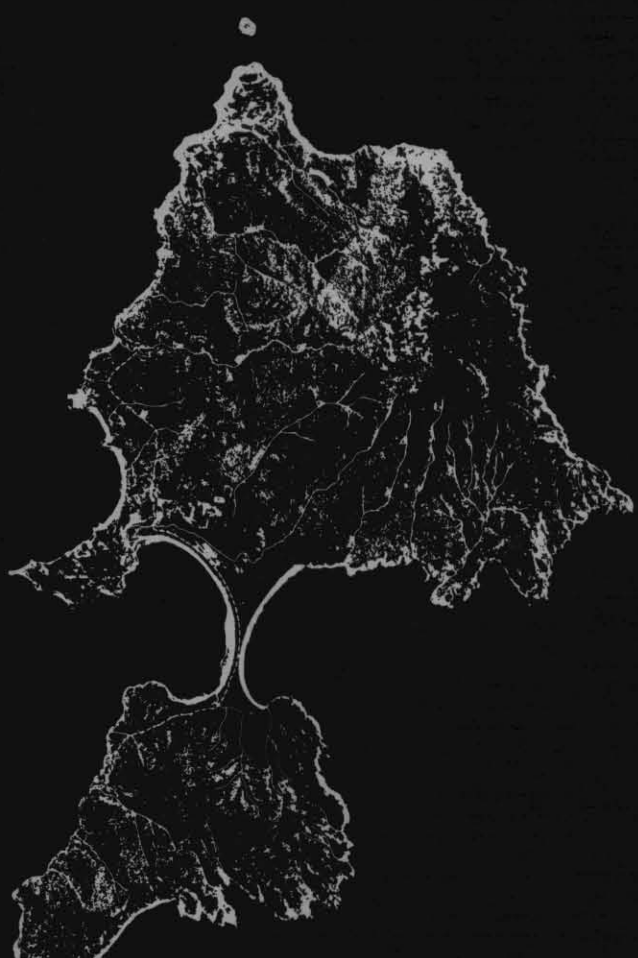
GEOLOGICAL SURVEY EXPLANATORY REPORT

SHEET 77

MARIA



TASMANIA DEPARTMENT OF MINES

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GEOLOGICAL SURVEY
EXPLANATORY REPORT

GEOLOGICAL ATLAS 1:50 000 SERIES

SHEET 77(8512N)

MARIA

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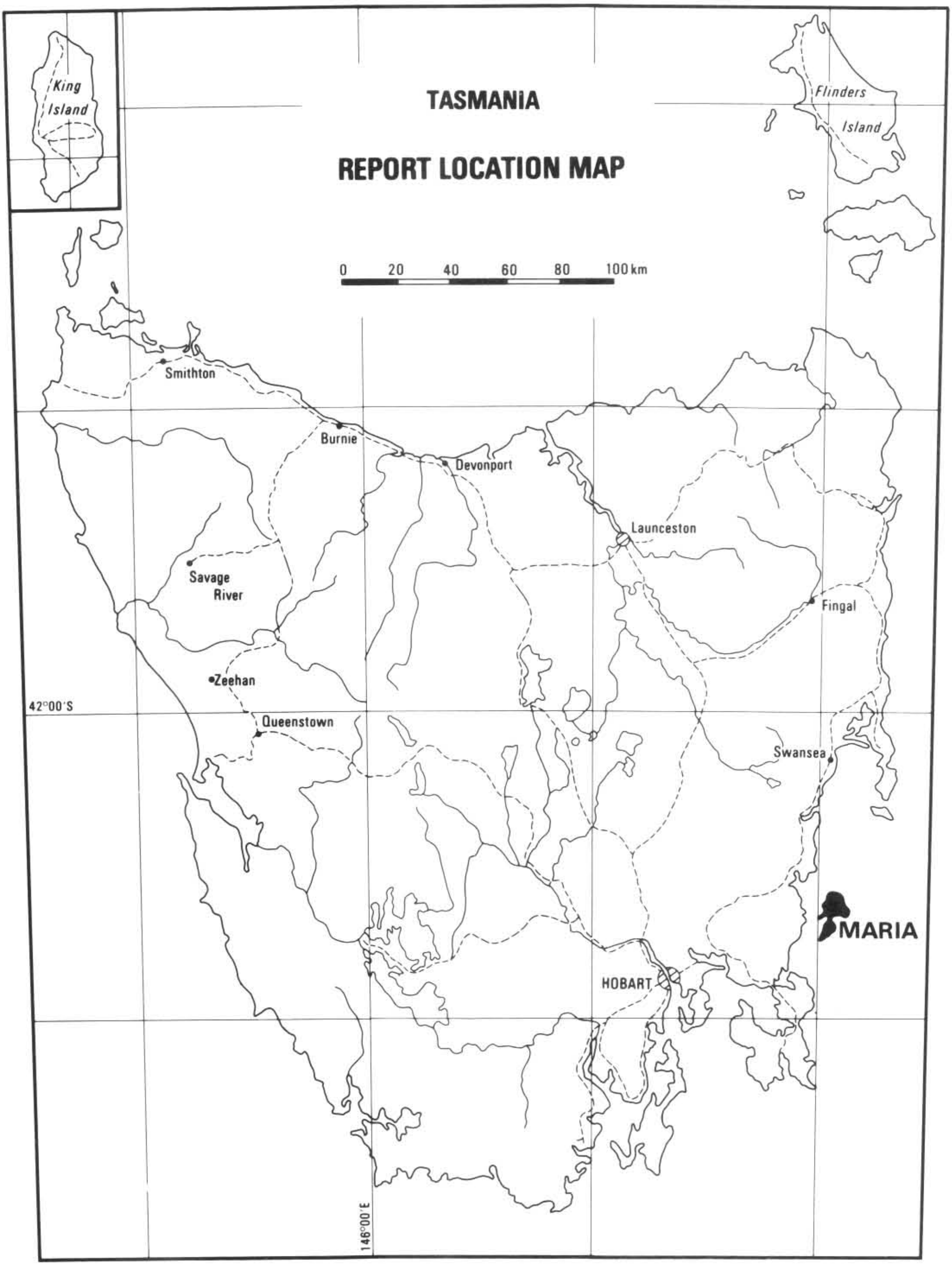

Figure 1. *Location of the Maria Quadrangle.*

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INTRODUCTION

The Maria Quadrangle covers a land area of 97 km^2 and embraces the Maria Island National Park together with a small portion of the east Tasmanian coast at Cape Bougainville in the west (fig. 1). Access to the island is by the regular ferry from Triabunna, or by light aircraft from Hobart.

The area is one of rugged scenic beauty with much of great interest to the historian and natural scientist in the fields of geomorphology, botany, and animal and bird wildlife. Geologically, the area is no less spectacular and, indeed, it is the geology which essentially provides the basis for the natural development of landforms, soils, vegetation and wildlife.

The magnificent sequence of Late Palaeozoic glacio-marine rocks and their extraordinary richness in fossils, probably represents the finest example of its kind anywhere in the world.

Mapping was at a scale of 1:15 840 and was carried out during 1978–1979. The map sheet was published in 1981 at a scale of 1:50 000. M. J. Clarke is responsible for the primary geological survey, and P. W. Baillie is responsible for the detailed structural analysis of the Siluro-Devonian Mathinna Beds, the subdivision of the various granitic rocks, and the interpretation of the Quaternary deposits in the vicinity of the isthmus. Observations and photographs of the inaccessible cliff sections along the east coast of the north island were made from charter boat. Both authors gratefully acknowledge the co-operation and assistance of various officers of the Department of National Parks and Wildlife, more especially the then Ranger-in-Charge at Darlington, Mr B. Carson. The Director of National Parks and Wildlife, Mr P. Murrell, and Mr R. Gatenby arranged the transport of a four wheel drive vehicle to and from Maria Island, and provided accommodation at Darlington. To these and many others, we express our thanks for facilitating the field studies.

PREVIOUS WORK

Johnston (1887, 1888, 1902) described the main geological features of the island and outlined the Permian sequence exposed at the Fossil Cliffs. He listed, described and figured some of the fossils. Montgomery (1891) added further comments on the section but was primarily concerned with the nature and extent of workable deposits of the so-called hydraulic limestone. Clemes (1920) reported his sea-borne observations of rock types, and stratigraphic and structural relationships visible in some of the more inaccessible cliff sections. Lewis (1937) described and commented on the nature of the basal unconformity and the basal beds exposed in the cliff sections on south Maria island immediately north of Cape Maurouard.

Everard (*in* Hughes, 1957) produced the first detailed geological map of the northern parts of north Maria island. He mapped the presence of Siluro-Devonian basement rocks immediately south of Four Mile Creek in the centre of the island, and discussed the extent and quality of limestone reserves. Banks (*in* Hughes, 1957) defined and detailed the type section of the Darlington Limestone in the Fossil Cliffs section, and gave extensive faunal information. Detailed lithological descriptions and summary fossil distributions of the complete Permian sequence are given by Banks (1958, 1962*a*). The first geological map of the whole island, based largely on air-photo interpretation supplemented by limited ground reconnaissance, is that of Banks (1970). Clarke (1973) listed and discussed the age of various fossil assemblages from north Maria Island. Reference to the Fossil Cliffs section is made in the stratigraphic and biostratigraphic summaries of Clarke and Banks (1975) and Clarke and Farmer (1976). Runnegar (1970, 1979) refers to, and figures material from the Fossil Cliffs in his systematic and palaeontological studies of *Eurydesma*. Crowell and Frakes (1971, 1975) in their summaries of the Late Palaeozoic glaciation in Australia, describe and comment on the spectacular ice-rafted clasts near the base of the Fossil Cliffs section.

PHYSIOGRAPHY

Maria Island consists of two well-defined islands which are joined by a low, sandy, tie-bar. North Maria island is much the larger of the two and is dominated in the east by a dolerite-capped ridge of high ground. At the northern end are the twin peaks of Bishop and Clerk and Mt Pedder (630 m), with Mt Maria (709 m) about half way to the south of the island. From Mt Maria the ridge continues to the south-east and loses height as the dolerite sheet steps down to a lower stratigraphic horizon. The ridge terminates at Little Raggedy Head immediately south of Perpendicular Mountain (453 m). To the west and south-west of the main Maria Range the topography is more subdued. Creeks flowing to the western coast and into Elephant Bight have cut steep-sided valleys with long, rounded interfluves. There are waterfalls in the headwater reaches of Counsel, Four Mile, Robinsons, McGuiness and Pine Hut Creeks where massive-bedded sandstone towards the summit of the Marra Formation presents a resistant barrier. The massive- and cross-bedded freshwater sandstone at the base of the Upper Parmeener Super-Group forms a prominent scarp and bench around the higher mid-slopes of the Maria Range. It is frequently breached and draped with dolerite talus. The western coast consists of long sandy beaches backed by vegetated dune sands and alluvial deposits between rounded dolerite headlands and low sandstone cliffs. Fossil Bay, which forms the northern coast of the island, is gently crescentic and is backed by sheer cliffs of subhorizontal Permian strata. The south-western portion of the island is a broad, poorly-drained plain of low elevation formed of alluvium and wind-blown sand.

South Maria Island is more subdued topographically but is structurally similar, its western parts being composed entirely of dolerite hills which descend to sea-level unbroken by any coastal plain. The east coast presents a cliff line of moderate height consisting of flat-lying Permian rocks resting unconformably on granite near sea-level. The south coast between Barren Head and Cape Maurouard consists of a series of bays and rugged headlands backed by steep granite cliffs.

STRATIGRAPHY

The oldest exposed rocks are the folded and cleaved Mathinna Beds of probable Siluro-Devonian age. They are intruded by coarse-grained alkali granite. The flat-lying Parmeener Super-Group (Permo-Triassic) rests with pronounced unconformity on a very irregular basement surface. The Lower Parmeener Super-Group is almost wholly marine with coarse sandstone, conglomerate and boulder beds at the base, followed by an extraordinary fossiliferous sequence of limestone, siltstone, calcareous siltstone, arkosic and glauconitic sandstone, and siltstone with minor conglomerate. The Upper Parmeener Super-Group is wholly freshwater and consists predominantly of well-washed, massive- and cross-bedded quartz sandstone with washouts and pods of clay pellet conglomerate, and lesser carbonaceous siltstone and red beds. Jurassic dolerite intrudes the Parmeener Super-Group as a major sheet-like body. Lateritic bauxite, of presumed Tertiary age, is well-developed in a small area around Bloodstone Point. Quaternary deposits of alluvium, wind-blown and dune sand are common in the floors of most valleys and in some coastal regions, and thick talus deposits mantle the steep higher mid-slopes of the Maria Range. These talus deposits extend down to sea-level in Elephant Bight.

Mathinna Beds (?Siluro-Devonian)

The folded sedimentary sequences underlying the flat-lying Parmeener Super-Group rocks of north-eastern and eastern Tasmania are known as the Mathinna Beds (Banks, 1962*b*) and crop out in three areas of Maria Island.

- *(a)* on the east coast of north Maria island from east of Bishop and Clerk [919842]* to east of Mt Maria [932800];
- *(b)* on the lowermost slopes to the south-west of Mt Maria from Pine Hut Creek [900765] to north-east of Ned Ryans Hill [875795];
- *(c)* on the south island to the east of the major fault, from Trigonia Corner [885734] to north-west of Haunted Bay [863700].

The Mathinna Beds are intruded by granitoids and may develop thermal metamorphic aureoles over one kilometre in width. They were folded and cleaved and underwent low-grade dynamic metamorphism prior to granite emplacement.

Because continuous structural profiles cannot be obtained, the total thickness of Mathinna Beds is unknown, but a thickness of 103 m was measured at Trigonia Corner.

On Maria Island the Mathinna Beds consist dominantly of quartzwacke beds with thin interlayered pelite. Thickness of quartzwacke beds is variable, reaching a maximum of 1·75 m but generally of the order of 200–800 mm. Maximum development of pelite observed was 2 m, but is usually 5–20 mm.

Graded-bedding and poor-sorting are characteristic features of the quartzwackes. Very rarely a full Bouma sequence is developed, but more commonly beds are either only massive or only planar-laminated and, or, cross-laminated. Cross-bedding is generally of the festoon type with the development of troughs reaching maximum dimensions of 400 x 100 mm. Occasionally ripple-drift cross-lamination is present. Flute casts are occasionally observed on the soles of quartzwacke beds.

Thin quartzwacke beds may show the development of pseudo-nodules.

Pelites are generally structureless although minor development of cross-lamination and slumping was observed.

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* All references lie within the 100 000 metre grid square EN.

In thin section (MA17, MA18, MA36, MA37) the quartzwackes are seen to be poorly to very poorly sorted (So 2-5–5-0) with a median grain size of 0·1–0·25 mm (range 0·05–0·7 mm) and consist of mono or poly-crystalline quartz, detrital mica together with lithic fragments, plagioclase, microcline and heavy minerals in a clay matrix. Occasionally clasts are very well-rounded (MA37) but more commonly are angular or sub-angular.

The quartzwackes are the result of deposition from turbidity currents which interrupted normal accumulation of muds precipitated from suspension in a deep-water environment.

There is no evidence for the age of the Mathinna Beds on Maria Island but they are similar to fossiliferous sequences in north-eastern Tasmania known to be Siluro-Devonian.

Parmeener Super-Group

LOWER DIVISION (P)

The maximum thickness of the Lower Parmeener Super-Group is about 350 m, but is considerably less in the region of basement highs, the two most spectacular of which occur in the headwater reaches of Montgomerys Creek [930775] and on south Maria island at 882715. All units are conformable. Six mappable units are recognised, five of which are given new formal stratigraphic names, and are indicated by an asterisk. The units are, from the youngest to the oldest:

Toarra Formation*
Marra Formation*
Counsel Creek Formation*
Skipping Ridge Formation*
Boullanger Formation*
Basal Beds

Within the Basal Beds, the Darlington Limestone has been defined (Banks, *in* Hughes, 1957), and several other characteristic, but thin units can be recognised. Since these units are of very limited areal extent, they are not given formal status.

BASAL BEDS (Pba and Pbb)

The Basal Beds constitute the most variable of all the stratigraphic units. They vary widely in character from place to place and range in thickness from a few metres to as much as 110 m. The most easily accessible development of the Basal Beds (Pba) is at the Fossil Cliffs [887855], a little over one kilometre north-east of Darlington. The sequence here is shown diagrammatically in Figure 2. The basal unconformity is not exposed and the lowest beds observed consist of about 5 m of essentially thick-bedded, laminated, calcareous siltstone and impure limestone with few clasts and bryozoans parallel with the bedding, interbedded with thinner and more irregular bands of pebble-rich quartzose granule conglomerate with many broken fragments of *Deltopecten* and fewer *Eurydesma* and spiriferids. These coarser bands are crudely graded. Then follows 800 mm of massive, granule, pebble, cobble and boulder conglomerate with a carbonate cement. Most of the clasts are locally derived quartzite and granite, but mica schist, black slate and limestone are also present. The top of this bed forms the prominent wave-washed bench at the base of the cliffs. The overlying 2·45 m consist essentially of platy calcareous siltstone with three prominent, and more resistant, lensoid beds of limestone. The lowest limestone bed contains a granite boulder almost a metre in length, and an even larger quartzite boulder. The granite clast is angular and has its long axis almost vertical. It disrupts and crumples the bedding as well as thick bilaminar colonies of *Stenopora* parallel to the bedding. Other clasts are abundant, but are usually sub-rounded to rounded and of cobble and pebble size. The tops and bottoms of the limestone beds are uneven and contain much winnowed and broken bioclastic debris. Fossils are abundant. Most are disarticulated and rolled to a greater or lesser degree, but the encrusting bilaminar and stick stenoporids are in growth position. *Trigonotreta*, *Deltopecten*, *Eurydesma* and bryozoans predominate. *Etheripecten*, *Merismopteria*, *Myonia morrisi* Etheridge, *Stutchburia*, *Ambikella*, *Gilledia*, *Pseudosyrinx*, *Peruvispira*, *Notoconularia* and crinoidal debris also occur.

These beds with their spectacular abundance of ice-rafted debris have been termed the 'Erratic Zone' by Johnston (1888) and later authors.

Next follows the type section of the Darlington Limestone (Pd) (Banks, *in* Hughes, 1957). The section from the base upwards is:—

1·05 m Thick-bedded *Eurydesma* limestone. The base in uneven and much winnowed with mainly comminuted spirified debris and quartz granule conglomerate. The fauna consists overwhelmingly of *Eurydesma*, but *Deltopecten* and *Trigonotreta* are also present in some abundance. The majority of the *Eurydesma* shells are disarticulated and rest with convex side up.

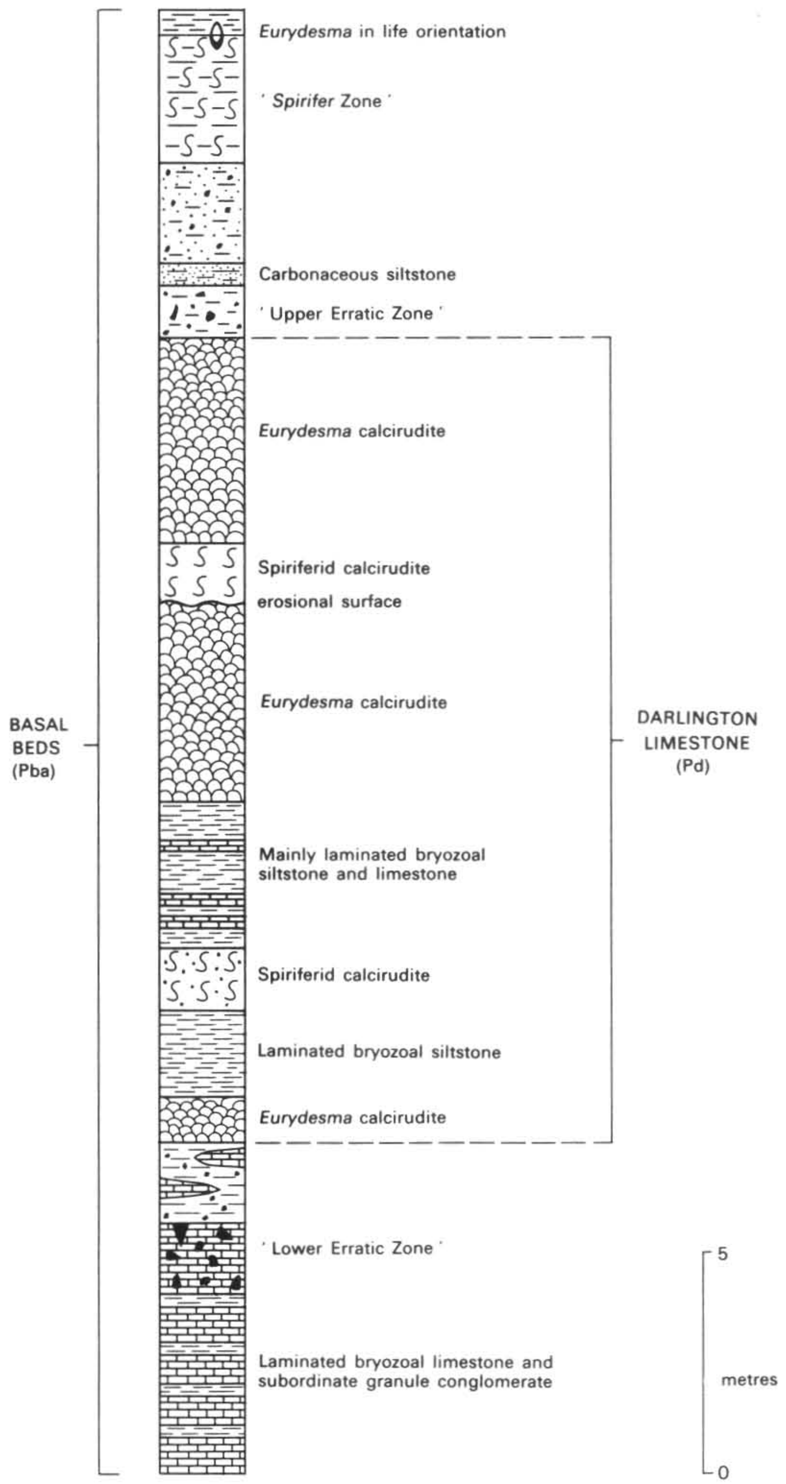


Figure 2. *The Basal Beds (Pba) at the Fossil Cliffs.*

5 cm

1·90 m Essentially platy calcareous siltstone with thin impure limestone. The siltstone is devoid of all but very small clasts and is rich in fenestellids and *Stenopora*. *Trigonotreta*, *Eurydesma* and *Keeneia* are rare. The subordinate limestone beds have larger and more frequent clasts, and are more richly fossiliferous.

1·25 m Thick-bedded spiriferid calcirudite with many clasts up to cobble size. *Trigonotreta*, *Ambikella*, *Deltopecten* and *Eurydesma* which are mostly disarticulated but little abraded for most part, occur in profusion.

0·30 m Shaley calcareous siltstone rich in fenestellids and *Stenopora*. Clasts small and rare.

0·20–0·25 m Compact spiriferid calcirudite; sublensoid.

2·50 m Shaley calcareous siltstone with thin discontinuous pods of spiriferid limestone.

4·20 m Massive-bedded *Eurydesma* limestone. *Eurydesma* less common in lower parts and mostly disarticulated; prolific in upper parts and mostly in growth position. Clasts up to 500 mm scattered throughout, but never common. Matrix is essentially of crinoidal, fenestellid and spiriferid bioclastic debris. *Eurydesma*, *Deltopecten*, *Ambikella*, *Trigonotreta*, *Pseudosyrinx* are common. A few more winnowed and reworked bands are also present. These are thin and discontinuous with many small pebbles and granules of quartz and other clastic detritus. *Peruvispira* is more abundant in these pods.

1·20 m Thin-bedded spiriferid calcirudite with *Trigonotreta*, *Ambikella*, *Deltopecten* and *Eurydesma*. The shells are mostly disarticulated and broken except for the smaller spiriferids. Some rounded and facetted clasts up to 400 mm but never common. The base of the bed is very irregular and erosional.

4·65 m Thick-bedded *Eurydesma* calcirudite with subordinate interbedded spiriferid calcirudite. Clasts small and uncommon.

The Darlington Limestone (Pd) thus consists of alternations of *Eurydesma* calcirudite, bryozoal siltstone and spiriferid calcirudite, and is 17·20 m thick. *Eurydesma* calcirudite predominates and forms the thicker and more massive-bedded units. Bryozoal siltstone characterises the alternating units lower down, whereas higher up, spiriferid calcirudite predominates.

The Darlington Limestone at the Fossil Cliffs was quarried intermittently from the late nineteenth century until 1930, and used in the manufacture of cement and lime. The two major units of *Eurydesma* calcirudite in the upper half of the formation were the principal horizons exploited. The calcium carbonate content exceeds 90% in selected samples, but a more average figure is about 75% (Hughes, 1957). Quarrying ceased because of shipping costs and the ever increasing overburden.

South-east of the Fossil Cliffs the Darlington Limestone dips shallowly to the south-east and disappears below sea-level. It reappears in the cliffs north of Bishop and Clerk with a shallow dip to the west or north-west. Rounding the north-east corner of the island the Darlington Limestone is underlain by a few metres of well-rounded cobble and boulder conglomerate with little matrix. A few hundreds of metres further south, almost immediately due east of Bishop and Clerk, it oversteps the conglomerate and rests directly on steeply dipping and folded Siluro-Devonian Mathinna Beds.

Above the Darlington Limestone at the Fossil Cliffs is 1·30 m of poorly-sorted, calcareous, granule conglomerate with numerous clasts mostly of cobble or small boulder size. One very large quartzite boulder measures 1·70 m. Granite clasts are plentiful, but quartzite predominates. Much comminuted shell debris occurs in the matrix together with a few disarticulated *Eurydesma* and *Deltopecten* shells, and some larger tabular bilaminar *Stenopora* colonies. Small lenses and pods of quartzose granule conglomerate also occur. This bed is almost as spectacular as those below the Darlington Limestone and could be termed an upper ' Erratic Zone '. It is overlain by 400 m of light and dark, carbonaceous and much bioturbated siltstone without clasts. Poorly-preserved plants are present which, together with the intense bioturbation and absence of marine fossils, probably indicate non-marine or marginal marine conditions of deposition. This is followed by 2·40 m or poorly-sorted, pebble- and cobble-rich sandstone with very subordinate bioturbated siltstone. Flat, bilaminar encrusting colonies of *Stenopora*, fenestellids, *Trigonotreta* and *Sulciplica* are very abundant, and disarticulated shells of *Eurydesma*, *Deltopecten* and *Ambikella* also occur. The uppermost 3·25 m of the Basal Beds consist of dark, calcareous siltstone extraordinarily rich in spiriferids. *Eurydesma* and *Deltopecten* are also common; strophalosiids are rare. Well-rounded, pebble-sized clasts occur sporadically. About 500 mm below the top of the unit very large, articulated and sponge-bored specimens of *Eurydesma hobartensis konincki* (Johnston) occur in abundance and in life orientation. The topmost 500 mm of beds consist of dark, bioturbated siltstone with many small rounded pebbles. Broken spiriferid debris is abundant at the base, but disappears upwards where bioturbation becomes very marked. The topmost 5·65 m of the Basal Beds (Pba) have been called the '*Spirifer Zone*' by Clarke and Farmer (1976).

Along the precipitous east coast of north Maria Island the Basal Beds (Pbb) are largely inaccessible. As viewed from the sea between a point due east of Mt Pedder and immediately north of Mistaken Cape [955774], a considerable thickness of boulder, cobble and pebble conglomerate followed by sandstone rests unconformably on folded Siluro-Devonian Mathinna Beds and granite. The surface of the unconformity is uneven, but it rises gradually southwards. In this stretch of coast the first recognisable unit above the Basal Beds is the massive crinoidal limestone of the Counsel Creek Formation (see p. 15). Between Mistaken Cape and Little Raggedy Head thick dolerite talus obscures the slopes between the dolerite of Perpendicular Mountain and the granite of Mistaken Cape, but if present, the Basal Beds must be thin. West of Little Raggedy Head the Basal Beds reappear between the granite and dolerite in Bunker Bay.

In the region of Montgomerys Creek [925765] a north-east to south-west trending ridge of granite rises to a height of 260 m and remained an island until Late Permian times. West of this, between Whalers Cove [915756] and Pine Hut Creek [900765], over 100 m of the Basal Beds (Pbb) occupy an uneven basement depression mainly on granite. The lowest beds consist of coarse boulder conglomerate with sub-rounded clasts of quartzite and granite in a matrix of medium- to well-sorted arkosic sandstone and granule conglomerate. Clast size rapidly decreases so that 10 m above the unconformity the beds consist of interbedded, well-rounded, cobble and pebble conglomerate and well-sorted arkosic sandstone. Some layers are predominantly composed of tabular quartzite clasts and display current imbrication. Fragmented shelly debris is uncommon.

West and north-west of Pine Hut Creek a few metres of poorly-sorted, arkosic sandstone and conglomerate rest on a flat plateau-like surface of Mathinna Beds. These beds have been mapped as part of the Counsel Creek Formation.

At French's Farm [856773] and at the eastern side of Elephant Bight erosional remnants of well-bedded and moderately well-sorted conglomerate rest on Siluro-Devonian Mathinna Beds. The clasts show current imbrication and are predominantly quartzite. Shelly debris is sparse.

On south Maria Island the Basal Beds (Pbb) are well-developed and they, together with the basal unconformity, are magnificently exposed along the east coast, north of Cape Bald [895705]. For the most part the unconformity is almost flat and occurs a few metres above high-water. At the northern and southern ends, however, it is rather more uneven with the basement surface gradually rising. The lowest 8–9 m consist of boulder conglomerate with a poorly sorted matrix of coarse-grained arkosic sandstone and granule conglomerate. Granite clasts are abundant but quartzite predominates. What at first sight appear to be large granite boulders several metres in length, are large *in situ* rounded tor-like granite residuals penetrated by irregular Neptunean dykes filled with arkosic sandstone and conglomerate. The crudely-bedded basal boulder conglomerate rapidly gives way to well-sorted and well-bedded cobble conglomerate with a continuous framework. Quartzite clasts are overwhelmingly predominant and shell fragments are present. This is followed by well-bedded, arkosic sandstone and subordinate pebble conglomerate. For most of the length of the cliff, but lensing out both to the north and the south, a characteristic unit of limestone (Pl) occurs about 15–18 m above the unconformity. It is about 2 m thick and consists of massive- and cross-bedded impure limestone with much coarse-grained sand and other clastic detritus. The limestone is richly fossiliferous, but almost without exception the shells are disarticulated and broken. The fauna includes abundant *Deltopecten*, *Eurydesma*, *Ambikella konincki* (Etheridge), *Sulciplica* sp. nov., *Trigonotreta stokesi* Koenig, *Stenopora* and other bryozoans, *Keeneia* and *Peruvispira*.

Inland the Basal Beds are exposed as a series of low cliffs and benches of arkosic sandstone and pebble and cobble conglomerate around the flanks of the spurs north-east of Blind Creek

[890707] and Stinking Creek [880720]. Small erosional outliers occur on the spurs north-west of Haunted Bay [863698].

The Basal Beds on south Maria Island have a total thickness of about 60 m, and like the southern part of north Maria island, they occupy the position between the unconformity and the massive crinoidal limestone of the Counsel Creek Formation. They were first described by Lewis (1937) and named by him the 'Cape Maurouard Series'. He erroneously correlated them with tillite at Little Peppermint Bay, Woodbridge and the ill-defined 'Lindisfarne Glacial Stage' of the Hobart area. He interpreted the lowest beds as a 'land moraine resting on a *roche-moutonnēed* [*sic*] granite surface'. The so-called *roches moutonnées* are probably those features here interpreted as tor-like granite residuals. Striated pavements and striated clasts have not been observed. Overall the basal beds on south Maria Island and the Riedle Bay area are here considered to represent the product of the atmospheric weathering and mass-wasting of granite and quartzite *in situ*, or nearly so, with subsequent reworking in a high energy, near-shore environment to produce beach boulder conglomerate and sub-littoral beds of coarse sandstone, cobble conglomerate and pebble conglomerate.

Palaeontology

At the Fossil Cliffs the Basal Beds (Pba) are extraordinarily fossiliferous. Fossils recorded from the Darlington Limestone (Pd) and the underlying beds include:

- *Ambikella konincki* (Etheridge)
- *Pseudosyrinx allandalensis* Armstrong
- *Trigontreta stokesi* Koenig
- *Gilledia* sp.
- Strophalosiid fragments
- *Deltopecten illawarensis* (Morris)
- *Etheripecten tenuicollis* (Dana)
- *Eurydesma cordatum* Morris
- *Eurydesma hobartensis hobartensis* (Johnston)
- *Eurydesma hobartensis konincki* (Johnston)
- *Merismopteria* sp.
- *Myonia morrisi* (Etheridge)
- *Stutchburia* sp.
- *Keeneia* spp.
- *Peruvispira* sp.
- *Notoconularia* sp.
- *Stenopora tasmaniensis* Lonsdale — both as massive encrusting bilaminar and branching colonies
- Fenestellids
- Crinoid debris
- *Calcitornella stephensi* (Howchin)

Deltopecten, Eurydesma, Trigonotreta, Stenopora and other bryozoans are enormously abundant and in comparison the other listed forms are rare. *Eurydesma hobartensis konincki* is the predominant form of *Eurydesma*. This fauna can be confidently assigned to the Middle Tamarian *Eurydesma cordatum* Zone (= Faunizone 2 of Clarke and Farmer, 1976). Age equivalents of the Early Tamarian (Quamby — Woody Island Formations) are absent.

The remainder of the Basal Beds (Pba) above the Darlington Limestone at the Fossil Cliffs yield a broadly similar fauna. Spiriferids are overwhelmingly predominant except near the top, where a thin horizon is characterised by an abundance of very large, sponge-bored and articulated specimens of *Eurydesma hobartensis konincki* in life orientation. *Sulciplica* sp. nov., *Notospirifer* sp. nov. and a new pseudopunctate davidsoniacean genus (homeomorphic with the impunctate *Schuchertella*) appear for the first time, and indicate a Late Tamarian age (= Faunizone 3 or *Sulciplica-Notospirifer* Zone of Clarke and Banks, 1975; = Faunizone 3 or *Sulciplica* sp. nov. Zone of Clarke and Farmer, 1976).

The lens of impure, cross-bedded limestone (Pl) on south Maria Island also yields *Sulciplica* sp. nov. and is thus of Late Tamarian age. It therefore represents a high energy, near-shore facies of the quieter water, further off-shore '*Spirifer* Zone' at the Fossil Cliffs.

Elsewhere fossils in the Basal Beds (Pbb) are relatively uncommon, very fragmentary, and are not diagnostic of a precise age. On south Maria Island and the southern parts of north Maria Island, the upper parts of the Basal Beds (Pbb) are probably Early Bernacchian in age since they are overlain by the Late Bernacchian Counsel Creek Formation. However, palaeontological proof is lacking.

BOULLANGER FORMATION (Pb)

The Boullanger Formation is here defined as that formation of thin-bedded, carbonaceous, pyritic and micaceous siltstone which lies conformably between the Basal Beds below and the Skipping Ridge Formation above. It is about 20 m thick and essentially of non-marine origin. It is exposed only in the cliffs behind Fossil Bay [895845] and is readily accessible solely on a prominent headland [886856] at the eastern end of the Fossil Cliffs, where a cliff track descends to sea-level.

The lowest 14·3 m of beds consist of dark grey, thin-bedded, pyritic, carbonaceous and micaceous siltstone with subordinate light grey, coarser grained siltstone. The light-coloured siltstone is also thin-bedded, but is not micaceous, and displays small-scale cross-bedding. The light-coloured siltstone becomes more prevalent towards the top. No clasts were observed but a few worm burrows are present. Poorly-preserved carbonaceous impressions of the plants *Glossopteris* and *Gangamopteris* occur sporadically.

The next 2·1 m consist of three more prominent beds of light-coloured siltstone, each between 250–300 mm thick, interbedded with dark-grey, pyritic, carbonaceous and micaceous siltstone.

The uppermost 3·5 m of beds consist of similar, dark grey, pyritic, carbonaceous and micaceous siltstone, but small, well-rounded pebbles and disc-shaped clasts are present in some layers. Bioturbation is moderate. No marine fossils were found in this survey, but Banks (1958) records the presence of *Notoconularia laevigata* (Morris) from the topmost beds.

The Boullanger Formation is thus a thin but characteristic unit of dark, thin-bedded, pyritic, carbonaceous and micaceous siltstone with subordinate lighter coloured and coarser grained siltstone. The general lithological characters, the essential lack of clasts throughout most of the formation, the presence of poorly-preserved plants and the general lack of marine fossils all indicate non-marine or marginal marine deposition. The uppermost parts of the formation were probably deposited under more marine conditions, but only marginally so.

Palaeontology

As noted above, macroscopic fossils are uncommon and poorly-preserved. Three samples from the base, middle and top of the formation were processed for palynological residues. Unfortunately all three proved barren except for abundant woody debris (Dr E. M. Truswell, pers. comm.). Inferentially, however, the Boullanger Formation would yield a Substage 3b microflora like the Faulkner Group, the Liffey Sandstone and Mersey Coal Measures elsewhere in Tasmania (Truswell, 1978), and is of Early Bernacchian age (see p. 19).

SKIPPING RIDGE FORMATION (Psk)

The Skipping Ridge Formation is here defined as that formation of thin- to medium-bedded calcareous siltstone and dark, blue-grey, impure, argillaceous limestone which lies conformably between the Boullanger Formation below and the Counsel Creek Formation above. It is about 35 m thick in its type section at the Fossil Cliffs where it is readily accessible near the top of the cliff track [885856] which descends to sea-level. It is richly fossiliferous with a profusion of the linoproductid *Cancrinella farleyensis* (Etheridge and Dun) and strophalosiids often in growth position, and fenestellid and other bryozoans. Spiriferids, *Etheripecten*, large *Deltopecten* and *Eurydesma*, and other fossils are also common. Small, well-rounded clasts are never common. It corresponds to the '*Productus* Zone' of Montgomery (1891) and subsequent workers.

The base of the Skipping Ridge Formation is marked by two prominent beds of tough, indurated, poorly-sorted, sub-greywacke sandstone. There is an abundance of sharp, angular, granule-sized quartz, feldspar and lithic fragments in a finer-grained matrix. The lower of the two beds has a marked concentration of winnowed pebbles at its base: most are well-rounded but some are angular and facetted. In the higher of the two beds the clasts are smaller and more randomly distributed, and bioturbation is intense. *Cancrinella farleyensis* and *Ambikella ovata* (Campbell) occur for the first time in the upper bed. The two sub-greywacke beds, which are 500 mm and 400 mm thick respectively, are separated by 600 mm of dark, cuboidally-weathering siltstone with many small, rounded clasts. As noted by Banks (1958) the two tough sub- greywacke beds were mistaken for tuff by Montgomery (1891).

The remainder and greater part of the Skipping Ridge Formation consists of richly fossiliferous productid and bryozoal siltstone interbedded with dark, blue-grey, thin- to medium-bedded, impure, argillaceous limestone. The limestone beds increase in thickness and frequency towards the top of the formation. In many cases the productids are in growth position with spines attached. Elsewhere, but predominantly at the tops and bottoms of beds, there is evidence of winnowing and re-working. Spiriferids, crinoidal and other shelly debris, and small, rounded pebble-sized clasts are commoner in these bands.

The Skipping Ridge Formation is thus characterised as a thin, but distinctive unit of richly fossiliferous, calcareous siltstone interbedded with dark, blue-grey, impure, argillaceous limestone with two prominent beds of resistant sub-greywacke sandstone at the base.

East of the Fossil Cliffs, the Skipping Ridge Formation is virtually inaccessible in the vertical cliffs behind Fossil Bay except at the centre of the bay where it is at sea-level. Thereafter it climbs and finally disappears at a point almost due east of Mt Pedder [924827] where it passes laterally into sandstone and conglomerate.

Inland the upper parts of the Skipping Ridge Formation are exposed in Bernacchis Creek at 881849, in Counsel Creek at 885827 and 890823, and in Coxswains Creek at [875816]. Abundant float is present on the slopes about Four Mile Creek south-east of Monah Hill [876803]. The best and most continuous exposures are those in Counsel Creek where repetition by faulting is clearly demonstrated. Everywhere the lithological characters are similar.

In the late nineteenth century the impure, argillaceous limestone (the so-called hydraulic limestone of Montgomery, 1891) near the top of the formation was worked for cement. The maps of Montgomery (1891) and Johnston (1902) show a number of workings on the ridge north-east of Darlington at 883853. However, they must have been small and the production negligible, as there is no trace of them today.

Palaeontology

Well-preserved fossils occur in profusion throughout the Skipping Ridge Formation except for the basal metre. Forms present include:

- *Euryphyllum cainodon* (de Koninck)
- Davidsoniacean gen. nov. (as in the '*Spirifer* Zone')
- *Anidanthus springsurensis* (Booker)
- *Cancrinella farleyensis* (Etheridge and Dun)
- *Echinalosia preovalis* (Maxwell)
- *Echinalosia preovalis pristina* (Maxwell)
- *Wyndhamia dalwoodensis* Booker
- *Ambikella ovata* (Campbell)
- *Ambikella profunda* (Campbell)
- *Pseudosyrinx* sp.
- *Punctospirifer etheridgei* Armstrong
- *Sulciplica stutchburii auctt.*
- *Sulciplica tasmaniensis* (Morris)
- *Trigonotreta cracovensis* (Wass)
- *Trigonotreta hobartensis* (Brown)
- *Gilledia homevalensis* Campbell
- *Deltopecten limaeformis* (Morris)
- *Etheripecten* spp.
- *Eurydesma hobartensis konincki* (Johnston)
- *Parallelodon* sp.
- *Promytilus* sp.
- *Streblopteria* sp.
- *Stutchburia* sp.
- Fenestellids, stenoporids, crinoid debris.

Particularly characteristic are the productids, strophalosiids, spiriferids, bryozoans and very large, articulated *Deltopecten* and *Eurydesma*. A solitary, poorly-preserved, specimen of the bivalve *Parallelodon* is recorded for the first time in Tasmania. *Cancrinella farleyensis* and *Ambikella ovata* first occur in the upper of the two sub-greywacke sandstone beds at the base of the formation, and the first *Anidanthus springsurensis* about two metres above this. The linoproductid *Terrakea* and the aulostegid *Taeniothaerus* are absent. The fauna of the Skipping Ridge Formation is assigned to the Early Bernacchian *Echinalosia preovalis pristina* Zone of Clarke and Farmer (1976), the *Cancrinella farleyensis* Zone of Clarke and Banks (1975), and the lower part of the *ovata* Zone of Runnegar and McClung (1975) and Runnegar and Campbell (1976). This zone is represented by the Nassau Formation in the Granton area, and the upper parts of the Hickman Formation in the Margate area (Farmer, 1981).

COUNSEL CREEK FORMATION (Pc)

The Counsel Creek Formation is here defined as that formation of medium- to thick-bedded, light coloured, coarse-grained, bioclastic crinoidal limestone with very thin, subordinate shale, passing up into more impure, argillaceous limestone which lies conformably between the Skipping Ridge Formation below and the Marra Formation above. On north Maria Island the formation maintains a thickness of about 65 m, and on south Maria Island it is a little over 70 m thick. The formation is fully exposed in the more northerly of the two headwater branches of Counsel Creek at 893823 and this is designated as the type section. It is also fully exposed in Pine Hut Creek at 908785 but its upper parts are virtually inaccessible in the face of a precipitous waterfall. The lower and middle parts of the formation are well-exposed in the old quarries north-east of Darlington, between [885852] and [885846]. Elsewhere the formation crops out boldly on the lower mid-slopes of the interfluvial ridges to the west and south-west of the Maria Range. It supports little soil cover.

At the Fossil Cliffs and in Counsel Creek the boundary between the Counsel Creek Formation and the underlying Skipping Ridge Formation is somewhat transitional. The base of the Counsel Creek Formation is placed at the base of the first bed of light-grey, massive-bedded, coarse-grained, bioclastic crinoidal limestone. A bed of dark, blue-grey, impure, argillaceous limestone typical of the Skipping Ridge Formation occurs less than one metre below. The lower and middle parts of the formation consist of thin- to medium- to thick-bedded, light-grey to pinkish, coarse-grained, bioclastic, crinoidal limestone with very subordinate and thin shale interbeds. The bedding surfaces are very uneven and many beds are sub-lensoid. Current-scour structures are present in places. Replacement of the original calcium carbonate by white chalcedonic silica occurs in tabular, irregular and ellipsoidal bodies. Some of the ellipsoidal bodies are in excess of one metre, and the original fabric is faithfully preserved. Clasts, mainly of quartzite, are never common. They are more or less randomly scattered throughout with no obvious correlation with the shale interbeds. Most are small- to medium-sized pebbles, with rare cobbles.

At the southern end of the southernmost and largest of the quarries at 885846 syn-depositional disturbance is present. Here about 5 m of beds form an anticlinal flexure about 15 m in amplitude. A quarry bench above this is talus and debris strewn, but the beds higher up are sub-horizontal. The higher parts of the quarry faces also display the effects of groundwater leaching and solution collapse structures.

The upper parts of the formation are less well-exposed and consist of medium-bedded, light- to medium-grey, impure, argillaceous limestone with subordinate calcareous shale and coarse-grained crinoidal limestone. The tabulate coral *Thamnopora* is particularly common in the more argillaceous horizons. The uppermost few metres consist of thin-bedded argillaceous limestone with increasing calcareous siltstone and sandstone interbeds.

In Pine Hut Creek [908787] and the tract between Pine Hut Creek and east of Monah Hill [885807], the Counsel Creek Formation rests directly on a flat plateau-like surface of Mathinna Beds. The lowermost beds consist of a few metres of poorly-sorted, arkosic sandstone and conglomerate but the remainder of the formation is lithologically similar to elsewhere.

East of Pine Hut Creek the Counsel Creek Formation rests on a substantial thickness of coarse boulder, cobble and pebble conglomerate and arkosic sandstone mapped as Basal Beds. A pronounced ridge of granite in the headwater regions of Montgomerys Creek [933775] remained as an upstanding island. Facies changes about this island must be abrupt, but the vegetation is thick and exposure inadequate to allow elucidation of the details. Massive-bedded, pale grey, coarse-grained, crinoidal limestone crops out within a few metres of rugged granite tors.

On south Maria Island the Counsel Creek Formation rests on a thick sequence of boulder, cobble and pebble conglomerate and arkosic sandstone except in the region of the spur and valley to the east of Stinking Creek [882715]. Here another northeast-southwest trending ridge of granite remained as an island until finally submerged by the Counsel Creek Formation. Although this ridge is of a lesser scale than that present in the headwater regions of Montgomerys Creek, exposure is excellent. It is particularly impressive in the north-east wall of the unnamed valley at 884719. Here the Counsel Creek Formation is banked up around and over a ridge of granite nearly 40 m in height. To the south-east the ridge can be traced down into the valley floor, up the valley side and across the spur as far as the fault. Facies changes in this area are extraordinarily rapid. Pebbly arkosic sandstone with abundant broken shells of *Deltopecten* and *Eurydesma* rests on the granite, but in less than a metre this gives way to coarse-grained, red and pink coloured, bioclastic crinoidal limestone studded with large fragments of feldspar and quartz and large plates of muscovite mica. Less than another metre away this gives way to the normal, pale grey, coarse-grained, crinoidal limestone with little or no detrital material.

The Counsel Creek Formation thus consists of a substantial sheet of coarse-grained crinoidal and subordinate, more argillaceous, limestone and shale. The transgression rapidly flooded those areas which had previously remained emergent except for a substantial but localised island around the headwater regions of Montgomerys Creek. On south Maria Island in the region of a smaller basement ridge, the granite surface must have been littered with the products of mass-wasting of the granite.

From the earliest convict occupation until as late as 1930, the limestone of the Counsel Creek Formation was worked intermittently for the production of cement and agricultural lime. The more argillaceous and rotten horizons were used as a source material for bricks. It is the predominant material in the convict-built dam on Bernacchis Creek. It has also been used as a coarse and rather unsatisfactory road foundation in the northern parts of north Maria Island. Although selected samples may contain more than 90% calcium carbonate, 70% is more typical (Everard, in Hughes, 1957). In addition the presence of erratics and frequent large silicified bodies further add to the impurities.

Palaeontology

The Counsel Creek Formation is richly fossiliferous. However, extraction is not always easy and detailed bed by bed collecting is rarely possible. The old quarries near Darlington provide the most readily and easily collected material. Other collections have been made in Counsel Creek and on south Maria Island. Everywhere the same broad assemblages are present, but their limits must be considered approximate pending further refinement. Fossils present include:

Euryphyllum spp.
Cladochonus nicholsoni (Etheridge)
Thamnopora wilkinsoni Etheridge
Davidsoniacean gen. nov.
Anidanthus springsurensis (Booker)
Cancrinella farleyensis (Etheridge and Dun)
Taeniothaerus subquadratus (Morris)
Terrakea concava Waterhouse
Terrakea pollex Hill
Wyndhamia dalwoodensis Booker
Ambikella ovata (Campbell)
Ambikella profunda (Campbell)
Ambikella plana (Campbell)
Ambikella inglelarensis (Campbell)
Ambikella etheridgei (McClung)
Ambikella plica (Campbell)
Sulciplica stutchburii auctt.
Sulciplica tasmaniensis (Morris)
Trigonotreta cracovensis (Wass)
Trigonotreta hobartensis (Brown)
Trigonotreta wairakiensis (Waterhouse)
Pseudosyrinx procera Armstrong
Punctospirifer etheridgei Armstrong
Fletcherithyris farleyensis Campbell
Gilledia ulladullensis Campbell
Atomodesma (Aphanaia) sp.
Deltopecten limaeformis (Morris)
Deltopecten multicostatus (Fletcher)
Etheripecten spp.
Eurydesma hobartensis konincki (Johnston)
Eurydesma hobartensis hobartensis (Johnston)
Myonia corrugata Fletcher
Streblopteria sp.
Stutchburia sp.
Volsellina sp. (or ?*Promytilus*)
Keeneia sp.
Peruvispira sp.
Bransonia australis (Etheridge)
Dichocrinus ?darlingtonensis Willink
Notiocatillocrinus nerimberae (McKellar)
Thaumatoblastus longiramus Wanner
Paraconularia derwentensis (Johnston)
Ostracods

Important entries at the base of the Counsel Creek Formation are the linoproductid *Terrakea pollex* and the aulostegid *Taeniothaerus subquadratus*. These two species together with *Cancrinella farleyensis* range through most of the formation, but are absent in the topmost 12 m of beds where *Ambikella plica*, *A. etheridgei* and *Terrakea concava* occur. *Ambikella ovata* occurs in the lower 28 m of the formation, but above this *Ambikella plana*, *A. ingelarensis*, *Gilledia ulladullensis* and *Myonia corrugata* enter. Previously these latter four species have been regarded as indicative of the Lymingtonian Stage, but this view must now be modified. The Late Bernacchian Stage (= Faunizone 5 of Clarke and Banks, 1975; Clarke and Farmer, 1976) is here defined as the Zone of *Taeniothaerus subquadratus*. It can be subdivided into a lower Subzone 5a characterised by *Ambikella ovata*, and an upper Subzone 5b characterised by *Ambikella plana* and *A. ingelarensis*. The topmost 12 m of the Counsel Creek Formation is here regarded as Lymingtonian and may be older than any beds in the original reference section at Deep Bay, Cygnet (Clarke and Farmer, 1976).

MARRA FORMATION (Pm)

The Marra Formation is here defined as that formation of sandstone and siltstone which lies conformably between the Counsel Creek Formation below and the Toarra Formation above. It is about 35 m thick. It is fully exposed in most of the major creek sections, often in precipitous waterfalls. The type section here designated is in the headwater reaches of Counsel Creek at 896817. The middle and upper parts of the formation crop out boldly around the flanks of the interfluvial ridges, but the lowest parts are usually less well-exposed.

Essentially the Marra Formation consists of sandstone with subordinate siltstone. Discontinuous pods and lenses or impure sandy limestone occur near its base. The lowest parts of the formation are thin- to medium-bedded sandstone and siltstone with several thin siltstone layers crowded with the large, thick-shelled, strophalosiid *Wyndhamia dalwoodensis* in growth position. The sandstone beds are moderately well-sorted with an abundance of pebble-sized clasts. Sometimes the clasts are more or less randomly scattered, but more often they form distinct layers. Fossils are common. Complete specimens occur but characteristically they are much broken and rolled. Higher up, the formation consists almost exclusively of medium- and thick-bedded, coarse-grained sandstone which becomes increasingly arkosic and glauconitic upwards. The glauconite content is sometimes as high as 23%, but more usually it is within the range of 7–10%. The glauconite may indicate slow and discontinuous deposition. Pebble-sized clasts occur sporadically throughout, but they are also concentrated at the base of several beds. Fossils are abundant at many horizons. Frequently they are much broken and comminuted. At several horizons abundant articulated or disarticulated but otherwise complete, and surprisingly well-preserved valves of large spiriferids, small terebratulids and pelecypods occur intermixed with much shelly debris; probably as a result of rapid burial. In one bed near the top of the formation, the burrowing mollusc

Vacunella curvata (Morris) occurs in life orientation and in great abundance.

Small, but prominent down-faulted benches of fossiliferous arkosic and glauconitic sandstone belonging to the Marra Formation occur on the lower slopes of Monah Hill [875804] and Ned Ryans Hill [882795].

On south Maria Island the lower part of the Marra Formation is preserved as a small outlier which caps the eastern-most ridge at 888716. The beds are leached and consist of coarse-grained, moderately well-sorted sandstone with abundant pebble-sized clasts. Fossils are much broken and rolled.

The Marra Formation thus represents a relatively thin but persistent sheet of coarse-grained sandstone and minor siltstone which was deposited over both islands except for a localised but substantial granite high around the headwater regions of Montgomerys Creek. It represents shallow-water sedimentation, often slow and intermittent, interspersed with brief periods of deposition and rapid burial of the benthos in a high energy environment.

Palaeontology

The Marra Formation is richly fossiliferous at many levels and extensive faunas can be collected almost everywhere. Major collections were made on Skipping Ridge at 888848, the northern slopes of Toarra Hill at 885840, and the ridge to the north of Counsel Creek at 883822. All collections are essentially similar. They include:

Terrakea brachythaera (Morris)
Wyndhamia dalwoodensis Booker
Ambikella brevis (McClung and Armstrong)
Ambikella etheridgei (McClung)
Ambikella isbelli (Campbell)
Ambikella oviformis (M'Coy)-*globosa* (Campbell) group
Ambikella ingelarensis (Campbell)
Ambikella plana (Campbell)
Ambikella plica (Campbell)
Ambikella magna (Campbell)
Ambikella undulosa (Campbell)
Fusispirifer sp. nov. (a form with obsolescent ornament)
Fusispirifer avicula (Morris)
Notospirifer minutus Campbell
Sulciplica tasmaniensis (Morris)
Sulciplica transversa Waterhouse
Trigonotreta wairakiensis (Waterhouse)
Punctospirifer etheridgei Armstrong
Fletcherithyris parkesi Campbell
Gilledia ulladullensis Campbell
Astartila intrepida (Dana)
Atomodesma (Aphanaia) sp.
Deltopecten multicostatus (Fletcher)
Deltopecten squamuliferus (Morris)
Eurydesma hobartensis hobartensis (Johnston)
Etheripecten leniusculus (Dana)
Etheripecten subquinquelineatus (M'Coy)
Megadesmus nobilissimus (de Koninck)
Merismopteria sp.
Myonia corrugata Fletcher
Pyramus myiformis (Dana)
Stutchburia sp.
Vacunella curvata (Morris)
Vacunella sp. nov.
Keeneia sp.
Ptychomphalina sp.
Stenopora crinita Lonsdale
Fenestellids and other bryozoans

Eurydesma is never common and is confined to and lowest part of the formation, whereas *Deltopecten* is common and ranges throughout. *Terrakea* is always rare, but *Wyndhamia dalwoodensis* is very common; both range throughout. *Ambikella plana, A. plica* and *A. etheridgei* are confined to the lower half of the formation, and *Ambikella magna* and *A. oviformis-globosa* group are confined to the upper half. Morphologies comparable to *Ambikella brevis, A. undulosa* and *A. isbelli* occur together in the upper beds. *Ambikella ingelarensis* occurs sparingly throughout. *Fusispirifer avicula, Sulciplica transversa* and *Vacunella curvata* are very common towards the top of the formation. These distributions together with the absence of *Megadesmus grandis* (Dana) and *Echinalosia ovalis* (Maxwell) indicate that the Marra Formation, despite its thinness, represents a substantial period of time ranging from the Early Lymingtonian *plana* Zone to the late Middle Lymingtonian *isbelli* Zone (Faunizones 6–9 of Clarke and Banks, 1975; Clarke and Farmer, 1976). Deposition was probably discontinuous.

TOARRA FORMATION (Pt)

The Toarra Formation is here defined as that formation of siltstone and minor conglomerate which conformably overlies the Marra Formation. Its boundary with the Upper Parmeener Super-Group has only been observed at one locality where it is apparently conformable. On a regional scale, however, the boundary is probably disconformable (see p. 19). The Toarra Formation has a maximum thickness of about 165 m in the region of Skipping Ridge in the north [900840], but thins noticeably to 120 m towards the south-east. Most of the formation is well-exposed in the headwater reaches of the major creeks which drain the Maria Range. The type section is that exposed in Counsel Creek at

897815. The uppermost parts of the formation and its contact with the Upper Parmeener Group are usually obscured by talus, and the only observed section is that exposed in Four Mile Creek at 897809. Both these sections are within relatively easy access from the Mt Maria walking track.

The Toarra Formation rests with abrupt lithological change on the massive-bedded, arkosic and glauconitic sandstone of the Marra Formation, and for most part consists of a monotonous sequence of medium-grey, thin- to medium-bedded, poorly-sorted siltstone with dispersed granules and pebble-sized clasts. Some beds are heavily bioturbated, but for most part the formation is essentially unfossiliferous. Three thin, but conspicuous horizons of conglomerate occur 9 m, 55 m and 120 m above the base of the formation. Each horizon is 3–4 m thick, and consists of massive- bedded, poorly-sorted conglomerate with sub-angular, pebble-sized clasts set in a matrix of poorly-sorted sandstone. Grains within the matrix are sub-angular to sub-rounded and are predominantly quartz with subordinate feldspar and rock fragments.

A richly fossiliferous bed about a metre in thickness occurs a few metres above the second conglomerate. Lithologically the bed consists of dark-grey, calcareous siltstone crowded with the spinose productids *Echinalosia ovalis* (Maxwell) and *Terrakea brachythaera* (Morris) in growth position. Spiriferids, various molluscans and other fossils occur near the base of the bed. First located beside the walking track to Bishop and Clerk (Clarke, 1973), this fossil bed has now been located in all the major creeks as far south as McGuiness Creek at 905790, and several localities on the hill slopes as indicated on the map.

The uppermost parts of the Toarra Formation and its junction with the Upper Parmeener Super-Group was observed only in Four Mile Creek at 897809. Here medium-grey, poorly-sorted siltstone with small rounded clasts is succeeded by about a metre of non-marine, black, carbonaceous and micaceous siltstone, with lesser light-grey and more quartzose siltstone. Hydroplastic structures are common. The boundary between the two is gradual and conformable. Samples of the uppermost Toarra Formation and the carbonaceous siltstone were processed for palynological residues. Both were barren apart from abundant woody debris in the carbonaceous siltstone (S. M. Forsyth, pers. comm.). Then follows massive- and cross-bedded, well-washed, quartz sandstone. The base of this sequence is clearly erosional with channels and wash-outs filled with pods of quartz conglomerate. On a regional scale it is probable that a disconformity occurs at or near the base of the Upper Parmeener Super-Group. In McGuiness Creek [905790] the characteristic productid bed occurs a few metres above the second conglomerate horizon which occupies its normal position about 55 m above the base of the Toarra Formation. The uppermost beds are not exposed but the total thickness of the Toarra Formation is no more than 120 m. If this attenuation is original, it must be confined to the upper half of the formation and this is considered to be less probable.

The prominent island about the headwater reaches of Montgomerys Creek was finally submerged by the upper parts of the Toarra Formation.

Palaeontology

For the most part the Toarra Formation is essentially unfossiliferous except for worm tubes and other biogenic structures which are abundant at some horizons. The productid bed has yielded the following fossils:

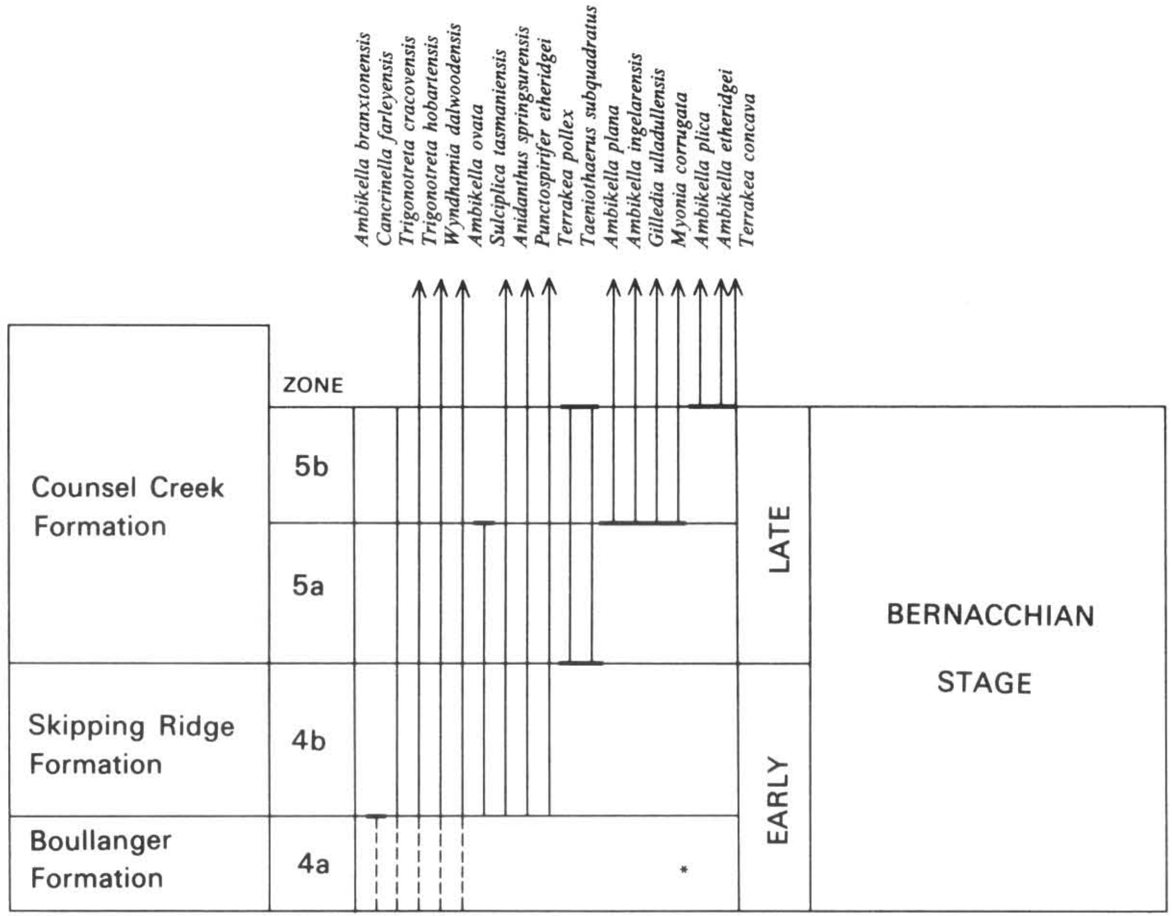
Euryphyllum sp.
Echinalosia ovalis (Maxwell)
Terrakea brachythaera (Morris)
Fusispirifer avicula (Morris)
Sulciplica transversa Waterhouse
Fletcherithyris parkesi Campbell
Atomodesma (Aphanaia) sp.
Etheripecten leniusculus (Dana)
Myonia carinata (Morris)
Vacunella curvata (Morris)
Peruvispira sp.
Stenopora crinita Lonsdale
Fenestellids, ostracods, crinoid debris

This assemblage is indicative of the Late Lymingtonian *ovalis* Zone (= Faunizone 10 of Clarke and Banks, 1975; Clarke and Farmer, 1976).

SUMMARY OF THE BIOSTRATIGRAPHY OF THE LOWER PARMEENER SUPER-GROUP

Rocks of the Lower Parmeener Super-Group on Maria Island are wholly Permian in age and range from Mid Tamarian (Asselian) to Late Lymingtonian (Kazanian). The older Late Carboniferous parts of the Super-Group (Hellyerian-Early Tamarian), corresponding to the Wynyard Tillite and Quamby Formation and their correlates, are absent.

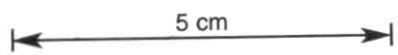
A stratotype for the Bernacchian Stage is defined and four successive faunas are recognised within it. On Maria Island the earliest Bernacchian is non-marine as is generally the case for most of Tasmania. This interval is represented by marine



* This interval is usually non-marine (Boullanger Formation, Mersey Coal Measures, Liffey Sandstone, Faulkner Group) and yields Substage 3b microfloras (Truswell, 1978). At Harts Hill, near Margate, the Hickman Formation is wholly marine and its lowest parts yield a *branxtonensis* Zone fauna (Farmer, in press).

Figure 3. *Subdivision of the Bernacchian Stage.*

Figure 4. *Palaeogeographic sketch maps — land areas denoted by horizontal ruling. A — Tamarian Stage; B — Early Bernacchian Stage; C — Early and Middle Lymingtonian Stage.*



beds in the lower parts of the Hickman Formation at Harts Hill near Margate, where a *branxtonensis* Zone fauna can be recognised (Farmer, in press). The diagnostic faunal characters of the Bernacchian Stage are summarised in Figure 3.

SUMMARY OF PALAEOGEOGRAPHY AND DEPOSITIONAL CONDITIONS

Late in the Carboniferous Maria Island presented a rugged terrain of folded Siluro-Devonian Mathinna Beds intruded by Devonian granite with a relief in excess of 260 m. High areas occurred in the centre of north Maria Island, around the headwater regions of Montgomerys Creek, and on south Maria Island (fig. 4). Evidence from the Riedle Bay area and south Maria Island suggests that the area was beyond the perimeter of glaciation proper, with the quartzite and granite subject to in situ mass-wasting in a periglacial environment.

Marine sedimentation commenced in the Middle Tamarian as conditions ameliorated. In the north, thick-shelled molluscans such as *Eurydesma* and *Deltopecten* together with the spiriferid *Trigonotreta stokesi* and massive colonies of the bryozoan *Stenopora tasmaniensis* proliferated in a shallow-water environment. Ice-rafted debris from melting icebergs occurs in considerable abundance. Alternating periods of strong current action and quiet-water conditions are indicated by the vast accumulations of reworked shell banks of *Eurydesma* and other shells, and the more platy, laminated bryozoal limestones respectively. Elsewhere coarse-grained, arkosic, boulder, cobble and pebble conglomerate accumulated marginal to the land areas in a high energy, sub-littoral environment. These rocks largely reflect the character of the underlying granite basement. In the Late Tamarian a brief episode of higher sea-level allowed the deposition of quiet-water spiriferid and fenestellid siltstone in the north. During the same time interval cross-bedded limestone with much clastic debris (Pl) accumulated briefly about the east coast of south Maria Island in a high energy sub-littoral environment.

The earliest Bernacchian is marked by regression and the development of a coastal plain bordering the sea. Non-marine, plant-bearing, micaceous and carbonaceous siltstone was deposited in the Fossil Cliffs area. The Skipping Ridge Formation shows renewed marine sedimentation. As in the Tamarian, more open marine conditions were restricted to a northeast-southwest trending gulf in the north, with arkosic sandstone and conglomerate accumulating around the high areas elsewhere. The Counsel Creek Formation represents a major Late Bernacchian transgression which rapidly flooded the remaining land areas except for a small island around the headwater reaches of Montgomerys Creek. Benthos proliferated.

The Early and Middle Lymingtonian witnessed a shallowing of the sea, and the rapid but intermittent deposition of coarse-grained arkosic sandstone with increasing amounts of glauconite. Benthos continued to flourish. The Late Lymingtonian witnessed further shallowing to produce a restricted, brackish estuarine environment in which poorly-sorted and sometimes bioturbated but otherwise unfossiliferous siltstone was deposited. Three brief episodes of conglomerate deposition occurred, and the final burial of the last vestige of the basement relief around the headwater regions of Montgomerys Creek was effected. Normal salinities returned only briefly when spinose strophomenids and other benthos flourished. Ice-rafted debris is always more or less in evidence throughout the marine Bernacchian and Lymingtonian, but never on the same spectacular scale as in the Tamarian.

UPPER DIVISION (TR)

Rocks of the Upper Parmeener Super-Group are wholly non-marine. They are sub-horizontal and rest with probable disconformity on the Lower Parmeener Super-Group. The principal outcrop forms a prominent topographic scarp and bench around the higher mid-slopes of the Maria Range, where it is frequently breached and draped with dolerite talus. Smaller outcrops of Upper Parmeener Super-Group rocks occur west of the major north-south fault. The largest of these is that which occurs in the coastal section about Howells Point [857833].

On the Maria Range the greatest exposed thickness of the Upper Parmeener Super-Group occurs on the ridge east-south-east of Toarra Hill at 901827. Here about 100 m of massive- and cross-bedded, quartz sandstone occurs as a double cliff and bench. The lowest beds are rather more feldspathic and less well-sorted, but for the most part the sequence is dominated by coarse-grained massive- and cross-bedded, well-washed, sparkling, quartz sandstone. The cross-bedding is of the large scale trough type. The bottoms of individual troughs are often erosional with lenses of well-rounded, quartz granule and pebble conglomerate.

On the Mt Maria walking track at 896812 the situation is similar except that dolerite talus descends to a lower level and only the one cliff and bench occurs which exposes about 60 m of massive-and cross-bedded sandstone.

The coastal section about Howells Point displays a more varied aspect. The base of the sequence occurs immediately north of Coxwains Creek [857818] and the beds young northwards. Near the dolerite contact the sandstone is mottled and saccharoidal. The effects of thermal metamorphism do not persist very far, and about ten metres further north the beds are unmetamorphosed and consist of thin-bedded, flaggy, carbonaceous and micaceous siltstone and sandstone, interbedded with more thickly-bedded sandstone. At [859829] about 2 m of red, cuboidal-weathering mudstone and siltstone occurs. The remainder of the section consists of massive- and cross-bedded, well-washed, quartz sandstone with frequent wash-outs and pods of clay pellet and quartz granule conglomerate. Excellent developments of recumbent overturned current-bedding occur at several horizons. Measurements of the trough- and current-bedding indicate derivation from the north-west (C. Calver and N. Farmer, pers. comm.). At the northern end of the section [862837] at the so-called 'Painted Cliffs', Liesegang rings are superbly developed. These result from the repeated precipitation of colloidal iron from groundwater solutions.

The total stratigraphic thickness of this coastal section is no more than 50–60 m. The stratigraphic position of these beds with respect to the Upper Parmeener Super-Group rocks on the Maria Range is unknown. In all probability the entire section is younger than any rocks exposed on the Maria Range.

Elsewhere on both islands the Upper Parmeener Super-Group is exposed as a series of small pods and inliers in the dolerite, principally close to the major north-south fault. Everywhere it presents cross-bedded, sparkling, quartz sandstone. The outcrops in the small creek immediately south of Darlington [872846], north of Four Mile Creek [869806], and those on south Maria Island are noticeably baked and indurated, but elsewhere metamorphism is slight. Dips are usually sub-horizontal. The sole exception is in Four Mile Creek at 874803 where the sandstone is much broken and the dip is almost vertical. The occurrence north of Trumpeter Corner [860698] is a sub-horizontal raft within the dolerite. Parts of this raft occur at sea-level in a series of large landslips.

Immediately south of Howells Point [857833] the sandstone was worked by the convicts as a building stone. It is a reasonable freestone but the surviving severely honeycombed blocks testify to its lack of resistance to weathering and erosion.

Macrofossils have not been observed in the Upper Parmeener Super-Group. Samples of carbonaceous siltstone from the Maria Range and the coastal outcrop about Howells Point were processed for palynological residues but all proved barren apart from abundant woody debris (S. M. Forsyth, pers. comm.). However, by analogy with developments elsewhere in east and north-east Tasmania, the Upper Parmeener Super-Group is considered to be wholly Triassic in age.

Tertiary (Tbx)

Lateritisation of Jurassic dolerite is confined to a small area about Bloodstone Point [845769]. It is presumed to be of Tertiary age by analogy with the widespread development of Tertiary laterite elsewhere in Tasmania. Here a low bluff displays about 5 m of crudely layered, bright red, pisolitic and creamy-white lateritic clay. The red layers are highly ferruginous and are more resistant to weathering. Irregular patches of ochreous limonitic material also occur. These deposits extend a considerable distance off-shore to low water, and probably beyond.

The Tasmanian Aborigines (and there are several old middens in the sand dunes behind Bloodstone Beach) exploited the deposit for ochre and rouge. The more pisolitic layers have been used as a durable and very satisfactory road metal on the track to Encampment Cove [850760], and the more clayey layers have been used in cement manufacture (Everard, *in* Hughes, 1957).

Quaternary

The Quaternary deposits on Maria Island include fluviatile, aeolian, mass-movement solifluction, and probable marine deposits. Because of the lack of good sections a reliable stratigraphic framework cannot be erected.

ALLUVIUM, SWAMP AND MARSH DEPOSITS (Qra)

Currently active creeks depositing significant amounts of alluvium and related deposits are present mainly on the western side of north Maria Island. Lithologies present indicate local derivation. Most deposits are dominated by dolerite with minor sedimentary rock detritus in a clayey-sand matrix.

VEGETATED AEOLIAN DUNE SANDS AND BEACH DEPOSITS (Qsd)

These deposits are best developed on the tombolo which unites north and south Maria Islands, where the two opposing arcuate dune systems reflect the prevailing wave patterns. The aeolian dunes developed on older beach berms. Lack of soil development indicates a Holocene age (compare Baillie, *in* McClenaghan *et al.*, 1982), and the deposits must have formed since sea level reached its present height about 6000 years B.P.

AEOLIAN SAND SHEETS (Qs)

In the south-east of north Maria Island [885770 and 850790] and the northern slopes of south Maria Island [870730], thin sheet-like bodies of well-sorted, fine- to medium-grained sand blanket the bedrock geology. No dune morphology has developed but they have a well-developed podsol soil on them, and they may be equivalent to the late Last Glacial sand bodies found elsewhere in Tasmania (Colhoun, 1975; Baillie, *in* McClenaghan *et al.*, 1982).

SCREE AND TALUS (Qt)

Well-developed and extensive talus deposits occur fringing the dolerite sheet of the Mt Maria montane area [900800] and Perpendicular Mountain [940770]. These deposits are typical of the talus fans that formed around dolerite mountains in the Late Pleistocene. Rather surprisingly, similar deposits are little developed on south Maria Island.

More enigmatic are talus deposits which crop out east and west of 893775 and 910770. These are discrete bodies, well removed from the nearest proved dolerite outcrop. They consist of poorly-sorted material composed predominantly of dolerite, up to several metres in diameter, and lesser clasts of Triassic sandstone and other Parmeener Super-Group rocks, and Siluro-Devonian Mathinna Beds. The dolerite clasts have thin weathering skins and a magnetometer survey (D. E. Leaman, pers. comm.) indicates that the deposits are talus, and that no dolerite bedrock is present. The ubiquitous presence of other lithologies also suggests that the deposits are transported and removed from their original source area.

OLDER MARINE SANDS AND BEACH AND RAISED-BEACH DEPOSITS (Qms)

Cropping out sporadically below or near the 20 m contour-line in sheltered areas on the western side of Maria Island and in the Crooked McGuiness Lagoon area [880765], are a flat-lying, seaward sloping series of coarse sands and clayey sands upon which beach-ridges are occasionally preserved. A thick soil is always developed on these deposits and a drill-hole that may have penetrated this sequence (Cromer, 1977; Hole 3) contained marine shells.

IGNEOUS ROCKS

Devonian granitic rocks (Dg)

Granitoids crop out unconformably below the Parmeener Super-Group, and are intrusive into the folded quartzwacke Siluro-Devonian Mathinna Beds. They occur in coastal areas on the eastern side of both north and south Maria Islands. Because of petrological similarities, and similar stratigraphic relationships with other granitoids in north-east Tasmania, it is assumed that the Maria Island granitoids are Devonian in age (McDougall and Leggo, 1965; Cocker, 1982).

The granitoids are divisible into two broad groups based on the size of the groundmass and the degree of alteration. Each group is further subdivisible into two sub-groups with respect to the size and relative amount of phenocrysts. Table 1 shows the major characters of each type. Chemical analyses of representative samples of three of the mapped rock types are listed in Table 2.

Table 1

DEVONIAN GRANITIC ROCK SYMBOLS USED FOR THE MARIA ISLAND SHEET

	Size of groundmass	Phenocryst abundance	Phenocryst size	Colour	Representative chemical analysis	Grid reference of location from which analysed specimen was obtained
Dgpq	Fine-medium	Common, but variable	10–40 mm	Pink	791683	882693
Dgpq′	Fine-medium	Common	40 mm	Pink-grey	n.a.	....
Dgpc	Coarse	Very common	25–50 mm	Grey	791684	885695
Dgpcs	Coarse	Sparse	25–40 mm	Grey	791682	881711

Table 2

CHEMICAL ANALYSES OF GRANITIC ROCKS

Analysis No.	791682	791683	791684
SiO_2	76·5	76·8	74·9
TiO_2	0·12	0·10	0·15
Al_2O_3	12·2	11·9	12·6
Fe_2O_3	0·45	3·32	0·14
FeO	1·1	0·61	1·4
MnO	<0·02	<0·02	0·05
MgO	0·13	0·06	0·11
CaO	0·47	0·34	0·60
Na_2O	2·6	2·8	2·8
K_2O	5·0	5·0	5·2
P_2O_5	0·09	0·07	0·09
CO_2	0·0	0·02	0·0
H_2O^+	0·99	0·83	0·88
H_2O^-	0·33	0·25	0·18
Total	99·98	99·10	99·10
Trace elements (ppm)			
Li	75	65	85
Rb	533	560	538
Sr	17	6	23
Ba	69	<40	212
Y	41	47	45
Zr	86	71	110
Nb	12	11	12
Zn	51	36	45

PORPHYRITIC, COARSE-GRAINED GRANITE (Dgpc)

This is the most widely distributed granite type on Maria Island and is a coarse-grained, grey granite. It may contain more than 50% by volume of euhedral megacrysts of K-feldspar. The coarse-grained groundmass contains quartz, plagioclase, K-feldspar, biotite and muscovite, and in thin section (MA6, MA13, MA16, MA28) is seen to have a hypidiomorphic, granular texture. In this rock type the potash feldspar is characteristically perthitic.

An intrusive contact between this rock type and meta-sedimentary Mathinna Beds occurs east of Trigonia Corner [886733]. The contact is sharp and the granite is very variable in composition close to the contact.

As will be more fully discussed later, field relationships indicate that this is the oldest granitoid on Maria Island.

SPARSELY PORPHYRITIC, COARSE-GRAINED GRANITE (Dgpcs)

This rock type is found on south Maria Island in an intermediate position between the previously described rock type and metamorphosed Mathinna Beds. The zone has a maximum width of 500 m. The rock is sparsely porphyritic, and where present, phenocrysts are usually less than 30 mm in length. In thin section (MA38, MA39, the rock is seen to be similar to the previously described rock type.

In this and the previously described rock type, segregations of quartz and tourmaline up to 200 mm in diameter are common.

VARIABLY PORPHYRITIC, FINE- TO MEDIUM-GRAINED GRANITE (Dgpq)

This grouping includes a wide variety of rock types that are clearly intrusive into the previously described varieties. Where observed, intrusive contacts are sharp, and the rock is characteristically pink in colour and is highly jointed. This gives it an easily recognisable 'blocky' outcrop appearance when compared to the large 'whale-back' type outcrops of the two previously described varieties.

The pink colour, the presence of altered biotite, low Ba, low Sr, and enriched Rb indicate that the granites grouped in this category have been altered (Higgins *et al.* in prep.).

One of the characteristic features of this rock type is its extreme variability with respect to the size and abundance of phenocrysts; although the groundmass is always pink-coloured and phenocrysts of both quartz and K-feldspar are invariably present. Phenocryst abundance ranges from 5% to 70% by surface area of the rock, and the size of euhedral K-feldspar phenocrysts is often less than 30 mm, whereas quartz phenocrysts are usually rounded and less than 15 mm in diameter.

As noted earlier, the rock type is intrusive into older varieties and the way individual contacts often change direction by 90° suggests that the porphyry was intruded by stoping along pre-existing joints in the older granites.

In thin section (MA1, MA5, MA7, MA9, MA21, MA24) the rock has easily recognised characteristics. It is porphyritic with phenocrysts of often rounded quartz and euhedral K-feldspar, in an allotriomorphic groundmass of globular quartz, K-feldspar, plagioclase (oligoclase-andesine), biotite (pleochroic red-brown), minor muscovite and tourmaline. Development of myrmekite is ubiquitous but its origin is not clearly understood (Phillips, 1974).

VERY PORPHYRITIC, FINE- TO MEDIUM-GRAINED GRANITE (Dgpq′).

This granite type crops out in the Whalers Cove area [915755] where it is apparently intrusive into Dgpc. Near Cape des Tombeaux [919954] this rock is seen to have a gradational contact with Dgpq.

In the Whalers Cove area shallow-dipping compositional layering is fairly common. Sheets of fine-grained, equigranular granite up to 300 mm in thickness are interlayered with coarser-grained, porphyritic granite. Doming may be present. Phenocryst size is usually 40–50 mm but reaches a maximum of 100 mm. Rounded quartz phenocrysts are usually present and the rock has a medium-grained groundmass. Xenoliths of metamorphosed Mathinna Beds and mafic segregations are more common in this granitoid rock type than the other three mapped varieties.

In thin section (MA27) K-feldspar is seen to be perthitic.

All the rocks described above (Dgpc, Dgpcs, Dgpq, Dgpq′) can be described as granites (*sensu stricto*).

MICRODIORITE (Dm)

A small body of microdiorite intrudes the Mathinna Beds at 878715. The body is only a few metres wide and it can be traced for about 60–70 m in a north-north easterly direction as far as the fault. No contacts were observed. It appears to be a narrow dyke-like intrusion and does not intrude rocks of the Parmeener Super-Group. It may be related to similar late stage intermediate dykes which are associated with the granites elsewhere in north eastern Tasmania (McClenaghan *et al.*, 1982).

M. P. McClenaghan (pers. comm.) reports: ' The rock in hand specimen is medium-grained, dark grey in colour with a randomly orientated mass of light-coloured feldspar laths set in a matrix of mafic minerals.

In thin section the texture is sub-ophitic with abundant andesine laths partly enclosed by grains of pale brown augite substantially altered to green-brown hornblende. Abundant large grains of magnetite are associated with minor amounts of biotite. Sparse small pools of quartz are present together with rare, thin needles and grains of apatite.

The plagioclase composition and grain-size characterise the rock as a microdiorite'.

Jurassic Dolerite (Jdl)

Jurassic dolerite occupies substantial areas on both islands west of the major north-south fault, and on north Maria Island a sheet at least 300 m in thickness caps the Maria Range and Perpendicular Mountain in the east.

For most part the dolerite is fine- to medium-grained and massive, and presents a rather monotonous and uniform aspect. Such characters are typical of the lower and middle portions of major sheet-like bodies. On the Maria Range the base of the sheet is at least 100–120 m above the base of the Upper Parmeener Super-Group. At Perpendicular Mountain the sheet steps down by more than 300 m and is intruded near to the base of the Lower Parmeener Super-Group.

South of Four Mile Creek [845805] and in the region of Pt Lesueur [826761] to Encampment Cove [850760], the dolerite texture is rather more variable. At Return Point [839796] the dolerite is characterised by closely-spaced, vertical and irregularly radiating joints. Thin dykes and veins of lighter-coloured quartz dolerite occur in some abundance. Most of these dykes are vertical or nearly so and trend in a general north-south direction. Strong compositional banding is developed in places. The layering dips at shallow angles to the west and north-west. Elsewhere around the Pt Lesueur peninsula the dolerite is invariably coarse-grained with irregular developments of granophyre. The granophyric developments often show large rosettes of pyroxene, and are usually decomposed or semi-decomposed. These characters are more typical of the upper parts of sheet-like bodies.

In summary, the dolerite west of the major north-south fault is most simply interpreted as the down-faulted extension of the major sheet on the Maria Range, since it is exclusively associated with rocks of the Upper Parmeener Super-Group. The unusual features at Return Pt and around Pt Lesueur indicate a different cooling history in the down-faulted block.

METAMORPHISM AND STRUCTURE

Mathinna Beds

REGIONAL METAMORPHISM

In north-eastern Tasmania the Mathinna Beds were subject to dynamic metamorphism during folding prior to emplacement of the granitoids (Turner, *in* McClenaghan *et al.*, 1982). Fine-grained muscovite-chlorite crystallised parallel to the axial surface cleavage. Similar metamorphism occurred on Maria Island.

CONTACT METAMORPHISM

Thermal metamorphism of the country rock accompanies granite emplacement and produced metamorphic aureoles, which on Maria Island, are linear and a little over a kilometre in width.

During mapping the criterion used to delineate the aureole was the presence of spotting in the pelites. Hornfelsing of quartzwacke was found to be an unreliable indicator of thermal metamorphism as hornfelsing can be confused with widespread silicification which is probably related to Tertiary groundwater movements.

On the Maria map a large tract of Mathinna Beds, about 3 km south-west of Mt Maria [885785], is shown as 'undifferentiated Mathinna Beds'. The lack of good outcrop, together with the lack of definite spotting in the meagre pelitic material present, and strong silicification as described above, made it extremely difficult to decide with any certainty whether the rocks had been thermally metamorphosed.

The best and most readily accessible contact on Maria Island is that which crops out approximately 500 m east of Trigonia Corner [880733]. Mapping has established that the aureole, as defined by spotting in pelite, is a little over a kilometre in width. Everard (see Appendix 1) has shown that the aureole is very narrow and suggests that assuming P_{total} = 10–25 kPa the temperature at the contact did not exceed 500–600°C. Cordierite is absent, and this implies that the spots are composed of chlorite near the edge of the aureole, and possibly andalusite closer to the contact.

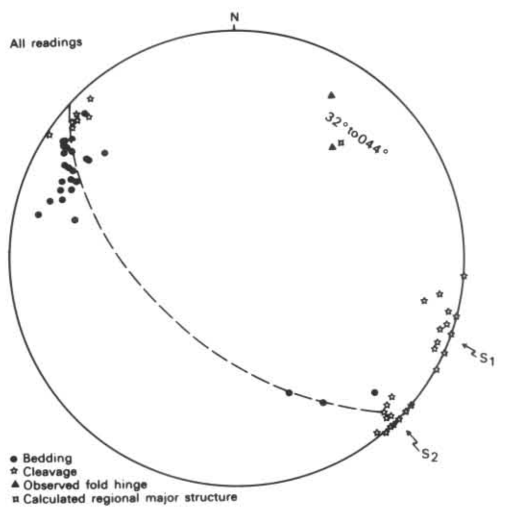


Figure 5. *Stereographic plot of structural data, north Maria Island.*

5 cm

STRUCTURE

Structural data were collected to the south-west of Mt Maria, and on south Maria Island. Because of difficulties of access, the east coast of north Maria Island was traversed by boat in an attempt to produce a reconnaissance structural profile.

NORTH MARIA ISLAND

In most outcrops examined, two sandstone cleavages were recognised and measured. The dominant cleavage is often spaced, trends approximately north-east to south-west and is seen to be the axial surface cleavage to upright megascopic folds observed in Pine Hut Creek [907764]. These folds were seen to rotate a pre-existing cleavage, which suggests that the north-easterly folds are structures generated by a second regional deformation event (D_2).

A stereographic plot of structural data from north Maria Island (Figure 5) is somewhat anomalous in that most of the data were collected in Pine Hut Creek along what is essentially a strike section. The statistical pole to the girdle of best fit agrees well with the observed D_2 folds in Pine Hut Creek. Vergence of the D_2 structures is to the west.

Thin sections (MA 33, 34, 35) indicate that the north-east to south-west trending cleavage (S_2) is a well-developed sandstone cleavage. In thin section (MA 33) the more northerly trending cleavage was seen to be crenulated by the north-easterly trending cleavage which is therefore the later.

No precise relationship between cleavage development and contact metamorphism could be ascertained.

Figure 6 is a structural profile of the east coast of north Maria Island obtained by tracing structural information from photographs taken from a boat. The diagram gives a good indication of fold style, but because of the gross inaccuracies incurred with taking measurements offshore on a moving boat, the direction of the fold hinges were not determined.

SOUTH MARIA ISLAND

Trigonia Corner

Mathinna Beds in the well-exposed section east of Trigonia Corner [880733] strike north-easterly and face north-westerly, but the dip direction is variable though always steep. The dominant cleavage is of a north-easterly trend but in a more northerly direction than the bedding, and is probably the same as the S_2 cleavage observed in

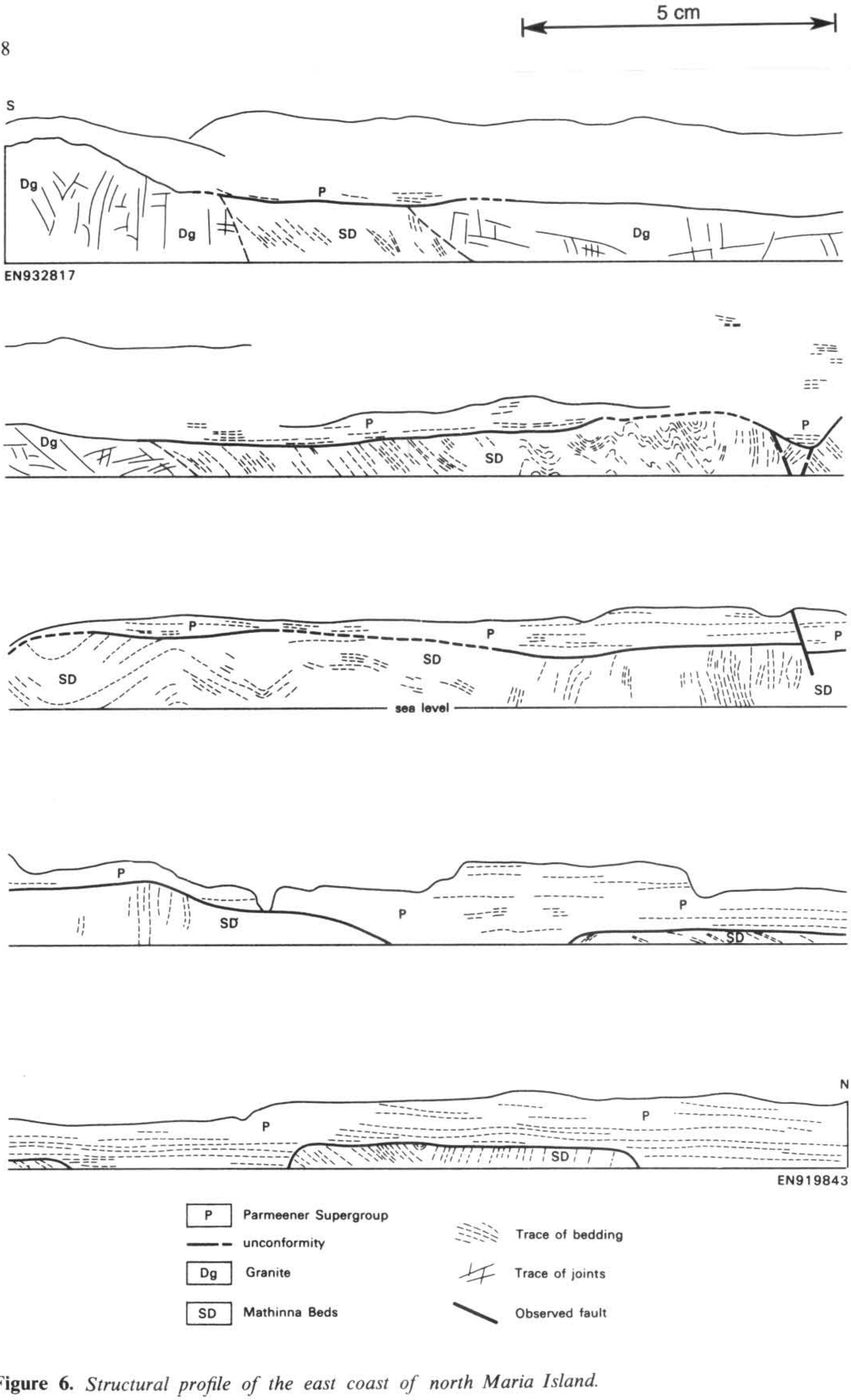


Figure 6. *Structural profile of the east coast of north Maria Island.*

5 cm

Pine Hut Creek. Thin section study (MA 17) shows that this cleavage intersects and disturbs minerals constituting the spots caused by thermal metamorphism associated with granite emplacement, which appears to have obliterated the pre-existing cleavage because no remnant early cleavage textures were observed.

Figure 7 is a stereographic projection of structural data from the Trigonia Corner section. The regional folding is similar to that in the Pine Hut Creek area.

Haunted Bay

Figure 8 is a stereoplot of structural data from the tract of country lying to the north-west of the granite in the Haunted Bay area of south Maria Island [867705]. Although the data show a large degree of scatter, the presence of two regional fold directions is inferred.

Granitic Rocks

Structural data were collected in all granite types on Maria Island with the exception of the inaccessible outcrops on the east coast of north Maria Island.

The fabric of a granite outcrop is determined by the geometric relationship between apparent lineations on different outcrop surfaces (Williams, *in* McClenaghan *et al.*, 1982). In weathered outcrops the three-dimensional form of K-feldspar phenocrysts can be determined and foliations defined, while in other cases phenocryst lineations are measured.

The regional pattern of steep fabric orientation of the granitic rocks of Maria Island has been established (fig. 9). Two major peaks are readily apparent; one at 010° and the dominant one at 045°. It is noted that both these directions are slightly oblique to the regional granite–Mathinna Beds contact which trends at about 030°, but that the average of these maxima approximates the regional contact. The 045° peak also closely matches the regional (D_2) fold axes (see fig. 5, 7, 8). The significance of this is not understood.

Phenocryst alignment is best developed in Dgpc and Dgpq′, no doubt due to the abundance of phenocrysts in these granite types. Alignment was sometimes observed in the fine-grained porphyry (Dgpq), but because of the scarcity of phenocrysts, no measurements were obtained from Dgpcs. From the measurements made on south Maria Island it is clear that dominant foliations are present in all granite types regardless of lithology, suggesting that development of the foliation is post emplacement.

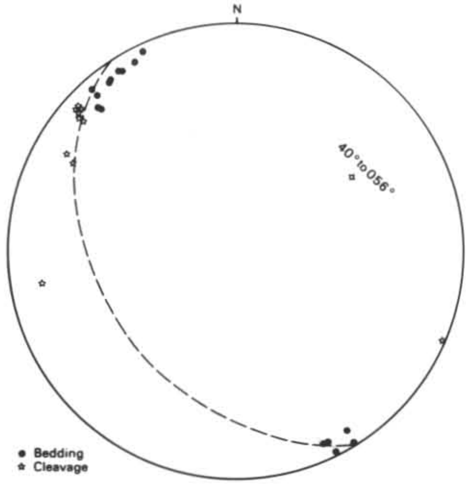


Figure 7. *Stereographic plot of structural data, Trigonia Corner.*

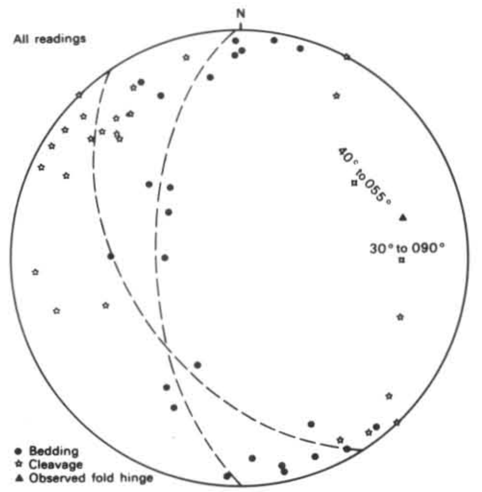


Figure 8. *Stereographic plot of structural data, Haunted Bay area.*

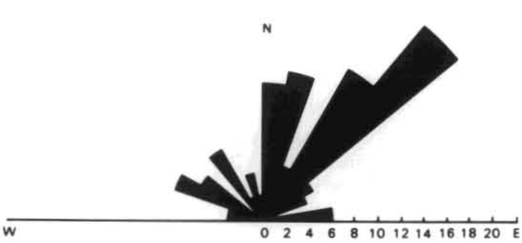


Figure 9. *Rose diagram of steep feldspar foliations and horizontal lineations (117 readings from all granite types from north and south Maria Island).*

There is no regional segregation of the foliation into discrete structural domains. Intersection foliations such as those described by Williams (*in* McClenaghan *et al*., 1982) were observed in many outcrops. Usually, the angle of intersection of the foliations was 90–100°.

Summary

Two deformation events are recorded in the Mathinna Beds. The second event is later than the thermal metamorphism due to the emplacement of the granitoids.

Foliations developed in the granitoids post-date intrusion and are probably stress-related.

There is a close correlation of the granite foliation peak and the regional D_2 fold axis.

Rocks of the Parmeener Super-Group have a shallow regional dip to the north-west of about 3°. At the Fossil Cliffs the dip is of a similar magnitude to the south-east. This anomaly may represent disturbance by faulting although the south-easterly dip is in the opposite sense to that expected by drag during displacement of known direction along a nearby fault surface. The dip in Bernacchis Creek [880850] which is close to the fault, is to the north-west, but is less than the regional dip.

A major post-dolerite fault which trends almost north-south truncates both islands. The downthrow is to the west and exceeds 400 metres. A branch fault on north Maria Island also downthrows to the west by about 35–40 m. The north-west to south-east trending faults on south Maria Island mostly downthrow to the north-east, and throws are small to moderate (5–50 metres). The approximate positions of the faults (fig. 10) in Shoal Bay [860750] were determined by an off-shore magnetometer survey (Leaman, 1979).

REFERENCES

BANKS, M. R. 1957. The Darlington Limestone and its correlates, in HUGHES, T. D. Limestones in Tasmania. *Miner. Resour. geol. Surv. Tasm.* 10:57-60.

BANKS, M. R. 1958. Recent additions to the knowledge of the Permian System in Tasmania. *20th Int. geol. Congr. Comision para la Correlation del Sistema Karroo* :151-177.

BANKS, M. R. 1962*a*. Permian, *in* SPRY, A. H.; BANKS, M. R. (ed.). The Geology of Tasmania. *J. geol. Soc. Aust.* 9(2):189-215.

BANKS, M. R. 1962*b*. Mathinna Beds, *in* SPRY, A. H.; BANKS, M. R. (ed.). The geology of Tasmania. *J. geol. Soc. Aust.* 9(2):182-184.

BANKS, M. R. 1970. Maria Island–a geological appreciation. *Tasm. Tramp* 19:21-27.

CLARKE, M. J. 1973. Faunas from the Ferntree Group of south-eastern Tasmania. *Tech. Rep. Dep. Mines Tasm.* 16:50-65.

CLARKE, M. J.; BANKS, M. R. 1975. The stratigraphy of the lower (Permo-Carboniferous) parts of the Parmeener Super-Group, Tasmania, *in* CAMPBELL, K. S. W. (ed.). *Gondwana Geology: papers presented at the 3rd Gondwana Symposium, Canberra, Australia, 1973* : 453-467. A.N.U. Press : Canberra.

CLARKE, M. J.; FARMER, N. 1976. Biostratigraphic nomenclature for Late Palaeozoic rocks in Tasmania. *Pap. Proc. R. Soc. Tasm.* 110:91-109.

CLEMES, W. H. 1920. Notes on the geology of Maria Island. *Pap. Proc. R. Soc. Tasm.* 1919:33-38.

COCKER, J. D. 1982. Rb-Sr geochronology and Sr isotopic composition of Devonian granitoids, eastern Tasmania. *J. geol. Soc. Aust.* 29:139-158.

COLHOUN, E. A. 1975. *A Quaternary climatic curve for Tasmania.* Royal Meteorological Society. Australasian Conference on Climate and Climatic Change, Monash University, 7-12 December 1975. (Unpublished)

CROMER, W. C. 1977. Groundwater investigations, Chinamans Bay, Maria Island. *Unpubl. Rep. Dep. Mines. Tasm.* 1977/52.

CROWELL, J. C.; FRAKES, L. A. 1971. Late Palaeozoic glaciation of Australia. *J. geol. Soc. Aust.* 17:115-155.

CROWELL, J. C.; FRAKES, L. A. 1975. The Late Palaeozoic glaciation, *in* CAMPBELL, K. S. W. (ed.) *Gondwana Geology: papers presented at the 3rd Gondwana Symposium, Canberra, Australia, 1973* : 313-331. A.N.U. Press : Canberra.

EVERARD, G. B. 1957. Maria Island, *in* HUGHES, T. D. Limestones in Tasmania. *Miner. Resour. geol. Surv. Tasm.* 10:235-241.

FARMER, N. 1981. Geological atlas, 1:50 000 Series, Sheet 88 (8311N). Kingborough. *Department of Mines, Hobart.*

FARMER, N. in press. Geological atlas, 1:50 000 Series, Sheet 88. Kingborough. *Explan. Rep. geol. Surv. Tasm.*

HIGGINS, N. C.; SOLOMON, M.; VARNE, R. *in press.* The genesis of the granitoids of the Blue Tier Batholith, N. E. Tasmania. *Geochim. Cosmochim. Acta.*

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

JOHNSTON, R. M. 1887. Contribution to the palaeontology of the Upper Palaeozoic rocks of Tasmania. *Pap. Proc. R. Soc. Tasm.* 1886:4-18.

JOHNSTON, R. M. 1888. *Systematic account of the geology of Tasmania.* Government Printer : Hobart.

JOHNSTON, R. M. 1902. Further notes on the 'Permo-Carboniferous Fossil Cliffs' at Darlington, Maria Island. *Pap. Proc. R. Soc. Tasm.* 1900-1901:11-20.

LEAMAN, D. E. 1979. Magnetic survey at Shoal Bay, Maria Island. *Unpubl. Rep. Dep. Mines Tasm.* 1979/5.

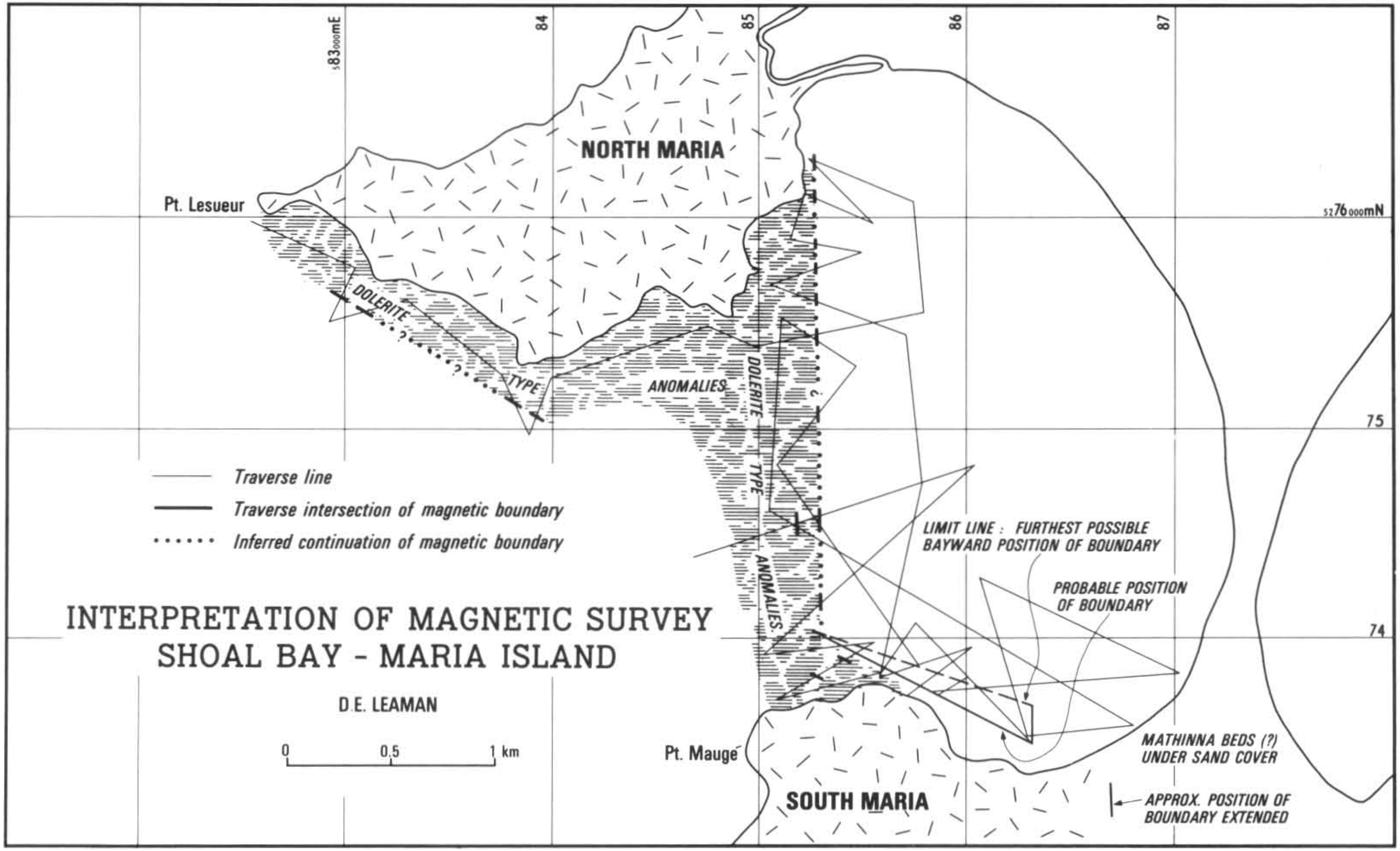


Figure 10. *Magnetometer survey, Shoal Bay (from Leaman, 1979).*

5 cm

LEWIS, A. N. 1937. Glacial Phenomena Committee. Tasmania. *Rep. Aust. N. Z. Ass. Advmt. Sci.* 23:433-434.

MCCLENAGHAN, M. P.; TURNER, N. J.; BAILLIE, P. W.; BROWN, A. V.; WILLIAMS, P. R.; MOORE, W. R. 1982. Geology of the Ringarooma-Boobyalla area. *Bull. geol. Surv. Tasm.* 61.

MCDOUGALL, I.; LEGGO, P. J. 1965. Isotopic age determinations on granitic rocks from Tasmania. *J. geol. Soc. Aust.* 12:295- 332.

MONTGOMERY, A. 1891. Report on the hydraulic limestones on Maria Island. *Rep. Secry Mines Tasm.* 1890-1891:22-25.

PHILLIPS, E. R. 1974. Myrmekite–one hundred years later. *Lithos* 7:181-194.

RUNNEGAR, B. 1970. *Eurydesma* and *Glendella* gen. nov. (Bivalvia) in the Permian of eastern Australia. *Bull. Bur. Miner. Resour. Geol. Geophys. Aust.* 116:83-118.

RUNNEGAR, B. 1979. Ecology of *Eurydesma* and the *Eurydesma* fauna, Permian of eastern Australia. *Alcheringa* 3:261-285.

RUNNEGAR, B.; MCCLUNG, G. R. 1975. A Permian time scale for Gondwanaland, *in* CAMPBELL, K. S. W. (ed.) *Gondwana Geology: papers presented at the 3rd Gondwana Symposium, Canberra, Australia, 1973* : 425-441.

RUNNEGAR, B.; CAMPBELL, K. S. W. 1976. Late Palaeozoic faunas of Australia. *Earth-Sci. Rev.* 12:235-257.

TRUSWELL, E. M. 1978. Palynology of the Permo-Carboniferous in Tasmania : an interim report. *Bull. geol. Surv. Tasm.* 56.

APPENDIX 1

Petrology of contact metamorphosed Mathinna Beds, near Trigonia Corner.

J. L. Everard

INTRODUCTION

During regional mapping of the Maria Quadrangle, P. W. Baillie mapped an area of contact metamorphic Siluro-Devonian Mathinna Beds psammite and spotted pelite, intruded by Devonian-Carboniferous porphyritic, fine- to medium-grained granite, to the east of Trigonia Corner, Maria Island. Baillie collected two samples of hornfels from the foreshore near 886733, one (MA18) about 50 m from the contact and another (MA19) from within a few centimetres of the contact. Polished thin sections were prepared and studied with the optical microscope and the electron probe microanalyser at the University of Tasmania in an effort to determine the metamorphic grade and possibly the physical conditions prevailing during intrusion of the granite.

PETROGRAPHY

MA18

This rock is a rather poorly sorted, weakly recrystallised psammite consisting of (n = 200) quartz (61%), orthoclase and albite (9%), intergranular muscovite (21%) and chlorite (8%), and accessory (1%) tourmaline, zircon, rutile and altered ilmenite (leucoxene).

Interlocking, equant anhedra of quartz (mostly 30–300 μm) and subordinate, equant to irregularanhedra of feldspar (typically 40–200 μm) comprise most of the rock. Feldspar is distinguished optically from quartz by a cloudy to finely-mottled appearance due to incipient to partial sericitisation, and electron probe microanalysis suggests that orthoclase is somewhat more abundant than albite. The frequent interlocking of quartz and feldspar grains and the unstrained nature of the quartz (unlike much quartz from Mathinna Bed rocks) suggest that thermal metamorphism has caused some recrystallisation, possibly driven by the releases of lattice strain of quartz, acquired during regional deformation and very low-grade regional metamorphism. However, curved to irregular grain boundaries and very unequal grain sizes indicate that equilibrium texture was not attained.

Muscovite and chlorite both occur as small (20–150 μm long), very ragged laths, splinters and irregular subhedral to anhedral fragments, lying between or interstitial to quartz and feldspar grains. There is a strong preferred orientation of the laths, probably corresponding to macroscopic cleavage. Muscovite and chlorite are often intergrown on a macroscopic scale with apparent crystallographic alignment, but usually occur separately. Muscovite is colourless, with high birefringence and a higher relief when orientated with cleavage parallel to the nicol; electron probe microanalysis (table 3) show the muscovite to be somewhat phengitic, with a high silica content and about 3 mol% trioctahedral component. Chlorite, which is pale yellow-green and almost isotropic, sometimes with anomalous berlin-blue birefringence, is a ferroan ripidolite (table 3) after the nomenclature of Hey (1954).

Accessory minerals include tiny (5–15 μm) rounded to ovate, cleavageless blebs of pleochroic, pale yellowish to orange-brown tourmaline; small (10–30 μm) elongate euhedral to rounded zircons; and very deep red to almost opaque ?rutile. Sparsely distributed, angular to irregular opaque material (rarely 200 μm, to dust) consists, according to probe analyses, of ilmenite now largely altered to titanium oxide ('leucoxene'). These minerals are probably all of detrital origin and have been reported in unmetamorphosed Mathinna Beds (*e.g.* Turner, *in* McClenaghan *et al.*, 1982, p. 14; Marshall, 1970, p. 19).

This rock has an essentially clastic mineralogy. Recrystallization is incomplete and an assemblage of metamorphic equilibrium has not been produced. Mineralogically it is comparable to the Mathinna Beds in general, from outside contact aureoles.

MA19

This is a granoblastic-polygonal quartz-feldspathic hornfels, differing from MA18 in not only being finer grained and less quartz-rich, but in showing more mineralogical and textural evidence of contact metamorphism. It consists of (n = 200) quartz (25%), albite and orthoclase (43%), biotite (28%) and muscovite, with accessory (1%) tourmaline, zircon and altered ilmenite. Biotite laths have a fairly well-developed preferred orientation, which could correspond either to regionally developed cleavage, or cleavage caused by stress associated with emplacement of the granite (*cf.* Marshall, 1970, p.71).

Quartz occurs as large (up to 400 μm), isolated equant anhedra, ranging to much smaller (= 30 μm) interlocking equant polygonal to irregular anhedra, often associated with similar (20–700 μm) polygonal anhedra of incipiently to partially sericitised alkali feldspar. Electron

Table 3

ANALYSES OF MINERALS, SAMPLE MA18

	Muscovites			Chlorite			
	A	B	C	D	E	F	G
SiO_2	47·27	47·85	46·53	24·68	23·85	25·09	25·10
Al_2O_3	36·24	36·45	36·30	20·84	19·32	22·35	21·46
FeO	0·98	0·69	0·79	27·16	28·43	27·41	29·04
MgO	0·52	0·59	0·42	11·58	10·46	13·75	13·09
Na_2O	0·32	0·45	0·47	....	....	....	....
K_2O	10·14	10·33	10·40	....	....	....	....
Total	95·46	96·35	94·91	84·27	82·07	88·60	88·70
H_2O (by difference)	4·54	3·65	5·09	15·73	17·93	11·40	11·30
Structural Formulae —							
	No. of ions assuming (0)=11			No. of ions assuming (0)=14, Z=10			
Si	3·114	3·122	3·091	2·766	2·773	2·645	2·665
Al_{IV}	0·886	0·878	0·909	1·234	1·227	1·355	1·335
Al_{VI}	1·928	1·925	1·933	1·519	1·422	1·422	1·350
Fe	0·054	0·038	0·044	2·546	2·765	2·417	2·578
Mg	0·051	0·058	0·042	1·935	1·813	2·161	2·072
K	0·851	0·860	0·881	....	....	....	....
Na	0·041	0·057	0·061	....	....	....	....
Fe/Fe + Mg	....	....	....	0·626	0·604	0·528	0·554

All analyses were obtained using a JEOL JX-50A electron probe microanalyser at the Central Science Laboratory, University of Tasmania. The 'spot' mode (beam diameter $<0{\cdot}5\ \mu m$, penetration 3–5 μm) was used. Oxides sought but not found include TiO_2, Cr_2O_3, MnO, and CaO. Analyses have been converted to structural formulae assuming all iron is in the divalent state and an ideal content of (O) and (OH).

Table 4

ANALYSES OF MINERALS, SAMPLE MA19

	Muscovites			Biotites		Secondary chlorite		
	A	B	C	D	E	F	G	H
SiO_2	45·86	46·50	46·22	38·35	36·54	39·17	35·68	24·26
TiO_2	0·40	....	0·26	1·88	2·76	2·19	1·73	....
Al_2O_3	29·76	35·70	32·31	19·84	18·08	19·11	19·14	20·86
FeO	1·94	1·90	3·35	17·50	19·26	16·85	23·00	33·27
MgO	1·51	....	1·23	9·81	8·37	8·07	6·97	6·33
CaO	....	....	0·63	....	....	....	0·40	....
Na_2O	....	....	0·42	0·50	....	....	....	....
K_2O	9·78	11·40	11·14	8·24	9·40	8·50	9·17	....
Total	89·25	95·50	95·56	96·12*	94·41	93·89	95·87	84·73
H_2O (by difference)	10·75	4·50	4·44	3·88*	5·59	6·11	4·13	15·27
Structural Formulae —								
Si	3·253	3·100	3·123	2·820	2·796	2·932	2·731	2·818
Al_{IV}	0·747	0·900	0·877	1·180	1·204	1·068	1·269	1.182
Al_{VI}	1·742	1·906	1·697	0·540	0·426	0·619	0·458	1·674
Ti	0·022	....	0·013	0·104	0·159	0·124	0·100	....
Fe	0·116	0·106	0·189	1·077	1·233	1·055	1·472	3·231
Mg	0·160	....	0·124	1·075	0·955	0·900	0·795	1·095
Ca	....	....	0·045	....	....	....	0·033	....
K	0·885	0·970	0·960	0·773	0·918	0·812	0·896	....
Na	....	....	0·055	0·071	....	....	....	....
Fe/Fe + Mg	....	....	....	0·501	0·564	0·540	0·649	0·747

* Recalculated to ideal H_2O^+

Analyses obtained and treated as for MA18 (Table 3).

probe microanalyses suggest that albite is somewhat more abundant than orthoclase. This interlocking quartz-feldspathic groundmass is somewhat more equidimensional, and with straighter grain boundaries, than in MA18, but nevertheless the even-grained polygonal equilibrium texture for quartzites (*cf.* Spry, 1969, p.188) has not been attained.

Short (30–100 μm) studdy laths of biotite are abundant throughout the slide. Biotite is pleochroic from deep red-brown ($b=y$) to nearly colourless (a), and basal sections give a virtually uniaxial negative interference figure. Electron probe microanalyses show a siderophyllite-like composition, with Fe/Fe + Mg = 0·50–0·57 and appreciable aluminium in the octahedral sites (table 3). Biotite is sometimes partly or wholly altered to a pale-greenish, length- slow, low birefringence brunsvigitic chlorite (table 4, analysis H).

Muscovite occurs as occasional ragged, colourless, high birefringence laths of similar size to those of chlorite, or colourless low-birefringence anhedral basal sections with a biaxial negative interference figure. Although less abundant than biotite, muscovite is well crystallised and is clearly prograde. Electron probe microanalyses (table 4), show that the muscovite is a silica-rich phengitic variety chemically similar to that of MA18, although with a greater trioctahedral component (about 10 mol%).

Accessory minerals of probably detrital origin include, as in MA18, small (=100 μm), elongate, rounded zircons, possibly orange-brown blebs of tourmaline, and rounded to irregular or hexagonal equant opaque blebs which analysis shows to be, as before altered ilmentite (leucoxene).

Despite a careful search, both optically and with the electron probe, no cordierite or altered cordierite was found.

BULK COMPOSITION

Whole rock analysis was not considered warranted and in any case little material remained after sectioning. However, two estimates of the bulk composition of each sample were made (table 5), firstly using a broad area (1 mm x 700 μm) scan on the electron probe microanalyser, and secondly by estimating the mode by point counting (n = 2000 and converting this to a bulk composition using, where necessary, average mineral compositions obtained by electron probe microanalysis (tables 3, 4). Given the errors and approximations involved, the estimates agree reasonably well.

Table 5

ESTIMATED BULK COMPOSITION OF SAMPLES

	MA18		MA19	
	Scan	Mode	Scan	Mode
SiO_2	83·87	77·5	62·00	65·4
TiO_2	....	1·5	0·63	0·7
Al_2O_3	8·02	11·4	19·06	14·9
FeO	3·00	2·8	5·10	6·2
MgO	1·09	1·2	1·60	2·6
CaO	....	....	0·33	0·04
Na2O	0·57	0·5	4·33	3·23
K_2O	2·34	3·1	6·94	5·53
H_2O^+	1·12*	2·0	7·19*	1·4
Total	100.00	100.0	100.00	100.00

* By difference

PHASE RELATIONS

As both samples contain negligible CaO and excess quartz, their mineralogy can, as outlined by Winkler (1979, p.39-44), be represented by A'FK diagrams, with quartz and albite as additional phases (fig. 11).

Despite a field appearance of hornfels, the mineralogy of MA18 (muscovite-chlorite-K-feldspar-albite-quartz) is similar to that of Mathinna Beds rocks from outside contact aureoles elsewhere in eastern Tasmania (*e.g.* Groves, 1977, p.16-17; Marshall, 1970, p.16-20, 69; Turner, *in* McClenaghan *et al.*, 1982, p.14-15, 114). Such rocks display very low grade regional metamorphism, here diagnosed by the coexistence of chlorite with potash feldspar (Winkler, 1979, p.212, 219). There is no textural or compositional evidence in MA18 that chlorite is retrograde after earlier contact metamorphic biotite or other minerals, and the relative lack of recrystallisation is consistent with very low-grade metamorphism. The absence of biotite only 50 m from the granite contact seems unusual, although little petrological work has been done on the contact aureoles of the Devonian granites within the Mathinna Beds of eastern Tasmania.

In contrast, in sample MA19 from within a few centimetres of the contact, chlorite has disappeared and biotite formed, to give the assemblage: phengitic muscovite-biotite-K-feldspar-albite-quartz.

The small amount of chlorite present is clearly retrograde after biotite and is compositionally different from the apparently prograde chlorite of MA18 (tables 3, 4). A possible reaction producing biotite in these rocks is:

(1) $3(Mg,Fe)5Al_2Si_3O_{10}(OH)_8 + 8KASi_3O_8 = 3KAl_2AlSi_3O_{10}(OH)_2 + 5K(Mg,Fe)3AlSi_3O_{10}(OH)_2 + 9SiO_2 + 4H_2O$

The actual stoichiometries would be slightly different as the minerals in MA18 and MA19 depart from their ideal compositions. Thermodynamic data from Helgeson *et al.* (1978) and Burnham *et al.* (1969) for the magnesium end-members suggest that G is negative (i.e. clinochlore and K-feldspar are incompatible) even at 1 bar (1 x 105 Pa) and 25°C, but this is open to doubt, and data for iron-rich chlorites are not available. In any case, the reactions leading to the appearance of biotite in pelitic rocks are not well understood (*e.g.* Winkler, 1979, p.219), and it is possible that an intermediate phase such as stilpnomelane is involved.

MA19 has an unsuitable bulk composition, with a too low FeO/FeO + MgO and too high K_2O + Na_2O, for the development of chloritoid (which is incompatible with alkali feldspar) or staurolite, even if appropriate physical conditions were attained (Winkler, 1979, p.222). At the relatively low pressures of contact metamorphism, these rocks are probably also too magnesium-rich for the development of almandine garnet (Miyashiro, 1973, p.213). However, the bulk composition cannot account for the absence of cordierite, which is well known from contact metamorphosed Mathinna Beds elsewhere in eastern Tasmania (*e.g.* Groves, 1977, p.16-17; McNeil, 1965, p.39-41; Turner, *in* McClenaghan *et al.*, 1982, p.119). Here two micas remain stable even at the contact, preventing the formation of the potash-feldspar-cordierite tie line (fig. 11). Thus the temperature at the contact was insufficient to produce rocks of the pyroxene-hornfels facies (termed the ' cordierite-K-feldspar facies ' by Winkler, 1967), and only the hornblende-hornfels facies was attained.

CONDITIONS OF METAMORPHISM

Some phase relations in the silica-saturated portion of the iron-free system $K_2O - MgO - Al_2O_3 - SiO_2 - H_2O$, are illustrated in Figure 12 (after Schreyer, 1976, p.312). The reaction

(2) $6KAl_2AlSi_3O_{10}(OH)_2 + 2KMg_3AlSi_3O_{10}(OH)_2 + 15SiO_2 = 3Mg_2Al_4Si_5O_{18} + 8KAlSi_3O_8 + 8H_2O$

passes near the points (1kbar, 520°C), (2kbar, 575°C), (3kbar, 620°C). Calculations based on the thermodynamic data of Helgeson *et al.* (1978) and Burnham *et al.* (1969) yield a slightly steeper equilibrium curve, with temperatures 10°–30°C higher. The effect of substitution of iron into phlogopite and cordierite is difficult to estimate, as a reliable internally consistent set of data including iron-cordierite (sekaninaite) does not seem to be available, but Schreyer (1965) concluded that the low temperature stability limit of Fe-cordierite was similar to that of Mg-cordierite. Another complication is the trioctahedral (phengitic) substitution into muscovite, and dioctahedral substitution into biotite in these rocks. This will probably stabilise the two-mica assemblage, shifting the equilibrium of (2) to higher temperatures.

Thus without further thermodynamic or experimental data it is not possible to accurately estimate a maximum temperature for the granite contact (MA19), even if the pressure is independently known. The most that can be said is that, assuming $P_{H_2O} \cong P_{total}$ = 1 to 2·5 kbar, the temperature at the contact probably did not exceed 500° to 600°C, and was only a few hundred degrees 50 m away.

POSSIBLE IMPLICATIONS

Some possible explanations for the unusually narrow aureole and low temperatures at the contact are:

(a) the granitic intrusive may only be a small body. Field evidence is inconclusive, as the granite contact is close to and roughly parallel to the coast, and its eastern extent is unknown (see Clarke and Baillie, 1981).

(b) transfer of heat from the intrusive rock to the country rock was poor; for example the intrusive rock was relatively dry and $P_{H_2O} < P_{total}$, inhibiting convection. This is though unlikely for a granitic intrusive.

(c) the granitic intrusive was intruded at a relatively low temperature. This seems the most likely explanation.

REFERENCES

Burnham, C. W.; Holloway, J. R.; Davis, N. F. 1969. Thermodynamic properties of water to 1000°C and 10,000 bars. *Spec. Pap. geol. Soc. Am.* 132.

Clarke, M. J.; Baillie, P. W. 1981. Geological atlas 1:50 000 series. Sheet 77 (8512N). Maria. *Department of Mines, Tasmania.*

Groves, D. I. 1977. The geology, geochemistry and mineralisation of the Blue Tier Batholith. *Bull. geol. Surv. Tasm.* 55:7-116.

Helgeson, H. C.; Delany, J. M.; Nesbitt, H. W.; Bird, D. K. 1978. Summary and critique of the thermodynamic properties of rock-forming minerals. *Am. J. Sci.* 278A.

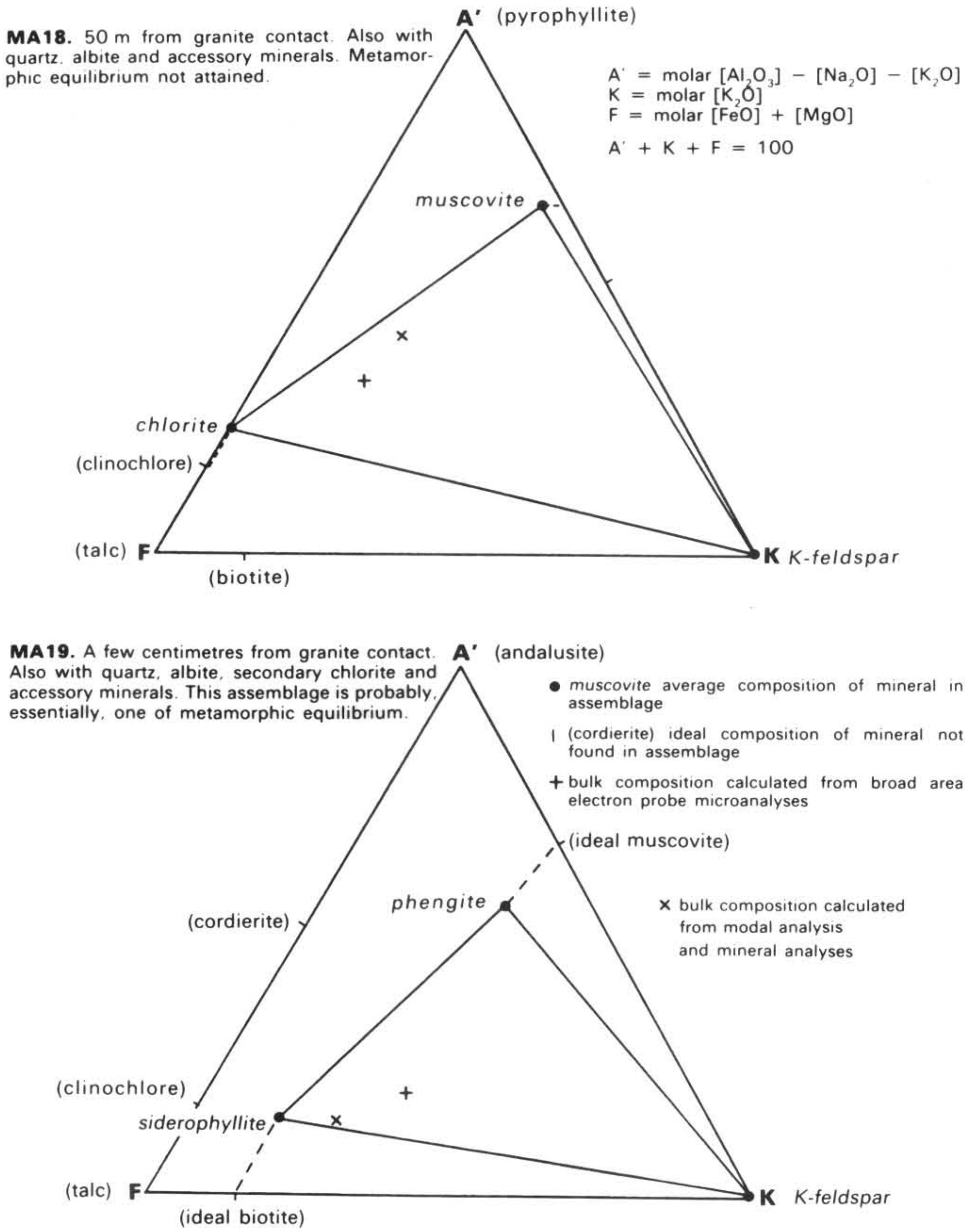


Figure 11. *Mineral compositions and assemblages of hornfels, plotted on A′FK diagrams.*

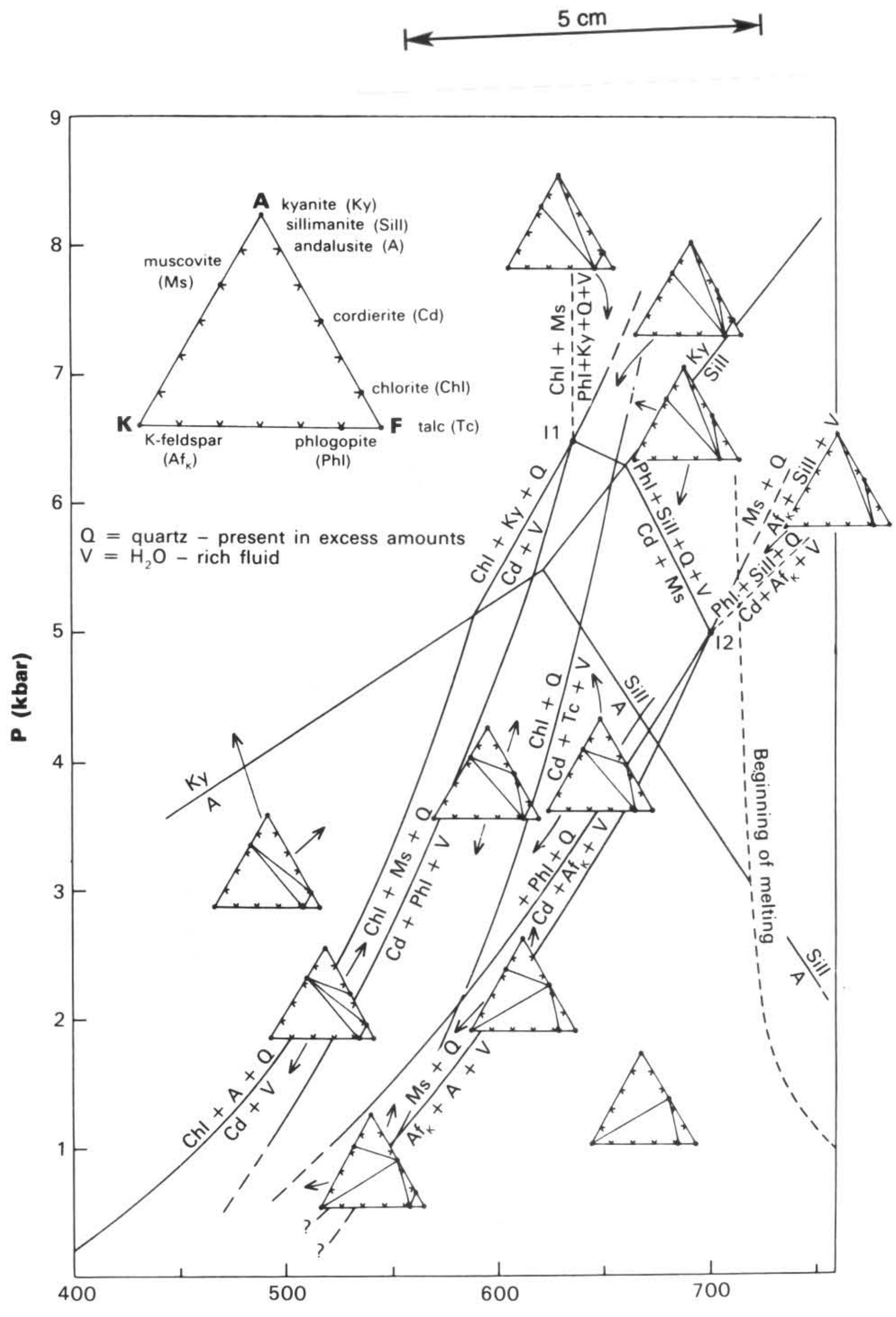


Figure 12. *Pressure-temperature diagram summarising the most important compatibility relations within the quartz-saturated portion of the system $K_2O — MgO — Al_2O_3 — SiO_2 — H_2O$ at elevated temperatures and pressures between 0 and 7 kbar based on the experimental work by Seifert (1970 and unpublished data). Except for quartz the crystalline phases involved in the reactions, and their abbreviations, are shown in the enlarged AKF-triangle (upper left) representing a projection of the H_2O- and SiO_2-saturated portion of the quinary system into a ternary subsystem $Al_2O_3(=A) — K_2O+Al_2O_3(=K) — MgO(=F)$ (from Schreyer, 1970, p.312).*

HEY, M. H. 1954. A new review of the chlorites. *Mineral. Mag.* 30:277-292.

MCCLENAGHAN, M. P.; TURNER, N. J.; BAILLIE, P. W.; BROWN, A. V.; WILLIAMS, P. R.; MOORE, W. R. 1982. Geology of the Ringarooma-Boobyalla area. *Bull. geol. Surv. Tasm.* 61.

MCNEIL, R. D. 1965. The geology of the Mt Elephant-Piccaninny Point area, Tasmania. *Pap. Proc. R. Soc. Tasm.* 99:27-49.

MARSHALL, B. 1970. Geological atlas 1 mile series. Zone 7, sheet 31 (8315N). Pipers River. *Explan. Rep. geol. Surv. Tasm.*

MIYASHIRO, A. 1973. *Metamorphism and metamorphic rocks.* Allen & Unwin : London.

SCHREYER, W. 1965. Zur stabilität des ferrocordierits. *Beitr. Mineral. Petrogr.* 11:297-322.

SCHREYER, W. 1976. Experimental metamorphic petrololgy at low pressures and high temperatures, *in* BAILEY, D. K.; MACDONALD, R. (ed). *The evolution of the crystalline rocks.* 261-331. Academic Press : London.

SPRY, A. H. 1969. *Metamorphic textures.* Pergamon Press : Oxford.

WINKLER, H. G. F. 1967. *Petrogenesis of metamorphic rocks. 2 ed.* Springer-Verlag : New York.

WINKLER, H. G. F. 1979. *Petrogenesis of metamorphic rocks. 5 ed.* Springer-Verlag : New York.

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