GSREC 7

TASMANIA

DEPARTMENT OF MINES

Geological Survey Record

No. 7

# A REAPPRAISAL OF A LOWER PERMIAN TYPE SECTION GOLDEN VALLEY, TAS.

by

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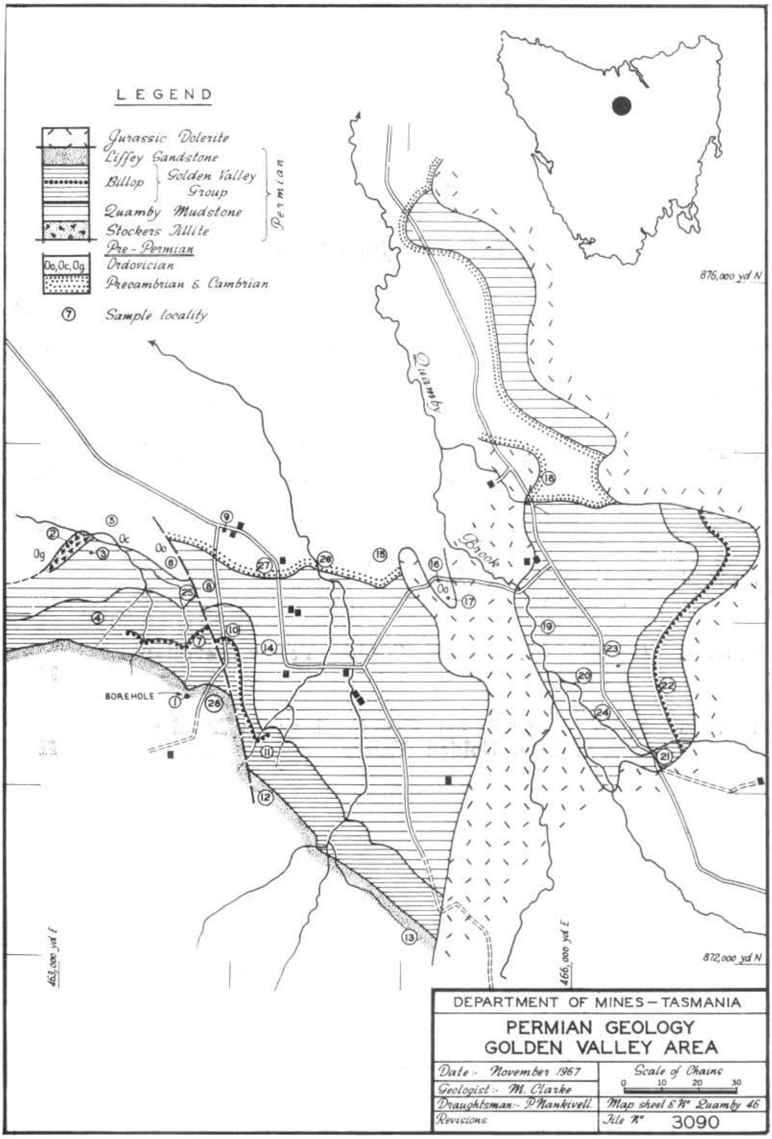
# Preface

A re-examination of the type section of the Quamby and Golden Valley Formations in N. Tasmania (Wells, 1957; both elevated to Group status by McKellar, 1957) reveals several important discrepancies between the field evidence and published accounts. Diamond drilling immediately adjacent to the type section demonstrates that these discrepancies are due to three principal factors; (1) the nature of the sub-Permian floor which has considerable relief; (2) poor exposure coupled with facies variation within the lower parts of the Golden Valley Limestone and Shale, factors which partly explain the original maldefinition of the lithological sequence; and (3) probably of most importance, that the type section is faulted thus reducing the observed thickness of the Golden Valley Limestone and Shale by one third, a factor which understandably caused a maldefinition of the higher parts of the Golden Valley Group lithological sequence. As a consequence the Quamby and Golden Valley Groups are redefined. The tripartite division of the Golden Valley Group first outlined by McKellar (1957) for the Poatina area is retained in broad outline. In detail it is shown that a new formational name is required for the lowest unit of the Golden Valley Group; this formation is named the Glencoe Limestone and Shale and is equivalent to the Brumby Marl and Upper Quamby Mudstone at Poatina (McKellar, 1957; Banks, 1962). Whilst the Golden Valley, Quamby Brook Valley and Poatina sections are shown to differ little in overall aspect, it would appear that the base of the Golden Valley Group in N. Tasmania does not correlate exactly with the base of the Darlington Limestone in S. Tasmania (Banks, 1962). A detailed descriptive, taxonomic and chronological palaeontology of the Quamby and Golden Valley Groups is not here considered, but will be fully described in a future bulletin.

J. G. SYMONS, Director of Mines.

# Contents

# List of Figures



LEGEND
Jurassic Dolerite
Liffey Sandstone
Billop
Golden Valley Group
Quamby Mudstone
Stockers Tillite
Permian
Pre-Permian
Oo, Oc, Og
Ordovician
Precambrian & Cambrian
Sample locality
876,000 yd N
872,000 yd N
463,000 yd E
466,000 yd E
Quamby
Brook
BOREHOLE
DEPARTMENT OF MINES – TASMANIA
PERMIAN GEOLOGY
GOLDEN VALLEY AREA
Date:- November 1967
Geologist:- M. Clarke
Draughtsman:- P. Nankivell
Revisions
Scale of Chains
0 10 20 30
Map sheet & No Quamby 46
File No 3090


FIG. 1.

5 cm

# Introduction

The Lower Permian (pre-Liffey Sandstone) rocks which outcrop on the northern slopes of Quamby Bluff in the southern parts of the Golden Valley and Quamby Brook Valley have been designated the type sequence for the Stocker's Tillite, the Quamby Mudstone, and the Golden Valley Limestone and Shale (Wells, 1957). As defined by Wells (*op. cit.*), the Stocker's Tillite (13.72 m) is the basal Permian formation which is seen to rest unconformably on Ordovician Gordon Limestone at the south-eastern extension of Stocker's Plain (loc. 2). The overlying Quamby Mudstone (110-172 m) comprises dark carbonaceous and pyritic mudstone with rare small erratics and without identifiable fossils. The Golden Valley Limestone and Shale (61 m) is stated to comprise a basal massive coquina limestone (about 6 m) followed by a somewhat contradictory sequence of 'richly fossiliferous, calcareous siltstone, erratic rich siltstone, bryozoan siltstone with few erratics, and erratic rich, fossiliferous siltstone' (Table p. 7); or, 'light-brown calcareous, fossiliferous shale with abundant fenestellids. Erratics are still abundant. The top beds are coarser, poorly-sorted shale and fine sandstone . . . rare large erratics are present and fossils plentiful' (text, p. 8); or, 'fine, poorly-sorted, richly fossiliferous sandstone' (Table p. 9).

Examination of the designated type section along the Glencoe Road (loc. 10) fails to confirm any of these successions. At most there is room only for about 82-85 m of Lower Permian rocks between the exposed basement of Precambrian Davey Group metasediments (loc. 9) and Ordovician conglomerate (loc. 6), and the exposed base of the Liffey Sandstone (loc. 28). This is less than half the accumulative thickness stated by Wells. As far as unsatisfactory exposure allows about 33-36 m of this thickness is of Quamby Mudstone lithology, and the remainder of presumed Golden Valley Limestone and Shale lithology. The passage from the one into the other appears to be one of transition, the dark carbonaceous and pyritic mudstone without fossils and with rare small pebbles of the Quamby Mudstone passing gradually upwards into fossiliferous mudstone and siltstone with abundant erratics. Limestone is not exposed but a 10 cm band of chert crowded with casts and moulds of *Eurydesma, Grantonia* and *Deltopecten* occurs about 22 m above the base of the unit. This probably represents the silicified equivalent of a once calcareous band. A small gap then occurs and is succeeded by about 7-8 m of blue-grey, buff-weathering, ill-sorted, micaceous sandstone, with abundant erratics and *Peruvispira, Spiriferella* and *Grantonia* in profusion. The uppermost 20 m of beds beneath the Liffey Sandstone are not exposed.

The neighbouring Quamby Brook Valley (locs. 18-24) displays a more continuously-exposed sequence. Here the Quamby Mudstone is about 96 m thick with its base nowhere exposed. The lowest beds visible constitute the Tasmanite Oil Shale (Newton, 1875; = Bakes Oil Shale of Wells) and are some 1.4 m thick (loc. 19). Then follows a more or less continuously-exposed succession of monotonous pyritic and carbonaceous mudstone with rare small erratics and without fossils as far as where the southern course of the Quamby Brook road crosses the easternmost headwater stream of Quamby Brook (loc. 21). There a fully-exposed sequence of erratic rich, very fossiliferous siltstone and mudstone (20 m), with beds of *Strophalosia* and *Costalosia* in growth position, *Grantonia, Deltopecten, Eurydesma, Stenopora* and other bryozoa, is followed by 7-8 m of massive coquina limestone largely composed of *Eurydesma* and *Keeneia,* and ends with 8 m of erratic-rich, ill-sorted sandstone with abundant *Peruvispira, Spiriferella* and *Grantonia.* A transgressive dolerite sill prevents further Permian outcrop.

The crux of the problem of defining the Quamby Mudstone and Golden Valley Limestone and Shale is most clearly presented by this section in Quamby Brook. Wells (*op. cit.*, table p. 7; text p. 8; table p. 9) defines the base of the Golden Valley Limestone and Shale as coincident with the base of the massive coquina limestone. Naturally, all later workers have followed a similar course (McKellar, 1957; Banks, 1958 *et. seq.*). The equation of the base of the Golden Valley Group in N. Tasmania with the base of the Darlington Limestone in S. Tasmania has followed (Banks, 1958 *et seq.*). However, the placing of the base of the Golden Valley Group in this position is at variance with the original mapping of Wells himself since he clearly mapped the base of the unit on the downstream side of the bridge crossing Quamby Brook (loc. 21), that is to say, in a position where unfossiliferous mudstone gives way to richly fossiliferous and erratic-rich siltstone. In fact, throughout the Golden Valley and Quamby Brook Valley area, Wells restricted the Quamby Mudstone to those mudstones without fossils and with rare small pebbles. Assuming a base to the Golden Valley Group at the base of the massive coquina limestone, some 20 m of richly fossiliferous and erratic-rich siltstone beneath the limestone must by necessity be included within the Quamby Mudstone, a course adopted by McKellar (*op. cit.*) at Poatina. However, this solution is not compatible with the original definition of the Quamby Mudstone (Wells, *op. cit.*, p. 8). Furthermore, it relegates the placing of the Quamby Mudstone and Golden Valley Group boundary on the type section to one of conjecture since limestone is not apparently developed.

Apart from these difficulties in defining the base of the Golden Valley Group in the type area, the exact nature of its upper parts is in considerable doubt. At Poatina correlates of the Golden Valley Limestone and Shale lend themselves to a tripartite subdivision (McKellar, *op. cit.*); a lower calcareous formation, the Brumby Marl (14 m), the Billop Sandstone (5 m), and the Macrae Mudstone (34 m). Of these formations the Billop Sandstone is readily recognised in the Quamby Brook and Golden Valleys, whilst the Brumby Marl and upper parts of the Quamby Mudstone at Poatina evidently correspond to the erratic rich, calcareous and richly fossilferous beds at Golden Valley and Quamby Brook. The original definition of the Brumby Marl (McKellar, *op. cit.*, p. 9) clearly suffers from the defect of assuming an undoubted base to the Golden Valley Group in the type area. However, in the Quamby Brook and Golden Valley area there is no apparent correlate of the Macrae Formation. This is surprising since Poatina and Golden Valley are no more than 20 miles distant and the overall lithological sequence in the two areas is broadly similar. It will be shown later that the Macrae Mudstone is nowhere exposed in the Golden Valley or Quamby Brook Valley area and that Wells (*op. cit.*) evidently considered the Billop Sandstone to be the uppermost unit of the Golden Valley Group.

In view of these several doubts and contradictions concerning the type section of the Lower Permian in N. Tasmania, a diamond drill borehole was sunk immediately west of the Glencoe road section (loc. 1). Original estimates based on the available field evidence programmed the hole for a depth of about 100 m. Pre-Permian rocks were not in fact encountered until a depth of 194 m. Siting problems, mainly concerned with ensuring an adequate water supply for drilling purposes, necessitated drilling a greater thickness of Liffey Sandstone than originally anticipated (16.15 m as against an estimated 6 m). The detection of a fault crossing the Glencoe Road section (its detection being a consequence of the borehole) added a further 27 m to the programmed depth. The remaining thickness increase (60 m plus) is apparently due to considerable pre-Permian basement relief. This basement relief is partly nullified on the ground by the fault crossing the type section.

# Borehole Section

The core sediments were examined in thin section and on polished slabs. The lithological classification is based on a modified Wentworth grade scale (Dunbar and Rodgers, 1957). The details of the lithological sequence are presented in Appendix I and a generalised section in figure 2. The hole was drilled vertically and cored NX to 97.22 m, BX to 181.3 m, and then AX to 201.1 m. Core recovery was virtually 100% throughout. Dips within the Permian sediments are negligible.

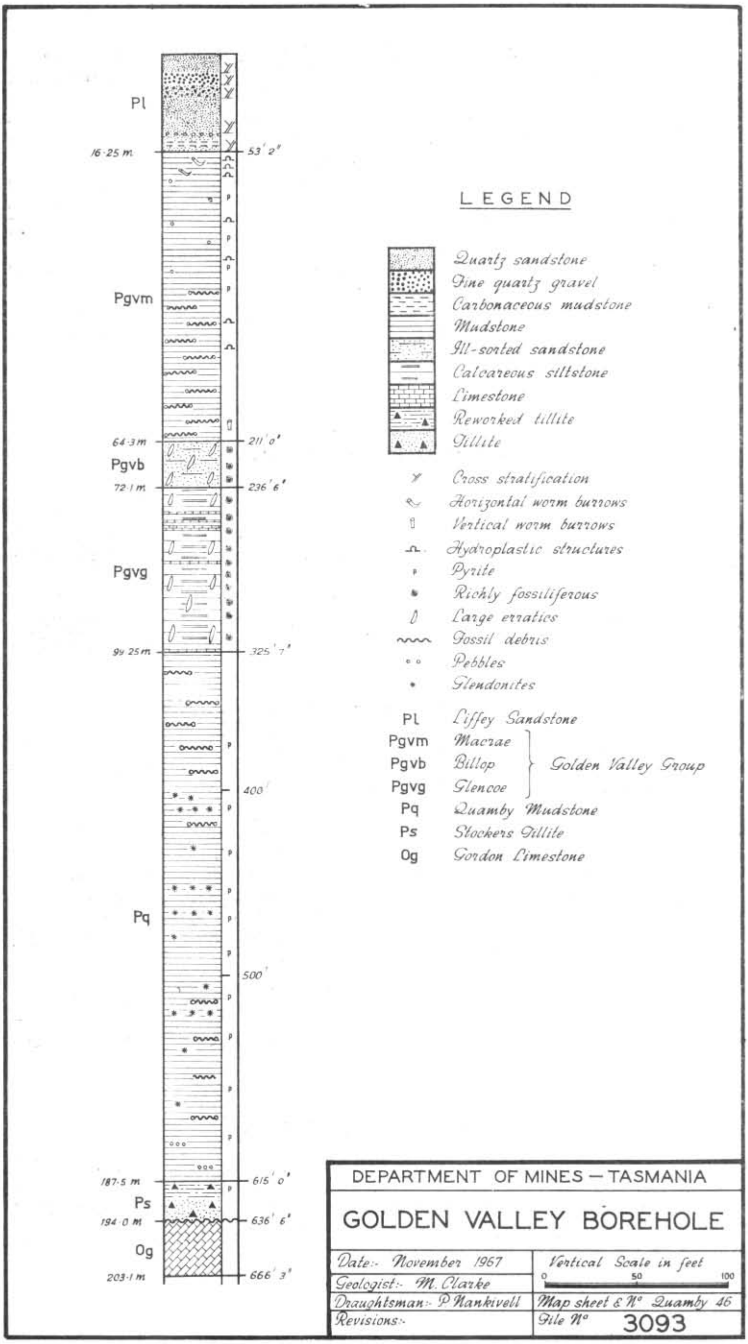
## GORDON LIMESTONE

The lowest 9.10 m of the core (203.1-194.0 m) consists of compact, crystalline dolomite. About 3 m of the dolomite immediately beneath the Permian is irregularly iron-stained and geoidal. Beneath this level the dolomite is more compact, medium grey in colour and without geoids. At 196.6 m (7.5 cm) and 197.95 m (25 cm) dark mudstone with much limestone debris occurs. These two bands are inclined some 25-30° to the horizontal and probably represent later infill of solution enlarged joints. Throughout, the dolomite is much jointed and stylolitic. The latter feature gives an overall appearance of brecciation in places. Shelly debris occurs at intervals, but no determinable fossils are present in the core.

Correlation with the Gordon Limestone is assumed through the surface association of Owen Conglomerate, Caroline Creek Sandstone and Gordon Limestone, and the absence of limestone of other Palaeozoic ages in the Golden Valley area.

## STOCKER'S TILLITE 6.5 M

Limestone tillite occurs from 194.0-187.5 m. Its contact with the underlying Gordon Limestone is sharp, but steep and irregular (fig. 3a). It seems unlikely that the observed core contact is typical of the sub-Permian floor. More probably it represents a solution hollow in the Gordon Limestone surface.



Pl
16·25 m
53' 2"
Pgvm
64·3 m
211' 0"
Pgvb
72·1 m
236' 6"
Pgvg
99 25 m
325' 7"
400'
Pq
500'
187·5 m
615' 0"
Ps
194·0 m
636' 6"
Og
203·1 m
666' 3"
LEGEND
Quartz sandstone
Fine quartz gravel
Carbonaceous mudstone
Mudstone
Ill-sorted sandstone
Calcareous siltstone
Limestone
Reworked tillite
Tillite
Cross stratification
Horizontal worm burrows
Vertical worm burrows
Hydroplastic structures
Pyrite
Richly fossiliferous
Large erratics
Fossil debris
Pebbles
Glendonites
Pl Liffey Sandstone
Pgvm Macrae
Pgvb Billop
Pgvg Glencoe
Golden Valley Group
Pq Quamby Mudstone
Ps Stockers Tillite
Og Gordon Limestone
DEPARTMENT OF MINES — TASMANIA
GOLDEN VALLEY BOREHOLE
Date:- November 1967
Vertical Scale in feet
0 50 100
Geologist:- M. Clarke
Draughtsman:- P. Nankivell
Map sheet & No Quamby 46
Revisions:-
File No 3093


FIG. 2.

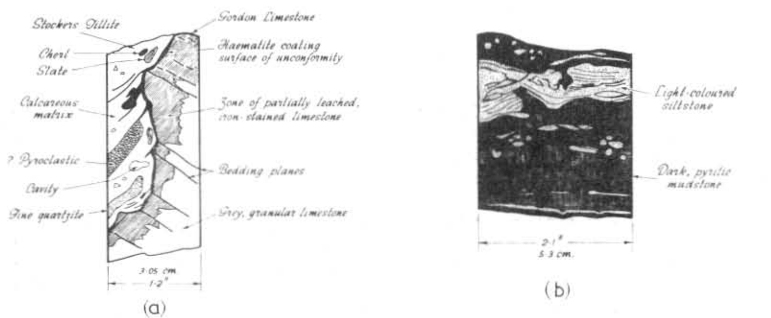
The lowest 3.65 m comprise true tillite. The rock is pale-grey in colour, completely unsorted, and consists of erratics ranging from 7.5 cm in diameter (a pebble of stylolitic Gordon Limestone with gastropods), although characteristically 2-5 cm in diameter, to fine gravel, sand and silt grade, enclosed within a calcareous and argillaceous matrix of clay grade. The included fragments are subrounded and predominantly limestone, but white, green and pink quartzite, a variety of igneous rocks, and green schist and other metamorphic rocks also occur. The 30.5 cm of tillite immediately above the Gordon Limestone has most of the limestone fragments leached out, leaving a cavernous mudstone.

The highest 2.74 m of the Stocker's Tillite may be water deposited. There is some evidence of a crude sorting and layering of the erratics, and the mud grade matrix is only feebly calcareous, but noticeably pyritic. The lower and upper units of the Stocker's Tillite are separated by 5 cm of dark, bedded mudstone with pebbles. The preponderance of limestone debris throughout the Stocker's Tillite reflects the underlying pavement of Gordon Limestone.

## QUAMBY MUDSTONE 88.25 M

From 187.5 m to 99.25 m the core consists of monotonous dark carbonaceous, pyritic and rarely micaceous mudstone with rare small pebbles and fossil debris.

The lowest 26.4 m (187.5-161.1 m) comprise pyritic and carbonaceous mudstone virtually devoid of fossils and pebbles. The few pebbles present are small and almost always well-rounded and disc-shaped, and of slaty or schistose composition. The sole exception is a subovoid quartzite pebble 3 cm in diameter at 164.0 m. Fossils include a strophalosiid fragment at 177.5 m, pyritised worm burrows parallel to the bedding at 167.3 m, and a dielasmid fragment at 161.12 m. Small glendonites occur at 175.0 m and 169.0 m.




CONTACT BETWEEN STOCKERS TILLITE AND GORDON LIMESTONE

HYDROPLASTIC STRUCTURES AND WORM BURROWS IN MACRAE MUDSTONE

FIG. 3.



5 cm

The overlying 16.3 m (161.1-144.8 m) consist of similar pyritic and carbonaceous mudstone almost without small pebbles and devoid of fossils, but characterised by an oblique wavy structure visible only on the core surface. This structure is outlined in black and simulates the appearance of a tabulate coral when sectioned obliquely to the length of the corallites. No structure is visible on polished surfaces or thin sections cut parallel to the bedding and the length of the core. The structure always appears to dip from left to right at about 45°, that is, it is helicoidally twisted with the axis running parallel with the core. Periodically the structure gradually dies out upwards and downwards; in other cases it abruptly terminates against the bedding. It seems most probable that the structure has been induced by the drilling. A thin band of small schistose pebbles occurs at 155.3 m and a larger pebble of tubicular (? worm-bored) sandstone at 149.1 m. Glendonites typically with long axes of 2-5 cm, good crystal outlines and occasionally twinned occur at 145.7 m, 147.6 m, 149.9 m, 153.7 m and in a zone from 154.5 m to 157.0 m. Their faces are coated with pyrite and the adjacent matrix shows a greater concentration of both finely-disseminated and nodular pyrite.

The overlying 22.6 m (144.8-122.2 m) comprise dark pyritic and carbonaceous mudstone with very rare small pebbles, but abundant glendonites. The glendonites are probably scattered throughout, but their distribution in the core suggests greater concentrations at 125.7-127.6 m (5), 135.2-135.5 m (7), and 140.3-140.7 m (5). Erratics are absent except for a small quartzite pebble at 141.4 m. Fossils are similarly very rare, but a strophalosiid fragment occurs at 125.6 m, a thin band of crinoidal debris at 128.7 m, a single complete specimen of *Grantonia* sp. nov. at 129.95 m, and a patch of shelly debris and very small slaty and schistose pebbles from 130.0 m to 131.0 m.

The uppermost 21.95m of the Quamby Mudstone (122.2-99.25 m) comprise dark carbonaceous mudstone. The highest parts are slightly micaceous and non pyritic, but by gradual transition these components are reversed in the lower parts. Glendonites are absent. Shelly debris associated with small pebbles occurs in well-defined bands at remarkably constant intervals of about 3 m. In these bands *Merismopteria* occurs at 100.0 m, a smooth ? dwarfed pectenid at 103.25 m, *Grantonia* fragments at 108.25 m and 114.8 m, crinoid debris at 117.6 m and *Keeneia* at 121.15 m. A zone of calcification was encountered between 112.0 m and 112.20 m. Its margins are very ragged, and enclosed within it is a group of 10-12 small slaty and schistose pebbles and a spiriferid fragment. These may have acted as a nucleus for the calcareous material.

The Quamby Group thus represented consists of a monotonous sequence of dark carbonaceous mudstone. The mudstone is slightly micaceous in its highest parts, but predominantly pyritic. Glendonites are present through an interval of 52.72 m in the middle of the unit. Fossils and groups of small pebbles are always rare. It is noteworthy that there seems to be a natural association of glendonites and pyrite, and shelly debris and pebbles. Pyrite concentration is greatest in the immediate vicinity of glendonites, and it is rare to see pebbles without shelly debris. Whilst pyrite occasionally replaces shelly material, glendonites do not occur with pebbles or shelly debris.

## GOLDEN VALLEY GROUP 83.0 M

### (*a*) GLENCOE FORMATION

The Glencoe Formation is here defined as that unit lying conformably between the Quamby Mudstone below and the Billop Sandstone above. In the borehole it is 27.15 m (99.25-72.1 m) thick. It maintains a similar thickness throughout the Quamby Brook and Golden Valley area. It is equivalent to the Brumby Marl and Upper Quamby Mudstone at Poatina (McKellar, 1957 and see later).

In essence the Glencoe Formation comprises a sequence of richly fossiliferous calcareous shale and limestone with abundant erratics of varying size. In detail it is the most variable unit lithologically within the Golden Valley Group, a factor which largely explains the confusion concerning the definition of the lower boundary of the Group.

The core presents a sequence of richly fossiliferous and erratic-rich, calcareous, ill-sorted siltstone and mudstone with thin shelly limestones at 76.5 m (15 cm) 77.5 m (2.5 cm), 78.1 m (7.5 cm), 79.25 m (20 cm), 84.6 m (10 cm) and 99.07 m (18 cm). The erratics vary in size from a few millimetres up to the largest encountered, a psammitic schist erratic with a dimension of 10 cm at right angles to the schistosity; in all probability the dimension parallel to the foliation was greater. Typically they average 2-5 cm in dimensions. Compositionally they comprise a wide variety of coarse- to fine-grained, variously coloured quartzites, psammitic schist and other metamorphic and igneous rocks. Amongst the smaller erratics, green schist, slaty fragments and black flinty material is in evidence.

Fossils are present in profusion throughout the Glencoe Formation though a little less abundantly towards its summit and base. In places, indigenous faunas in growth position can be recognised. These bands are thin, usually a few centimetres in thickness, and erratics are much less in evidence. Three broad communities are present; (1) a strophalosiid community with lesser *Stenopora,* (2) a stenoporid-fenestellid community, and (3) a *Eurydesma, Grantonia* and *Keeneia* community. Elsewhere, and comprising the bulk of the formation, the fossils are indiscriminately mixed with the matrix and erratics. *Eurydesma, Grantonia, Strophalosia, Ambikella, Keeneia, Deltopecten, Stenopora* and other bryozoa with crinoidal debris in places, occur together in random proportions and orientations. *Calcitornella* frequently encrusts the inner shell surfaces of *Strophalosia* and *Grantonia,* but a similar encrustation of the upper surfaces of pebbles has not been observed (compare McKellar, 1957, p. 8). These faunas are clearly reworked and of several generations. Particularly noticeable are rolled and smoothed fragments of the thick hinge plate and umbonal regions of *Eurydesma,* and the callosed ventral cardinal and umbonal regions of *Grantonia.* At the same time complete and unworn specimens with the two valves still in articulation of *Eurydesma, Grantonia, Deltopecten* and *Aviculopecten* also occur.

The limestones are essentially similar faunally to the latter mentioned reworked siltstones and mudstones, except that the matrix is composed almost entirely of bioclastic calcareous material of sand and silt grade.

### (*b*) BILLOP SANDSTONE 7.8 M

Overlying the Glencoe Formation between 72.1 m and 64.3 m is a sequence of lighter-coloured and coarser-grained, blue-grey to buff-coloured, ill-sorted micaceous sandstone. Large and small well-rounded erratics are very common. Fossils are abundant. Complete individuals of *Peruvispira*, *Spiriferella* and *Grantonia* occur in profusion with lesser *Myonia carinata* (Morris), *Strophalosia*, and a large dielasmid, probably *Fletcherithyris*. Shelly debris is also abundant, fragments of *Ambikella*, *Deltopecten*, *?Paromphalus*, spiriferids, fenestellid and treptostome bryozoa, crinoidal debris and rare *Eurydesma* also occur.

The base of the Billop Sandstone is abruptly defined lithologically from the underlying Glencoe Formation, but its upward limit is somewhat transitional. Its summit in the core has been taken as coincident with the last large erratic, a level broadly consistent with the colour and grain size change.

### (c) Macrae Mudstone 48.5 m

Between 64.3 m and 16.25 m the core displays a return to a monotonous sequence of poorly-fossiliferous, dark, ill-sorted siltstone and mudstone. It may be subdivided into two units of approximately equal thickness. The lower unit comprises dark, ill-sorted micaceous mudstone and siltstone with little or no pyrite, and with occasional bands of sub-rounded pebbles up to 2.5 cm in diameter associated with shelly debris. The shelly debris is more abundant and less finely comminuted than similar material in the Quamby Mudstone. *Grantonia*, *Ambikella*, *Merismopteria*, *Deltopecten*, *Stenopora* and other bryozoa can be recognised at intervals. The higher unit comprises similar dark ill-sorted, micaceous mudstone and siltstone, but with finely-disseminated pyrite abundant, small erratics, and fossils and fossil debris absent. A further character of distinction is the presence of structures resulting from movement in hydroplastic muds and worm burrows which disturb the bedding (fig. 3b). These structures occur most abundantly in a zone of 5 m immediately beneath the overlying Liffey Sandstone. Selenite is present on some joint surfaces.

The Macrae Mudstone poses a problem for the field geologist if and when it is exposed. Whilst drilling, the Macrae Mudstone was recovered in more or less solid 3 m rods. In the few weeks which have since elapsed, the core has suffered serious deterioration, principally in the oxidation of the pyrite to ferrous sulphate. This oxidation has destroyed the cohesion of the rock and the core is rapidly breaking down into small lenticular fragments similar to the weathered appearance of the Quamby Mudstone in outcrop exposure (rather surprisingly the cored Quamby Mudstone for the most part shows no such breakdown). The rapid breakdown of the Macrae Mudstone partly explains its lack of exposure in the Golden Valley area. In isolated natural exposures it might prove impossible to differentiate lithologically the Macrae and Quamby Mudstone. The lower Macrae might possibly be recognised by its more abundant fossil debris and larger pebbles, but the upper Macrae would lose all trace of its hydroplastic structures and thus merge with the Quamby Mudstone.

## LIFFEY SANDSTONE 16.25 M

(Drilling commenced on the first topographic bench developed within the Liffey Sandstone outcrop. The total thickness of the Liffey Sandstone in the Golden Valley area is about 33-35 m).

The highest 16.25 m of the core consists of massive, soft, micaceous quartz sandstone and fine quartz gravel, with minor partings of carbonaceous mudstone towards the base. The rock is well-sorted and pale grey-white when fresh, but khaki to buff-coloured when weathered. It is current-bedded throughout. From 0-3.20 m the rock is a micaceous quartz sandstone. Very coarse quartz sandstone and fine quartz gravel occurs from 3.20 m to 4.88 m, with bands of well-rounded, white vein quartz pebbles at 3.40 m and 4.72 m. From 4.88-7.62 m coarse quartz sandstone and fine quartz gravel alternates with finer quartz sandstone; the finer bands are very micaceous and parted by numerous coal streaks, whereas the coarser bands have rare coal streaks and no mica. From 7.62 m to 16.25 m the rock is a medium-grained micaceous sandstone with numerous coal streaks. A band of vein quartz pebbles occurs at 13.4 m, and thin seams of black carbonaceous mudstone occur at 14.85 m (5 cm), 14.90 m (2.5 cm), 15.05 m (5 cm) and 15.2 m (7.5 cm). All subsidiary lithologies—the pebble bands, the coal streaks and the carbonaceous mudstones—are developed parallel to the cross stratification.

Thus, within the core, the Liffey Sandstone develops a variety of lithologies. No precise similarity with any part of the quadripartite division of the Liffey Sandstone at Poatina is evident (McKellar, 1957). Comparison with the well-exposed natural cliffs immediately below the drill site demonstrates that most of the lithological variations are dependent in their development to the incidence of cross-bedded channels, washouts and other sedimentary phenomena. Non marine conditions of deposition are probable (Wells, 1957; McKellar, 1957; Banks, 1962).

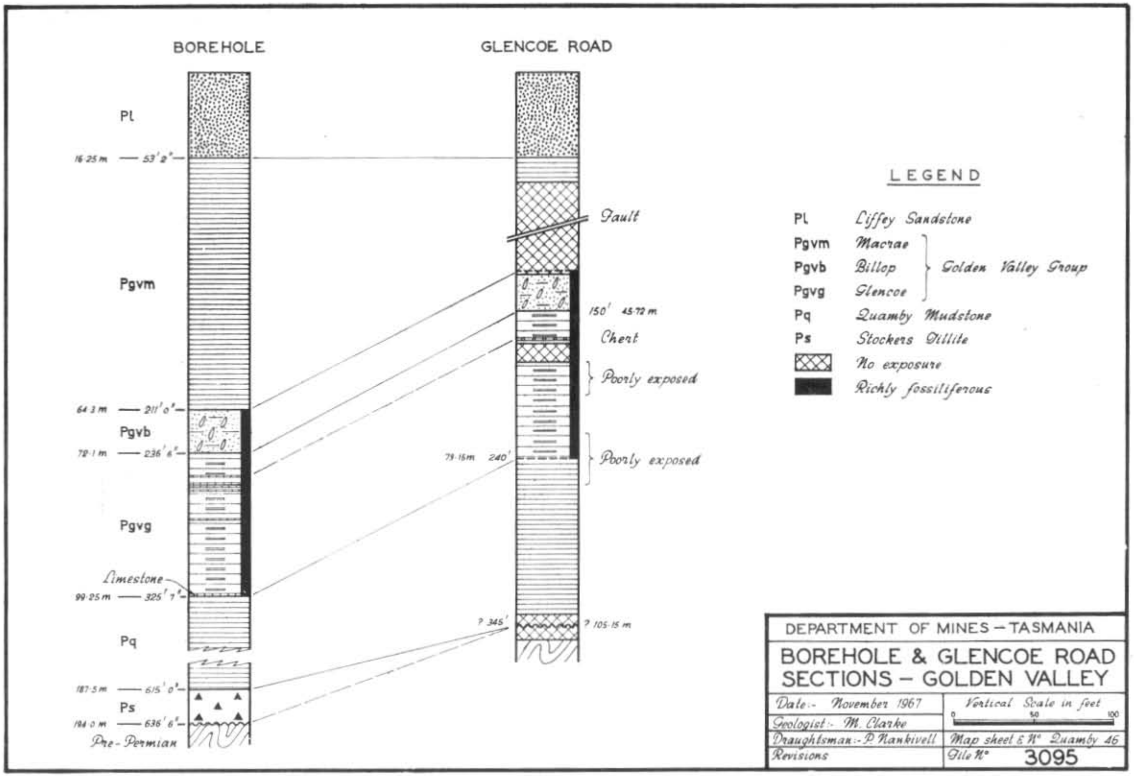
## Correlation of Borehole and Local Surface Sections

Figure 4 shows a tabular comparison of the borehole and Glencoe Road sections, and Figure 5 tabulates all available sections throughout the Quamby Brook and Golden Valley area.

On the road section some 33-35 m of Quamby Mudstone occurs. Exposure is more or less continuous except for the contact with the Precambrian Davey Group metasediments and the highest parts immediately beneath the Golden Valley Group. The Golden Valley Group is poorly-exposed apart from the Billop Sandstone. A 10 cm band of chert crowded with fossils about 4.6 m below the base of the Billop Sandstone is probably equivalent to the highest of the limestone bands in the core. Beneath this chert there are 22 m of intermittently exposed bryozoal siltstones with few erratics and shelly siltstones with abundant erratics. These lower beds become less fossiliferous and less pebbly towards their base but non exposure prevents an exact placing of the Quamby Group—Golden Valley Group boundary.

The Billop Sandstone is well-exposed and forms a prominent bench on the road. Lack of exposure prevents proving its summit, but it is unlikely to extend much higher since 7.5 m are exposed on the road. Thereafter there is no exposure for 15-18 m. Immediately beneath the Liffey Sandstone some 4.5-6.0 m of poorly-exposed, much weathered, light-brown coloured, ill-sorted carbonaceous and micaceous

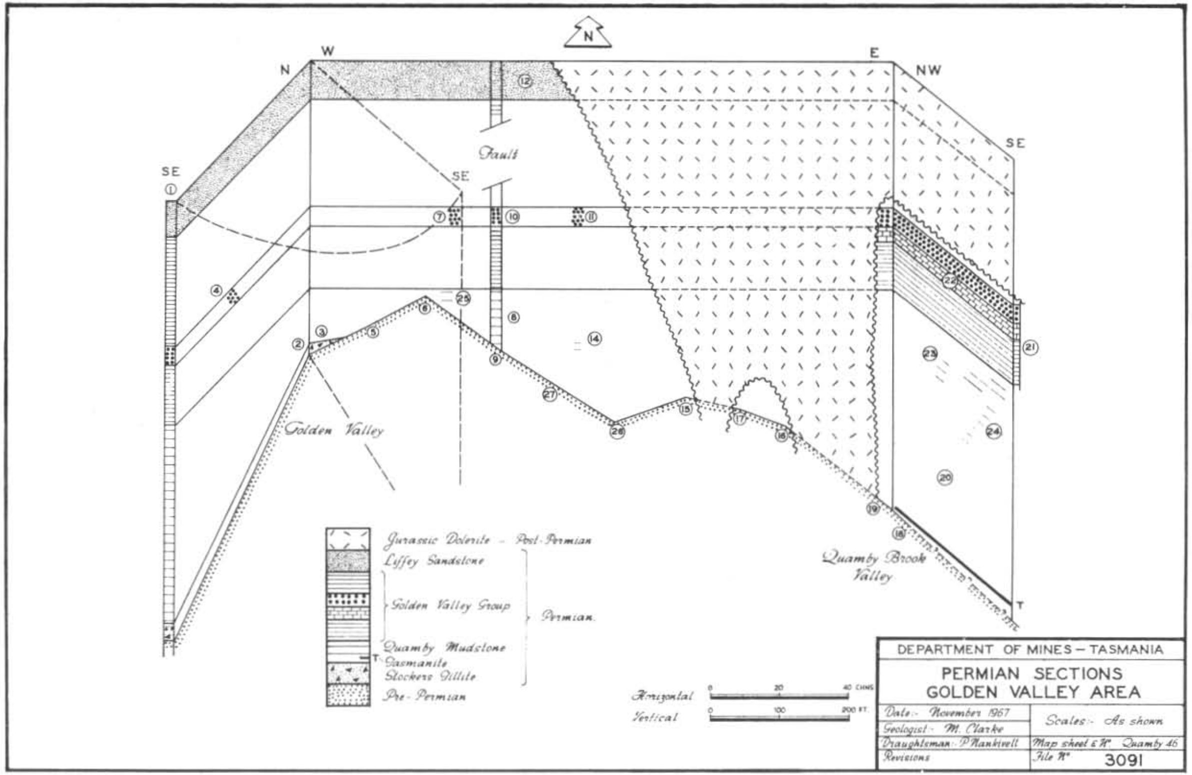
5 cm



BOREHOLE
GLENCOE ROAD
Pl
16·25 m — 53' 2"
Pgvm
64·3 m — 211' 0"
Pgvb
72·1 m — 236' 6"
Pgvg
Limestone
99·25 m — 325' 7"
Pq
187·5 m — 615' 0"
Ps
194·0 m — 636' 6"
Pre-Permian
Fault
150' 45·72 m
Chert
Poorly exposed
73·15 m 240'
Poorly exposed
? 345'
? 105·15 m
LEGEND
Pl Liffey Sandstone
Pgvm Macrae
Pgvb Billop
Pgvg Glencoe
Golden Valley Group
Pq Quamby Mudstone
Ps Stockers Tillite
No exposure
Richly fossiliferous
DEPARTMENT OF MINES – TASMANIA
BOREHOLE & GLENCOE ROAD SECTIONS – GOLDEN VALLEY
Date:- November 1967
Vertical Scale in feet
0 50 100
Geologist:- M. Clarke
Draughtsman:- P. Nankivell
Map sheet & N° Quamby 46
Revisions
File N° 3095


FIG. 4.

5 cm



N
W
E
NW
SE
SE
SE
Fault
Golden Valley
Quamby Brook Valley
T
Jurassic Dolerite - Post-Permian
Liffey Sandstone
Golden Valley Group
Quamby Mudstone
Tasmanite
Stockers Tillite
Permian
Pre-Permian
Horizontal 0 20 40 CHNS
Vertical 0 100 200 FT.
DEPARTMENT OF MINES — TASMANIA
PERMIAN SECTIONS
GOLDEN VALLEY AREA
Date:- November 1967
Geologist:- M. Clarke
Draughtsman:- P. Nankivell
Revisions
Scales:- As shown
Map sheet & Nº Quamby 46
File Nº 3091


FIG. 5.

siltstone occurs. In all there is sufficient room for 22 m of Macrae Mudstone between the Billop and Liffey Sandstones on the road compared with the 48.05 m encountered in the borehole. A fault upthrowing the lower parts of the road section against the higher parts must therefore cross the road somewhere in the area of no exposure above the Billop Sandstone.

West of the road a complete section of the Billop Sandstone occurs in the creek flowing off the Liffey scarp (loc. 4). Exposure above and below this horizon is negligible. Billop Sandstone debris also occurs on the valley side immediately west of the Glencoe Road (loc. 7). Although in the correct topographical position on the downthrow side of the fault, it could well be float from the upthrown Billop which outcrops on the road. Below the level of the Billop Sandstone exposure is poor; no portion of the Glencoe Formation can be seen. At the extreme southeastern extension of Stocker's Plain (loc. 2), Stocker's Tillite rests on and abuts against steeply dipping and overturned Gordon Limestone. The tillite differs from that in the core. The contact with the Gordon Limestone comprises about 6 mm of coarse, but well-sorted, water-deposited, fine quartz gravel with small limestone fragments, followed by 2 m of tillite very considerably coarser than that developed in the core. Though stated by Wells (*op. cit.*) to be 13.72 m thick, it seems likely that the exposure at this locality represents more or less its total thickness since no more than fifty metres to the east, and no more than three metres higher topographically, recent bulldozer excavations of a new water hole show typical dark Quamby Mudstone (loc. 3). Quamby Mudstone is also exposed in the creek immediately west of the Glencoe Road (loc. 25). Pre-Permian rocks are well-exposed, however, and constitute hard quartzitic sandstones (loc. 5) and Owen Conglomerate (loc. 6). The latter exposure is apparently an exhumed *roche moutonée.*

East of the Glencoe Road exposure is equally poor. Quamby Mudstone is exposed alongside the Lake Highway (loc. 14), and a 12 m section of Billop Sandstone and shelly siltstone immediately below (loc. 11) provides the most continuous pre-Liffey Sandstone section anywhere in the Golden Valley.

The Liffey Sandstone forms a well-exposed scarp and bench along the south flank of the Golden Valley from the extreme west to the extreme east (locs. 28, 1, 12, 13). Both ends are truncated by discordant dolerite.

Separating the Golden Valley and Quamby Brook Valley is a minor basement high. Details are difficult to obtain since dolerite blankets the greater part of the area. Basement rocks can be seen, however, at localities 15-17.

The Quamby Brook Valley Permian outcrop, although areally less extensive than that of the Golden Valley, is much more completely-exposed. The lowest exposed Permian rocks occur in the stream bed a little south of where the road from Golden Valley to Quamby Brook crosses the creek (loc. 19), and constitute the Tasmanite Oil Shale (Bakes Oil Shale of Wells). The Tasmanite is about 1.4 m thick; when fresh it is blue-grey in colour, but weathers rusty brown. It is fissile and the bedding planes are crowded with the orange-brown flattened spheroids of *Tasmanites punctatus* Newton. The

Tasmanite is about 96 m below the base of the Golden Valley Group. Though stated by Wells (*op. cit.*) to be 19.8 m above the base of the Quamby Mudstone, the topographic height of the nearest exposed Cambrian rocks (loc. 18) suggests that it is no more than 6.25 m above the base of the Permian sequence. Above the Tasmanite a more or less continuous sequence of dark-grey, carbonaceous and pyritic mudstone with rare small pebbles and without fossils is exposed in the stream bed of the easternmost headwater creek of Quamby Brook (locs. 20, 24) as far upstream as where the southern extension of the Quamby Brook road crosses the creek (loc. 21). At this point there is an abrupt lithological change. Bands of large erratics with *Eurydesma* and *Keeneia* are interbedded with layers of *Strophalosia*, *Grantonia* and *Stenopora*. These beds persist for 20-22 m and are overlain by 6.25-7.5 m of massive coquina limestone with abundant erratics and otherwise largely composed of *Eurydesma* and *Keeneia*. The limestone is in turn overlain by about 7.5 m of erratic rich, micaceous, ill-sorted sandstone with abundant *Peruvispira*, *Grantonia* and *Spiriferella*. Transgressive dolerite prevents further Permian outcrop.

The Billop Sandstone together with the underlying coquina limestone forms a very prominent feature along the eastern flank of the Quamby Brook Valley. More or less continuous exposures of the higher parts of the Quamby Mudstone occur on and alongside the Quamby Brook road (locs. 23-21), and up the valley sides where the Glencoe and Billop Formations are also exposed (loc. 22).

# Redefinition of Quamby Mudstone and Golden Valley Group

As indicated in the preceding paragraphs, the original definition of the Quamby Mudstone and the Golden Valley Limestone and Shale (Wells, *op. cit.*) presents several anomalies. With the additional information provided by the borehole the following can be surmised:—

(1) Despite designating the Glencoe Road as type section for the Quamby Mudstone, Golden Valley Limestone and Shale, and Liffey Sandstone, Wells based his definition of the lower boundary of the Golden Valley Group on the more completely-exposed Quamby Brook section. It is perhaps unfortunate that the Golden Valley section is complicated by facies change, but at the time of his original definition Wells was inconsistent in his placing of the base of the Golden Valley Group as coincident with the base of the massive coquina limestone, a decision at variance with his mapped lithological boundaries; certainly those 20.22 m of richly fossiliferous and erratic rich siltstones and mudstones beneath the coquina limestone cannot be placed within the Quamby Mudstone as defined by Wells (p. 8). Indeed, throughout the Quamby Brook area these beds were mapped by Wells with the Golden Valley Limestone and Shale.

(2) The original definition of the Golden Valley Group takes no account of the Macrae Formation. This is more easily understood since nowhere in the Golden Valley or Quamby Brook Valley area is the Macrae Mudstone exposed; the Glencoe Road section is

faulted thus effecting a much reduced apparent thickness, and throughout the Quamby Brook sections, transgressive dolerite obscures horizons above the Billop Sandstone. It is evident that Wells considered the highest parts of the Golden Valley Group to be of Billop Sandstone lithology—'the top beds are coarser, poorly-sorted shale and sandstone, pale-grey and blue-grey in colour, light-brown and yellow on weathered surfaces. [Rare] large erratics are present and fossils plentiful'. This conclusion is strengthened by his mapping of Liffey Sandstone beneath the dolerite sill in the Quamby Brook Valley. There is in fact, no evidence for Liffey Sandstone in the Quamby Brook Valley.

(3) The thicknesses of the various Permian Formations as given by Wells are roughly double their actual values. Thus the Stocker's Tillite is 0-6 m thick (not 13.72 m), the Quamby Mudstone is up to 96.0 m thick (not 162 m), the Golden Valley Group (in reality the Glencoe and Billop Formations only) is 35.0 m thick (not 61.0 m), but 83.10 m thick with the Macrae Mudstone, and the Liffey Sandstone is no more than 33-35 m thick (not 76.2 m).

## QUAMBY MUDSTONE 3-96 M

The Quamby Mudstone is defined as that unit which lies conformably between the Stocker's Tillite below and the Golden Valley Group above. It is characterised as a dark, blue-grey mudstone, usually pyritic and carbonaceous. Small pebbles are sparsely distributed throughout. Finely comminuted fossil debris is usually associated with these pebble horizons. Larger fossil fragments also occur but are very rare. Glendonites characterise the middle parts. In places, notably the Glencoe Road and in the Quamby Brook Valley, it seems probable that the Stocker's Tillite is absent and the Quamby Mudstone rests directly on pre-Permian rocks. The designated type section on the Glencoe Road is satisfactorily exposed and lithologically typical, although its thickness (33-35m) is much reduced by a basement high. The most complete section occurs in the Quamby Brook Valley and is upwards of 96.0 m thick ranging from the Tasmanite Oil Shale below to the Golden Valley Group above.

## GOLDEN VALLEY GROUP 83.0 M

The Golden Valley Group is redefined as consisting of those three formations which lie conformably between the Quamby Mudstone below and the Liffey Sandstone above. A broadly similar tripartite division was first proposed for the Poatina area (McKellar, *op. cit.*).

### (*a*) Glencoe Limestone and Shale 27.4 m.

The Glencoe Formation is here proposed to include those richly fossiliferous and erratic rich siltstones, mudstones and limestones which lie conformably between the Quamby Mudstone below and the Billop Sandstone above. It equates with the Brumby Marl and upper Quamby Mudstone at Poatina (McKellar, *op. cit.*). The type section is here designated as that exposed in the stream bed in the headwater reaches of the easternmost creek of Quamby Brook (loc. 21; coordinates 873350N/466450E).

The type section is unusual in that the highest 6.25-7.5 m of the formation consists of massive coquina limestone. In the Golden Valley area this limestone shows a lateral facies change into richly fossiliferous siltstone with thin bands of shelly limestone.

### (*b*) Billop Sandstone 7.8 m

This formation lies conformably between the Glencoe Formation below and the Macrae Mudstone above. The type section is in the Poatina area (McKellar, *op. cit.*). A series of equally well-exposed sections occur in the headwater reaches of Quamby Brook (loc. 21), on the Glencoe Road (loc. 10), and in creeks immediately east and west of the Glencoe Road (locs. 11 and 4). The differentiation into a lower conglomeratic level and an upper sandstone level recorded at Poatina (McKellar, *op. cit.*) is nowhere evident in the Golden Valley or Quamby Brook Valley area.

### (*c*) Macrae Mudstone 48.05 m

The Macrae Formation lies conformably between the Billop Sandstone below and the Liffey Sandstone above. Its type section is in the Poatina area (McKellar, *op. cit.*). Nowhere in the Quamby Brook or Golden Valley area is the Macrae Mudstone exposed.

# Outline Faunal Sequence

The following remarks are based on preliminary indentifications of the faunas obtained from the Quamby Brook and Golden Valley areas. A more detailed treatment will be published separately.

## QUAMBY MUDSTONE

Fossils are extremely rare throughout the Quamby Mudstone. There is no evidence of indigenous life; all fossil material is associated with clastic debris. An exception to this may be a small (? dwarfed) pectenid. No systematic treatment of microfossils has yet been attempted.

*Grantonia* sp. nov.
*Merismopteria* sp.
?*Keeneia* sp. (or *Platyschisma* sp.)
Smooth pectenid
Strophalosiid fragments
Dielasmid
Worm burrows

## GOLDEN VALLEY GROUP

### Glencoe Formation

Fossils are extremely abundant throughout. Indigenous and reworked assemblages can be recognised.

*Calcitornella stephensi* (Howchin)
*Strophalosia* sp. nov. et subsp. nov. (Aff. *S. preovalis* Maxwell group)
*Strophalosia* sp. nov. (Aff. *S. jukesi* (Etheridge))
*Costalosia* sp. nov. (Aff. *C. argentea* (Douglas))
*Grantonia* spp. nov.

*Ambikella* spp. (= *Ingelarella; Tomiopsis; Martiniopsis* Auctorum)
*Schuchertella* sp.
*Keeneia platyschismoides* Etheridge
? *Paromphalus ammonitiformis* (Etheridge)
*Aviculopecten tenuicollis* (Dana)
*Deltopecten mitchelli* (Etheridge and Dun)
*Eurydesma cordatum* (Morris)
*Merismopteria macroptera* (Morris)
*Stenopora johnstoni* Auctorum
*Stenopora tasmaniensis* (Lonsdale)
Fenestellids including *Polypora* sp.
Crinoid debris

### BILLOP SANDSTONE

Fossils are very common, but always show some evidence of reworking.
*Grantonia* sp. nov.
*Spiriferella* sp. nov. (Aff. *S. supplanta* Waterhouse)
*Peruvispira* sp.
*Myonia carinata* (Morris)
*Deltopecten* sp.
?*Paromphalus ammonitiformis* (Etheridge)
*Ambikella* sp.
*Strophalosia* sp.
?*Fletcherithyris* sp.
*Eurydesma cordatum* Morris
Crinoid debris

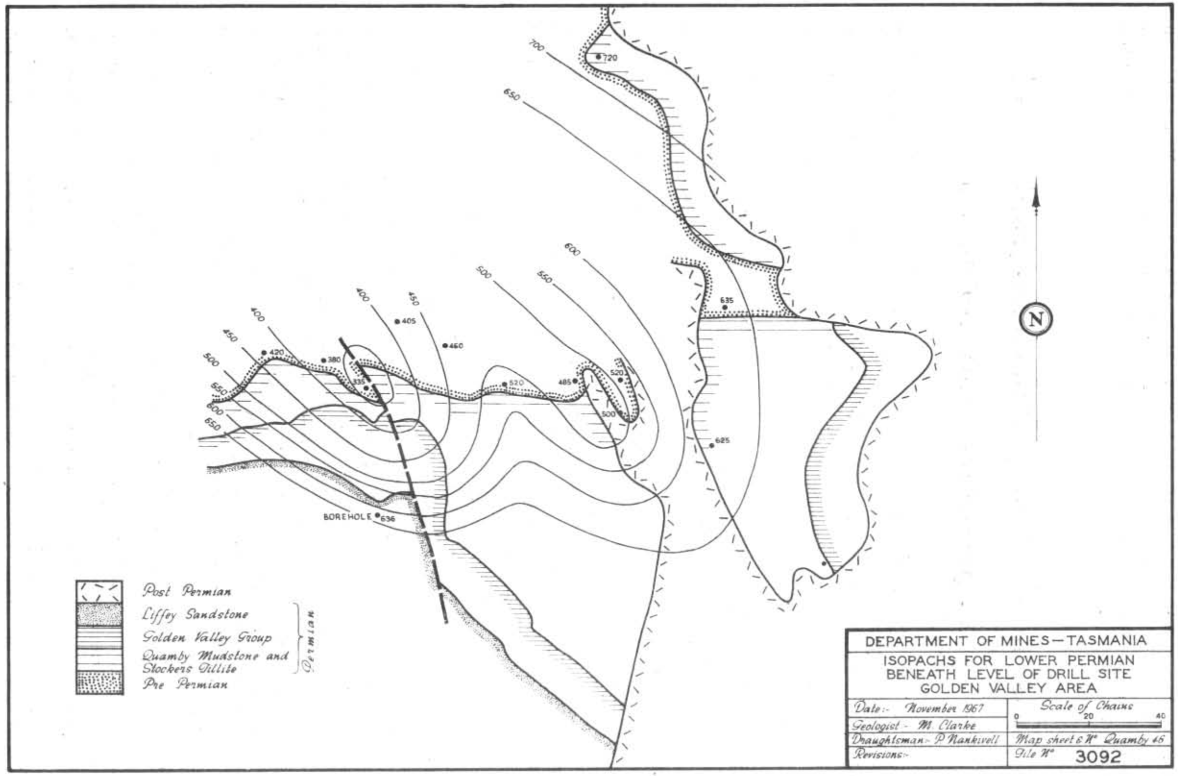
### MACRAE MUDSTONE

Fossils are rare in the lower half and absent in the higher parts. All fossils are reworked.
*Ambikella* sp.
*Grantonia* sp. nov.
*Deltopecten* sp.
*Merismopteria* sp.
*Stenopora tasmaniensis* (Lonsdale) and other bryozoa

## DISCUSSION

As noted by Banks (1962), foraminiferal faunas, bryozoa (Crockford, 1951), lamellibranchs and gastropods all indicate a broad correlation with some part of the Dalwood Group in New South Wales, more especially the Allandale and Rutherford Formations. In detail this correlation may prove tenuous. *Grantonia* spp. nov. cannot be compared with previously described species: *Strophalosia* sp. nov. A et subsp. nov. shows affinities with *Strophalosia preovalis* Maxwell from Queensland, and *Strophalosia* sp. nov. B is probably ancestral to *Strophalosia jukesi* (Etheridge) from the Cascades Stage of Tasmania. A similar strophalosiid fauna is unknown elsewhere in Australia or New Zealand (Waterhouse, 1964), and it is possible that the Golden Valley forms are older than any previously described assemblage. Rather enigmatically the supposed warm water genera *Costalosia*, nearest to *Costalosia argentea* (Douglas) from Persia and *Spiriferella* (Aff. *S. supplanta* Waterhouse from New Zealand) are here recorded for the first time in Tasmania in what are undoubtedly cold water sediments.

5 cm



N
Post Permian
Liffey Sandstone
Golden Valley Group
Quamby Mudstone and Stockers Tillite
Pre Permian
Permian
BOREHOLE 636
700
650
600
550
500
450
400
720
635
625
520
485
500
460
405
420
380
335
DEPARTMENT OF MINES—TASMANIA
ISOPACHS FOR LOWER PERMIAN BENEATH LEVEL OF DRILL SITE GOLDEN VALLEY AREA
Date:- November 1967
Geologist - M. Clarke
Draughtsman:- P. Nankivell
Revisions:-
Scale of Chains
0 20 40
Map sheet & Nº Quamby 46
File Nº 3092


FIG. 6.

Overall there is little to suggest that the Golden Valley Group faunas are younger than Sakmarian. The Quamby Mudstone is also probably Sakmarian, the Permo-Carboniferous boundary therefore occurring in some part of the Wynyard Tillite or its correlates (Guilline, 1967).

# Basement Relief, Palaeogeography and Depositional Environments

Figure 6 illustrates the pre-Permian relief. Two marked NW-SE trending basement highs largely controlled by resistant Owen Conglomerate occur with their crests a little to the west of the Glencoe Road, and between the Quamby Brook and Golden Valleys. It seems most probable that the basement relief was progressively drowned by the Quamby Mudstone which has a uniform and horizontal aspect everywhere. Reworking of the higher parts of the Stocker's Tillite indicates a break between it and the Quamby Mudstone, and suggests no lateral facies equivalence between them. The emphasis by Banks (1962) on the apparent uniform height of the Tasmanite (about 15.25 m) above the base of the Quamby Group appears to be unwarranted. New exposures in the Oonah area show the Tasmanite to vary in height above the top of the tillite from 6.10 m to 15.25 m; in the Hellyer Gorge it is 13.7 m; at Chudleigh it is 9.15 m (as stated by Banks, 1962); at Latrobe it is 22.8 m (recent excavations for a pumping site have greatly clarified the section); and the Quamby Brook occurrence cannot be accurately assessed. The occurrence of the Tasmanite in the Quamby Brook and Golden Valley area is considered to be dependent on the basement relief since it appears to occur only in the deeper basins.

The succession Stocker's Tillite, Quamby Mudstone, Golden Valley Group to the base of the Liffey Sandstone comprises a complete cycle of sedimentation consistent with the retreat of a dry base glacier (Carey and Ahmad, 1961). It should be emphasized however, that in detail there are several factors at variance with the broad postulations of Carey and Ahmad (*op. cit.*). Fossils and erratics are never common in the Quamby Mudstone. Where they occur, the erratics are always small, disc-shaped and well-rounded, and typically of a foliated metamorphic character. The fossils are much fragmented and intimately mixed with the erratics. These thin horizons, repetitive in the higher parts of the Quamby Mudstone, are virtually absent in the middle and lower parts. They are unlikely to represent lag deposits, and may possibly indicate introduced material by way of turbidity current (Banks, 1962).

Personal observation indicates that glendonites do not occur in association with fossils or erratics. They characterise those featureless parts of the middle Quamby Mudstone and occur in association with much nodular and finely disseminated pyrite. Calcareous concretions are rare in the Golden Valley area, but common at Poatina.

The Glencoe and Billop Formations were probably deposited within the iceberg zone (Carey and Ahmad, *op. cit.*). Shallower, well-oxygenated and often calcareous conditions suitable for the establishment and proliferation of sessile and vagrant benthonic faunas can be surmised. Current action is much in evidence.

The Macrae Formation marks a return to quieter, less-oxygenated conditions. The lower portions with repetitive bands of erratics and shelly debris are similar to the highest parts of the Quamby Mudstone. The higher parts, however, without pebbly and shelly material but with much pyrite, indicate a restricted reducing environment. Those portions characterised by hydroplastic structures and worm activity, notably immediately beneath the base of the Liffey Sandstone, may indicate littoral and tidal flat or tidal lagoon deposits separating a brackish marine environment below and freshwater sedimentation above. (McKellar, 1957; Banks, 1962; Van Straaten, 1959; 1961).

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# Appendix I

## GOLDEN VALLEY BOREHOLE

| DEPTH | | | | THICKNESS | | | | LITHOLOGY |
|---|---|---|---|---|---|---|---|---|
| Ft | Ins | Metres | Cms | Ft | Ins | Metres | Cms | |
| 0 | 0 | 0 | 0 | 4 | 6 | 1 | 37 | Overburden. |
| 4 | 6 | 1 | 37 | 6 | 0 | 1 | 83 | Medium-grained, well-sorted, current-bedded, micaceous quartz sandstone with carbonaceous pellets. Iron-staining present as an irregular mosaic. |
| 10 | 6 | 3 | 20 | 5 | 6 | 1 | 68 | Current-bedded, well-sorted, very coarse quartz sandstone and fine quartz gravel. Feebly calcareous. Vein quartz pebbles at 11′ 2″ and 15′ 5″. |
| 16 | 0 | 4 | 88 | 9 | 9 | 2 | 97 | Alterations of current-bedded, well-sorted, fine quartz gravel and finer sandstone. Sandstones with much mica and numerous coal streaks, coarse bands without mica and with rare coal streaks. Iron-stained mosaic ceases at 24′ 0″. |
| 25 | 9 | 7 | 85 | 22 | 9 | 7 | 00 | Current-bedded, well-sorted, micaceous quartz sandstone with numerous coal streaks. Band of vein quartz pebbles at 44′ 0″. |
| 48 | 6 | 14 | 85 | .... | 2 | .... | 5 | Black carbonaceous mudstone. |
| 48 | 8 | 14 | 90 | .... | 1 | .... | 2.5 | Micaceous quartz sandstone. |
| 48 | 9 | 14 | 92 | .... | 1 | .... | 2.5 | Black carbonaceous mudstone. |
| 48 | 10 | 14 | 95 | .... | 8 | .... | 20 | Micaceous quartz sandstone. |
| 49 | 6 | 15 | 05 | .... | 2 | .... | 5 | Black carbonaceous mudstone. |
| 49 | 8 | 15 | 10 | .... | 4 | .... | 10 | Micaceous quartz sandstone. |
| 50 | 0 | 15 | 20 | .... | 3 | .... | 7.5 | Black carbonaceous mudstone. |
| 50 | 3 | 15 | 37 | 2 | 11 | .... | 88 | Current-bedded, well-sorted, micaceous quartz sandstone with coal streaks. |
| 53 | 2 | 16 | 25 | 4 | 10 | 1 | 43 | Dark carbonaceous mudstone with lenses and worm burrows of light-coloured micaceous siltstone (Hydroplastic structures). Disseminated pyrite. |

| DEPTH | | | | THICKNESS | | | | |
|---|---|---|---|---|---|---|---|---|
| Ft | Ins | Metres | Cms | Ft | Ins | Metres | Cms | LITHOLOGY |
| 58 | 0 | 17 | 68 | 2 | 0 | .... | 61 | Light-coloured siltstone with hydroplastic structures. Feebly calcareous. |
| 60 | 0 | 18 | 29 | 1 | 6 | .... | 45 | Dark carbonaceous mudstone with disseminated pyrite. |
| 61 | 6 | 18 | 74 | 4 | 9 | 1 | 45 | Light-coloured siltstone with hydroplastic structures. Feebly calcareous. |
| 66 | 3 | 20 | 19 | 1 | 0 | .... | 31 | Dark carbonaceous mudstone with pyrite and abundant pebbles of quartzite, quartz schist and chlorite schist. |
| 67 | 3 | 20 | 50 | 53 | 3 | 16 | 22 | Dark carbonaceous, ill-sorted, pyritic mudstone with scattered small pebbles. Hydroplastic structures at intervals. Oxidation of pyrite causing breakdown of core at frequent intervals. |
| 120 | 6 | 36 | 72 | .... | 9 | .... | 24 | Light-coloured, feebly calcareous siltstone. |
| 121 | 3 | 36 | 96 | 7 | 9 | 2 | 36 | Dark, ill-sorted, carbonaceous and pyritic mudstone. |
| 129 | 0 | 39 | 32 | 82 | 0 | 24 | 98 | Dark, ill-sorted, micaceous mudstone with less pyrite and rare hydroplastic structures. Frequent bands of small erratics and shelly debris. *Grantonia*, *Stenopora*, *Deltopecten*, *Ambikella*, fenestellids. |
| 211 | 0 | 64 | 30 | 25 | 6 | 7 | 80 | Blue-grey and buff-coloured, ill-sorted, micaceous sandstone with abundant erratics of various size. Fossils abundant especially *Grantonia*, *Peruvispira* and *Spiriferella*. |
| 236 | 6 | 72 | 10 | 14 | 6 | 4 | 40 | Shelly, erratic-rich, ill-sorted, micaceous siltstone. *Ambikella*, *Eurydesma* and *Merismopteria*. |
| 251 | 0 | 76 | 50 | .... | 6 | .... | 15 | Shelly *Eurydesma* calcirudite-calcarenite. |
| 251 | 6 | 76 | 65 | 3 | 0 | .... | 85 | Erratic-rich, dark, ill-sorted, micaceous and richly fossiliferous siltstone. |
| 254 | 6 | 77 | 50 | .... | 9 | .... | 23 | Shelly *Eurydesma* limestone. |
| 255 | 3 | 77 | 53 | 1 | 3 | .... | 37 | Richly fossiliferous siltstone. |
| 256 | 6 | 78 | 10 | .... | 3 | .... | 7.5 | Shelly *Eurydesma* limestone. |

| DEPTH | | | | THICKNESS | | | | |
|---|---|---|---|---|---|---|---|---|
| Ft | Ins | Metres | Cms | Ft | Ins | Metres | Cms | LITHOLOGY |
| 256 | 9 | 78 | 17 | 3 | 3 | .... | 98 | Erratic-rich, ill-sorted, richly fossiliferous siltstone. |
| 260 | 0 | 79 | 15 | .... | 8 | .... | 20 | *Eurydesma* Limestone. |
| 260 | 8 | 79 | 35 | 16 | 10 | 5 | 25 | Erratic-rich, ill-sorted, richly fossiliferous siltstone. |
| 277 | 6 | 84 | 60 | .... | 4 | .... | 10 | *Eurydesma* limestone. |
| 277 | 10 | 84 | 70 | 2 | 2 | .... | 55 | Erratic-rich, ill-sorted, richly fossiliferous siltstone. |
| 280 | 0 | 85 | 35 | 5 | 9 | 1 | 72 | *Strophalosia*-bryozoal siltstone; erratics, *Eurydesma* and *Grantonia* much less in evidence. |
| 285 | 9 | 87 | 07 | 7 | 3 | 2 | 23 | Erratic-rich, ill-sorted *Eurydesma*, *Grantonia* siltstone. |
| 293 | 0 | 89 | 30 | 25 | 5 | 7 | 76 | *Strophalosia*-bryozoal siltstone, *Eurydesma* absent, *Grantonia* less common and erratics smaller and less abundant. Fossils less abundant downwards. |
| 318 | 5 | 97 | 06 | .... | 2 | .... | 5 | Band of erratics and shelly material. |
| 318 | 7 | 97 | 11 | 6 | 5 | 1 | 96 | Micaceous siltstone with frequent bands of small pebbles and shelly debris. *Grantonia*, *Stenopora* and fenestellids. |
| 325 | 0 | 99 | 07 | .... | 7 | .... | 18 | Fine-grained limestone with *Keeneia*, *Eurydesma*, *Grantonia*, crinoid debris and pebbles. |
| 325 | 7 | 99 | 25 | 41 | 9 | 12 | 75 | Dark, mica mudstone with rare, thin bands of small schistose pebbles and finely comminuted shelly debris. |
| 367 | 4 | 112 | 00 | .... | 8 | .... | 20 | Calcified zone. Margins very ragged and gradational. Small pebbles and shelly debris. |
| 368 | 0 | 112 | 20 | 33 | 0 | 10 | 06 | Dark mudstone; mica less in evidence, pyrite more abundant. Rare thin bands of small schistose pebbles and shelly debris. |
| 401 | 0 | 122 | 26 | 74 | 0 | 22 | 60 | Dark pyritic mudstone almost devoid of small pebbles and fossil debris. First glendonite at 401″ 0′, thereafter abundant at frequent intervals. Pyrite very abundant in vicinity of glendonites. |

| DEPTH | | | | THICKNESS | | | | |
|---|---|---|---|---|---|---|---|---|
| Ft | Ins | Metres | Cms | Ft | Ins | Metres | Cms | LITHOLOGY |
| 475 | 0 | 144 | 86 | 53 | 6 | 16 | 30 | Dark, pyritic mudstone with very rare small schistose pebbles and without fossils. Oblique ? drill-induced structure present on core surface. Tubicular sandstone pebble at 489′ 3″. |
| 528 | 6 | 161 | 10 | 63 | 6 | 19 | 30 | Dark, pyritic mudstone with very rare, thin bands of small pebbles and shelly debris. Large quartzite pebble at 538′ 0″. Last glendonite at 574′ 0″. |
| 592 | 0 | 180 | 40 | 23 | 0 | 7 | 10 | Dark pyritic mudstone with rare small pebbles. Fossils absent. |
| 615 | 0 | 187 | 50 | 9 | 0 | 2 | 70 | Light-coloured ill-sorted tillitic mudstone. Pyritic and only slightly calcareous. Crudely bedded. |
| 624 | 0 | 190 | 20 | .... | 2 | .... | 5 | Dark, pyritic, well-bedded pebbly mudstone. |
| 624 | 2 | 190 | 25 | 12 | 4 | 3 | 75 | Pale grey, unsorted tillite. Erratics of limestone, variously coloured quartzite, igneous and metamorphic material set in matrix of calcareous argillite. Last twelve inches with most of limestone erratics leached out leaving cavernous mudstone. Surface of underlying Gordon limestone coated with haematite, very sharp, but steep and irregular. |
| 636 | 6 | 194 | 00 | 8 | 6 | 2 | 60 | Compact, iron-stained, granular dolomite; stylolitic and geoidal. |
| 645 | 0 | 196 | 60 | .... | 3 | .... | 7.5 | Limestone fragments in dark mudstone matrix. ? Joint infill. |
| 645 | 3 | 196 | 67 | 4 | 3 | 1 | 28 | Compact, iron-stained, granular dolomite; stylolitic and geoidal. |
| 649 | 6 | 197 | 95 | .... | 10 | .... | 25 | Limestone fragments in dark mudstone matrix. ? Joint infill. |
| 650 | 4 | 198 | 20 | 15 | 11 | 4 | 90 | Compact, grey, granular dolomite. No geoids, but much jointed and stylolitic. |
| 666 | 3 | 203 | 10 | .... | .... | .... | .... | Hole completed. |

# Appendix II

LIMESTONE ANALYSES

Specific gravity determinations and chemical analyses were made on two samples of cored Gordon Limestone. The values obtained were:—

| Reg No. | Sample | S.G. | CaO | MgO | $CO_2$ | Others |
|---|---|---|---|---|---|---|
| 672414 | 653 | 2.88 | 29.6 | 17.0 | 42.3 | 11.1 |
| 672415 | 656 | 2.91 | 29.6 | 20.2 | 45.4 | 4.8 |

In each case the carbon dioxide analysis is less than 1% at variance with the theoretical value required to saturate the calcium and magnesium oxide content. Thus the impurities are certainly non carbonate and are probably largely siliceous. Sample 653 is 1000 Ca 883 Mg, and Sample 656 is 1000 Ca 977 Mg. Virtually pure dolomite is unusual in the Gordon Limestone (Hughes, 1957).

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REFERENCE


**HUGHES, T. D., 1957—Limestones in Tasmania. Miner. Resour. Tasm., 10.**



D. E. WILKINSON, Government Printer, Tasmania.