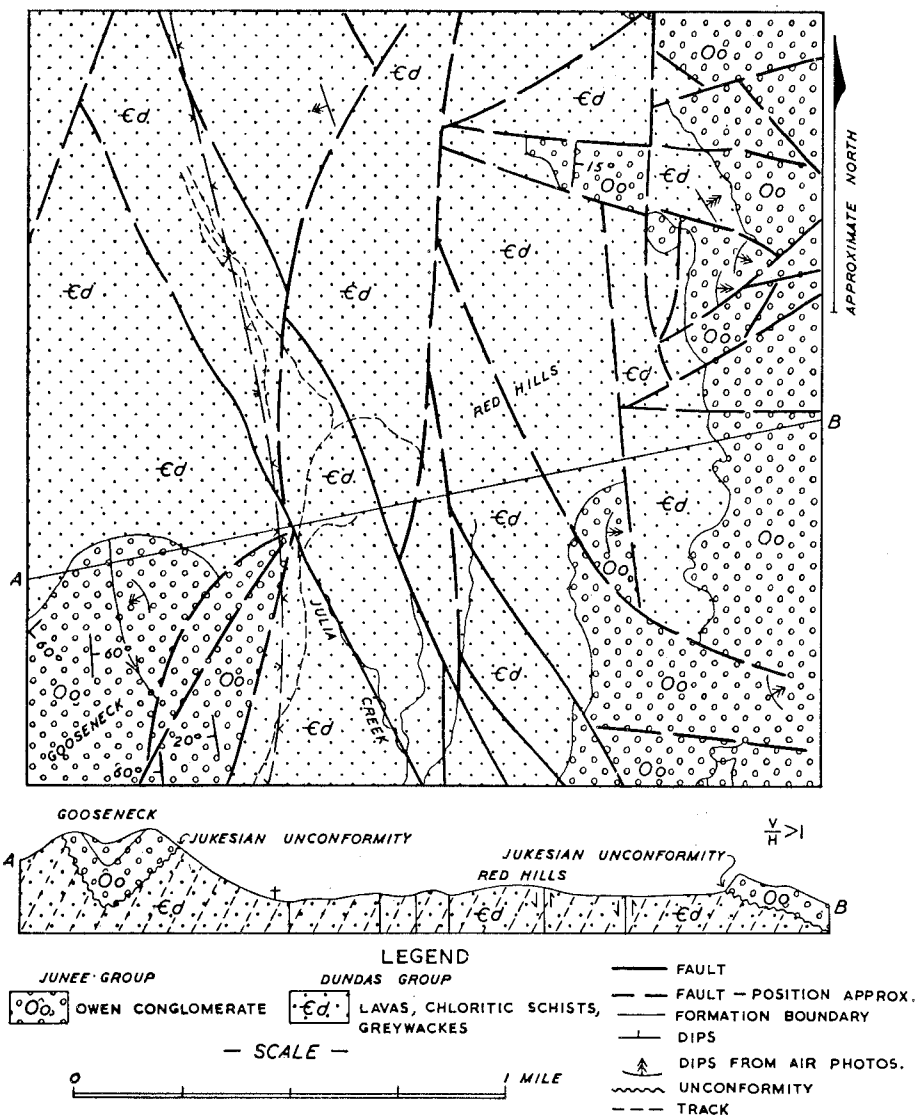


FIG. 5.—Geological map of the Red Hill area with a section from the Gooseneck to Red Hill.

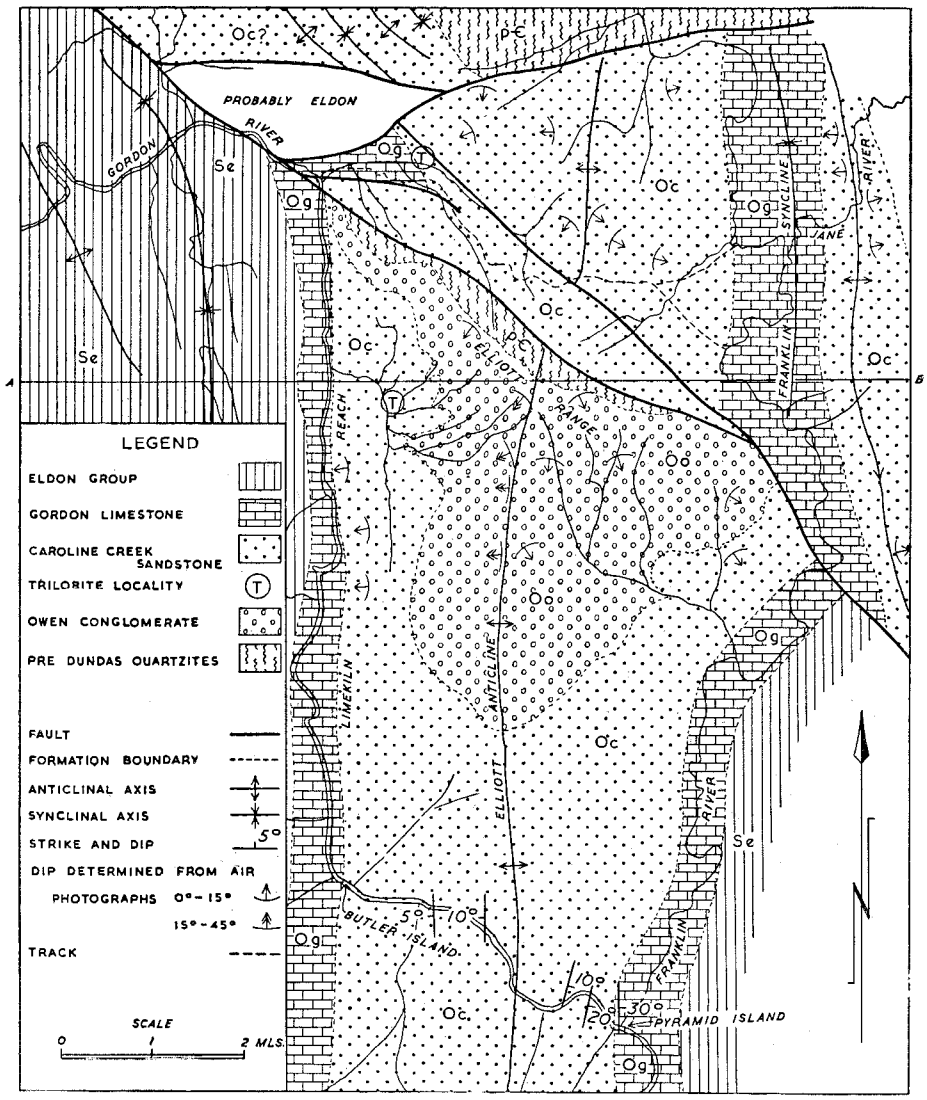


FIG. 6.—Geological Map of the Elliott Range Area, Western Tasmania.

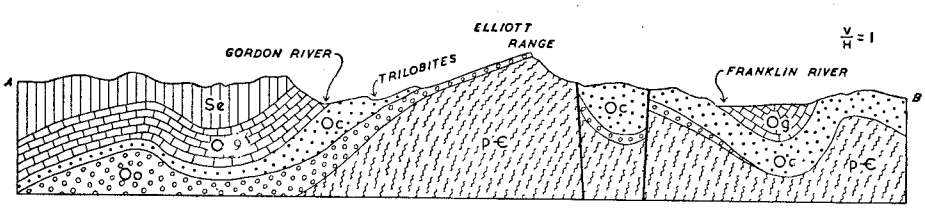


FIG. 7.—Section through Elliot Range area showing the Tyennan Unconformity (Symbols, legend and scale as for Fig. 6).

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-bedded 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

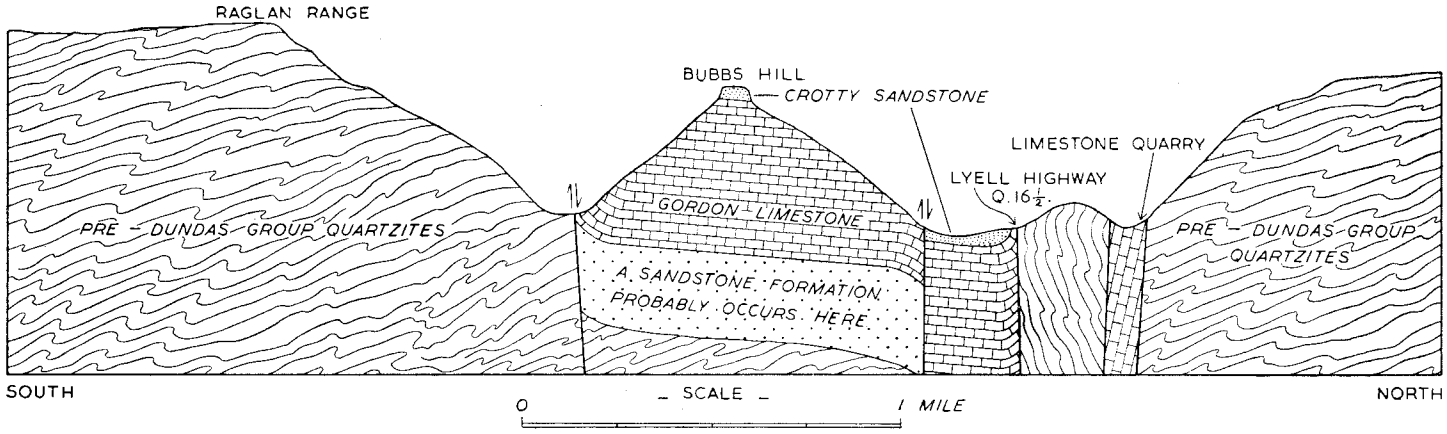


FIG. 8.—Section through Bubb's Hill and the Raglan Range, Western Tasmania.

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.

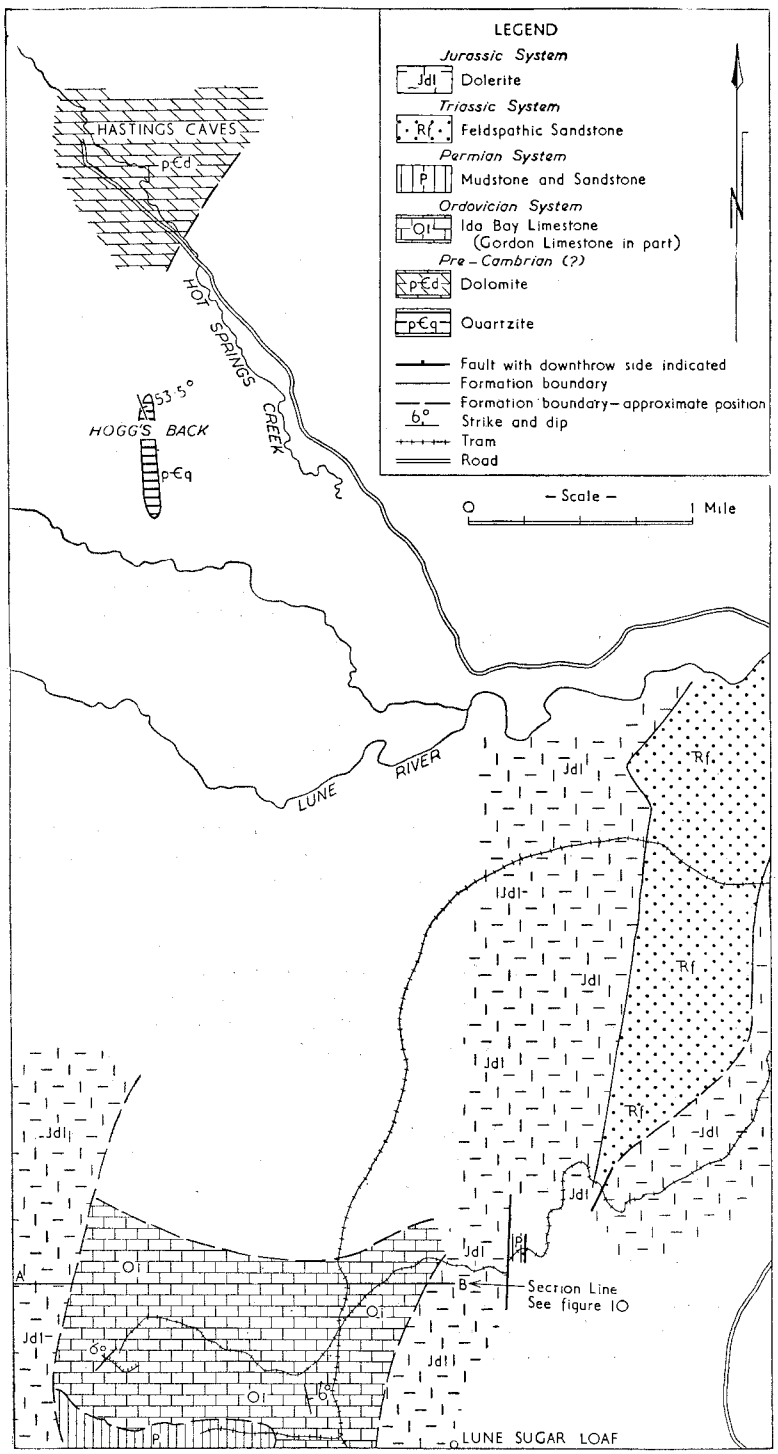


FIG. 9.—Geological map of the Ida Bay area, S.E. Tasmania.

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.

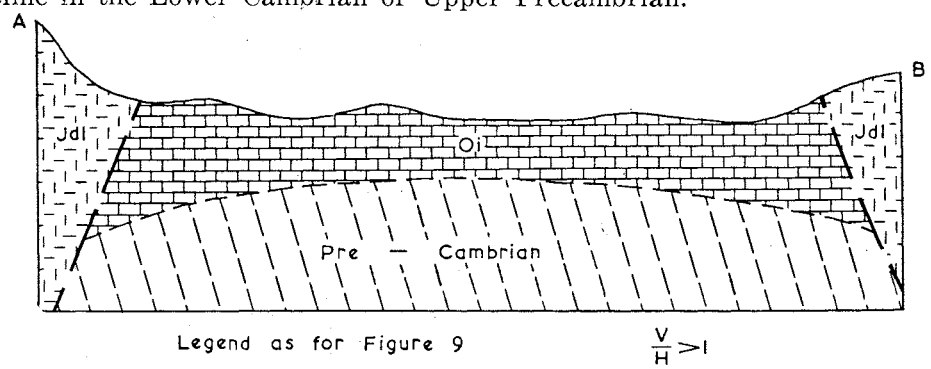


FIG. 10.—Geological Section of the Ida Bay area.

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°.

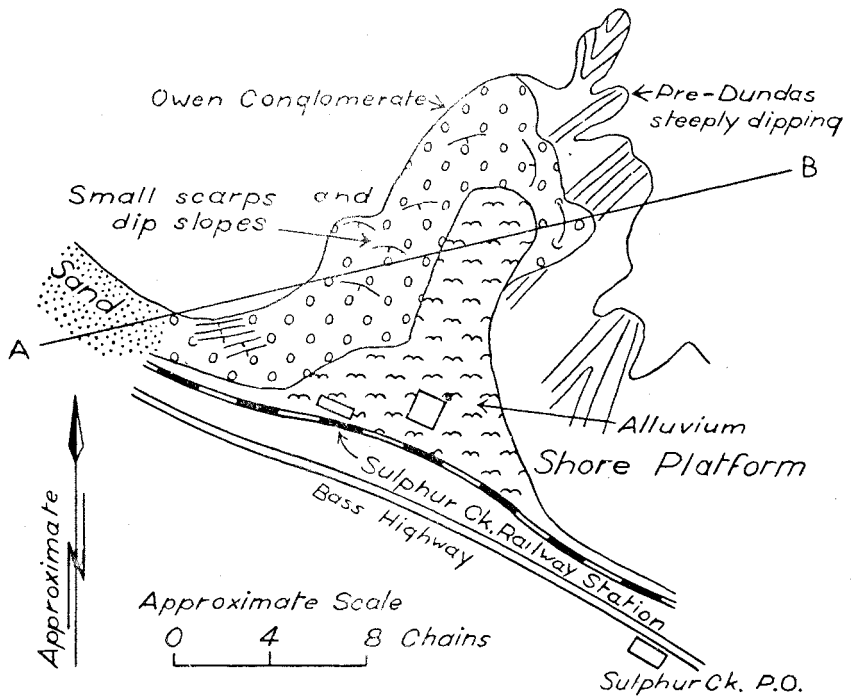


FIG. 11.—Geological Map of a headland between Sulphur Creek and Howth, N.W. Tasmania.

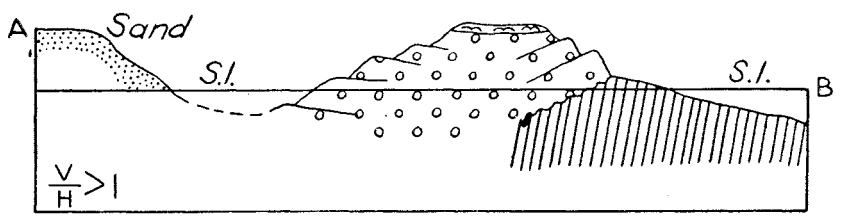


FIG. 12.—Geological section through the unconformity near Howth.

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."

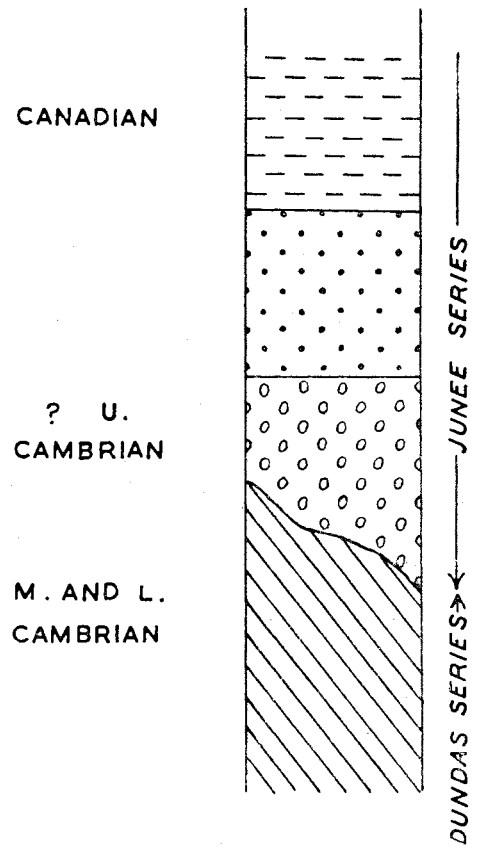


FIG. 13.—The Tyennan Unconformity of Browne.

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 recognised 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 recognised 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 meridan 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 quartz 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.

BROWNE, W. R., 1949.—Some Thoughts on the Division of the Geological Record in the Commonwealth of Australia Pres. Address. Sect. C, *A.N.Z.A.A.S.*, vol. XXVII, Hobart, 1949.

CAREY, S. W., 1953.—Geological Structure of Tasmania in Relation to Mineralization. Geology of Australian Ore Deposits. *5th Empire Mining Congress*, Vol. I, pp. 1108-1129.

DAVID, T. W. E. (ed. Browne), 1950.—The Geology of the Commonwealth of Australia. London.

ELLISTON, J., 1953A.—The Moina District. Geology of Australian Ore Deposits. *5th Empire Mining Congress*, Vol. I, pp. 1194-1199.

————, 1953B.—Platinoids in Tasmania. *ibid*, pp. 1250-1254.

————, 1954.—Geology of the Dundas District, Tasmania. (This volume, pp. 161-183.)

HALL, G., COTTLE, V. M., ROSENHAIN, P. B. AND MCGHIE, R. R., 1953.—The Lead-Zinc Deposits of Read-Rosebery and Mt. Farrell. Geology of Australian Ore Deposits. *5th Emp. Mining Congress*, Vol. I, pp. 1145-1159.

HILLS, L., 1913.—The Jukes-Darwin Mining Field. *Tas. Dept. Mines Geol. Surv., Bull.* No. 16.

HILLS, L. AND CAREY, S. W., 1949.—Handbook for Tasmania. Geology. *A.N.Z.A.A.S.*, Hobart Meeting, pp. 21-44.

LEWIS, A. N., 1940.—Geology of the Tyenna Valley. *Pap. & Proc. Roy. Soc. Tas.*, 1939 (1940), pp. 33-59.

MONTGOMERY, A., 1895.—Report on Progress of the Mineral Fields in the Neighbourhood of Zeehan; viz., Mackintosh River, Mount Black, Mount Read, Mount Dundas, Mount Zeehan, Stanley River, and Mount Heemskirk. *Sec. Mines Rep.* 1894-5, pp. vii-li.

NYE, P. B., 1928.—Correlation of the Pre-Cambrian, Cambrian, and Ordovician Formations in Tasmania. MS rept. *Tas. Dept. Mines*, 12.5.'28.

NYE, P. B., 1929.—The Osmiridium Deposits of the Adamsfield District. *Tas. Dept. Mines Geol. Surv. Bull. No.* 39.

NYE, P. B. AND BLAKE, F., 1938.—The Geology and Mineral Deposits of Tasmania. *Tas. Dept. Mines Geol. Surv. Bull.* 44.

OFFICER, G., BALFOUR, L., AND HOGG, E. G., 1895.—Geological notes on the country between Strahan and Lake St. Clair, Tasmania. *Proc. Roy. Soc. Vic.*, VII, No. 5, pp. 119-130.

OPIK, A. A., 1951A.—Notes on the Stratigraphy and Palaeontology of Cambrian, Ordovician and Silurian Rocks in Tasmania. *Bur. Min. Res. Geol. & Geophysics, Recs.* 1951-5.

————, 1951B.—Cambrian Fossils from Leven Gorge, Northern Tasmania. *Bur. Min. Res. Geol. & Geophysics, Recs.* 1951-59.

REID, A. M., 1925.—The Dundas Mineral Field. *Tas. Dept. Mines Geol. Surv. Bull.* No. 36.

STEPHENSON, J., 1954.—An unconformity in South-West Tasmania. *Pap. & Proc. Roy. Soc. Tas.* Vol. 88, pp. 151-152.

THOMAS, D. E., 1945.—Rept. of the Director of Mines, Tasmania, for 1943.

TWELVETREES, W. H., 1908.—Report. *Tas. Dept. Lands and Surveys Ann. Rept.* 1907-1908, pp. 25-32.

————————, 1909A.—Gunns Plains, Alma, and other Mining Fields, North-West Coast. *Tas. Dept. Mines Geol. Surv. Bull.* No. 5.

————————, 1909B.—Report. *Tas. Dept. Lands and Surveys Ann. Rept.* 1908-1909, pp. 25-31.

————————, 1909C.—Outlines of the Geology of Tasmania. *Tas. Sec. Mines Rept.* 1908 (1909).

WARD, L. K., 1908A.—Report. *Tas. Dept. Lands and Surveys Ann. Rept.* 1907-1908, pp. 33-39;

————, 1908B.—The Mt. Farrell Mining Field. *Tas. Dept. Mines Geol. Surv. Bull.* No. 3.

————, 1909.—Report. *Tas. Dept. Lands and Surveys Ann. Report*, 1908-1909, pp. 31-35.

LOCALITY INDEX

	Quadrangle	Latitude	Longitude
Adam River	Huntly 73	42° 44′	146° 16′
Adamsfield	Huntly 73	42° 44′	146° 20′
Avon Rivulet	Zeehan 50	41° 50′	145° 27′
Bell Mount	Sheffield 37	41° 27′	146° 06′
Bubb's Hill	Lyell 58	42° 07′	145° 45′
Cardigan R.	Lyell 58	42° 08′	145° 49′
Cave Hill	Adamson 93	43° 27′	146° 52′
Cethana	Sheffield 37	41° 28′	146° 10′
Cracroft R.	Arthur 86	43° 10′	146° 28′
Deloraine	Quamby 46	41° 31′	146° 40′
Denison Range	Huntly 73	42° 34′	146° 17′
Dundas	Zeehan 50	42° 53′	145° 24′
Eden Siding	Zeehan 50	41° 59′	145° 18′
Elliott Range	Pillinger 65	42° 30′	145° 42′
Florentine R.	Huntly 73	42° 35′	146° 30′
Frankford	Frankford 38	41° 19′	146° 45′
Golden Valley	Quamby 46	41° 37′	146° 43′
Gooseneck	Murchison 51	41° 52′	145° 33′
Gunns Plains	Sheffield 37	41° 18′	146° 01′
Hastings Caves	Adamson 93	43° 24′	146° 53′
Heazlewood	Magnet 35	41° 30′	145° 18′
Hog's Back	Adamson 93	43° 24′	146° 52′
Howth	Devonport 29	41° 05′	146° 01′
Humbolt Mine	Styx 81	42° 45′	146° 30′
Huskisson R.	Corinna 43	41° 39′	145° 27′
Ida Bay (district)	Adamson 93	43° 27′	146° 54′
Judith Creek	Zeehan 50	41° 54′	145° 28′
Lake Dora	Murchison 51	41° 58′	145° 39′
Lake Julia	Murchison 51	41° 54′	145° 34′
Lake Rolleston	Murchison 51	41° 55′	145° 37′
Leven Gorge	Devonport 29	41° 15′	146° 10′
Lodders Point	Devonport 29	41° 07′	146° 08′
Magnet	Magnet 35	41° 28′	145° 26′
Main Creek	Huntly 73	42° 44′	146° 20′
Mount Arrowsmith	St. Clair 59	42° 12′	146° 04′
Mount Claude	Sheffield 37	41° 30′	146° 12′
Mount Darwin	Lyell 58	42° 16′	145° 36′
Mount Farrell	Mackintosh 44	41° 44′	145° 34′
Mount Hopetoun	Picton 87	43° 13′	146° 31′
Mount Jukes	Lyell 58	42° 11′	145° 36′
Mount Murchison	Murchison 51	41° 50′	145° 36′
Mount Sorell	Pillinger 65	42° 15′	145° 32′
Mount Wedge	Pedder 80	42° 50′	146° 17′
Needles	Huntly 73	42° 44′	146° 28′
Nelson R.	Lyell 58	42° 07′	145° 43′
New River	Adamson 93	43° 27′	146° 35′
Penguin	Devonport 29	41° 07′	146° 03′
Ragged Range	Pedder 80	42° 46′	146° 16′
Raglan Range	Lyell 58	42° 08′	145° 46′
Red Hill	Murchison 51	41° 52′	145° 35′
Rosebery	Murchison 51	42° 48′	145° 32′
Stables	Zeehan 50	42° 53′	145° 24′
Sticht Range	Murchison 51	41° 52′	145° 38′
Sulphur Creek	Devonport 29	41° 07′	146° 02′
Thumbs	Huntly 73	42° 41′	146° 20′
Tim Shea	Huntly 73	42° 43′	146° 29′
Tyenna Valley	Huntly 73	42° 44′	146° 30′
Walfords Peak	Murchison 51	41° 56′	145° 48′
Wallace's Tram	Zeehan 50	42° 50′	145° 26′
Wedge River	Huntly 73	42° 45′	146° 11′

PLATE I, FIG. 1.—Unconformity between Owen Conglomerate and pre-Dundas Group quartzites, Elliott Range, W. Tasmania. (Photo. by B. Glenister)