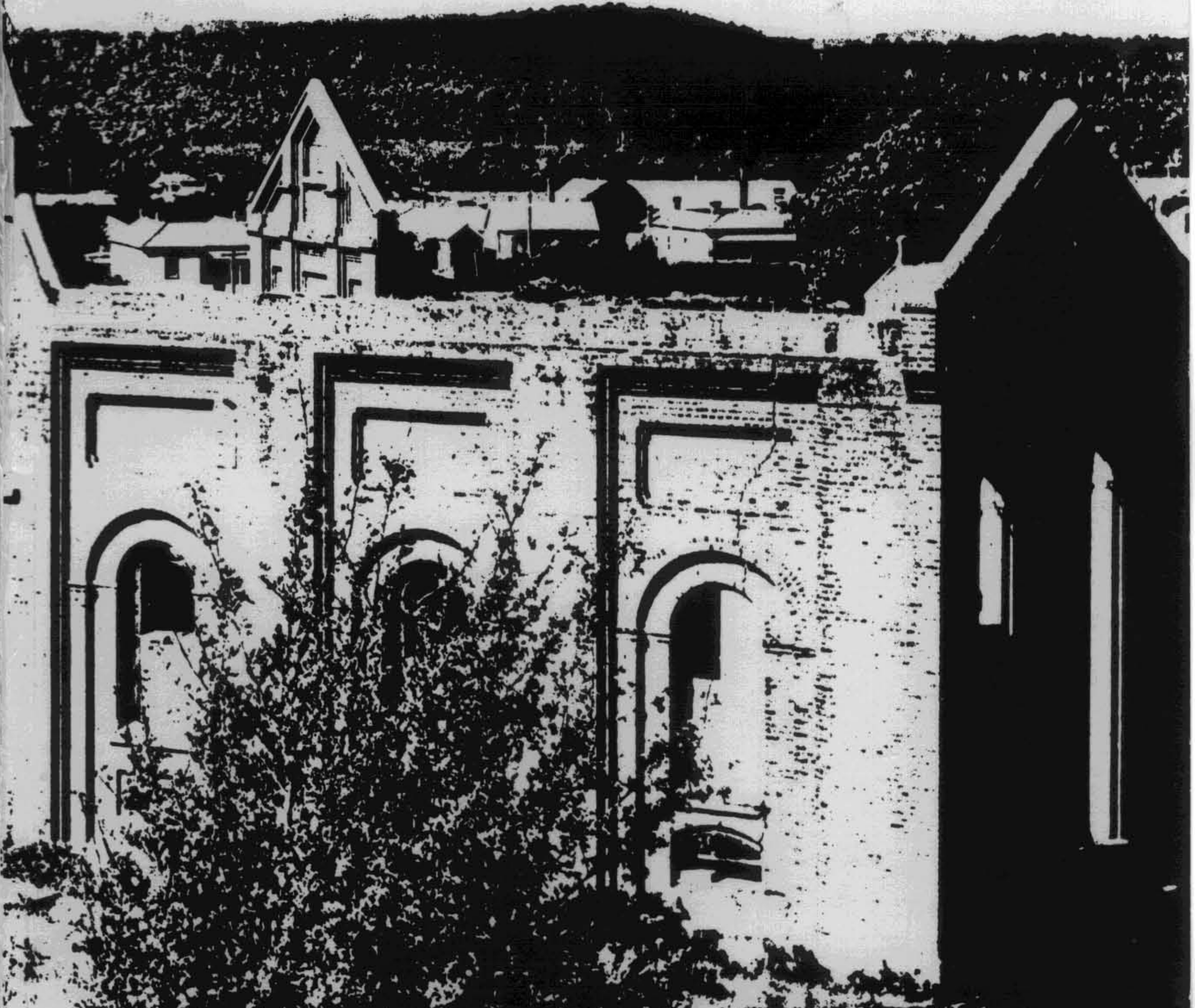
GEOLOGICAL SURVEY EXPLANATORY REPORT

DEPARTMENT OF MINES TASMANIA

SHEET 30

BEACONSFIELD

SECOND EDITION



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1979

GEOLOGICAL SURVEY EXPLANATORY REPORT

GEOLOGICAL ATLAS 1 MILE SERIES

ZONE 7 SHEET No. 30 (8215N)

BEACONSFIELD

SECOND EDITION

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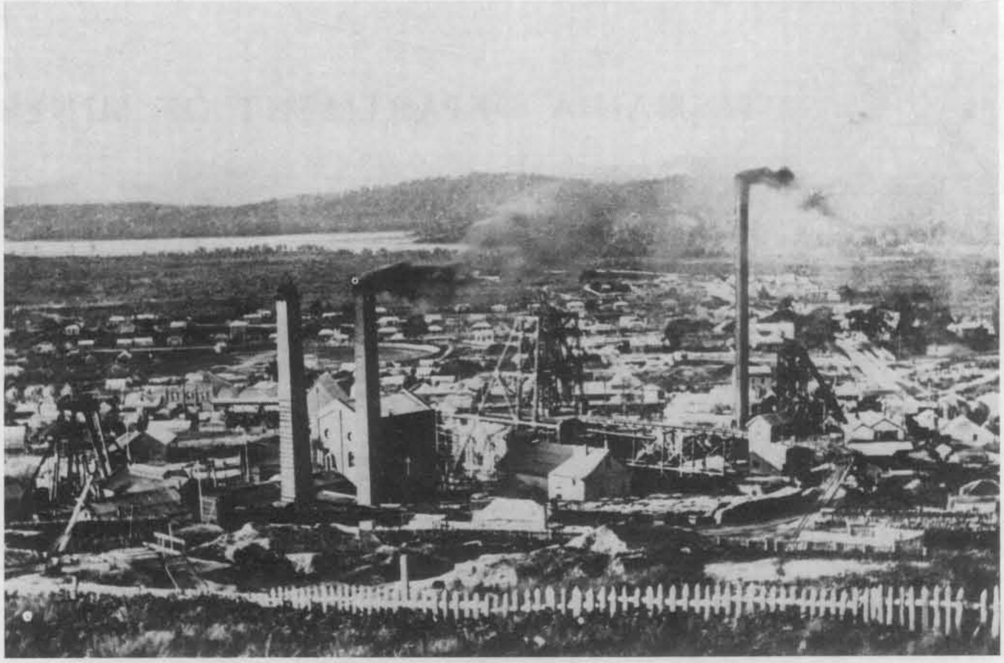

Plate 1. *Tasmania mine, Beaconsfield, 1914.* [*State Library*]

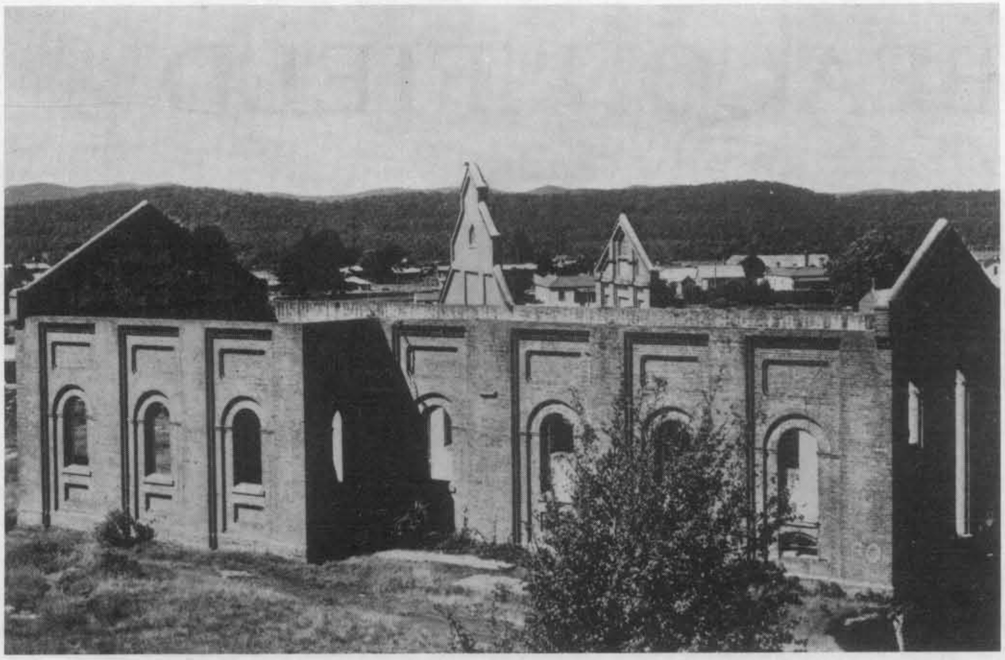

Plate 2. *Tasmania mine, Beaconsfield. Ruins of the Hart's shaft engine room (foreground) and the remains of the central boiler house and of Grubb's shaft engine room (centre).* [*Don Stephens*]

PREFACE

The Beaconsfield geological atlas 1 mile sheet, which was published in 1971, covers an area of the central north coast of Tasmania and includes Port Sorell and the northern part of the River Tamar estuary.

Early development of the area was entirely due to mining, which received great impetus from the discovery of gold at Lefroy in 1869 and at Beaconsfield in 1877. Potential for the exploration of minerals still exists, although the present economy is based upon farm and forest products and such industrial developments as aluminium smelting and the production of ferro-manganese alloy at Bell Bay on the East Tamar.

This explanatory report describes the geology of the area and considers the mineral resources in a regional context. Particular attention has been given to the great differences between the Lower Palaeozoic rock types east of the River Tamar, which are typical of the whole of north-eastern Tasmania, and those west of the River Tamar and typical of the West Coast Range of Tasmania.

J.G. SYMONS, Director of Mines

PREFACE TO THE SECOND EDITION

The main body of the text remains essentially unchanged. Supplementary material included with the first edition has been incorporated within the text and a chapter on groundwater has been added.

The issue of this new edition coincides with the centenary celebrations marking the change of name from Brandy Creek to Beaconsfield in 1879.

J.G. SYMONS, Director of Mines

GEE, R.D.; LEGGE, P.J. 1979. Geological atlas 1 mile series. Sheet 30(8215). Beaconsfield. *Explan. Rep. Dep. Mines Tasm.*

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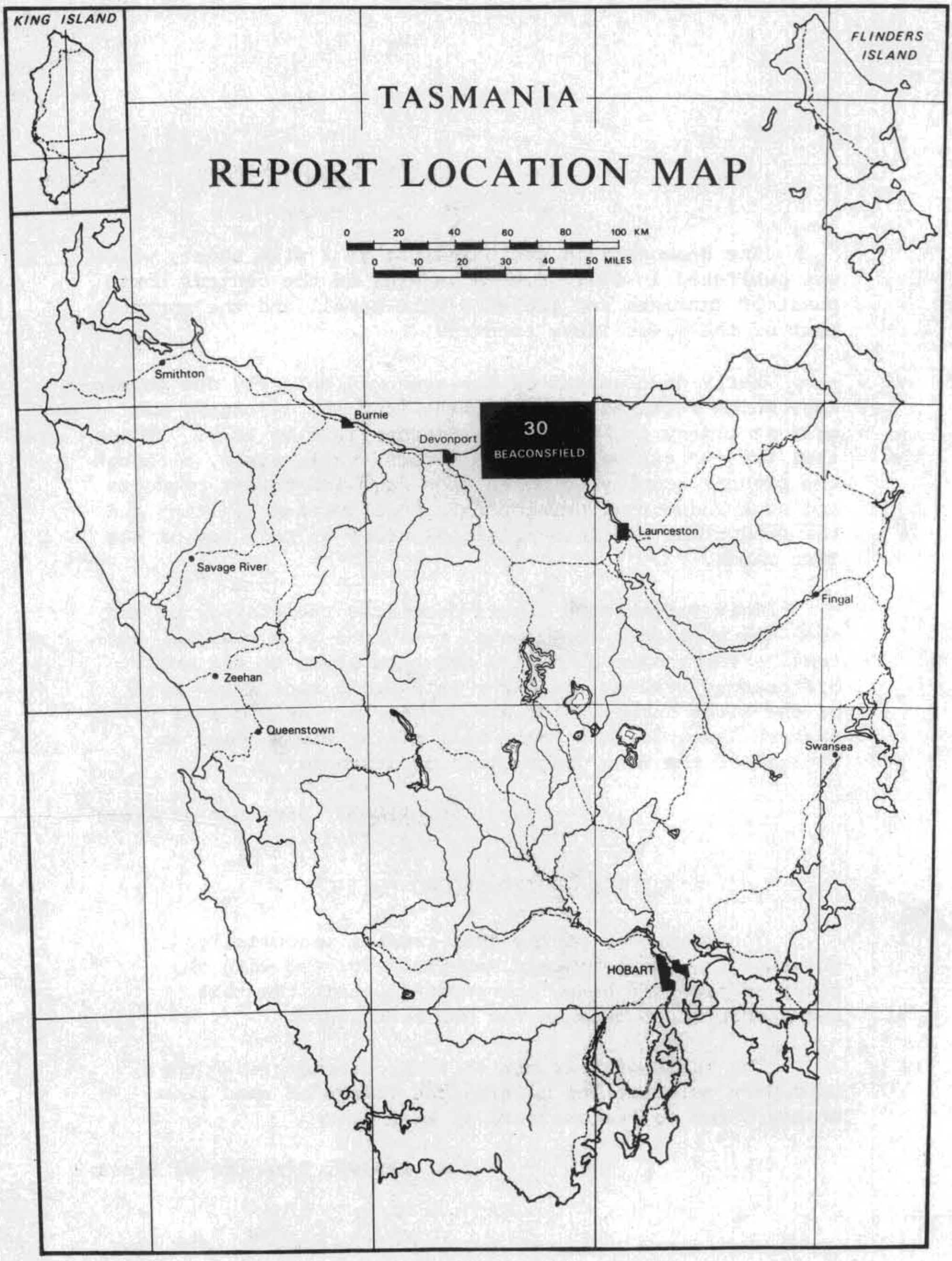
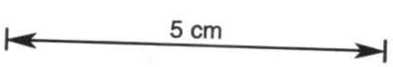


Figure 1. *Location of the Beaconsfield Quadrangle.*



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INTRODUCTION

The Beaconsfield Quadrangle (fig. 1) is located on the central north coast of Tasmania and straddles the northern part of the Tamar River estuary. It lies between latitude 41° and 41°15'S and longitude 146°30' and 147°E.

At present this is a rural area with an economy based upon farm and forest products, although important industrial development is now taking place, including aluminium smelting and the production of ferro-manganese alloys at Bell Bay on the East Tamar. The original development of the area was due to mining ventures, particularly in the Beaconsfield and Lefroy goldfields. Potential for exploitation of gold and other minerals still exists today, and this report is intended to place the metallic and non-metallic mineral potential in a regional geological context.

Mapping and compilation of the area west of the Tamar Estuary was done by R.D. Gee, and to the east by P.J. Legge. The work was carried out under the supervision of Dr E. Williams, whose contribution through discussion we acknowledge. We also make acknowledgment to A.J. Noldart, who undertook detailed regional mapping around the township of Beaconsfield, and whose summary of the mineral resources is appended. Much of the work of Dr D.I. Groves on the Lefroy goldfield has been incorporated in the map and in this report. M.J. Clarke has identified fossils from the area.

The early history and development of the area was entirely due to mining. Evans (1822) mentioned the iron deposits. Gould (1866) first made geological observations on the area, and reported on the iron and asbestos deposits at Andersons Creek. The asbestos was quarried intermittently until 1917, and Twelvetrees (1900, 1903a, 1917) and Reid (1919) described these prospects. A review and geological account of the asbestos deposits was given by Taylor (1955).

Exploitation of the iron deposits mentioned by Gould (1866) was attempted in 1872 by the Tasmania Charcoal Iron Company which built a tramway from the deposits at Andersons Creek and erected a smelter at Redbill Point, West Arm. Smelting was hampered by the high chromium content, and when operations were suspended in 1877 only 10 000 tonnes of pig iron had been produced. Twelvetrees and Reid (1919) gave a description and historical summary of the venture. Later boring (Nye, 1930) showed a potential reserve of 1 320 000 tonnes but no improvement in the quality of the ore.

The greatest stimulus for the development of the area was the discovery of gold at Specimen Hill, Lefroy in 1869 and at Cabbage Tree Hill, Beaconsfield in 1877. During the 1880s and 1890s both goldfields flourished and became the centres of large populations. The Tasmania Mine at Beaconsfield became the richest mine in Tasmania, producing 26 435 kg of gold, before its closure in 1914. Continued treatment of tailings and slimes raised the final production figure to 26 580 kg. Total gold production from the Lefroy field has been estimated at 5 160 kg. A further 155 kg is estimated to have been won from alluvial deposits.

The early geological literature of the Beaconsfield Quadrangle pertains to the goldfields, the major reports being those of Montgomery (1891) and Twelvetrees (1903b) for Beaconsfield, and Thureau (1882, 1883b), Montgomery (1897) and Broadhurst (1935) for Lefroy. More recent literature includes accounts by Noldart (1964) and Hughes (1953) for Beaconsfield, and Groves (1965) for Lefroy.

Other notable mineral occurrences include lateritic nickel (Hughes, 1957, 1962) and alluvial chromite (Noldart, 1963), both associated with the Andersons Creek ultramafic complex.

Other geological work of a regional nature within the Beaconsfield Quadrangle include Green (1959) and Sutherland (1971). Sutherland (1969) has also published an account of the petrology of the Tertiary basalts of the Tamar Valley.

PHYSIOGRAPHY

The Beaconsfield Quadrangle lies between two major physiographic units: the undulating basalt slopes with eroded sea scarps of the North West Coast and the extensive coastal surfaces coated with Cainozoic terrestrial sediments of the North East Coast.

Physiographically the quadrangle may be divided into six units, each reflecting the major geological units. These are described below, from west to east.

BASALT HILLS AT PORT SORELL

Partly dissected undulating basalt hills range in height from 60-120 m. They slope down to the coast and form a continuation of the Lower Coastal Surface of Davies (1959) in the adjacent Devonport Quadrangle (Burns, 1965). They are developed in an interbedded sequence of Tertiary basalt flows and terrestrial sediments. Dissection in the estuary area of the Rubicon River has exposed Jurassic dolerite, and Permian and Cambrian sedimentary rocks. A pre-Tertiary surface of considerable relief is partly exhumed.

A youthful marine platform of probable Pleistocene age is cut into the seaward edge of the Lower Coastal Surface. It is coated with a thin veneer of sand and landslide debris. A scarp 60 m high, presently retreating by active solifluction, forms the landward edge of this low-level marine platform.

ASBESTOS AND DAZZLER RANGES

These ranges are the expression of an elongate basement high of Precambrian rocks, trending NW, and extending into Bass Strait as the promontory of Badger Head; they range in height from 200-530 m. They have a sharp ridge profile, with deeply incised gullies on the flanks. The Asbestos and Dazzler Ranges separate the areas of sheet-type basalt to the west and the areas of more restricted flows to the east, and thus appear to have acted as a barrier to the flood-type basalts so characteristic of the North West Coast.

The northern end of the Asbestos Range slopes gently seaward forming a narrow erosional surface at an altitude of 120-60 m. This is a comparable altitude to the Lower Coastal Surface further west. The seaward edge of this surface is marked by sea cliffs up to 60 m in height. Isolated rounded and discoidal pebbles occur on this surface suggesting that it may be an exhumed pre-Tertiary erosional surface.

WEST TAMAR PLAIN

Between the Asbestos Range and the Tamar Valley a partially dissected flat landform ranges in height from sea level to 75 m. This landform is mainly cut into Tertiary sediment, but in places underlying Jurassic dolerite, gently dipping Permian and folded Lower Palaeozoic rocks are exposed. The

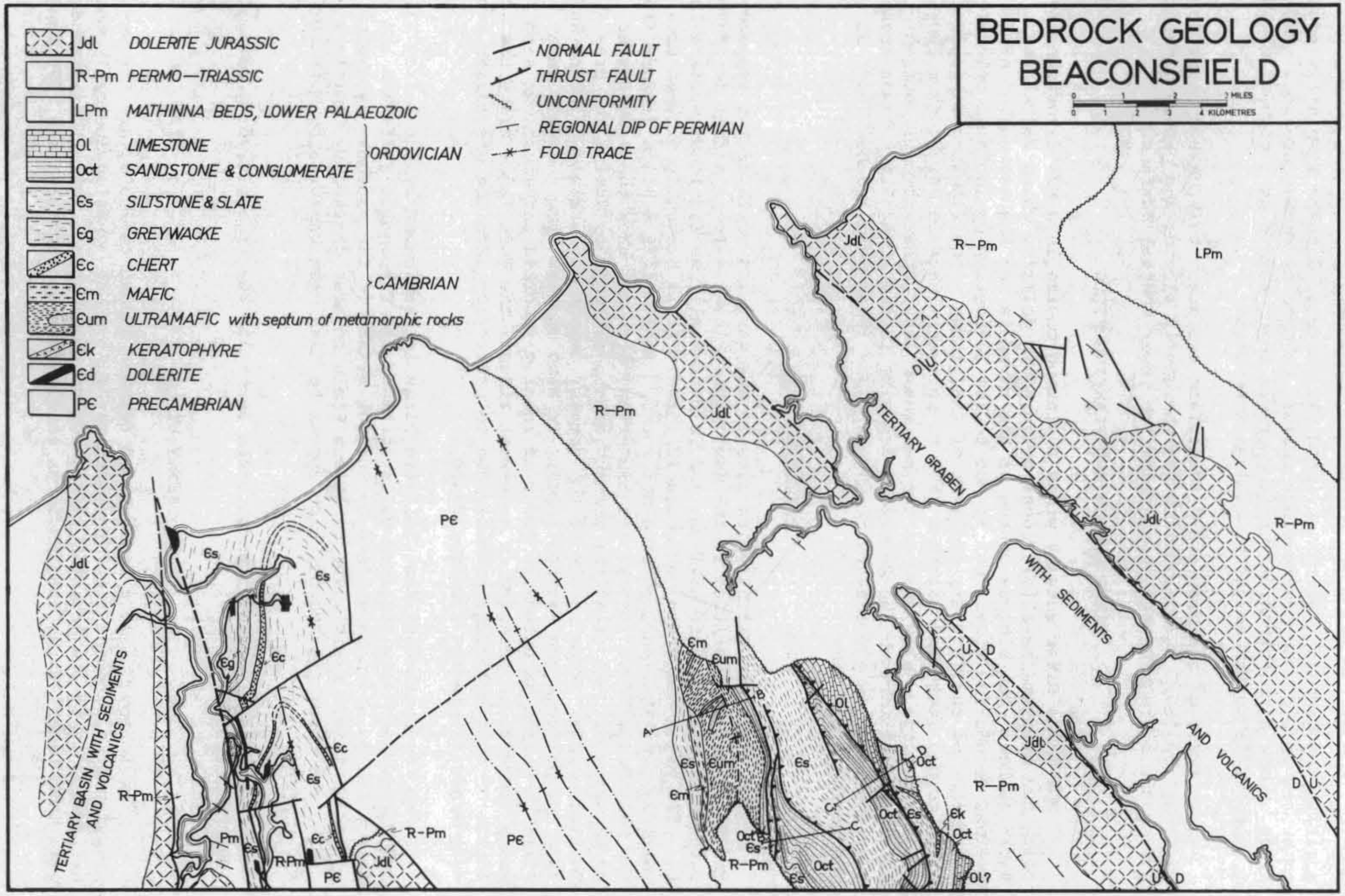

BEDROCK GEOLOGY
BEACONSFIELD
Jdl DOLERITE JURASSIC
R-Pm PERMO—TRIASSIC
LPm MATHINNA BEDS, LOWER PALAEOZOIC
Ol LIMESTONE
Oct SANDSTONE & CONGLOMERATE
ORDOVICIAN
Ꞓs SILTSTONE & SLATE
Ꞓg GREYWACKE
Ꞓc CHERT
Ꞓm MAFIC
Ꞓum ULTRAMAFIC with septum of metamorphic rocks
Ꞓk KERATOPHYRE
Ꞓd DOLERITE
CAMBRIAN
PꞒ PRECAMBRIAN
NORMAL FAULT
THRUST FAULT
UNCONFORMITY
REGIONAL DIP OF PERMIAN
FOLD TRACE
TERTIARY GRABEN WITH SEDIMENTS AND VOLCANICS
TERTIARY BASIN WITH SEDIMENTS AND VOLCANICS

Fig. 2.

positive topographic features on these plains (*e.g.* Cabbage Tree Hill) appear to be remnants of the pre-Tertiary relief, exhumed by recent erosion. Remnants of the once extensive Tertiary gravel cover remain at altitudes of 150 m, comparable to the height of Cabbage Tree Hill.

In terms of the previously identified surfaces, this unit appears to mark the low-level marine surface and the gently sloping and partly dissected hinterland represents the remnants of the Lower Coastal Surface.

TAMAR GRABEN AND FLANKING HILLS

The Tamar River estuary winds a sinuous course in a NNW direction between two elongate parallel ridges of Jurassic dolerite which define the fault graben. The sinuous course of the river is not the expression of a drowned meandering river, but is due to its relocation by isolated volcanic extrusions on the Tertiary sediment of the graben. The flanking Tippogoree Hills to the east, and Ralstons Hill to the west range in height from 100-300 m and slope gently down to the sea where they appear as small buried hills showing through the Cainozoic deposits in the lower River Tamar area. They disappear as two seaward reaching points (West Head and Low Head) at the mouth of the Tamar.

CIMITIERE PLAIN

The Cimitiere Plain, which lies to the east and north of the Tippogoree Hills has similarities to the West Tamar Plains. It is a flat landform ranging from 15-30 m in altitude and is essentially an erosional surface in the Tertiary sedimentary and volcanic rocks. It is broken by exhumed pre-Tertiary positive features of older rocks. The Cimitiere Plain differs from the West Tamar Plain in that its hinterland does not show the same degree of erosion, either during the present erosional cycle or during the pre-Tertiary cycle. This is due to the greater amount of Jurassic dolerite which caps and protects the Permian rocks. It also differs from the West Tamar Plain in having an extensive cover of locally reworked and windblown sand which tends to be arranged in east-west ridges; the West Tamar Plain has little of this material, probably due to protection from the prevailing westerly winds due to the Asbestos Range.

To the south-east the Cimitiere Plain is terminated by the Lefroy Hills. The narrow southerly tapering valley between the Tippogoree Hills and the Lefroy Hills, which is drained by Curries River, is the southern extension of the Cimitiere Plain. The Cimitiere Plain is also drained by Cimitiere Creek, the upper reaches of which appear to have been captured by Curries River.

The coastal plain extends to the east into the Pipers River Quadrangle (Marshall, 1970).

LEFROY HILLS

The Lefroy Hills, a low rounded feature rising to 200 m, are the expression of a basement rise of folded Mathinna Beds. Physiographically they are analogous to the Asbestos Range, for on the regional scale they extend well into Pipers River Quadrangle as an elongate positive feature (Den Ranges).

SUMMARY OF GEOLOGICAL HISTORY

QUATERNARY	RECENT	Dissection of previous landforms, redispersal of superficial material by wind and streams.
	PLEISTOCENE	Uplift exposing coastal surfaces close to present coastline.
	TERTIARY	Extensive erosion forming on surface between 60 and 180 m above sea level and partly exhuming pre-Tertiary relief.
		Deposition of gravel, sand and clay in fault troughs and on flood plains, associated with intermittent outpouring of basaltic rocks.
		Faulting and gentle tilting, probably concurrent with extensive erosion producing rugged relief.
		Formation of laterite on dolerite and pisolitic ironstone on pyroxenite.
	CRETACEOUS	*Extensive erosion*
	JURASSIC	Intrusion of extensive dolerite sheets into Permo-Triassic rocks.
	TRIASSIC	Terrestrial sandstone and carbonaceous shale.
	PERMIAN	Dominantly marine sequence, 450 m thick.
		Extensive erosion
	DEVONIAN	Folding and thrusting of Lower Palaeozoic rocks, gold mineralisation ≡ Tabberabberan Orogeny.
	SILURIAN	Sandstone and mudstone (Mathinna Beds), earliest sedimentation possibly coeval with Ordovician rocks.
	ORDOVICIAN	Limestone, siltstone, sandstone and conglomerate.
	CAMBRIAN	Intrusion and serpentinisation of ultramafic complex (Beaconsfield) and basic dykes (Port Sorell).
		Siltstone, mudstone, greywacke, chert and minor keratophyre deposited in basins on either side of Badger Head Block.
	PRECAMBRIAN (PROTEROZOIC?)	Folding of Badger Head Group ≡ Penguin Orogeny?
		Sandstone and siltstone (Badger Head Group).

The ages of some of the above divisions are uncertain. The Badger Head Group on the Asbestos Range is considered to be Precambrian on structural grounds. The folded sequence at Port Sorell is assigned to the Cambrian entirely on the grounds of lithological association. As yet there is no faunal control on the Mathinna Beds in this region, and evidence from elsewhere indicates a range from Lower Ordovician to Upper Silurian.

The major stratigraphic and structural features of the area are shown in Figure 2.

PRECAMBRIAN

BADGER HEAD GROUP

The Badger Head Group is that structurally complex assemblage exposed at Badger Head and in the Asbestos and Dazzler Ranges, consisting of a non-metamorphosed sequence of interbedded greywacke-type arenite and slate. This group forms a major elongate structural high, flanked to the east and west by Lower Palaeozoic rocks. There is no positive evidence for its age. In lithology and structural style it resembles both the Proterozoic Burnie Formation of the North West Coast (Gee, 1968) and the Lower Palaeozoic Mathinna Beds of north-eastern Tasmania.

This sequence is considered to be Proterozoic on regional structural evidence:

(1) The flanking Cambrian sequences to the west at Port Sorell and to the east at Beaconsfield dip and face away from the Asbestos Range.

(2) The Asbestos Range is a fragment of a once larger structure involving the overturning of a thick stratigraphic sequence.

The Asbestos Range has the features of a basement structural high. The contacts with the flanking Lower Palaeozoic rocks are concordant structural dislocations, without traces of unconformity or sedimentary onlap that might have occurred along the contact.

Sedimentary Features

The Badger Head Group consists of a well-bedded monotonous alternation of quartzwacke and siltstone, and slaty mudstone. The slate is commonly black and pyritic. The arenite is composed of detrital angular quartz and muscovite, in a chloritic-sericitic matrix. Some arenite beds contain a carbonate cement. A minimum thickness of 900 m is indicated from the structural profile (fig. 5) but the total thickness may be much greater.

The arenite beds commonly show graded bedding. The tops of the beds are fine-grained, with fine lamination and cross-lamination. Small scour structures, accentuated by load casting and cleavage development, are present on the soles of the arenite beds.

The sedimentary features indicate deposition by turbidity currents, from a predominantly quartzose sedimentary parent rock.

Structure

Minor structures

The Badger Head Group is tightly folded. Abundant mesoscopic folds of several styles and orientations are visible on the coastal exposures at Badger Head, and the chronological relations can be deduced from the interaction of planar and linear structures.

The earliest folds, termed P_1, are of the 'drag fold' type, usually occurring in well bedded sequences of alternating competent and incompetent beds. The arenite beds form flattened concentric folds with smooth rounded profiles and slight thicknening in the core. A fanned sandstone cleavage is present, more or less symmetrical about the axial plane. The slaty beds

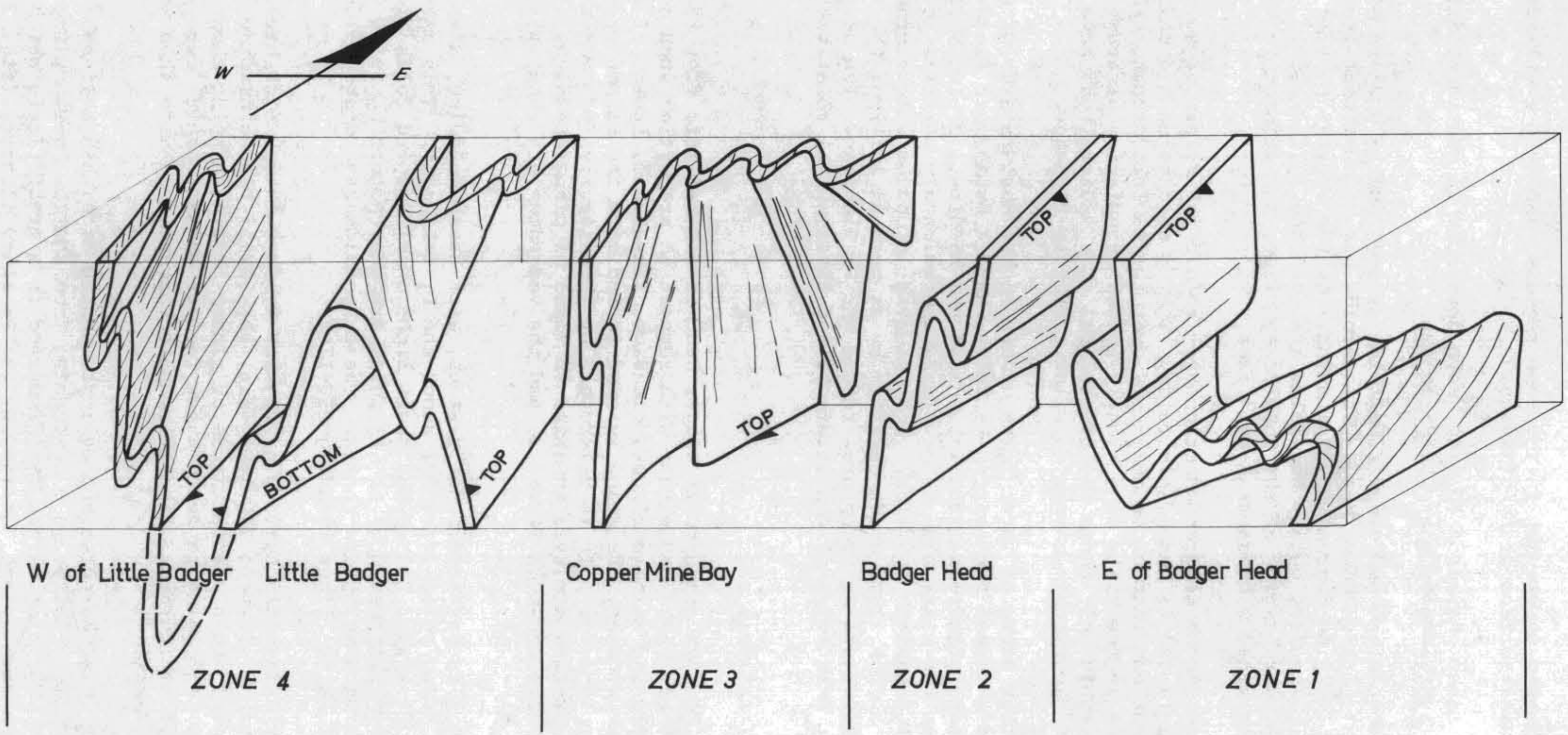
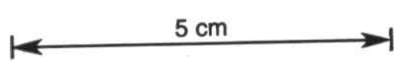


Figure 4. *Generalised Precambrian structure, Badger Head.*



show pronounced thickening in the core regions, and have a well-developed, glossy, axial-surface slaty cleavage.

Two later phases of folding, each developed in spatially different areas are superimposed upon the P_1 folds.

A group of second generation folds is seen on the western side of Badger Head at Little Badger Head. These folds have a competent-incompetent style with varying degrees of flattening. On the crestal portion of the major anticline (see below) the folds are open and cylindroidal. Further east in the core region of the coupled syncline, the mesoscopic folds are tightly flattened with sheared-out limbs.

These second generation structures refold the P_1 cleavage, and in places refold the P_1 mesoscopic folds. The P_2 fold cores are characterised by P_1 lineations that cross obliquely over the P_2 fold crests. The generated P_2 cleavage in the slate is a closely spaced crenulation cleavage with microlithons visible only under the microscope. The arenite beds have a slightly convergent sandstone cleavage, similar to the P_2 cleavage.

Another group of later folds occurs on the eastern side of Badger Head These folds, termed the eastern P_2 folds, have a broad open flexural style, and form non-cylindroidal undulations of the bedding. A planar strain-slip cleavage in the slate beds is developed approximately parallel to the axial plane of the eastern P_2 folds. This cleavage produces a fine crenulation lineation in the slate which deviates by as much as 10° from the fold hinge line. The eastern P_2 structures refold the P_1 cleavage. The western P_2 and eastern P_2 structures do not interact, and their mutual relationships are unknown.

Structural analysis

The coastal exposure at Badger Head is divided into four zones (fig. 3, 4) that are each homogeneous with respect to properties such as attitude of fold axes and axial surfaces, cleavage, lineations, facing of bedding and folds, and vergence. Vergence is used to indicate the asymmetry of a series of mesoscopic folds. It is determined by the direction of over-riding, or from bedding-cleavage relationships in zones of planar bedding. The orientation data are shown in Figure 3, and the vergences are shown diagramatically in Figure 4.

Zone 1 is characterised by steep, east facing bedding, with a dispersion of bedding poles (fig. 3*a*) about the P_1 fold axis. This axis plunges at about 20° toward 340°. The short limbs on P_1 coupled folds are overturned. Superimposed upon the P_1 folds are the eastern P_2 folds which return the bedding to upward facing. These P_2 folds have doubly plunging, subhorizontal, hinge lines trending 350-170°.

Zone 2 is characterised by regular P_1 drag folds which have shallow plunging hinge lines to 340-160° (fig. 3*h*), axial planes dipping approximately 70° NE, and a mean attitude of planar bedding dipping about 80° SW (fig. 3*e*). According to sedimentary facings and structural vergence the sequence is overturned. A stratigraphic thickness of more than 900 m occurs in this segment.

Zone 3 is characterised by a steepening of P_1 hinge-lines. The direction of first scatter is a steepening from shallow, north-plunging axes (fig. 3*k*). The hinge-lines are dispersed in a great circle which corresponds to the mean axial plane, defined by the P_1 slaty cleavage (fig. 3*j*). Folds

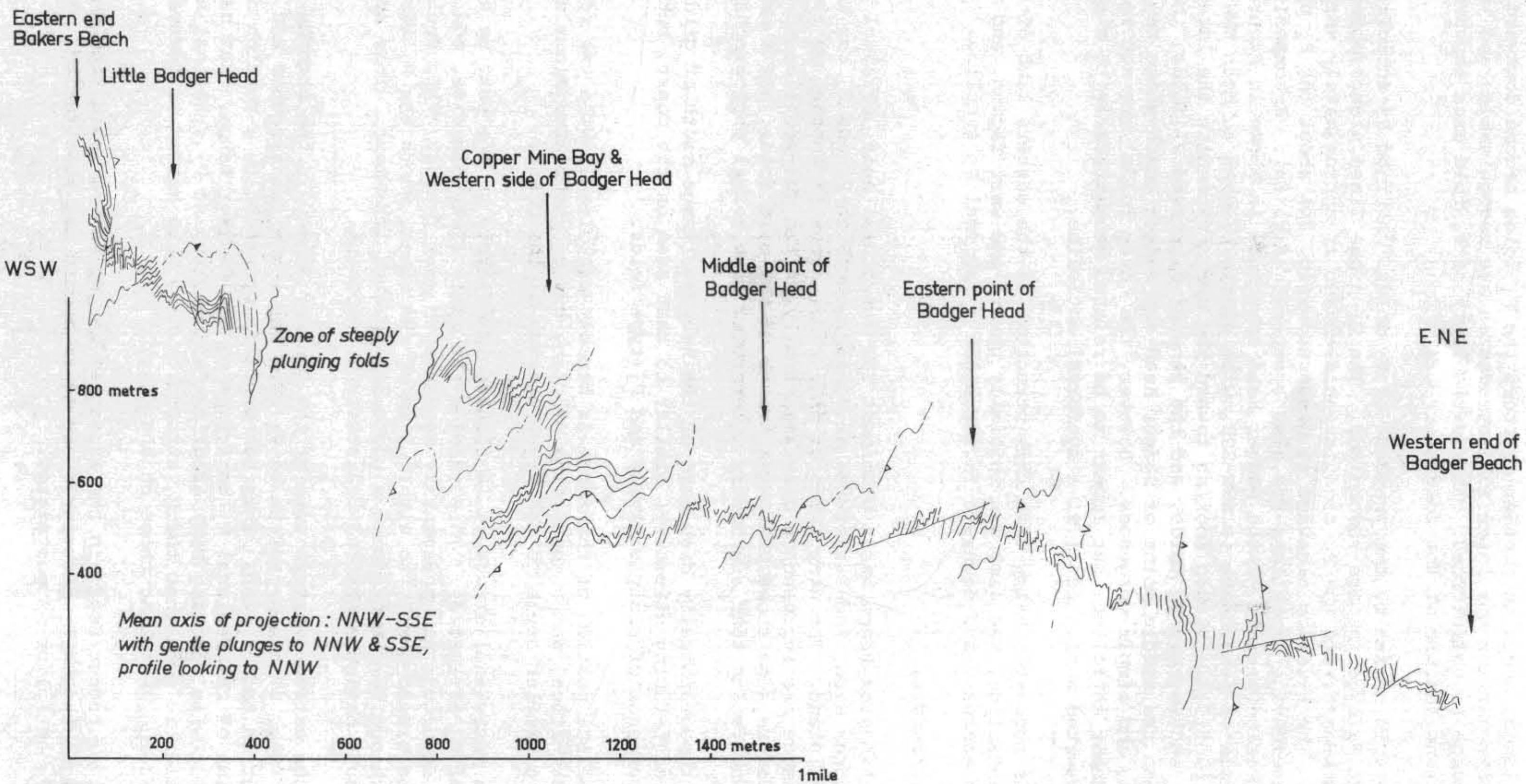


Figure 5. *Composite axial projection profile, Badger Head.*

5 cm

become reclined, and with further scatter, the P_1 folds become downward facing. Neither earlier nor later fold structures are recognisable, and the slaty cleavage is undistorted. This variability of P_1 fold axes appears to be an inherent feature of the folding.

Zone 4 is marked by the presence of P_2 folds. A broad P_2 anticline and a tight P_2 syncline are recognised. The P_2 hinge lines plunge moderately to the south-east, and the P_2 crenulation cleavage is approximately vertical (fig. 3*o*). The P_1 slaty cleavage is dispersed (fig. 3*m*) about the P_2 axis. P_1 bedding-cleavage lineations are also scattered (fig. 3*n*). A composite axial projection profile of the Badger Head structure is shown in Figure 5. The mean axis of projection is NNW-SSE, with gentle plunges to both NNW and SSE. The profile is viewed looking toward the NNW. Excluding the later eastern P_2 and western P_2 folds, and the zone of dispersed P_1 folds, the profile between the middle point of Badger Head and Badger Beach shows regional overturning and simple vergences. However, the 'drag folds' are not related to a recumbent anticline, but appear to be related geometrically to a completely inverted anticline, *i.e.* a synformal anticline.

It is suggested below that this structure is the eastern limb of a major P_1 anticline, the limb was initially upward and west facing, and was rotated to eastward and downward facing about a regional P_2 syncline.

Regional structure

The Asbestos Range has a prominent NNW structural axis, parallel to that on Badger Head, and structures of similar style to P_1 and P_2 can be recognised inland. The structures of individual areas of outcrop on the Asbestos Range are represented diagrammatically in the sub-profiles of Figure 6. This figure also shows the axial traces of the main folds, and a set of ENE trending faults that are mostly interpreted from aerial photographs.

The topographically high part of the Asbestos Range south of grid line 30N is an east-facing structure, similar to that seen on the coast, but with opposite vergence of slaty cleavage and P_1-type folds.

The axial portion of the range is broadly anticlinal, with two recognisable anticlines, and a connecting syncline having associated minor structures with a similar style to the P_1 structures on the coast.

This anticlinal structure is flanked immediately to the west by a later syncline of P_2 affinities. This refolds the early slaty cleavage, and returns the structure and sedimentary sequence to east facing. This dual structure can be traced north, to within 5 km of the coast, where the P_1 structures suddenly change vergence across a photo-interpreted lineament. This appears to be a fault having a dextral transcurrent component.

On the extreme western edge of the Dazzler Range, in the Branchs Creek road area (fig. 6) a sub-profile of P_1 type has a similar vergence and facing to that on Badger Head. This sub-profile appears to be a portion of the western limb of the regional P_1 anticline on the Dazzler Range, that has rotated clockwise (looking NNW) about a shallow plunging P_2 synclinal hinge. This rotation is such that the P_1 structures have been turned to downward and east facing, matching those on the coast.

West of Badger Head, in the exposures behind Bakers Beach, the sedimentary sequence and P_1 structures are again upward and west facing, and a regional P_2 anticline is postulated.

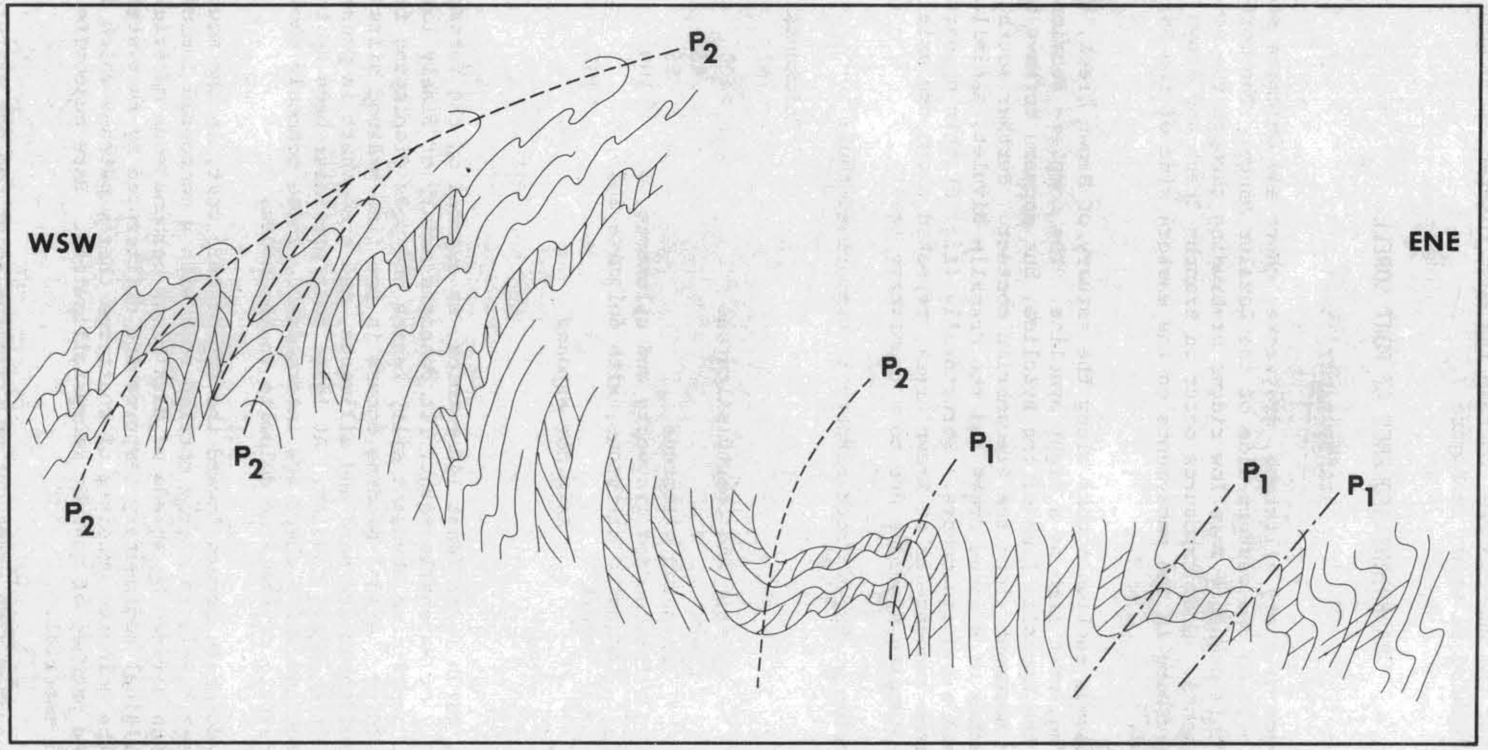


Figure 7. *Postulated composite structure of the Badger Head Group, Asbestos-Dazzler Range.*

A possible overall structure for the Badger Head Group is achieved by piecing together the sub-profiles to form the most coherent structure. The structure postulated is shown in Figure 7.

CAMBRIAN? SEQUENCE AT PORT SORELL

STRATIGRAPHY

A sequence of slaty siltstone, greywacke, chert and dolomite occurs in a meridional belt on the western side of the Dazzler Range. The more resistant units of this sequence form low ridges protruding through the cover of Tertiary sediments. Good exposures occur in Branchs Creek and Brown Creek and on the foreshore in the embayments on the eastern side of the Port Sorell Inlet (fig. 8).

A continuous section occurs along the estuary of Brown Creek, forming the east facing, west limb of a tight syncline. The complete section does not occur on the opposite limb of the syncline, but appears to have been thrust out by movement along the Precambrian contact. Further south, in the estuarine reaches of Branchs Creek and the Franklin Rivulet, a similar though not so complete a section occurs. Structurally (fig. 8) this appears to be part of the same sequence as at Brown Creek, repeated along the axial trace of the south-plunging syncline due to a transverse fault.

The section at Brown Creek estuary is summarised thus:

		Thickness (m)
Unit E	Pyritic and cherty siltstone	>400
Unit D	Chert	43
Unit C	Laminated siltstone	55
Unit B	Interbedded greywacke and siltstone	100
Unit A	Laminated siltstone, with dolomite and chert	>140
	Base not exposed	

Unit A

Unit A, which is at least 140 m thick, is exposed on the foreshore in the vicinity of Marshalls Point. It consists mainly of finely laminated dark mudstone containing abundant silty lenses and pods displaying fine wavy cross-bedding. Graded bedding occurs in the fine-grained siltstone. Many of the mudstones are hard and siliceous, and true chert is present in thin laminae or as small nodules. At least four prominent beds up to 0.6 m thick, of black and white chert are interbedded. These commonly show boudinage with coarsely crystalline dolomite in the nodes.

Bedded dolomite occurs toward the top of this unit, in the mouth of Marshalls Creek. This is a grey mottled rock with a contorted lamination and a foliation defined by shreds of dark black carbonaceous material. Although the original sedimentary textures are obliterated by recrystallisation up to 5% of the dolomite consists of scattered cherty patches which form pockets around patches of coarser recrystallisation. Rare muscovite is the only detrital material.

This sequence also crops out on Griffiths Point, on the eastern head of the mouth of Port Sorell inlet. A less pure dolomite occurs here, containing up to 15% muscovite in shreds parallel to the bedding, and scattered cherty quartz. Micro-porphyroblasts of albite (0.15 mm in diameter) occur in the shreds of muscovite.

Unit B

This unit, which is 100 m thick, consists of well-bedded, white, leached greywacke siltstone and sandstone, interbedded with minor slaty mudstone. It crops out on the southern bank of the mouth of the estuary of Brown Creek, in North East Arm. Specimen 69-126* is a typical greywacke, containing up to 70% poorly sorted quartz grains, in a matrix of fine quartz, sericite and chlorite. Many of the quartz grains are broken fragments of once well rounded grains. Most grain boundaries are corroded by the matrix, but overgrowths in optical continuity are preserved in places. Other detrital material includes muscovite flakes up to one millimetre, and fragments of once rounded tourmaline.

Unit C

About 55 m of laminated argillaceous siltstone (argillite) with a weak slaty cleavage and micaceous bedding fissility overlies Unit B on the southern bank of North East Arm. Thin interbedded chert occurs toward the top.

Unit D

This unit consists of 43 m of well-bedded grey and white chert. This bed can be traced from the head of North East Arm southward to near Eagle Point.

Unit E

This unit, which is at least 400 m thick, crops out in the lower reaches of Brown Creek. The underlying chert of Unit D grades upward into interlaminated argillite. The transitional beds are about 90 m thick. Most of Unit E consists of an interlaminated siltstone and slaty mudstone which is in part pyritic and carbonaceous. Graded bedding and fine wavy cross lamination is common. Specimen 69-131 is typical. It consists of dark chlorite and carbonaceous laminae containing abundant disseminated pyrite, and siliceous laminae. The siliceous laminae contain detrital quartz grains averaging 0.04 mm, in a cherty and chloritic matrix.

A greywacke sequence of uncertain thickness occurs near the top, and is exposed in Brown Creek [558292]†. The detrital components (69-132) consist of angular quartz, plagioclase (andesine) laths, irregularly shaped albite, chert and muscovite ranging in size from 0.6 to 1.2 mm. The matrix amounts to about 30% of the rock.

Further south in Branchs Creek, beds correlated with those of Unit E (fig. 8) are rich in syngenetic pyrite. At the Branchs Creek pyrite prospect, diamond drilling by the Department of Mines showed four layers, ranging from 6 m to 13 m with a sulphur content of more than 10% (Hughes, 1955).

STRUCTURE

The major structure of the belt of Cambrian rocks is a tight syncline trending N-S, sub-parallel to the Precambrian contact. The sequence immediately adjacent to the Precambrian basement faces to the west away from the

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*Numbered specimens are in the Department of Mines collection, Hobart.
†All grid references lie in 100 kiloyard grid square 49.

basement. The contact is essentially a near-vertical fault of uncertain displacement, although at least 335 m of the Cambrian sequence which occurs on the western limb of the syncline is faulted out against the Precambrian. The Cambrian sequence is not a marginal facies and there is no suggestion of any provenance from the Precambrian rocks of the Asbestos Range. The contact therefore seems to be a major fault.

An equal-area plot of 80 poles to bedding, showing the 0% contour, and differentiating between overturned and correct-way-up facings is shown in Figure 8. The simple syncline with a steeply dipping eastern limb, and a steeply dipping western limb, in part overturned is also shown in Figure 8. The fold axis plunges 180° at about 45°. The slaty cleavage has a general axial plane relationship, and the lineations are widely dispersed within the mean axial plane.

In several places, anomalous bedding-cleavage relations suggest that the cleavage has been impressed upon the fold after the formation of the fold. On the western limb in the vicinity of South East Arm and Marshalls Point, the bedding dips fairly steeply east and is known to face east, and the cleavage is steeper.

However, further north, on the southern bank of North East Arm, the cleavage dips east more shallowly than the bedding. Within the core of the syncline, the bedding-cleavage relations return to the normal vergence, consistent with a simple syncline. The gross-aspect of bedding and cleavage is shown in the profile (fig. 8).

The synclinal structure is cut by a NE-trending fault with an apparent dextral displacement. The stratigraphic sequence to the north of this fault is also partly present south of the fault. The chert bed which crops out intermittently around the crest of the south-plunging syncline south of this fault is correlated on stratigraphic grounds with Unit D. This implies that the fault has a considerable downthrow to the north. For a plunge of 45°, about 3 700 m of vertical movement would be required to repeat the stratigraphy along the crestal trace of the syncline.

A late vertical strain-slip cleavage trending ENE cuts the slaty cleavage. This cleavage appears to be related to late angular-style kinks of the bedding with ENE axial planes, and steep plunging axes.

DOLERITE

Tabular dolerite bodies, ranging in width from a few metres up to 30 m intrude the siltstone. These bodies are generally concordant to the bedding but some are also concordant to the slaty cleavage. Chilled margins against the wall rock show their intrusive nature. Some petrographic features suggest a very shallow intrusion.

Petrographically, they are andesine-pyroxene dolerites showing various degrees of alteration. The least altered specimen (69-130), from Brown Creek estuary, consists of andesine laths (0.5-1.5 mm) forming an interlocking network, and ophitically including smaller clinopyroxene (augite?). The mesostasis, which amounts to about 5%, consists of a green chlorite with anomalous blue-grey interference colours. Bladed ilmenite accounts for about 5%.

Unaltered dolerites showing gradations from sub-ophitic to porphyritic textures are present. Specimen 69-122 from Branchs Creek contains plagioclase in slender laths up to 2 mm in an interlocking network, and subophitically including some clinopyroxene. Most clinopyroxene is intersertal and mesostasis amounts to about 15%. The mesostasis consists of sericitised plagioclase, chlorite, and scattered quartz. The texture is modified by movement during late stages of cooling. The larger laths are bent and splintered in microscopic channelways, along which the mesostasis has flowed, producing a flow orientation of the feldspar. Penninite occurs as intersertal patches between feldspar laths and also as larger vug fills.

Specimen 66-280, also from Branchs Creek is a fine-grained dolerite containing some interlocking feldspar laths averaging 0.5 mm, with intersertal clinopyroxene. Phenocrysts of plagioclase up to 2.5 mm are present and ophitic textures occur only in such plagioclase. The groundmass amounts to about 20% and consists of chlorite, sericite, small plagioclase and quartz.

Specimen 69-123 has a texture more like an extrusive rock. It consists of euhedral phenocrysts and glomoporphyritic clusters of clinopyroxene (1 mm in diameter) and phenocrysts of plagioclase (0.6 mm) in a groundmass of fine clinopyroxene, turbid feldspar, ilmenite and sphene.

The strongly altered dolerites (69-133 and 69-134) from Griffiths Point consist of anhedral actinolite and skeletal ilmenite resembling pyroxene cross-sections, in a turbid groundmass of clinozoisite, chlorite, sphene, quartz and apatite needles.

All these dolerite bodies are considered to represent post-folding high-level, near-surface intrusions.

LOWER PALAEOZOIC FOLD BELT AT BEACONSFIELD

Lower Palaeozoic folded rocks crop out over an area of about 50 km^2 in the Beaconsfield-Andersons Creek area. This belt consists mainly of Cambrian slates and Ordovician arenites in imbricate thrust slices shuffled up against the Precambrian during the Tabberabberan (Upper Devonian) Orogeny. The belt contains an ultramafic complex of Cambrian age in a structural position close to the Precambrian-Lower Palaeozoic boundary.

Stratigraphic terminology

Previous stratigraphic terminology (Green, 1959) and the terminology to be used here is summarised below:

	Previous	*Present*
ORDOVICIAN	Grubb Beds Gordon Limestone	Gordon Limestone correlate.
	Leonardsburg Siltstone	Now included in the Cambrian sequence.
	Caroline Creek Sandstone Cabbage Tree Conglomerate Blyths Creek Formation	Cabbage Tree Formation.
CAMBRIAN	Dally Siltstone Ilfracombe Slate	Cambrian sequence.

A variety of approaches have previously been used for stratigraphic terminology. In the Cambrian, some of the thrust slices were given formal names (Ilfracombe Slate and Dally Siltstone) and in the Ordovician a sequence following the terminology of the Junee Group was used. The term Cabbage Tree Conglomerate was used by Twelvetrees (1900). The Caroline Creek Sandstone was a borrowed Junee Group term. The Blyths Creek formation was a new term defined out of sequence with respect to the other rock units in Beaconsfield and was implied to be equivalent to the Jukes Breccia. The Gordon Limestone, was also a borrowed Junee Group term, but this is probably a valid approach in view of the widespread occurrences of this limestone in Tasmania. The Leonardsburg Siltstone was considered to be a lateral facies variant of the Gordon Limestone. The Grubb Beds, which occur only as isolated outcrops were thought to be equivalent to the Mathinna Beds which occur extensively in north-eastern Tasmania.

The present mapping has failed to reveal any basis for the equivalence of the Gordon Limestone and the Leonardsburg Siltstone, and the latter is now considered to be Cambrian in age. Recent drilling on behalf of Allstate Mining N.L., has shown that the Grubb Beds in the township area of Beaconsfield are the surface expression of one of several sandy intercalations in the Gordon Limestone. It is also considered that there is no lithological basis for the simple division of the arenaceous Ordovician rocks into conglomerate and sandstone, since true conglomerate is minor and occurs as small interbedded pods in sandstone. Consequently, the rudite-arenite association is referred to as the Cabbage Tree Formation. Conglomeratic exposures are indicated on the geological map. The term Blyths Creek Formation is not used and is considered to be another thrust slice of the Cabbage Tree Formation. The term Gordon Limestone is not used, although the implied correlation is probably correct and it is therefore referred to as the Gordon Limestone correlate.

CAMBRIAN

A eugeosynclinal suite of slate, chert and greywacke with minor keratophyre occurs in the Lower Palaeozoic belt at Beaconsfield. Four structural slices of Cambrian occur within this imbricate thrust zone. Cambrian fossils have been found in only one slice (4.5 km SSW of Beaconsfield [779217]) where Green (1959) found *Dresbachia* and *?Balaspidella* which indicate a lower Upper Cambrian (Dresbachian) age. The other slice is considered Cambrian on the grounds of lithological similarity. The lithology of the four slices is described below, from east to west.

Middle Arm Creek Slice

This slice occurs to the east of the Salisbury Hill-Cabbage Tree Hill strike ridge in the vicinity of Middle Arm Creek. It has a minimum stratigraphic thickness of 370 m, incorporates the Dally Siltstone of Green (1959) and contains the keratophyre lens.

The lower 100 m lying adjacent to the Ordovician Limestone in Dally's Quarries is a glossy slate, greyish when fresh, and weathering to a buff colour with limonitic cavities. The cleavage is more fissile than the bedding. The slate is overlain by interbedded slate and greywacke, which in places is gritty with rounded and angular quartz and mudstone fragments up to 10 mm. This is overlain by what appears to be a discontinuous lens of keratophyre. Above this at the fossil locality [779217] is a grey-green slaty siltstone with thin discontinuous laminae of fine sandstone. These sandstone laminae contain a fauna of fragmented trilobites. Further north at Salisbury Creek, at a comparable stratigraphic position is an interbedded sequence of glossy slate and graded greywacke sandstone,and the keratophyre appears to be absent.

The keratophyre is exposed on the ridge between Salisbury Creek and the west Tamar Highway; it is about 70 m thick. It is a green-grey rock with conspicuous patches of green epidote, is generally massive, but in places [777218] has a colour and compositional banding parallel to its regional trend.

Green (1959) considered that it was originally a pyroxene andesite with up to 20% clinopyroxene and 70% calcic plagioclase. The original pyroxene forms zoned subhedral prisms up to 1 mm in diameter, but now mostly altered to small euhedral tremolite and penninite. Strongly sericitised plagioclase with recognisable remnant twinning has a composition ranging from An_3 to An_{12} in different specimens. A preferred dimensional orientation of the plagioclase laths, parallel to the mesoscopic layering is common. The groundmass contains abundant epidote laced with tremolite and penninite, together with turbid anhedral sodic plagioclase, sphene and quartz.

Ilfracombe Slice

This forms a broad belt, up to about 1.5 km wide comprising a stratigraphic thickness of about 300 m, in the area between Cabbage Tree Hill and Peaked Hill to the west. It incorporates the Ilfracombe Slate of Green (1959) and extends well to the north-west and includes the 'undifferentiated Lower Palaeozoic' of Green near Leonardsburg.

Outcrops and extensive surface rubble of slate and slaty siltstone occur on Leviathan Hill, the southern end of Howards Road, and near Leonardsburg. Most of the belt comprises a fissile, glossy grey slate with limonitic cavities. Bedding is recognised by thin sandy laminae oblique to the slaty cleavage. On the western slopes of Leviathan Hill the lower 100 m consists of a siliceous siltstone with small-scale wavy cross-bedding.

Peaked Hill Slice

This is a narrow strip about 500 m wide occurring on the western side of Peaked Hill. Structural considerations suggest that this belt extends several kilometres to the north where it becomes the Leonardsburg Siltstone of Green (1959), and merges into the Ilfracombe slice.

At both Leonardsburg and Peaked Hill the rock is a buff to grey, well-cleaved interbedded fine-grained siltstone and slate. The slate is characteristically spotted with fine, brown oxidising cavities, some of which are clearly organic. Calyptoptomatids, possibly *Hyolithes* occur in a deep track cutting at [724213].

Further south [734199], in a stratigraphic and structural position beneath the Ordovician sandstone, surface rubble includes slate and siltstone, chert, limonitic slate breccia and serpentine. This suggests the presence of an ultramafic body disconnected from the main Andersons Creek mass.

Andersons Creek Slice

A narrow strip of slate, limonitic slate breccia and chert, about 400 m wide, lies between the ultramafic mass at Andersons Creek and the Precambrian block forming the Asbestos Range. The contact between this belt and the Precambrian is not exposed, although considering the nature of the deformation in the Lower Palaeozoic fold belt, it is almost certainly a high-angle thrust. The sediments in the Cambrian give no suggestion of derivation from the Precambrian block. Apart from these general considerations, the palaeogeographic relations between the Precambrian and Cambrian rocks is unknown. Slate is dominant in the south, but chert becomes more abundant to the north. At the northern end of the ultramafic mass [687282] well-bedded massive cherts occur adjacent to the gabbro. An isolated outcrop of massive chert also occurs 5 km to the north in York Town Rivulet.

Both the slate and the chert show metamorphic effects which are attributed to the adjacent ultramafic rocks. Typically the slate is spotted and the chert has a saccharoidal texture, superficially resembling quartzite.

The strongest effects of metamorphism occur in a pyritic cherty and carbonaceous siltstone, rubble of which occurs on Symmonds Hill [697223]. It contains andalusite in idioblastic, inclusion-free, needle-like prisms up to 10 mm long, together with cordierite in xenoblastic grains up to 0.1 mm. The andalusite is fractured and marginally altered. These metamorphic minerals occur in a patchy matrix of coarsely cryptocrystalline chert, and a fine mosaic of quartz and albite with shreds of pyrite and carbonaceous material which define a contorted flow foliation around the large andalusite needles. Splintered and altered muscovite flakes of probable detrital origin are also present.

This assemblage indicates a degree of contact metamorphism just above the boundary between the albite-epidote hornfels facies and the hornblende hornfels facies. According to Winkler (1967, p. 73) this represents a temperature between 500°C and 540°C, and is not strongly pressure dependent.

ORDOVICIAN

Cabbage Tree Formation

The Cabbage Tree Formation includes both the quartzose sandstone and minor conglomerate. It occurs in four NNW-trending belts, structurally interlayered with Cambrian sediments. The belts vary in lithology and thickness. The fossils recorded by Green (1959) come mainly from the westernmost belt. These include *Tritoechia* sp., a *Paurorthis*-like brachiopod, *Tasmanaspis lewisi* Kobayashi and *Prosopiscus subquadratus* Kobayashi, which indicate an Early Ordovician age. *Tritoechia* was recovered from diamond drill cores (M.J. Clarke, pers. comm.) during exploratory drilling of the old Tasmania mine at Beaconsfield (Noldart, 1968).

The best exposed and thickest section (280 m) occurs in road cuttings where the Flowery Gully road passes through the Middle Arm Creek gorge in the Cabbage Tree Hill-Salisbury Hill strike ridge. In this section the lower contact is not exposed. The lowermost bed is a fine-grained black pyritic and siliceous mudstone, strongly sheared and with a lustrous black sheen on bedding surfaces. The lowermost 30 m exposed in Middle Arm Creek is an alternation of medium-bedded, hard, black, well-cemented siliceous sandstone and thin beds of quartz conglomerate; chromite grains are common.

Conglomerate becomes more abundant about 30 m above the base of the sequence. The conglomeratic zones are predominantly medium- to coarse-grained sandstone in bedding units 20 cm thick, with diffuse lenses of conglomerate at the base of each bed. The mean pebble size is about 8 mm. Single beds of conglomerate are rare. Most pebbles are of rounded chert and vein quartz. Quartzite pebbles are uncommon.

About 60 m above the base of the sequence the sandstone beds lose the gritty lenses and become flaggy cross-bedded medium- to fine-grained sandstone. The uppermost 200 m of the section, is a well bedded association of flaggy micaceous quartz sandstone and buff-coloured siltstone.

Good exposures of conglomeratic sandstone occurs in the bottom of gravel pits [733272] on the northern extremity of the Cabbage Tree Hill slice.

The rock is a well-bedded coarse, gritty sandstone in bedding units up to one metre in thickness and containing lenses of chert and quartz conglomerate at the base of each bed and within cross-bedded lenses. The actual conglomerate pods contain well rounded particles ranging from 4-20 mm in diameter in a quartz granule matrix.

The easternmost slice of Cabbage Tree Formation is a medium-grained quartz sandstone, which is poorly exposed in the Middle Arm Creek area immedidately to the east of the West Tamar Highway. A disused 'limestone' quarry [767235] occurs within this sandstone. The true nature and significance of this rock is uncertain, the old reports (Twelvetrees, 1903*a*; Montgomery, 1891) refer to it as the 'marble quarry', and Nye (1924) describes it as a 'tuffaceous limestone of secondary origin'. Whatever its age and origin, it seems clear that it is not the Gordon Limestone and presents no great stratigraphic or structural problems.

The Cabbage Tree Formation on Peaked Hill is similar to that at Cabbage Tree Hill itself. The conglomeratic beds are about 30 m thick and occur approximately 50 m above the base. The sequence consists essentially of a well-bedded medium-grained sandstone with cross-bedding and basal lenses of granule and small pebble conglomerate.

The westernmost slice of Cabbage Tree Formation lies along the eastern margin of the Andersons Creek ultramafic complex. At the southern end of the slice [718220] near Holwell it is a flaggy, argillaceous, fine-grained, friable, tubicolar sandstone thinly interbedded with siltstone. Conglomerate beds are absent. At the northern end of this belt a conglomeratic horizon 10 m thick occurs within the normal thinly interbedded argillaceous siltstone and fine-grained sandstone. The conglomeratic interval is dominantly a medium-grained flaser-bedded sandstone containing pods and beds of conglomerate averaging 8 cm in thickness, but occasional beds up to 30 cm in thickness also occur. In this locality the conglomerates are of chert and contain small amounts of chromite. Both angular and rounded chert fragments are present and they range in size from 2-30 mm.

The precise nature of the contact between this slice and the ultramafic complex is uncertain, despite recent bulldozing by the Broken Hill Proprietary Company across the contact. Regionally, this contact may either be a thrust or an unconformity, and is probably a thrusted unconformity. Green (1959, p. 4) established that the complex was exposed to erosion during deposition of the lower part of the Cabbage Tree Formation which contains detrital chromite and magnetite and small amounts of garnet and probable pyroxene.

In an attempt to reconstruct the palaeogeography of the Junee Group, Green (1959) used thickness variations to suggest the Junee Group was thinning out from its postulated source area to the west, the Asbestos Range. Such reconstructions based on thickness variations in a thrusted fold belt are meaningless. Furthermore, it is evident that the Cabbage Tree Formation was derived principally from the underlying Cambrian cherts and not from the Precambrian rocks of the Asbestos Range.

Gordon Limestone Correlate

Limestone outcrops are restricted to a small area immediately to the east of Cabbage Tree Hill in the Middle Arm Creek area [760236] at a locality known as Dally's Quarries. It is a massive grey-blue limestone, apparently devoid of fossils, and probably of the order of 150 m in thickness. In a structural sense the limestone overlies the Cabbage Tree Formation.

Sub-surface data from old reports and recent drilling shows that the limestone belt continues to the north along the eastern side of Cabbage Tree Hill where it is covered by substantial thicknesses of Tertiary sediment. The deep-lead flanking Cabbage Tree Hill is in fact developed within the limestone. Diamond drilling, sited on the eastern edge of the deep lead, in the vicinity of the old Tasmania mine at Beaconsfield intersected about 135 m of hard grey-blue limestone and about 310 m of transition limestone-siltstone beds before passing into the quartzite of the Cabbage Tree Formation (Noldart, 1968).

The Grubb Beds (Green, 1959) consist of micaceous siltstone. They occur in two small exposures in the township area of Beaconsfield [747259], [750254]. Recent drilling on behalf of Allstate Mining N.L., has shown that limestone again occurs to the east of the Grubb Beds at shallow depths beneath Tertiary sands, and indicates that the Grubb Beds are silty intervals within greater thicknesses of limestone.

South of Dally's Quarry, the slice of Gordon Limestone wedges out so that Cambrian rocks closely overlie the Ordovician sandstone. In the area immediately to the east of the Salisbury Hill strike ridge, drilling by the Broken Hill Proprietary Co., revealed a shallow deep lead with rare pieces of limestone rubble. If limestone occurs in this area it cannot be more than 30 m thick.

The limestone is therefore about 300 m thick at the north end of the slice and thins toward the south. It is probably absent at the south end of the slice (fig. 2).

STRUCTURE

The Lower Palaeozoic fold belt consists of alternate slices of Ordovician and presumed Cambrian rocks dipping and facing east. This is interpreted as an imbricate thrust pile against the stable Precambrian block of the Asbestos Range. The Andersons Creek ultramafic complex is located close to the boundary between the Lower Palaeozoic fold belt and the Precambrian block. Folding and thrusting is attributed to the Tabberabberan Orogeny which is of pre late Middle Devonian age elsewhere in Tasmania.

There are four thrust slices of Ordovician arenite. No major reversals of dip or facing are known. No actual thrust planes have been identified in field exposures, but the imbricate structure is based on lithological correlations supported by palaeontological evidence. Thus, just south of Beaconsfield township arenite of the Cabbage Tree Hill-Salisbury Hill strike ridge containing Early Ordovician brachiopods underlies slate containing Middle Cambrian trilobites.

A composite section showing the favoured reconstruction and including some of the important thrusts is shown in Figure 9. Lines of section are shown on the bedrock geological map (fig. 2). Thrusts probably occur at the soles as well as the tops of the slices of arenite. Thus both the Cabbage Tree and the Peaked Hill strike ridges taper out to the north. This feature is associated with flexural folding of the arenite near the lower contacts. Slices of the Ordovician Gordon Limestone correlate are probably caught between the slices of arenite and the overlying Cambrian siltstone, although most of the limestone has been thrusted out. The largest area of limestone is under the deep lead just east of Cabbage Tree Hill. The old geological records of the goldfield (Twelvetrees, 1903*a*) show that shaly limestone dips east and strikes N-S, obliquely to the Cabbage Tree Hill strike ridge. This slice of limestone also appears to be tapering to the south.

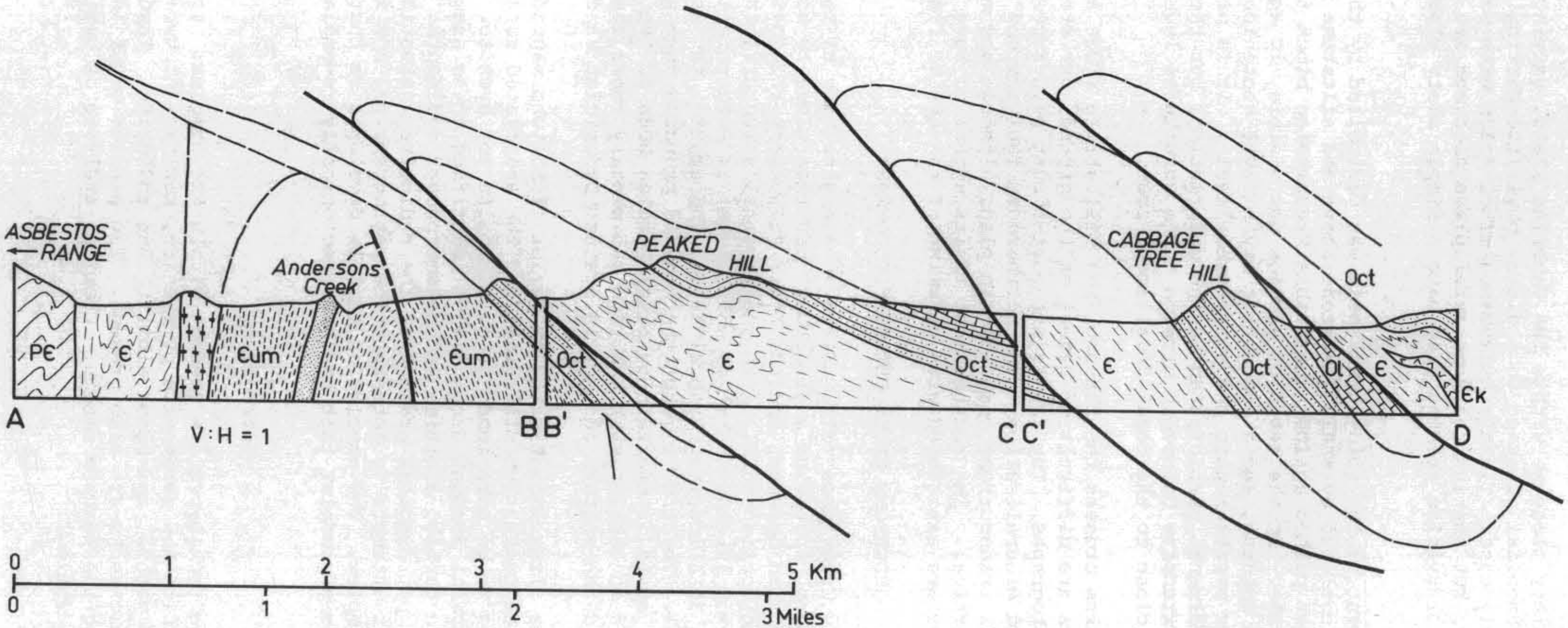


Figure 9. *Composite cross-section Lower Palaeozoic fold belt, Beaconsfield area.*

There is a slaty cleavage within the Cambrian slate, varying in intensity from a weak phacoidal cleavage to a glossy phyllitic parting. It strikes NNW and dips steeply east. Tightly attenuated minor folds with variably orientated fold axes, but sharing the same axial plane cleavage are common. Shaly beds in the Ordovician arenite also have a simple slaty cleavage oblique to the bedding.

The development of the fold-thrust belt was controlled by the thick competent arenite enclosed by shaly limestone above and siltstone below. The sedimentary pile was pushed against the stable Precambrian block to form an imbricate thrust pile. At the level of erosion now visible, it appears that thrusting preceded folding, and a concentric style cover tectonics is envisaged for the higher stratigraphic and structural levels. It is probable that Siluro-Devonian sediments participated in the deformation, but these were later removed by extensive Cainozoic erosion. The structural level now exposed is probably close to the basal décollement zone.

A set of faults crosses the Cabbage Tree Hill strike ridge at a high angle. Such faults are difficult to detect on the ground, but are conspicuous on aerial photographs. The faults are post-thrust structures and have controlled the gold mineralisation. The northermost faults trend NE and have an apparent dextral transcurrent component in plan, although the movement is probably mainly vertical. The southernmost faults appear to have a conjugate nature in plan, and are associated with buckling of the strike ridge.

ANDERSONS CREEK ULTRAMAFIC COMPLEX

The Andersons Creek mass (fig. 10) in an elongate body of serpentinite, pyroxenite and gabbro, occupying a structural position close to the boundary between the Precambrian basement and the Lower Palaeozoic fold belt. It is elongate in a NNW direction parallel to the regional structural trend. The total surface outcrop is about 6 km^2 of which 5 km^2 is serpentinite and pyroxenite occurring at a lower structural level, and about 1 km^2 is at a higher structural level. The true size of the body is probably much greater than presently exposed, as it is overlain by basal Permian beds to the north and south. The mass is in contact with Cambrian sedimentary rocks along its western margin, and the eastern contact is against Ordovician sandstone.

This mass was first investigated by Taylor (1955) who mapped the pyroxenite the associated rocks, but mis-identified the associated rock types which he considered to be hornblende granite, aplite and syenite. In essentially a petrological account Green (1959) identified these associated rock types as hornblende gabbro, albitite and metamorphosed sediments. Baker (1959) has given a petrological account of the rodingite (garnetised gabbro). The present account attempts to integrate the petrographical and structural features of the complex. The conclusion that is developed is that the mass is primarily a layered complex that has been tectonically re-emplaced as an alpine-type body.

Petrography

The following rock types are present within the complex: serpentinite, peridotite?, enstatite and websterite pyroxenite, noritic and two-pyroxene gabbro, hornblende gabbro, and minor albitite and rodingite. Three included septa of metamorphic rocks are also present. The gabbros occur in the northern part, and along the western margin. Chemical analyses of various rock types are given in Table 1.

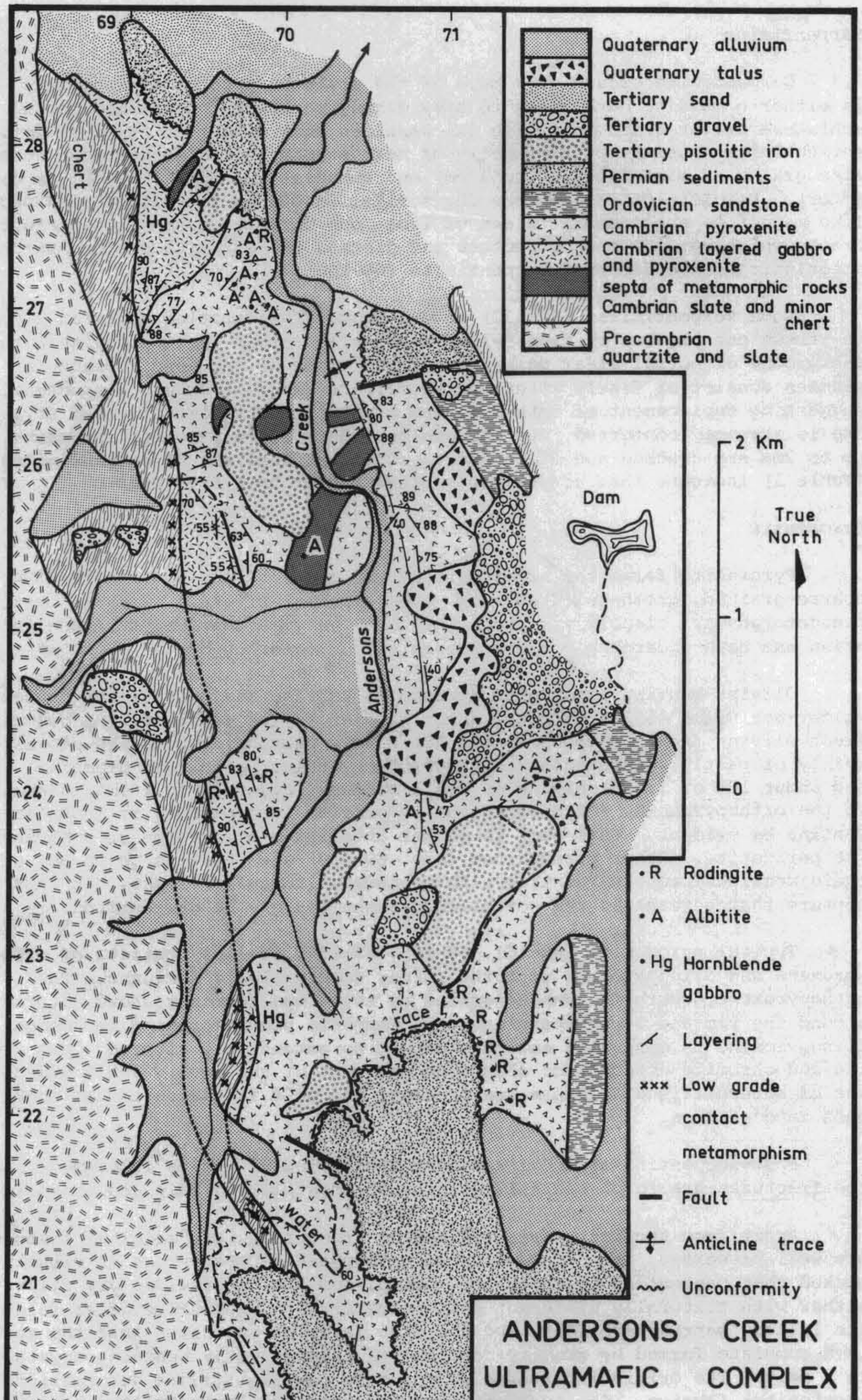

Quaternary alluvium
Quaternary talus
Tertiary sand
Tertiary gravel
Tertiary pisolitic iron
Permian sediments
Ordovician sandstone
Cambrian pyroxenite
Cambrian layered gabbro and pyroxenite
septa of metamorphic rocks
Cambrian slate and minor chert
Precambrian quartzite and slate
2 Km
1
0
True North
Dam
chert
Creek
Andersons
race
water
• R Rodingite
• A Albitite
• Hg Hornblende gabbro
Layering
××× Low grade contact metamorphism
Fault
Anticline trace
Unconformity
ANDERSONS CREEK ULTRAMAFIC COMPLEX
5 cm

Figure 10.

Serpentinite

Serpentinite occurs over much of the southern part of the complex. It is either a massive dark green to grey glassy rock when undeformed, or a schistose bright green rock with slickensides when deformed. Typical deformed serpentinite consists predominantly of mesh serpentine, with numerous dust-like grains of magnetite (up to 2 mm) and euhedral chromite (up to 1 mm diameter). Veinlets of cross-fibre chrysotile, in places interlaced with needle-like magnetite are common. A set of fine, sub-parallel post-serpentinisation cracks which cut the mesh structure and distend the chromite grains are characteristic of the deformed serpentinite (69-164).

Some serpentinites (69-152) have a brown-green mottled appearance due to strewn out patches of fine felted needle-like brown amphibole within the background of normal clear mesh serpentine. Some of the more rectangular patches consist of finely interlayered coloured and colourless serpentine, suggesting replacement of orthopyroxene crystals. This interlayered structure is strongly contorted into microfolds. Dark brown picotite in grains up to 2mm are cracked and drawn apart. Chemical analyses of serpentinites (Table 1) indicate that considerable olivine must have been present.

Pyroxenite

Pyroxenite forms the major part of the mass. It is a dense, medium- to coarse-grained, green-coloured rock. The original crystals or their bastite pseudomorphs are clearly visible. They show varying degrees of serpentinisation and have undergone post-serpentinisation deformation.

Olivine-bearing pyroxenite appears to be rare and neither the present writer nor Green (1959) detected any. However Taylor (1955, p. 26) records fresh olivine from one specimen (30 A5). This particular specimen consists mainly of partly serpentinised orthopyroxene grains up to 1 mm diameter, and about 10% of fresh olivine as small anhedral crystals (0.1 mm) intersertal to the orthopyroxene. Transformation of olivine into patches of mesh serpentine is evident. This rock is either an olivine pyroxenite or a harzburgite peridotite. Other pyroxenites (*e.g.* 69-139) also contain up to 30% of equidimensional mesh serpentine with preserved irregular cracks. It thus appears that several of the so-called pyroxenites may be peridotites.

Typical pyroxenite (69-161, 69-145, 69-139, 69-146) consists of orthopyroxene and clinopyroxene with the former nearly always dominant. The orthopyroxene occurs in rounded grains up to 10 mm, commonly shows alteration around the rim and along the cleavage. Complete pseudomorphing is common. Clinopyroxene is generally smaller and not so extensively altered. Magnetite and chromite account for about one per cent of the rock. Small quantities of saussuritised feldspar are present, and this increases as the rocks pass into gabbros.

Post-serpentinisation kinking and fracturing of grains is common, and the fractures are in places filled with neo-crystallised talc and tremolite.

Apart from the post-serpentinisation fracturing, the original textures are well preserved. Anhedral, rounded orthopyroxene grains are so closely packed that tangential contacts are common, and the interstices are filled either with texturally different serpentine or with saussurite after feldspar. The latter 'matrix material', and the fine layering indicates that the rock is a cumulate formed by gravity settling of independently behaving crystals in a melt. The original textures do not have paracrystalline deformation (tectonite) fabrics. The pyroxenes are arranged in alternate laminae of

Table 1. CHEMICAL ANALYSES OF ROCKS FROM ANDERSONS CREEK

	1	2	3	4	5	6	7	8	9	10	11	12
SnO_2	43.2	46.6	38.4	40.00	43.0	48.4	51.5	53.3	46.4	59.9	62.0	75.5
Al_2O_3	0.42	1.8	1.4	1.02	0.9	0.47	1.1	1.3	13.8	14.6	15.0	13.3
Fe_2O_3	2.3	1.2	4.08	8.07	4.1	1.2	1.6	1.3	2.0	1.8	1.4	0.48
FeO	6.0	3.5			1.1	4.9	6.1	6.9	8.5	7.1	6.3	0.33
MnO	0.10	0.19	0.05	0.09	0.09	0.11	0.17	0.18	0.19	0.13	0.10	0.01
TiO_2	0.02	0.07	NA	NA	NA	0.07	0.08	0.09	0.24	1.6	1.5	0.16
P_2O_5	0.01	0.01	NA	NA	NA	-	0.03	0.01	0.01	0.21	0.23	0.03
CaO	-	1.2	-	-	-	0.51	2.6	1.3	13.0	1.6	2.8	0.44
MgO	36.3	27.4	34.0	37.3	38.4	35.5	30.1	32.4	2.5	4.2	3.6	0.4
Na_2O	0.02	0.02	NA	NA	NA	0.02	0.05	0.06	0.40	1.4	1.36	3.1
K_2O	0.02	0.02	NA	NA	NA	0.03	0.07	0.08	0.19	4.0	3.7	5.6
CO_2	Tr	Tr	NA	NA	NA	-	-	-	-	-	-	-
H_2O^-	0.69	0.49	-	-	-	0.29	0.62	0.15	0.20	0.17	0.06	0.13
H_2O^+	11.4	7.1	11.6	12.1	12.1	8.0	5.5	2.5	2.8	2.8	1.94	0.24
Cr_2O_3	NA	NA	1.03	1.8	NA	NA	NA	NA	NA	NA	NA	NA

Analyses by Department of Mines Laboratories, Launceston

1. Serpentinite (69-164), 2. Serpentinite (69-152), 3, 4, 5. Serpentinite, Taylor (1955), 6. Serpentinised orthopyroxene pyroxenite (69-139), 7. Slightly altered orthopyroxene pyroxenite (69-145), 8. Orthopyroxene-clinopyroxene minor plagioclase pyroxenite (69-163), 9. Gabbro (69-146), 10. Metasediment (69-140), 11. Metasediment, Taylor (1955), 12. Albitite (69-143).

orthopyroxene and orthopyroxene-clinopyroxene crystals. This lamination is on a scale of the order of one or two crystals wide. It is difficult to detect in natural exposures but is apparent in polished hand specimens.

Gabbro

In hand specimen the gabbro is identified by a dark grey leucocratic appearance and a conspicuous fine lamination. Generally the gabbro is interlayered with pyroxenite; the layers are usually a few metres thick.

Variation in the type of gabbro is due to variation in the relative proportion of clino- and orthopyroxene and the presence of primary amphibole.

Typical gabbro (69-146, 69-159) consists of 40% clinopyroxene, about 30% orthopyroxene and 30% of feldspathic material. Magnetite and chromite is uncommon. Orthopyroxene usually occurs as cores within bastite pseudomorphs 0.2-1.0 mm in diameter. Clinopyroxene occurs as fresh rounded grains of similar size, often (*e.g.* 69-159, 69-138) surrounded by stellate bundles of brown hornblende. Secondary clear actinolite replaces the clinopyroxene along cleavage or around the periphery. The original feldspar now occurs as trails of near-opaque saussurite included with fine granular zoisite. This material moulds into the interstices between pyroxene crystals. More rarely, ghosted remnants of small subhedral plagioclase are visible. Specimen 69-163 consists dominantly of orthopyroxene and is therefore a norite.

The fine lamination of the gabbro is due to alternation of pyroxene and feldspathic layers; the layers being a few millimetres or centimetres thick. The pyroxene layers have textures similar to the cumulate textures of the pyroxenite with an intercumulus filling of saussurite or felted tremolite. Graded lamination has not been observed, although small-scale mesoscopic cross-lamination occurs in thinly interlayered gabbro and pyroxenite. Although fracturing and partial disaggregation is always present, there is no evidence of tectonite fabrics.

Hornblende gabbro is present but amounts to only about one per cent of the exposed mass. Fine-grained hornblende gabbro (69-370, 69-150) from the western gabbro zone on Simmonds Hill contain strongly coloured euhedral hornblende up to 1.0 mm in length in a sericitic groundmass in which ghosted feldspars, flecks of talc and needles of apatite are present. Rare large crystals of fresh orthopyroxene occur. The feldspathic layers of specimen 69-370 contain mosaic patches of clear subhedral albite (An_6).

Foliation in these fine-grained hornblende gabbros is due to a segregation into feldspathic and hornblende laminae and with a linear orientation of hornblende *c* axes in the lamination. The laminae are a few millimetres in thickness. Closely spaced (1-5 mm) sub-parallel anastomosing cracks cut the lamination at a high angle and are associated with granulation of the hornblende and growth of tremolite, albite and minute granular zoisite.

A distinctive coarse-grained hornblende gabbro occurs in the northern gabbro zone [695277]. It varies from a leucocratic rick with about 25% hornblende to a black spangled rock in which hornblende constitutes the whole rock. Hornblende (*Y* = deep reddish brown, *X* = pale greenish brown, *Z* = reddish brown) occurs in slender euhedral prisms up to 3 cm long, either as single crystals, or as clusters of intergrown crystals. The prismatic cleavage is commonly kinked and contains clear subhedral talc in the fractures. Remnants of the original plagioclase are recognisable, now altered to sericite but with very little epidote. Iron oxides constitute only about one per cent of the rock.

There is a weak planar and linear orientation of hornblende needles and a segregation into hornblende and feldspathic-rich laminae. Such textures are probably due to lateral flowage differentiation in the sense of Bhattacharji and Smith (1964). Evidence for lateral flowage of a porphyritic magma is shown by the intrusion of irregular tongues of hornblendite into leucocratic hornblende gabbro, with a chilled margin in the former.

Albitite

Small bodies of albitite are common throughout the complex, but they account for less than 1% of the total exposed mass. Taylor (1955) first recorded their occurrence and termed them aplites. Green (1959) identified them as albitites and considered them to be of post-serpentinisation 'hydrothermal' origin.

They occur in the gabbroic rocks, in the pyroxenite and even in the included septa of metamorphic rocks. The field occurrence is uncertain, they are mostly located as patches of large boulders of surface rubble. At the northern Andersons Creek locality [699272] they appear to be roughly elliptical pods in the pyroxenite. In the layered pyroxenite to the south [708239] albitite occurs as a concordant tabular sill-like body 25 cm in width. It occurs in small irregular pods in the metamorphic rocks of Settlers Hills [701254].

In the septum of metamorphic tremolitic rocks [694277], surface float shows fine flame-like piercements of sheared albitite penetrating the host rock. It appears that these rocks occur as small irregular dykes.

The albitites consist dominantly of albite (An_5 to An_8)(from 50% to more than 90%), quartz and K-feldspar. Minor components include actinolite, epidote, zoisite, sphene, talc and small interstitial pockets of clear serpentine and crenulated veinlets of brown antigorite. Albitites [699272] near rodingite (see below) show evidence of alteration (*e.g.* 69-369) similar to that shown by the rodingite. In these altered rocks garnet occurs as granules (1 µm) in small veins and small colourless clinopyroxene is scattered throughout.

Textures vary from medium- to coarse-grained allotriomorphic granular to foliated mortar textures. In the igneous-textured rocks, (69-367) quartz occurs in large (0.5-10 mm) anhedral grains generally without undulose extinction and with straight or gently curved grain boundaries. Albite occurs as strain-free interlocking laths although commonly sericitised. Green (1959, p. 17) has noted possible graphic intergrowths. Potash feldspar occurs as large anhedral crystals that appear to have grown late and enveloped quartz and albite.

Specimen 69-368 from the central Andersons Creek locality is a weakly foliated rock containing folded veinlets of brown antigorite. The original subhedral feldspar laths are fractured, and are set in a fine albite mosaic in stringers parallel to the axial plane trace of the microfolds. Stronger foliated mortar textures (*e.g.* 69-162) result in a strewn out mosaic of quartz and albite which wraps original lozenge-shaped albite in a porphyroblastic habit.

The albitites have intruded a variety of host rocks before serpentinisation occurred, and have subsequently undergone slight cataclastic deformation, as have the gabbro, pyroxenite and serpentinites.

Rodingite

Rodingite occurs in several localities throughout the complex but is less common than albitite. The main area of rodingite occurs in a NNW-trending zone in the southern part of the area in the neighbourhood of the nickeliferous laterite (fig. 10), where it appears to be derived from pegmatitic gabbro. Rodingite also occurs in the northern albitite locality [699272] where there is some petrographic evidence (69-369) that they may be derived from albitite as well as pegmatitic gabbro.

These lime-rich garnet rocks were first noted by Ward (1912). Green (1959) and Baker (1959) have given petrological accounts and both consider them to be due to lime metasomatism. The following is a summary of that work.

The rodingite is a heavy, hard, leucocratic rock with a mottled greenish white colour. In the extreme cases of lime metasomatism the rodingite consists of massive micro-granular grossularite together with thin veinlets of vesuvianite. The garnet is very close to the pure grossularite end member. The original rock, which occurs in the core of the rodingite mass in the southern locality, is a pegmatitic hornblende gabbro with hornblende (up to 20 cm) in a turbid calcic plagioclase groundmass. With alteration, grossular aggregates develop from plagioclase crystals, and the hornblende is replaced by a pale brown calcic(?) chlorite. Associated minerals include vesuvianite, prehnite, clinozoisite, sphene and actinolite. The metasomatic process involved introduction of CaO, H_2O, Al_2O_3 and removal of SiO_2, K_2O, Na_2O and possibly FeO, while MgO remained approximately unchanged. Three chemical analyses of rodingite from Andersons Creek are given in Table 1.

Septa of metamorphic rocks

Three septa of metamorphosed greywacke-type rocks occur in the central and northern part of the complex. These rocks, which consist predominantly of quartz, biotite, albite and K-feldspar, have been variously described as 'coarse-grained sediment.......of aluminous or argillaceous material with... ...decomposed feldspar' (Twelvetrees, 1917), as 'granitoid rock' (Reid, 1919) and 'syenite' (Taylor, 1955). Green (1959) established that these rocks were not igneous and he introduced the name Settlers Metamorphosed Greywacke. He considered it to occur in eight separate bodies which were remnants of a once overlying cover of Cambrian greywacke. The present mapping, having regard to the outcrop pattern in relation to topography, and to the distribution and basin relief (more than 30 m in places) of the pre-Tertiary pisolitic ironstone, shows that there are two steeply dipping tabular belts in the central part of the complex. A third septum occurs in the northern gabbro zone.

These rocks are hard, resistant hornfels and stand out as a NE-trending ridge on Mt Vulcan (formerly known as Settlers Hills). In the Mt Vulcan area it is a medium-grained crystalline hornfels from black to light grey in colour; biotite is readily visible in hand specimen. The marginal zones against the enclosing pyroxenite have a schistosity parallel to the contact.

Mineralogically, the metamorphic rocks in the central area are simple, and so far, appear to be devoid of alumino-silicates. Quartz makes up from 30% to 60% of the rock. Biotite is always abundant as a major component (up to 40%). Muscovite is a minor constituent. Albite (An_0-An_6) generally shows some degree of sericitisation. Remnants of zoned plagioclase are occasionally present. K-feldspar is nearly always present in scattered xenoblastic megacrysts up to 5 mm in diameter which envelop biotite and quartz but not muscovite. Accessory minerals include chlorite and epidote.

These metamorphic rocks have advanced hornfels textures. Quartz occurs as single-crystal equant grains with either slightly sutured contacts against other quartz and albite grains, or straight contacts against sub-idioblastic biotite. Most quartz grains show slight undulose extinction and some composite grains occur. The equant quartz appears to be set in an interstitial sericitic 'matrix' and this can usually be shown to be altered albite. The only evidence of clastic material is occasional zoned plagioclase grains which are extensively sericitised and have clear poikilitic muscovite flakes growing in the cores.

In the schistose hornfels on the margins of the septa, the single-crystal quartz grains become elongate and progressively break up into elongate crypto-crystalline mosaics. The biotite has a weak dimensional orientation in the schistosity which tends to wrap the quartz composites. Biotite flakes lying across the schistosity are kinked. Such textures are considered to be due to low temperature cataclastic deformation and are similar in style to the post-serpentinisation deformation that characterises the igneous rocks.

Two chemical analyses (Table 1) show the rock to have the composition of a greywacke high in K_2O and Na_2O and low in Al_2O_3 and CaO. On an AKF diagram these lie on the tie-line between biotite and K-feldspar for all facies of contact metamorphism. Muscovite in minor quantities can coexist with K-feldspar up to the top of the hornblende hornfels facies, where it breaks down to form more K-feldspar and andalusite (or its polymorph) at the beginning of the pyroxene hornfels facies. However in these rocks the Al_2O_3 component is low, and is nearly all taken up in the feldspar. The metamorphic grade is therefore impossible to estimate.

Further north [694278] another elongate belt of siliceous metamorphic rock is considered to be another septum. It consists of quartz and xenoblastic albite in a fine-grained streaked mosaic of biotite and colourless sub-idioblastic tremolite. Scattered xenoblastic K-feldspar is rimmed with albite, and shows extensive core alteration to sericite which has in turn been transformed to clear poikilitic muscovite.

As far as can be determined in the field, these septa are parallel to the igneous layering. Regionally, this relationship is clear (fig. 10). The origin of these septa is discussed later.

Contact Metamorphism

The metamorphism on the western contact between the complex and the Cambrian chert and slate has been mentioned previously (p. 26). Green (1959) described a variety of metamorphic rocks ranging from soft black slate to gneissic amphibolite occurring as surface rubble and sparse outcrop in a contact zone on Simmonds Hill. The present author considers that the contact is between hornblende and pyroxene gabbro (as a southerly continuation of the western gabbro zone) and low grade slate, so that the 'high grade' rocks of Green are altered and deformed igneous rock.

The maximum contact metamorphics effects are considered to be andalusite hornfels indicating a temperature of formation between 470 and 500°C (Winkler, 1967; p. 73).

Structure

The internal structure of the complex is described in terms of the following features: microscopic textures of the primary ferromagnesian minerals, microfracturing, igneous lamination, attitude and nature of layering, regional distribution of rock types, septa of metamorphic rocks and the anticlinal nature.

The cumulative textures in the pyroxenite and the fine lamination in the gabbro have already been mentioned.

Layering occurs in both the pyroxenite and gabbro zones. In the gabbro zones it is due to interlayered gabbro and pyroxenite; in layers of a few centimetres up to several metres thick. Alternations of feldspar-rich and feldspar-poor gabbros also produce a layering. In the pyroxenite, layering is seen as colour changes on weathered surfaces due to changes in grain size and the relative proportion of the two pyroxenes. Cross-bedding has been observed in both gabbro [696261] and pyroxenite [696271]. The attitude of layering, the regional distribution of rock types, and the septa of metamorphic rocks all combine to outline a single faulted anticlinal structure with an axial-plane trace trending 340° and an axis plunging moderately to the north-west.

On the western flank the layering is arcuate from N-S to NE-SW and is abruptly terminated by the fault along the axial plane. The few examples of 'cross-bedding' show that this limb faces north-west. The eastern limb strikes uniformly NNW with moderate dips to the east. The septa of metamorphic rocks, which are restricted to the western flank, lie parallel to the layering as far as can be determined and illustrate the faulted anticlinal structure.

Layered gabbro is also confined to the western limb of the anticline. The contact between gabbroic rocks and the pyroxenite follows closely the mean trend of the layering. The gabbros are confined to the structurally and 'stratigraphically' higher portions of the complex (fig. 9).

Evidence for post-serpentinisation fracturing is ubiquitous in all rock types on the microscopic scale. This is also recognisable mesoscopically as sheared and slickensided serpentinite in the southern part of the complex, parts of the interlayered gabbro and serpentinite in the western gabbro zone close to the western margin and along the line of the broken anticline. The best development of cross-fibre and slip-fibre asbestos occurs in this axial region. Taylor (1955, plate II) shows that the asbestos occurs in vein systems trending NNW, parallel to the axis.

Intrusive History

The upward zoning from pyroxenite to gabbro, the igneous laminations, layering, and occasional 'cross bedding' show that the Andersons Creek complex was formed by the intrusion of a gabbroic magma, supporting a two pyroxene (and probably olivine) crystal mush, into a floored chamber at depth. Deposition was mainly under the influence of gravity, although a detailed study of the nature of the layering is required to evaluate the relative roles of gravity settling, repeated intrusion and lateral flow differentiation. A similarity with the layered stratiform gabbro-norite peridotite complexes (*e.g.* Stillwater, Bushveld and Muskox) is apparent. No comment can be made on the original shape of the complex. Typically such complexes are lopoliths in slightly deformed strata. The Muskox intrusion in Canada (Irvine and Smith, 1967) is an elongate body about 10 km in width, funnel shaped in cross section and with an inferred vertical feeder dyke. It lies near the boundary between basement rocks and a thick sequence of gently tilted Middle Proterozoic strata. It is thought that the magma rose through a steep fracture in the basement and spread along or near the unconformity. A similar setting for the Andersons Creek complex may be envisaged with the magma rising along a major fracture during segmentation or taphrogenesis of the Precambrian basement, and spreading out along the bottom of a pile of Proterozoic-Lower Cambrian sediments. The magma chamber may have grown either by down-warping of the floor or by raising its roof. Either case would result in distention of the roof so that large planar slabs could be 'stoped' off and incorporated into the mass as it grew. Such a process would provide an explanation for the included septa of metamorphosed greywacke-type sediments.

Considering the serpentinite body in its present position against the Cambrian sediments, two alternative origins are possible: it could either have been serpentinised in its present position, or intruded as serpentinite. The temperature during metamorphism of the Cambrian country rock was about 500°C, which is compatible with the first alternative. However, there are several features against this. Whatever the exact nature of the serpentinisation process, it must involve metasomatism by one or more of soda, lime, silica or magnesia. There is no evidence for this in the country rock. The relatively low grade of country rock metamorphism shows that the primary body could not have crystallised in its present position. If it was intruded as a primary body by solid-state flow (involving grain-boundary migration at moderate to low temperatures) tectonite fabrics on the mesoscopic and microscopic scale would be expected. These are not present and such a process would certainly destroy the cumulate textures and delicate lamination.

The body appears to have intruded in its serpentinised condition, that is, it is tectonically emplaced. The contact effect show that it was not a cold intrusion but was at about 500°C. This may suggest that the complex was serpentinising as it was rising from its initial magma chamber to its present position. It is noteworthy that experimental deformation of serpentine at elevated temperatures (Raleigh and Paterson, 1965) shows that it suddenly loses ductility at about 500°C and undergoes brittle deformation, a phenomenon that was considered to be due to incipient dehydration. Under such conditions the serpentinite is likely to be intruded in several independently behaving fault-bounded blocks that were lubricated by the generation of high internal pore-fluid pressures from the liberation of water during dehydration of serpentinite. The mis-match of 'stratigraphy' across the anticlinal crestal fault, the presence of asbestos veins in the axial zone, and the presence of post-serpentinisation deformation textures are compatible with such a mechanism of intrusion.

In conclusion, it is postulated that the complex was intruded into a sedimentary pile probably of Middle or even Lower Cambrian age, during a period of tectonic quiescence, and was later tectonically re-intruded into early Upper Cambrian sedimentary rocks along a line of structural weakness. Its participation in the Tabberabberan Orogeny is considered to be minimal.

MATHINNA BEDS

The rocks of the eastern part of the Beaconsfield Quadrangle are grouped with the Mathinna Beds which form the folded basement of much of north-eastern Tasmania. The term Mathinna Beds has been applied to all folded pre-Permian sedimentary rocks in north-eastern Tasmania (Banks, 1962*a*, p. 182) Two lithological associations have been identified in north-eastern Tasmania; an older dominantly lutite association which grades into a younger dominantly arenite association (Banks, 1962*a*; Longman, 1966; Marshall, 1970; Threader 1967). Graptolites from the Mathinna Beds at west Turquoise Bluff and the

Back Creek area in the north-western part of the adjoining Pipers River Quadrangle indicate a Lower Ordovician age (M.R. Banks, pers. comm). Fossil plants further to the east from Warrentinna (Ringarooma Quadrangle) and Scamander suggest an Upper Silurian-Lower Devonian age. This suggests a younging of the sequence from west to east.

No fossils were located in the area mapped but the continuation of these rocks with similar rocks in the Pipers River Quadrangle indicates a possible Lower Ordovician age. Lack of outcrop does not permit differentiation between lutite and arenite, except in the Lefroy region where Groves (1965) mapped thin discontinuous belts of slate within an arenaceous sequence. Stratigraphic marker horizons are not recognised and estimates of stratigraphic thickness are not possible. The sedimentary history of the Mathinna Beds is therefore not discussed here, although Marshall (1970) has commented on the age and shape of the Mathinna basin.

The arenite varies from a coarse-grained siltstone to a medium-grained sandstone and less commonly, to a coarse-grained sandstone. A siliceous matrix is present in the finer grained rocks, but the coarser rocks usually have an argillaceous matrix. Graphitic phyllite crops out just east of the upper reaches of Curries River.

The regional folding of the Mathinna Beds in Beaconsfield Quadrangle is on NW-SE trends which is parallel to the regional trend for north-eastern Tasmania. This folding is due to the Tabberabberan Orogeny, the upper limit of which can be dated by post-tectonic granitic stocks which intrude the Mathinna Beds further east. These have an age of about 370 m.y., *i.e.* late Devonian (McDougall and Leggo, 1965).

Minor structures

A coastal section perpendicular to the structural trend occurs west of Beechford and reveals the general structural style of the Mathinna Beds in this area (fig. 11). This section consists of interbedded arenite (average thickness of beds 0.9 m) and slaty mudstone (average thickness of beds 0.4 m). Facings can be obtained at a few localities from grading, bottom scour structures, and bedding cleavage relationships.

In general the beds strike NW and dip shallowly west, are overturned and face east. Minor strike and dip variations are common however and are attributed to small-scale folds, mostly kink-folds which have disturbed the broad pattern. At the eastern end of the section the beds dip east for some

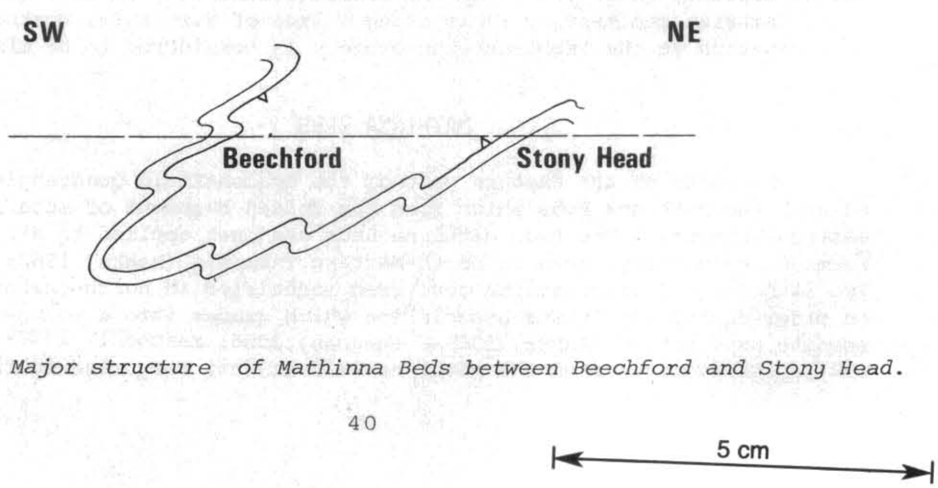
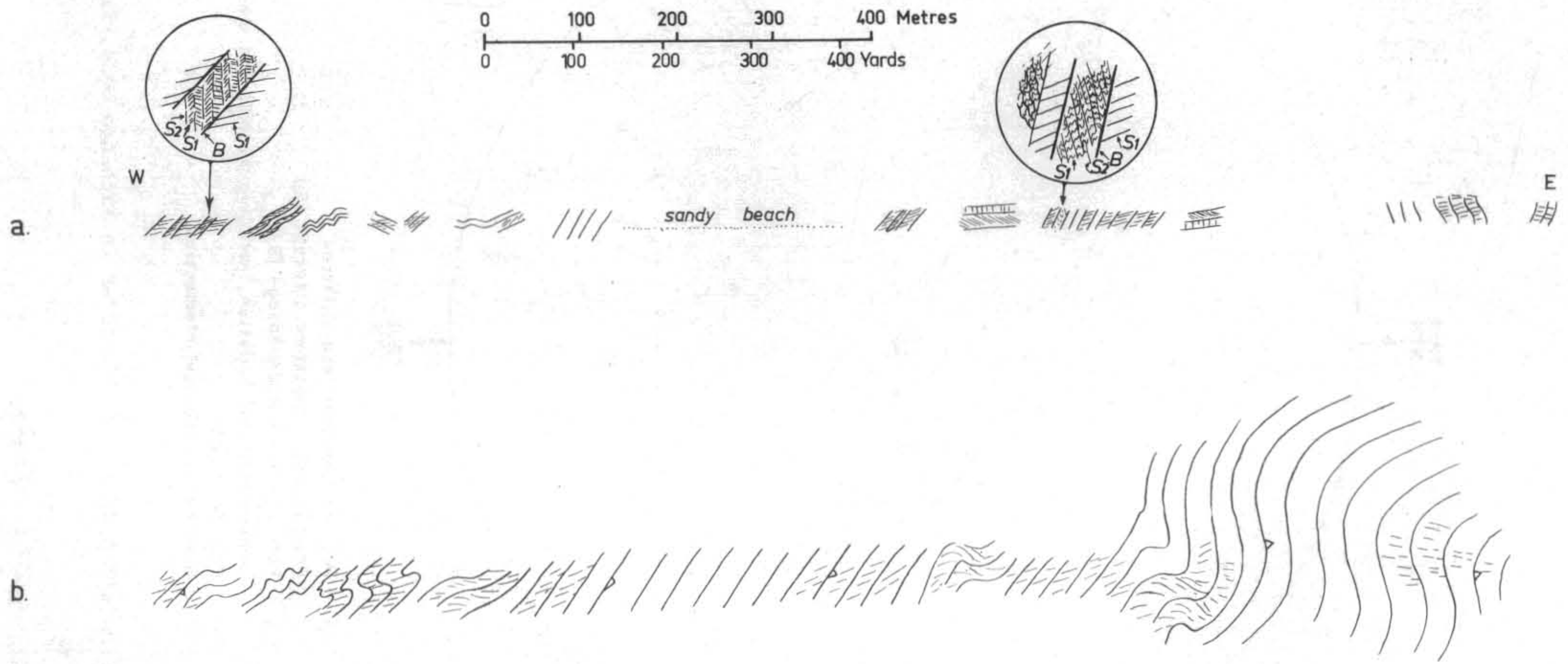


Figure 11. *Major structure of Mathinna Beds between Beechford and Stony Head.*



a. *Structural profile of Mathinna Beds at Beechford*
b. *Suggested generalised regional structure*

Figure 12. *Structural profiles of Mathinna Beds, Beechford.*

5 cm

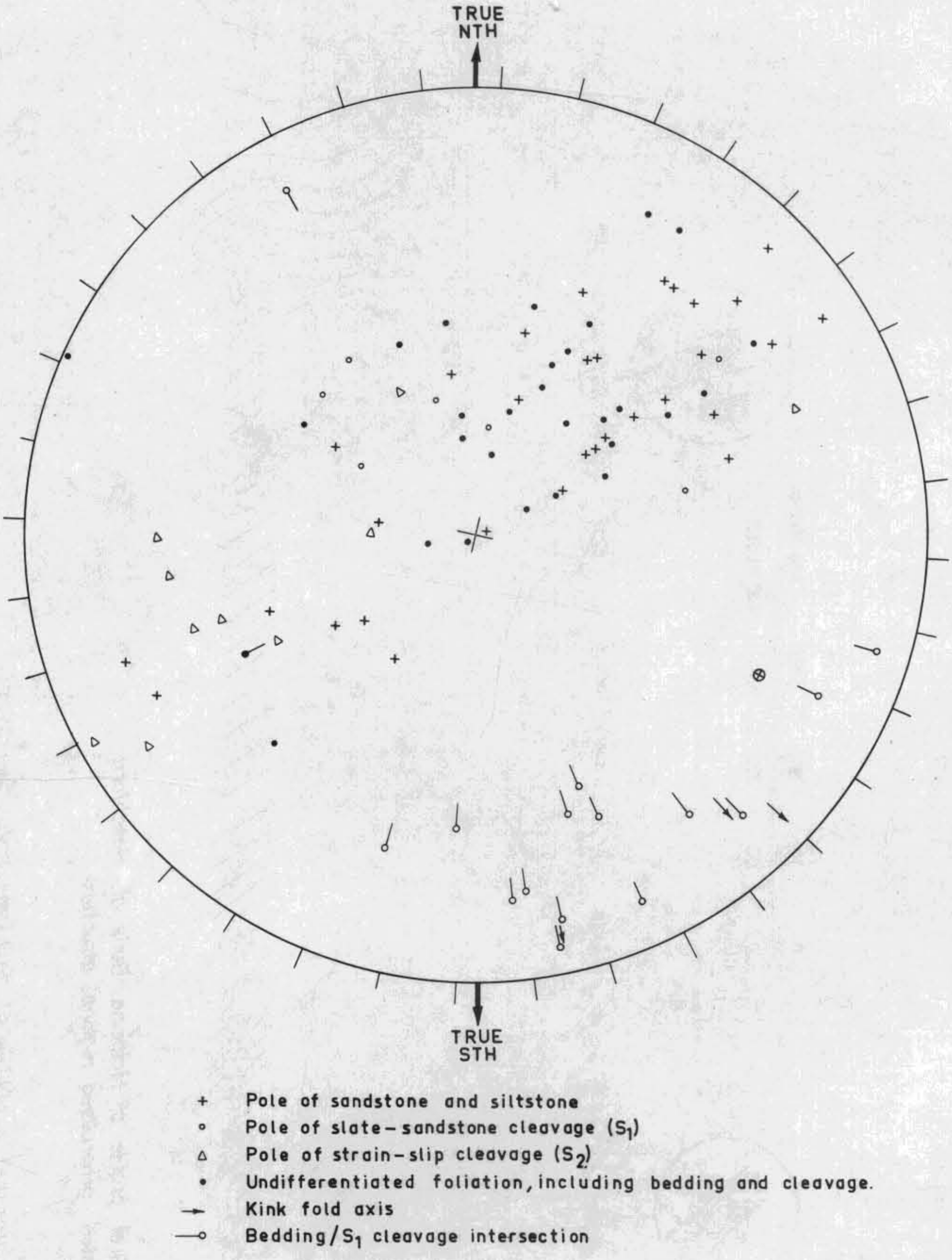
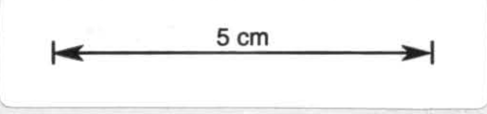


Figure 13. *Orientation of minor structures in Mathinna Beds, Beechford.*



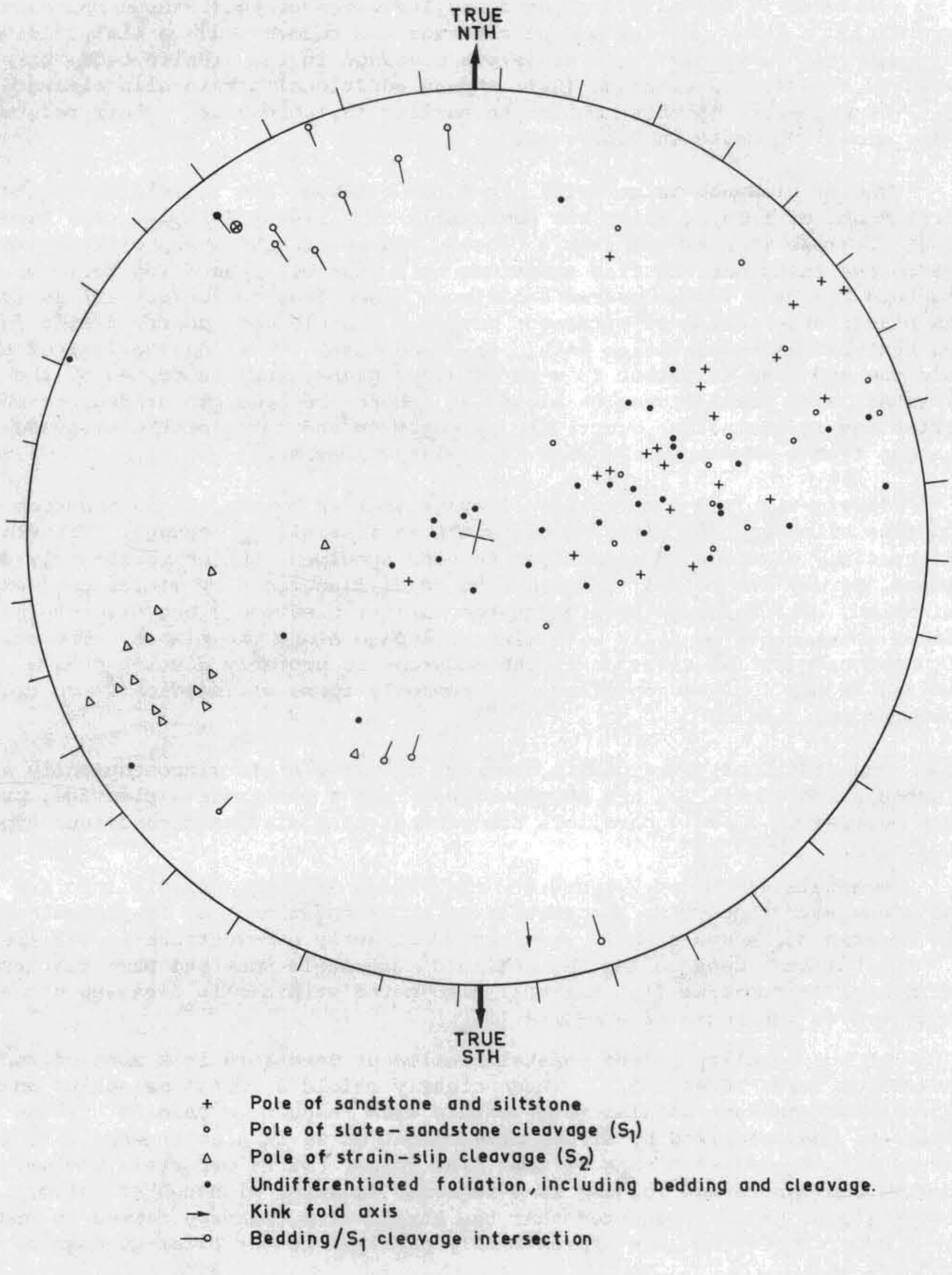


Figure 14. *Orientation of minor structures, Mathinna Beds, Lefroy.*

5 cm

80 m (across strike) and are the correct way up. Because of dip reversals, overturning, faulting, and the absence of marker horizons, no estimate of the gross thickness of the Mathinna Beds for this area is possible.

Cleavage is strongly developed and indicates at least three phases of deformation. Three generations of cleavage are recognised: a slaty cleavage (S_1) and its counterpart, the sandstone cleavage in the arenite beds; strain-slip and crenulation cleavage (S_2); and an additional strain-slip cleavage (S_2') of different orientation to the earlier (S_1) cleavage. Their relationships are illustrated in Figure 12.

The S_1 cleavage is an axial plane fan cleavage and is related to the first phase of folding which was dominantly of a flexural style. The sandstone cleavage (S_1) ranges from a closely spaced discontinuous cleavage in the coarse siltstone and fine sandstone to a coarsely spaced (up to 10 mm) fracture cleavage in the coarse sandstone. The cleavage surface arises from the planar orientation of micaceous minerals and elongate quartz grains forming textural discontinuities within the sandstone. The cleavage (S_1) of the mudstone and fine siltstone is a penetrative planar surface formed by the orientation of small micaceous minerals. Where the beds are graded, or where variations in grain size occur, the orientation and habit of the cleavage changes from a sandstone cleavage to a slaty cleavage.

Strain-slip and crenulation cleavage (S_2) is common in the mudstone and fine siltstone and often obscures the earlier slaty cleavage. Crenulation of the slaty cleavage is recognised in hand specimen, but where strongly developed, S_2 may resemble S_1 and needs to be distinguished by microscopic examination. S_2 is formed by kinking the earlier cleavage along discrete planes spaced about 0.5-2 mm apart with minor slippage along the planes. The strain-slip and crenulation cleavage in the mudstone is probably developed as a kinking in the coarser sandstone. S_2 commonly forms a lineation L_2 on broken surfaces and bedding.

The additional strain-slip cleavage S_2' is visible microscopically as a crenulation of S_2. S_2 has not developed into a penetrative cleavage, probably because it closely parallels the pre-existing slaty and sandstone type cleavages.

Marshall (1970, p. 77) divided the Pipers River Quadrangle into two sub-areas with respect to homogeneity of S_1 orientation. S_1 is predominantly sub-horizontal in sub-area II and is predominantly sub-vertical in sub-area I. The Mathinna Beds in the Beaconsfield Quadrangle show the same features as Marshall's sub-area II. Marshall also noted strain-slip cleavage strongly developed in the rocks of sub-area II.

At one locality on the coastal section at Beechford is a zone of second generation folds (Figure 12). These clearly refold S_1 which maintains an approximate constant angular relationship with respect to bedding. These zones are characterised by strong development of S_2 in a north-west direction, parallel to the axial planes of some kink folds. It is uncertain whether this second-generation folding is a regional feature, although at Lefroy Groves (1965, p. 67) suggested that the strain-slip cleavage formed in broad folds superimposed on axes approximately parallel to the first-generation folds.

Orientation data for the Beechford-Lefroy area are shown in equal area projection in Figures 13, 14. Bedding and S_1 show a spread in a girdle about a shallowly (and doubly) plunging axis trending about NNW-SSE. The plot of linear structures, however, shows a tendency for a spread in the horizontal plane. This feature warrants further study.

Faults

In the absence of marker horizons the recognition of major faults in the Mathinna Beds has not been possible. Comment is restricted to minor faulting in the Lefroy gold mining area.

The auriferous lodes fill a series of faults, sometimes in shear zones up to 60 m wide, which trend 88° and generally dip south although lodes in the central part of the field dip steeply north (Broadhurst, 1935). The fractures have dips ranging from 65° to vertical and have features suggesting repeated movement (Groves, 1965; Broadhurst, 1935).

Two further fault sets trending NW and NE displace the E-W trending auriferous lodes and also deflect on these lodes; this indicates that the NW and NE sets are younger faults than the E-W set. The E-W auriferous lode/fault system displays a distinctive 'ladder' zone which trends NW. Broadhurst (1935) suggested that sub-horizontal shear movement occurred near the boundaries of the interbedded siltstone-sandstone sequence, containing the lodes, and the relatively barren slates to the east and west.

Two major linears are displayed on the north-western and western boundaries of the Mathinna Beds. Along the north-western boundary of the Mathinna Beds a linear may be constructed marking the abrupt termination of surface exposures. This linear can be followed to the south-west and passes into the Tamar River just south of George Town. The origin of this line is speculative but it does lie on the NE trend common to the established faults at Lefroy and to the probable fault-line followed by Curries River in its middle reaches. The south-western limit of the Mathinna Beds forms a well defined linear along Cimitiere Creek and the upper reaches of Curries River. This linear appears to mark the position of the Permian/Mathinna Beds unconformity.

Regional structure

There are two major structural domains, which are homogeneous with respect to sedimentary facings and vergence of the first generation folds, in the Mathinna Beds in Pipers River, Noland Bay and Beaconsfield Quadrangles.

(1) In the Beechford-Lefroy area and sub-area II of Pipers River (Marshall, 1970), S_1 generally dips west more shallowly than bedding, which is usually overturned. The vergence of the folds is described as 'over-riding down to the south-west'.

(2) At Stony Head in the Noland Bay Quadrangle (Jennings, 1967) the beds dip west more shallowly than S_1 and are upward facing. The fold vergence is described as 'over-riding up to the north-east'.

A large recumbent syncline is indicated on a NNW-SSE trend, and an axial plane dipping SW (fig. 12*b*).

PERMIAN

A gently tilted Permian sequence 680 m thick unconformably overlies the Lower Palaeozoic rocks. The sequence extends from the basal pebbly beds to the Triassic sandstone. There are three main areas of outcrop within the Quadrangle. The best exposures are in the estuarine inlets of the Tamar River in the Beaconsfield area. All the type sections of the mappable units are defined in this area. The second area lies 15 km west, on the western side of the Dazzler Range. The third area lies on the eastern side of the

Tamar River, on the north-eastern flanks of the Tippogoree Hills.

BEACONSFIELD AREA

The Permian sequence has a uniform dip of 10-15° NE, and good foreshore sections are exposed in West Arm and Middle Arm. The Middle Arm section, which has been described by Green (1959), extends from the top of his Golden Valley correlate through to the Triassic, but much of it is obscured by superficial foreshore mud. On the northern bank of West Arm the section from the Liffey Sandstone to the Triassic is well exposed. The section below the Liffey Sandstone is exposed on the southern bank of West Arm, and in the lower estuarine reaches of Masseys and Andersons Creeks which run into the head of West Arm.

In his description of the Middle Arm section, Green introduced several local formation names (*e.g.* Swifts Jetty Sandstone, Bowens Jetty Sandstone and Clog Tom Sandstone). These were used in conjunction with certain other names (*e.g.* Quamby Siltstone, Darlington Limestone, Liffey Sandstone, Woodbridge Formation, Springmount Siltstone, Palmer Sandstone and Blackwood Conglomerate) originally defined elsewhere in Tasmania. It is not clear whether these implied correlations were intended as purely lithological or as time equivalents, but in neither case was lithological or faunal continuity established. It is therefore neither desirable, nor justifiable to use many of these 'borrowed' terms, most of which came from the Western Tiers, over 65 km away.

The section at West Arm is similar to that at Middle Arm, and is merely an extension of the same north-westerly striking structural belt. Although the intervening 6 km is mostly covered by superficial Tertiary deposits, individual units can be matched lithologically and faunally. From the point of view of regional mapping there are five mappable units. Each of these contain discrete lithological units, (fig. 15), some of which may later warrant formational status. The five mappable units* are, from the youngest to the oldest:

CLOG TOM SANDSTONE	Carbonaceous and micaceous quartz sandstone.
MIDDLE ARM GROUP	Interbedded unfossiliferous worm-cast argillaceous sandstone and dark mottled siltstone.
WEST ARM GROUP	Fossiliferous sequence of sandstone, pebbly sandstone, siltstone, calcareous siltstone, limestone.
LIFFEY SANDSTONE	Well-sorted, cross-bedded carbonaceous sandstone.
MASSEYS CREEK GROUP	Calcareous siltstone, sandstone, limestone and mudstone, commonly fossiliferous and pebbly in places.

Masseys Creek Group

The Masseys Creek Group is here defined as that sequence of intermittently fossiliferous siltstone, calcareous siltstone, pebbly sandstone, tilloid, limestone and mudstone which rests with pronounced angular unconformity

*Three new stratigraphic names are introduced. The names Clog Tom Sandstone (Green, 1959) and the Liffey Sandstone are retained for the upper and lower freshwater sequences respectively.

on a folded basement of earlier Palaeozoic rocks. It is overlain with apparent conformity by the Liffey Sandstone. It incorporates the Quamby Siltstone, the Darlington Limestone and the Swifts Jetty Sandstone as used by Green (1959). This sequence has subsequently been referred to in the literature as the 'Golden Valley' and the 'Quamby' Formations or Groups in the Beaconsfield area.

The Masseys Creek Group is of the order of 350 m thick, based on a regional dip of 8° NW. The possibility of thickness exaggeration by strike faulting cannot be ruled out although there is no obvious repetition of the sequence.

The basal portion, overlying folded Lower Palaeozoic rocks is poorly exposed, but judging by surface float consists of less than 30 m of boulder beds. (See Appendix 1). The lowermost 260 m mainly comprises dark grey mudstone which exhibits a conchoidal fracture when weathered and contains few fossils and pebbles. Interbedded pebbly and fossiliferous beds occur at several levels. About 200 m below the Liffey Sandstone, a bed, 1.2 m thick, of impure bioclastic limestone is exposed in Andersons Creek [706288]. Clarke (1969) lists the fauna which includes *Deltopecten waterfordi* Dickins, *Eurydesma cordatum* Morris, *Grantonia* sp. nov., *Strophalosia subcircularis* Clarke and *Calcitornella stephensi* (Howchin). This bed occurs within about 10 m of fossiliferous siltstone. About 6 m of poorly bedded and poorly sorted pebbly sandstone occur about 120 m below the Liffey Sandstone. This sandstone crops out at the mouth of Andersons Creek, in the unnamed creek to the north, and again in Masseys Creek. Both well-rounded and angular erratics occur, ranging in size from 1 cm to 40 cm. Irregular granule patches occur in the matrix. This may be tillite. About 12 m above the tillite(?) exposed in Masseys Creek and beneath the road bridge [702313], is a more pebbly and fossiliferous variant of the otherwise monotonous grey mudstone. It contains the following fossils (Clarke, 1969): *Deltopecten illawarensis* (Morris), *D. waterfordi* Dickins, *Eurydesma cordatum* Morris, *Eurydesma hobartensis* Johnston, *Grantonia* sp. nov., *Pseudosyrinx* sp. nov., and *Strophalosia subcircularis* Clarke. Ten metres above this fossil bed is a horizon of large calcareous nodules. These are exposed on the foreshore between Andersons Creek and the unnamed creek to the north [706304]. The nodules vary from 10 cm to 4 m in diameter, are discoidal and lie flat in the bedding.

The remaining 60 m below the Liffey Sandstone mainly comprise poorly-sorted fossiliferous siltstone and pebbly fossiliferous sandstone. A bed of extremely fossiliferous conglomeratic sandstone 30 cm thick, at a level of 52 m below the Liffey Sandstone marks the base of the sandstone. It contains *Grantonia* sp. nov., and *Keeneia platychismoides* Etheridge. There is a gap in the outcrop in the West Arm section corresponding to a stratigraphic thickness of 35 m which is followed by an exposure of unfossiliferous laminated and cross-laminated fine-grained micaceous sandstone with a clay matrix. This is overlain by a well-sorted conglomerate bed 20 cm thick, which is taken as the base of the Liffey Sandstone. In a long disused and now largely overgrown quarry near Middle Arm Creek at [769258], about 12 m of richly fossiliferous, glauconitic and conglomeratic sandstone is exposed. This sequence commences about 17 m below the base of the Liffey Sandstone. This is the Swifts Jetty Sandstone of Green (1959) which is underlain by a bed of limestone with *Eurydesma cordatum* Morris. Fossils from the Swifts Jetty Sandstone include *Deltopecten illawarensis* (Morris), *Myonia morrisi* Etheridge, *Pyramus laevis* (J. Sowerby), *Grantonia* sp. nov., *Martiniopsis* sp. nov., aff. *M. symmetrica* (Campbell), *Notospirifer* sp. nov., and var. nov. aff. *N. hillae* Campbell, and *Pseudosyrinx* sp. nov. (Clarke, 1969).

Liffey Sandstone

The base of the Liffey Sandstone is exposed on the southern bank of West Arm [716310]. The underlying material is the fine-grained sandstone, described above, which forms the top of the Masseys Creek Group. The base of the Liffey Sandstone is a round-stone conglomerate bed, 20 cm thick, composed of rounded quartz pebbles up to 10 cm, in a quartz granule matrix. Following this are two thick beds of medium-grained sandstone, with lenses of granule conglomerate in the lower part of each bed. The details of this boundary are shown in Figure 16.

The main part of the Liffey Sandstone is a well-sorted medium-grained brown friable quartz sandstone. Bedding units range from 0.3-2.4 m, and are planar or wedge-shaped with abundant planar cross bedding.

The top of the Liffey Sandstone is exposed on the small point on the northern bank of West Arm [713315]. The upper 5 m is an alternation of carbonaceous and micaceous sandstone, and richly carbonaceous cross-laminated shale with flaser-bedded fine-grained sandstone pods. The carbonaceous shale beds are generally wedge-shaped. The details of the top contact are shown in Figure 16. The top is taken as a clearly defined change in lithology from a medium-grained well-sorted micaceous sandstone containing scattered carbonaceous fragments, to a grey coarse-grained siltstone with scattered pebbles and abundant worm tubes. This siltstone is 0.6 m thick, and is overlain by grey-blue siltstone which has a conchoidal fracture when weathered. It contains fenestellids and spiriferids. The contact is conformable and sharp.

West Arm Group

The West Arm Group is here defined as that sequence of fossiliferous and pebbly siltstone, calcareous siltstone, sandstone and limestone which occurs conformably between the Liffey Sandstone below and the Middle Arm Group above. In its type section on the northern shores of West Arm [714317] it is 58 m thick. The new name replaces the Woodbridge and Garcia Formations of Green (1959). Its base is taken as coincident with the base of a coarse-grained worm-cast siltstone 0.6 m thick. Its top is taken as coincident with the top of a fossiliferous sandstone sequence which Green (1959) correlated with the Garcia Sandstone at Poatina (McKellar, 1957).

The basal worm-cast siltstone is overlain by about 3 m of grey pebbly micaceous siltstone also with worm-casts. Then follows about 20 m of intermittently exposed pebbly micaceous siltstone with spiriferids and fenestellids. About 21 m above the Liffey Sandstone a conglomeratic sandstone yields the giant conulariid *Paraconularia derwentensis* (Johnston) in abundance. This bed is also prominent at Middle Arm [771267]. About 25 m above the Liffey Sandstone there is an interval 4.5 m thick which contains three compact beds of limestone interbedded with calcareous siltstone. The limestone beds average 20 cm in thickness, are predominantly composed of bioclastic debris, and yield a rich shelly fauna. Brachiopods overwhelmingly predominate and include *Fletcherithyris parkesi* Campbell, *F. amygdala* (Dana), *F. reidi* Campbell, *Martiniopsis* sp. (cf *M. angulata* (Campbell)), *M. ingelarensis* (Campbell), *M. undulosa* (Campbell), *Sulciplica transversa* Waterhouse and large *Wyndhamia dalwoodensis* Booker (Clarke, pers. comm.). The limestone beds are followed by 18 m of siltstone and pebbly siltstone with abundant bryozoa, *Martiniopsis strzeleckii* de Koninck and large trunks of fossil wood.

At Middle Arm [771267] the calcareous horizon is more massive-bedded, much finer-grained and is best described as a calcite mudstone. The fauna is here dominated by mollusca and components other than brachiopods which

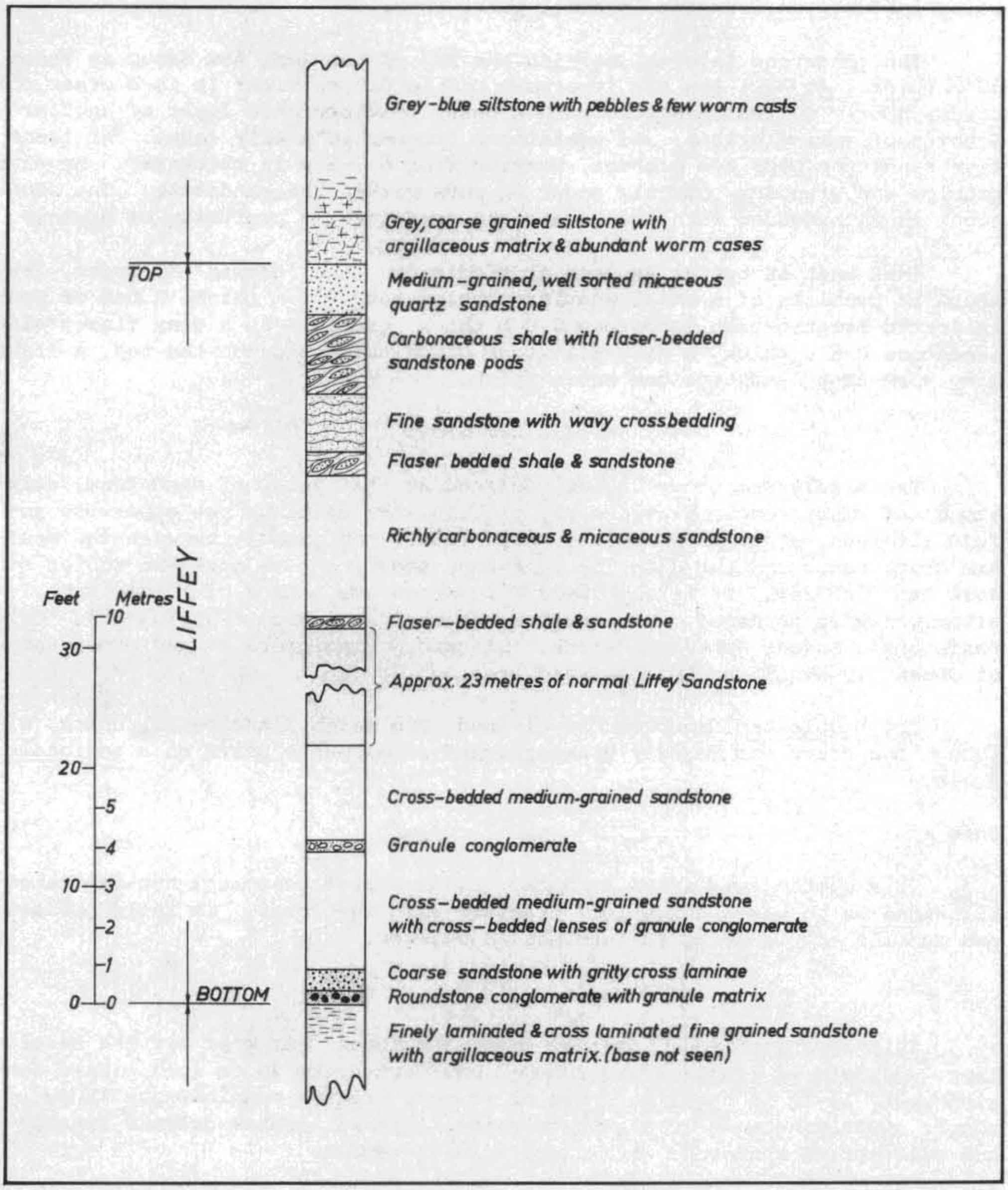


Figure 16. *Section showing the top and bottom contacts of the Liffey Sandstone.*

are quite rare. The fauna includes *Astartila intrepida* (Dana), *Conocardium, Etheripecten* spp., *Myonia* cf. *corrugata* Fletcher, *Stutchburia* spp., *Schizodus, Keeneia, Warthia micromphala* (Morris), *Hyolithes* and abundant ostracods, together with rarer specimens of blastoids and large michelinoceratids. The lithology and the nature of the fauna may indicate a more restricted, quiet-water lagoonal environment (Clarke, pers. comm.).

The sandstone interval marking the top of the West Arm Group is about 10 m thick. At West Arm the lowermost bed is 0.6 m thick; it is a cream coloured, poorly sorted sandstone with a basal conglomeratic layer of angular pebbles of varied origin, and contains a fragmented shelly fauna. At least five sandstone beds are present, varying from 0.3-1 m in thickness. Angular pebbles and granules commonly occur in pods within the sandstone. The sandstone is interbedded with grey siltstone containing a profusion of bryozoa.

This unit is better exposed at Middle Arm (the 'Garcia' of Green, 1959) where it consists of a basal angular conglomerate 0.4 m thick, a bed or poorly sorted erratic-rich sandstone 0.9 m thick, overlain by a grey fine-grained sandstone 0.6 m thick, a grey siltstone 0.5 m thick and, on the top, a light grey worm-cast sandstone one metre thick.

Middle Arm Group

The Middle Arm Group is here defined as that group of sandstone, siltstone and minor conglomerate units, rich in worm markings but otherwise unfossiliferous, about 180 m thick, which occurs conformably between the West Arm Group below and the Clog Tom Sandstone above, on the northern shores of West Arm [720325]. It is also well exposed on the shores of Middle Arm, after which it is named. It incorporates the 'Springmount Siltstone', 'Palmer Sandstone', Bowens Jetty Sandstone, 'Blackwood Conglomerate' and other units of Green (1959) in the Beaconsfield area.

The Middle Arm Group can be divided into seven lithological units, although these are not readily distinguished as mappable units on a regional scale.

Unit A

This bottom unit is 60 m thick. It is a buff coloured, non-laminated siltstone which has a conchoidal fracture when weathered. It lacks pebbles and fossils and is quite featureless in outcrop.

Unit B

This is a sandstone interval about 3 m thick. At West Arm the basal layer consists of elongate and rounded boulders up to 30 cm long. This conglomeratic layer is basal to a bed of rounded granule conglomerate 15 cm thick. Overlying this is a buff to white, leached, medium-grained friable and well-sorted sandstone with a ferruginous cement.

On the southern bank of Middle Arm a slightly thicker sequence is exposed. The bottom bed, a coarse granule conglomerate, is 15 cm thick. This is overlain by 2 m of worm-cast quartz sandstone, another 2 m of a pinkish, fine-grained sandstone with shaly partings and then 3 m of massive white, argillaceous medium-grained sandstone containing scattered quartzite pebbles. The same unit is also exposed on the northern side of Middle Arm at [767298] where the basal conglomerate contains rounded mudstone fragments and pebbles of quartzite and vein quartz. Also at this locality fragments of opalised wood occur in the sandstone. At Middle Arm, Unit B has been correlated with the Palmer Sandstone at Poatina by Green (1959).

Unit C

At both Middle Arm and West Arm, this unit is 55 m thick and consists mainly of mottled siltstone with some interbedded sandstone. The siltstone is dark blue-grey in colour, commonly mottled due to the abundance of worm tubes. The interbedded sandstone ranges from a clean white medium-grained quartz sandstone, often with granules of vein quartz, to a dark grey poorly sorted sub-greywacke sandstone.

Unit D

Unit D consists of about 40 m of well-bedded, fine-grained to coarse-grained tough sandstone. It has a very hard white argillaceous and siliceous matrix which imparts a light cream colour to the rock. It contains abundant worm tubes up to 15 mm in diameter which occur both across and along the bedding. Exotic boulders of quartz, quartzite, conglomerate, schist, granite, quartz porphyry and opalised wood are common. The bedding units average 0.4 m in thickness, and coarse siltstone is commonly interbedded. The features of this unit are distinctive and can be recognised at several localities. Units C and D together constitute the Bowens Jetty Sandstone of Green (1959).

Unit E

At West Arm this unit is 33 m thick, and is a mottled dark bluish grey micaceous siltstone with worm tubes, interbedded with minor sandstone of a similar lithology to the sandstone in Unit D. At Middle Arm on the western slopes of Ralstons Hill [774835], Unit E is either missing or very thin. Here the conglomerate (Unit F) overlies a bed of cream, laminated siltstone, 1.2 m thick.

Unit F

This distinctive single conglomerate bed has been correlated with the Blackwood Conglomerate at Poatina by Green (1959). It marks the commencement of the lithological change from worm-cast (presumably marine) siltstone and sandstone, to micaceous and in part carbonaceous (presumably fluvial) sandstone. It is a useful marker horizon because it generally forms a line of conglomeratic rubble in areas with no outcrop.

At Middle Arm, on the western shores of Ralstons Hill [774283] the conglomerate bed is 0.6 m thick. It consists of well rounded and spherical quartz and quartzite pebbles varying from 5-80 mm across. The matrix is of rounded quartz of coarse sand grade, and is itself bonded by finer very hard siliceous and argillaceous matrix. At West Arm [722327] the bed is 0.4 m thick, and contains exotic pebbles of a similar variety and range to those in the underlying units.

The variation in lithology beneath the conglomerate may either be interpreted as a low-angle unconformity or as facies changes within the shallow-water marine sandstone units below. The predominance of pebbles and boulders of local but recycled origin indicates some of erosion of underlying units, followed by concentration by reworking and winnowing.

Unit G

Immediately above the conglomerate Unit F at West Arm is a grey-blue, medium-grained siltstone which has a conchoidal fracture when weathered, interbedded with moderately well sorted gritty sandstone lenses. This unit is of uncertain thickness, at least 1.2 m and less than 10 m. These beds mark the transitional environment.

Clog Tom Sandstone

The Clog Tom Sandstone (Green, 1959) is a formation of micaceous and carbonaceous quartz sandstone which crops out on the western shores at Ralstons Hill at Middle Arm [774286]. At this locality the passage upward from Unit F of the Middle Arm Group is not exposed, and furthermore, the Clog Tom Sandstone is in faulted contact with the presumed Triassic sandstone.

At West Arm, the Clog Tom Sandstone is 50 m thick. It is a thinly bedded medium-grained to fine-grained sandstone with thin shaly partings of micaceous and carbonaceous siltstone containing leaf and plant stem remains. The sandstone beds range from 5-60 cm in thickness, and commonly have an internal planar cross-lamination accentuated by the abundance of muscovite and flaky carbonaceous material. Discoidal clay pellets up to 3 cm in diameter occur in the sandstone.

The actual base is not exposed at West Arm, but appears to overlie the worm cast siltstone with clean sandstone stringers at the top of the Middle Arm Group. The top is taken arbitrarily, in order to separate carbonaceous sandstone which correlates approximately with the Cygnet Coal Measures, from the typical Triassic sandstone. The boundary, from the point of view of field recognition, is the disappearance of carbonaceous matter, a feature which corresponds with the change from thinly bedded micaceous fine-grained sandstone, to a massive, thickly bedded medium-grained to coarse-grained pure quartz sandstone.

TIPPOGOREE HILLS

Permian rocks occur on the northern slopes of the Tippogoree Hills and on the eastern slopes of Mt George. A poorly exposed, but complete section occurs from Tippogoree Hills across Curries River to the hills of the older Mathinna Beds. Sufficient creek exposures and road cuttings exist to distinguish the mappable units, and many of the sub-units of the section at Beaconsfield can be recognised.

An approximate stratigraphic column based on altimeter readings across the section and corrected for a regional dip of 10° SW is shown in Figure 17.

Masseys Creek Group

Between the Mathinna Beds and the Liffey Sandstone there is an indicated thickness of 235 m. This thickness is comparable with, but less than, the pre-Liffey thickness at Beaconsfield.

The basal beds are not exposed, but trains of pebbles and boulders in the soils and Quaternary silts usually indicate the approximate position of the unconformity. These floaters range from well-rounded to angular, and include vein quartz, quartzite, siliceous conglomerate, sandstone, slate, schist, granite and porphyry.

The sparse exposures of the pre-Liffey sequence are of monotonous grey mudstone and pebbly siltstone. Fossiliferous siltstone is exposed near the junction of Dalrymple Main Road and the Bridport Highway [874359]. It contains bryozoa, *Stenopora tasmaniensis* Lonsdale, crinoid columnals, and *Eurydesma cordatum* Morris. On the basis of the 10° regional dip, this exposure

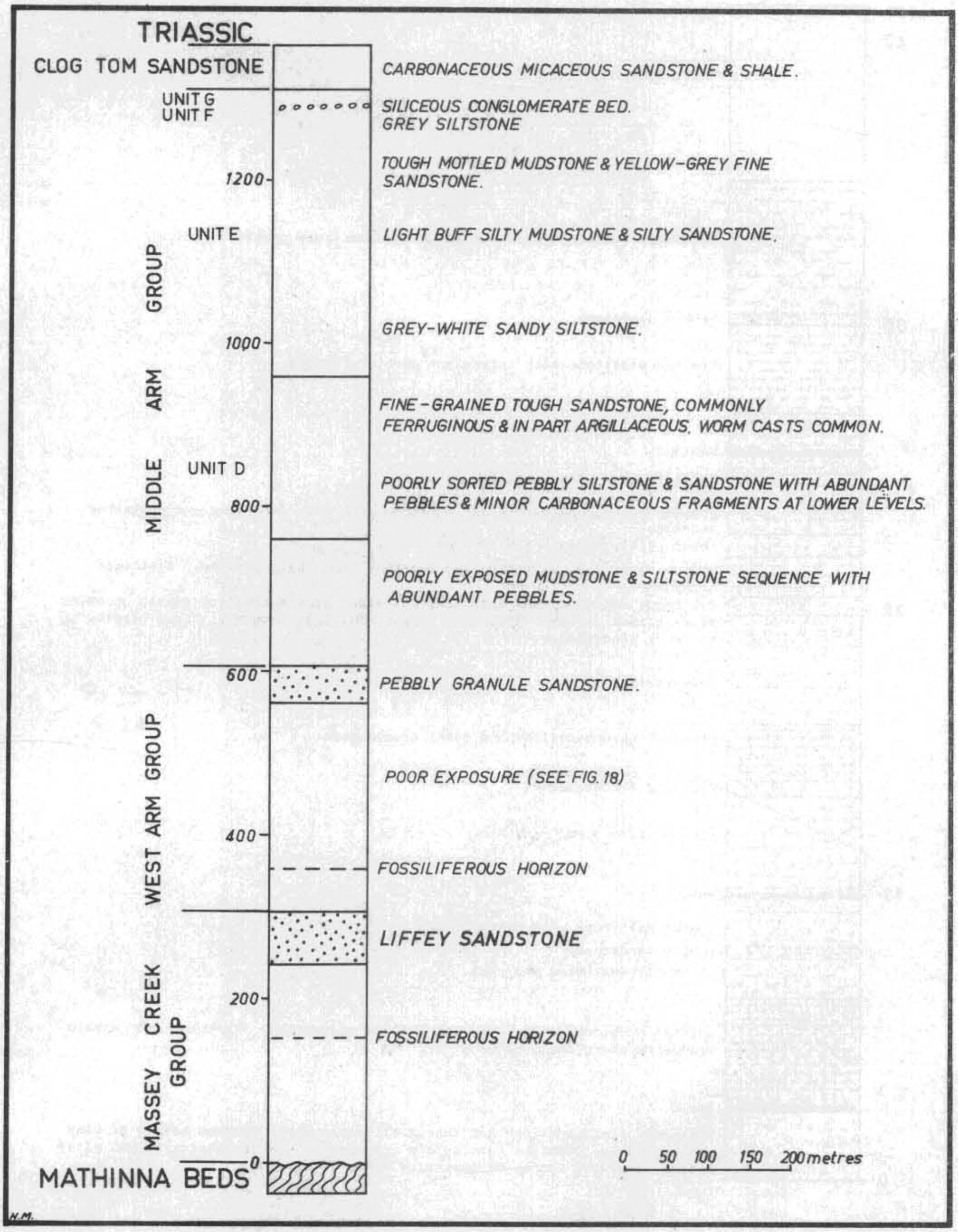


Figure 17. *Permian section, Tippogoree Hills.*

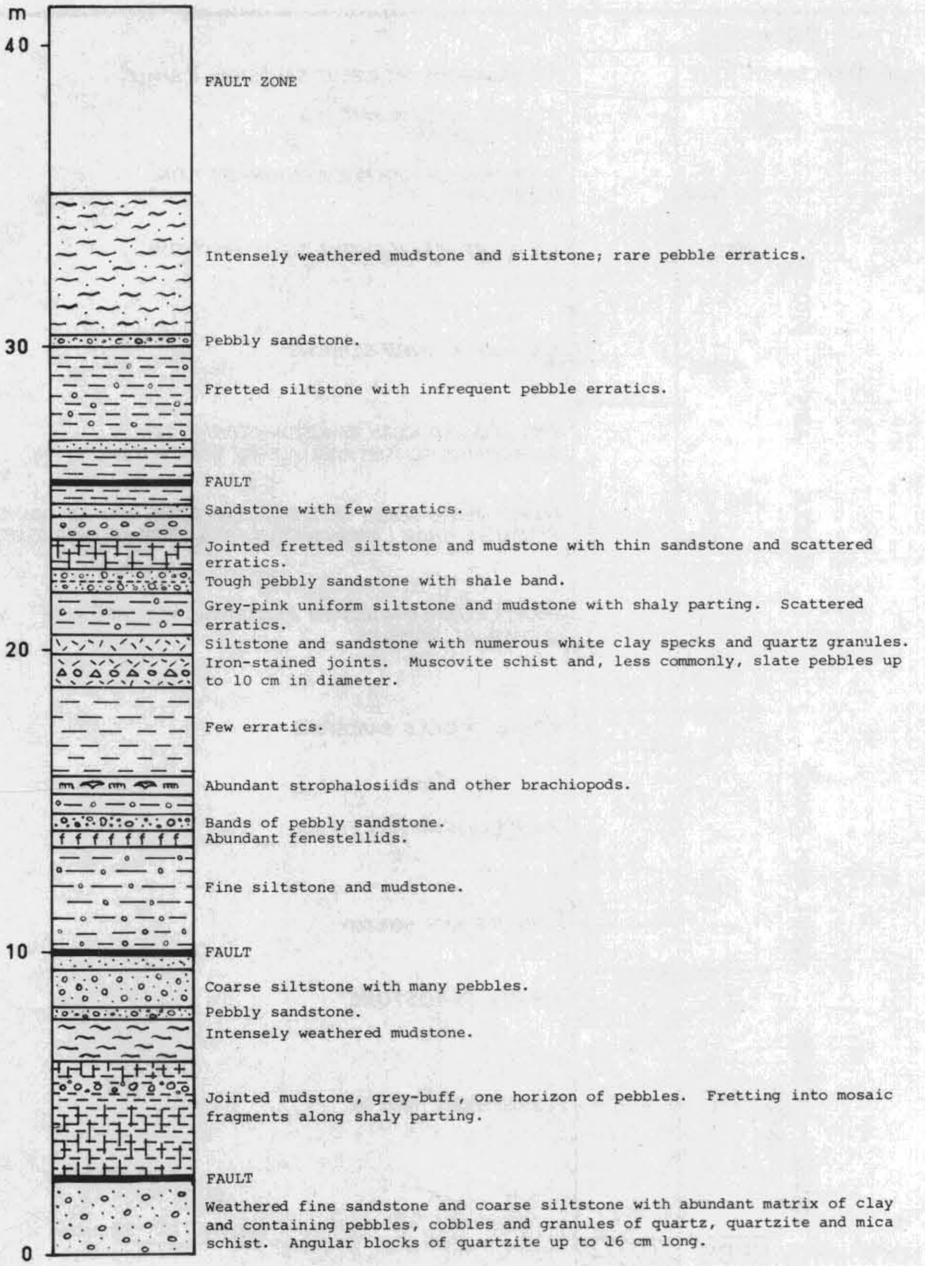


Figure 18. *Section of the fossiliferous portion of the West Arm Group, Lefroy-George Town road.*

would occur 85 m below the Liffey Sandstone.

Liffey Sandstone

A disturbed exposure of Liffey Sandstone occurs in the road cuttings on the Dalrymple Main Road [874358]. Three lithological types are present, each bounded by faults.

The oldest is about 3 m of medium-grained, well-sorted sandstone, with large-scale festoon cross bedding. This is faulted against thickly bedded quartz sandstone containing ellipsoidal mud pellets and scattered, rounded quartz pebbles. Bedding units up to one metre thick are defined by thin purple shale layers. These shaly layers have been very mobile during the faulting and are injected along the fault planes. These beds lie adjacent to what is probably the youngest unit, about 3 m of dark brown shaly mudstone with finely laminated and cross-laminated carbonaceous-rich layers and thin sandstone lenses.

West Arm Group

This group is poorly exposed, but may be recognised as the fossiliferous unit of varied lithology above the Liffey Sandstone.

The lowest outcrop occurs stratigraphically 20 m above the Liffey Sandstone [868360]. It is a grey siltstone interbedded with poorly sorted sandstone containing bryozoa, *Stenopora crinita* Lonsdale and *Grantonia* cf. *hobartensis* Brown. About 55 m above the Liffey Sandstone is a coarse-grained, poorly sorted sandstone and granule conglomerate interbedded with bryozoal siltstone. This is probably the sandstone sequence marking the top of the West Arm Group at Beaconsfield.

A partial section of the West Arm Group is exposed in road cuttings on the George Town-Lefroy Road [853364]. This section (fig. 18) is 35 m thick. At the bottom is a mudstone and pebbly siltstone association followed by about 10 m of fine siltstone with abundant *Wyndhamia* sp., spiriferids, bryozoans and orthotetids. This is overlain by a group of conglomeratic sandstone beds, thought to mark the top of the West Arm Group. The overlying grey-blue mudstone is thus the base of the Middle Arm Group.

Middle Arm Group

Surface float on the Tippogoree Hills shows the gross lithology of the Middle Arm Group to be similar to that of the Beaconsfield area. Although lack of outcrop prevents a detailed comparison, some of the units can be identified. The most conspicuous is a 40 m thick sequence of interbedded medium-grained hard argillaceous sandstone and mottled cream siltstone. Many of the sandstone beds contain angular exotic pebbles of varied type. This is probably Unit D.

Above this unit is a sequence of mottled grey, hard argillaceous mudstone with some interbedded fine-grained yellow sandstone and siltstone. Clay pellets and worm tubes are common. This has a thickness of approximately 60 m.

Overlying this is a distinctive bed 0.4 m thick of very hard conglomerate, correlated with Unit F. Above the conglomerate [890320], is an unknown but small thickness of mudstone, correlated with Unit G, marking the top of the Middle Arm Group.

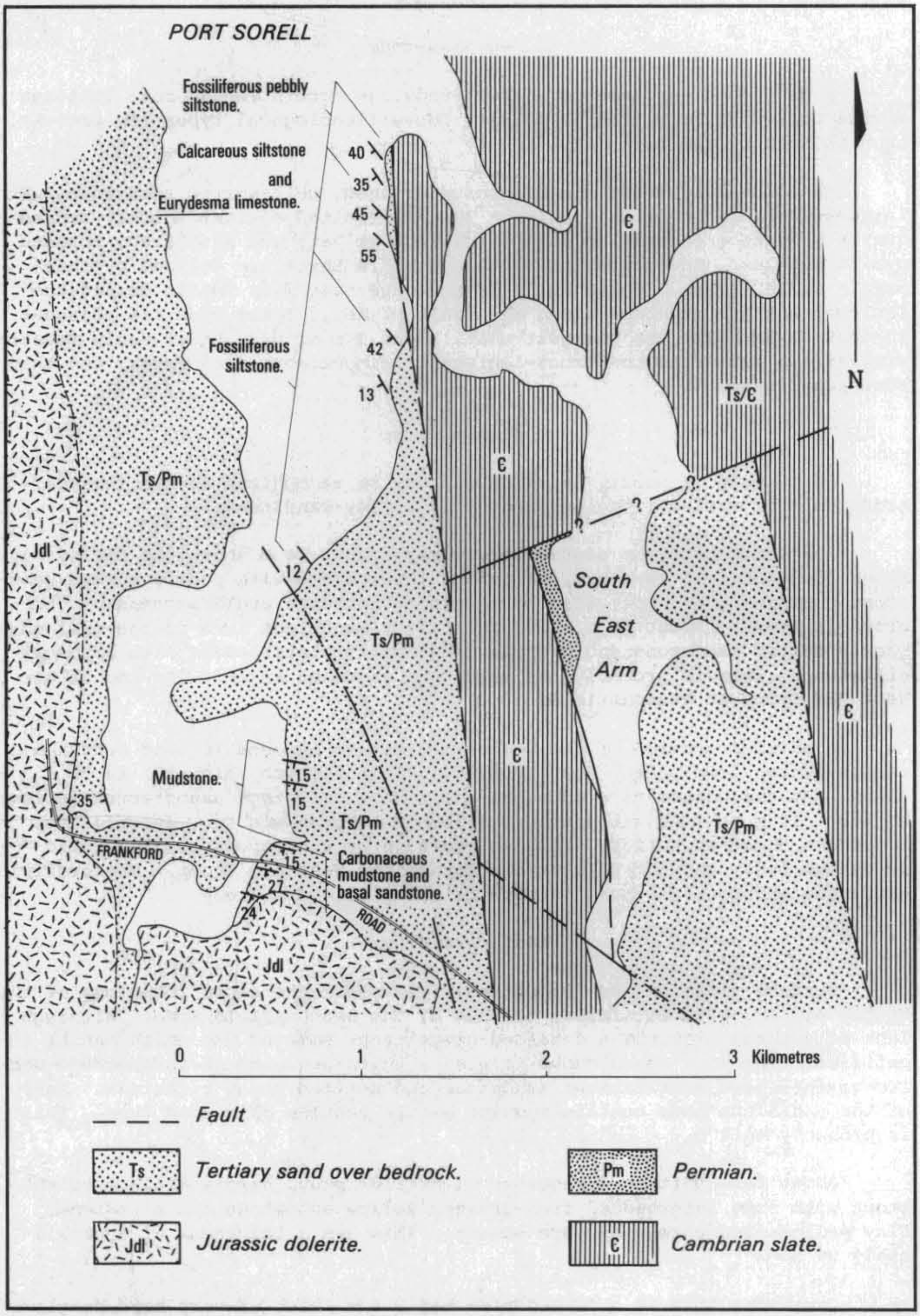


Figure 19. *Geological map of Permian areas, Port Sorell inlet.*

5 cm

Clog Tom Sandstone

A micaceous, carbonaceous quartz sandstone crops out in two creeks near the Musk Vale Estate [816376, 819377]. At the latter locality, the sandstone is underlain by mudstone which is so rich in carbonaceous material that it resembles a cannel coal. Beneath this is 5 m of uniform grey mudstone (probably Unit G of the Middle Arm Group).

PORT SORELL

On the western side of the Dazzler Range in Port Sorell Inlet is a discontinuous and poorly exposed sequence (fig. 19). It occurs on the western side of the peninsula between South East Arm and the Rubicon Estuary, in the area locally known as the 'Tongue'. The section is of interest since it appears to contain a considerable thickness of fossiliferous pre-Liffey beds, correlated with, and mapped as, the Masseys Creek Group.

These rocks lie to the west of a large fault trending 350° that throws Cambrian slate against the Permian. Nowhere is the unconformity exposed. The Permian rocks that are exposed along the foreshore have strikes ranging from 320° to 340°, and dip SW at angles varying from 45° next to the fault, to 13° away from the fault. Using a Buskian construction drawn at right angles to the limits of the strike variability, a minimum thickness of 350 m and a maximum of 520 m is indicated for the Masseys Creek Group correlate. These figures assume no duplication by faulting. The section is shown in Figure 20.

Masseys Creek Group

The lowermost beds exposed on the point of the peninsula [534250] consist of unfossiliferous conglomeratic sandstone, and are overlain by about 60 m of poorly sorted sandstone and interbedded pebbly siltstone. Fossils are abundant and include *Deltopecten illawarensis* (Morris), *Grantonia* sp. nov., *Stenopora tasmaniensis* Lonsdale, *Peruvispira, Strophalosia subcircularis* Clarke and bryozoa. This is overlain by grey monotonous mudstone containing common shelly fragments and sparse pebbles.

Above this is an extremely fossiliferous calcareous siltstone interval with limestone beds. This interval occurs both to the north and south of the narrow isthmus near the point of the peninsula [535240], but is interrupted by an exposure of Cambrian rocks lying to the east of the fault. The dips in the Permian suggest structural continuity between the two exposures, in which case the calcareous interval is 116 m thick, including 58 m for the gap in exposure. The lowermost exposure (north of the isthmus) contains at least six bioclastic limestone beds up to one metre thick. The uppermost exposure contains at least two limestone beds. The limestone is hard and solid, and composed dominantly of *Eurydesma cordatum* fragments. The important fossils from this locality (Clarke, 1969) include *Deltopecten illawarensis* (Morris), *Keeneia platyschismoides* Etheridge, *Grantonia* sp. nov., *Pseudosyrinx* sp. nov., and *Strophalosia subcircularis* Clarke.

Further to the south-west, at the widest part of the peninsula, [529226] 15 m of a fissile siltstone with common fossiliferous pebbly layers is exposed. The fauna is similar to that of the calcareous interval below. Assuming structural continuity, this exposure would be at least 150 m above the previous beds.

Undifferentiated Permian

Permian rocks are also exposed in the estuary of the Rubicon River in

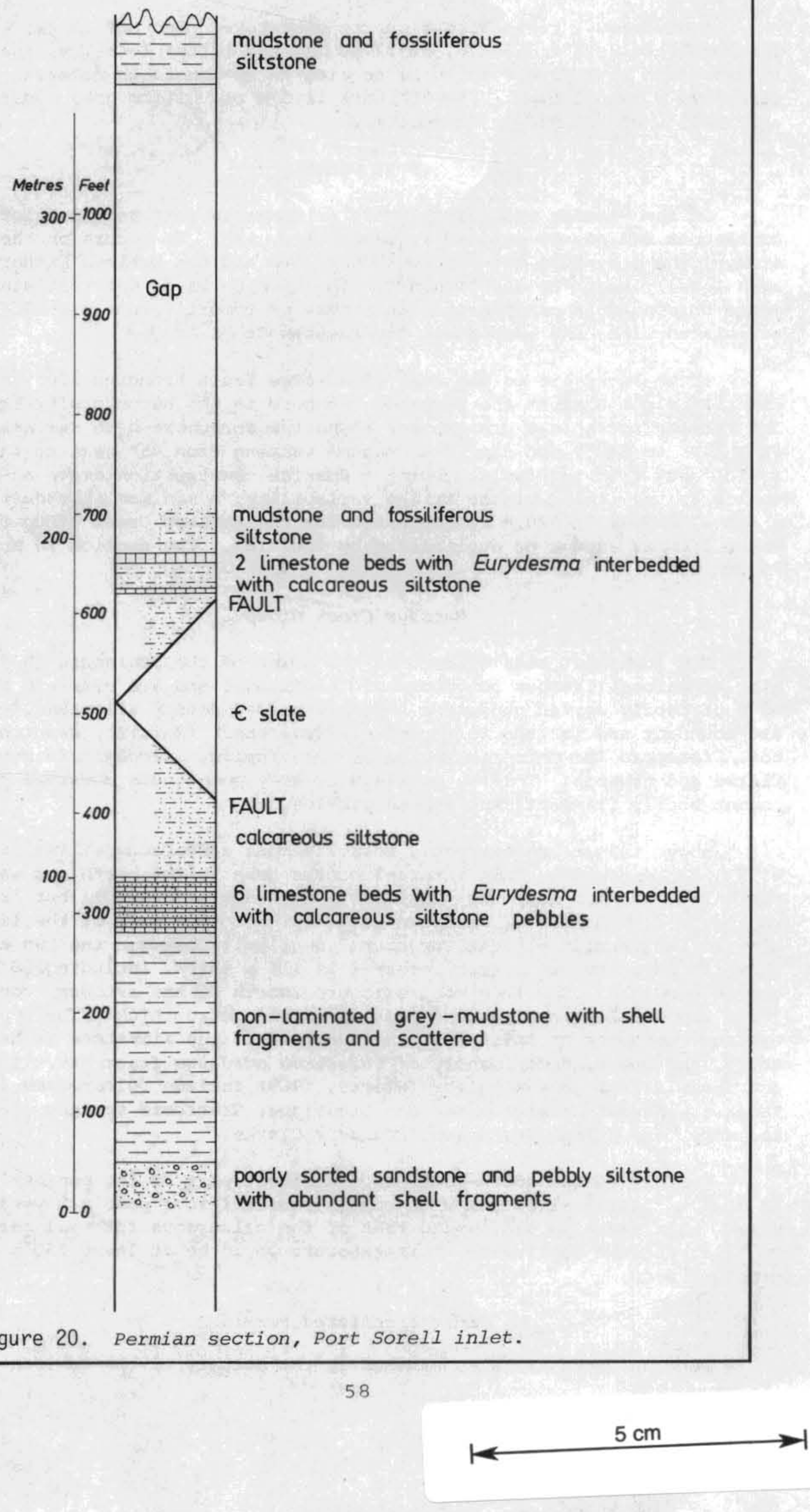


Figure 20. *Permian section, Port Sorell inlet.*

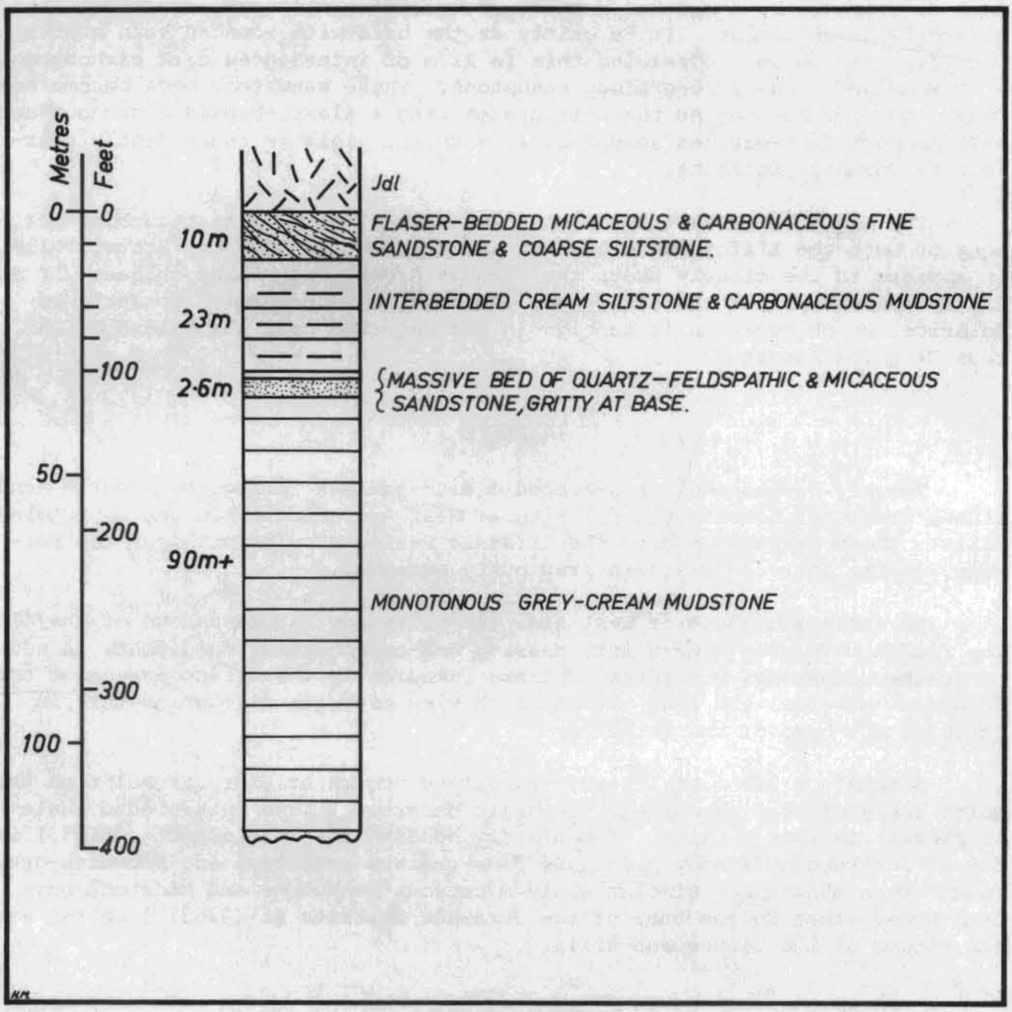


Figure 21. *Unassigned Permian section, Rubicon Bridge.*

the vicinity of the Exeter Highway bridge. The relation of this section to that further north on the peninsula is uncertain, although the regional dip is similar (15-24° SSW). This suggests that it is younger. Regional mapping to the south (A.B. Gulline, pers. comm.) points to the presence of a large fault under the Tertiary sediments that separates this exposure from those to the north (fig. 21).

The lowest unit consists of 80 m of monotonous grey-cream mudstone. This is overlain by a bed 2.4 m thick of quartzose-micaceous sandstone with an argillaceous cement. It is gritty at the base with rounded vein quartz pebbles up to 10 mm. Overlying this is 21 m of interbedded dark carbonaceous siltstone and cream fine-grained sandstone. These sandstone beds become more common towards the top as the unit grades into a flaser-bedded micaceous and carbonaceous fine-grained sandstone 12 m thick. This is concordantly overlain by Jurassic dolerite.

The age of this section is unknown. Lithologically it resembles portions of both the Liffey Sandstone and the Clog Tom Sandstone. Structurally it appears to lie closely above the Masseys Creek Group which suggests it is Liffey Sandstone. On the other hand it is in close proximity to Jurassic dolerite, which suggests it is high in the sequence near the Triassic, and thus Clog Tom Sandstone.

TRIASSIC

Thickly bedded and cross-bedded medium-grained ferruginous quartz sandstone, crops out beneath the dolerite at West Arm, Middle Arm and Tippogoree Hills. These are assigned to the Triassic Period as distinct from the Permian, on the basis of criteria previously outlined.

Up the north shore of West Arm, the siltstone and sandstone of the Clog Tom Formation passes upward into massive non-carbonaceous sandstone. A bed of coarse sandstone, 2 m thick, follows immediately the disappearance of carbonaceous material and from the point of view of regional mapping this is taken as the base of the Triassic.

A total of 275 m of Triassic sandstone occurs at Clarence Point on the north shore of West Arm beneath Jurassic dolerite. Thin interbedded shale is present in this section. Immediately beneath the dolerite at [741333] is 5 m of interbedded flaggy micaceous fine-grained sandstone and brownish-grey featureless mudstone. Similar shaly micaceous sandstone and mudstone have been noted close to the base of the Jurassic dolerite at [896310] on the eastern slopes of the Tippogoree Hills.

JURASSIC DOLERITE

Hills of Jurassic dolerite occur in the Tamar Valley and at Port Sorell. The dolerite is the usual massive medium-grained type occurring abundantly at thick intrusive sills and sheets in Permo-Triassic rocks throughout Tasmania. It is tholeiitic in composition, consisting of labradorite and clinopyroxene (pidgeonite-augite).

In the Tamar Valley the dolerite intrudes the quartzose-feldspathic Triassic sandstone. A concordant basal dolerite contact is well exposed at Clarence Point on the West Tamar. A chilled concordant contact, disturbed by faulting is exposed at Middle Arm. Top contacts are not present, the overlying rocks having been stripped by extensive Cainozoic erosion.

Further west, at the mouth of the Rubicon River a basal concordant dolerite contact overlies carbonaceous sandstone that is probably close to the Permo-Triassic boundary. The main mass of dolerite to the west of Port Sorell is in faulted contact with the Permo-Triassic sequence.

TERTIARY

The Beaconsfield Quadrangle has extensive deposits of semi-consolidated terrestrial sediment and basalt flows. The thickest accumulations occur in the Tamar trough, which is a graben in this Quadrangle, and the Port Sorell trough, and thinner blankets spill out of the troughs and lap on to topographically higher areas underlain by Precambrian and Lower Palaeozoic rocks.

The sedimentary sequences are in part fossiliferous, especially further south in the Launceston Basin of the Tamar trough (Gill, 1962), and are of Palaeocene - Early Eocene age. The interbedded basalt flows also demonstrate a Tertiary age, and in the absence of fossils, this latter criterion is used for identifying Tertiary sediment. The extensive deposits that are not demonstrably interbedded with basalt flows are termed Cainozoic, with the implication that they are probably of Tertiary age.

IGNEOUS ROCKS

Tamar graben

A sequence including at least two basaltic flows occurs in several places in the Tamar graben of the Beaconsfield Quadrangle. On the East Tamar a continuous basalt horizon extends from Donovans Bay, through Bell Bay to George Town. An upper basalt separated from the lower by about 30 m of sediment occurs in the Bell Bay - Point Effingham area.

A similar, and probably equivalent sequence, occurs on the West Tamar. The lower basalt occurs at Inspection Head and can be traced north at sea level to Lyetta and Greens Beach. It is overlain by about 30 m of sediment, followed by an upper basalt that occurs on the cliffs behind Beauty Point. This upper basalt can be traced for about 2.5 km to the south-west, and wedges out beneath siliceous gravels north of Beaconsfield township. These basalt flows, on both sides of the Tamar, dip gently to the north.

Further south at Deviot a lower and an upper basalt wedge out abruptly on to the western dolerite wall. Equivalence between the Deviot and Beauty Point sections is doubtful, because of the intervening thick basanitic dolerite body in the Rowella area. This body is confined to a steep-walled valley incised in the sediments, and therefore is younger than the basalt flows that are intercalated with the sediments.

Sutherland (1971) has outlined the evolution of the palaeogeography of the ancestral Tamar Valley.

Port Sorell trough

There is evidence of three basalt horizons in the dissected basalt country west of Port Sorell. The lower and middle basalts are the direct mappable continuations of the Thirlstane Basalt (lower) and the Moriarty Basalt (middle) defined by Burns (1965) in the Devonport Quadrangle. Burns studied the old deep-bore data, and described the succession in the Moriarty - Wesley Vale - Northdown Deep Lead.

The lowest basalt (Thirlstane Basalt) occurs on the Pleistocene sea cliffs between Northdown and West Head, and appears to be a local development. The succeeding basalt (Moriarty Basalt) is more extensive, and occurs in the Harford area. The third basalt is preserved as an isolated remnant on a higher hill about one kilometre south-west of Harford.

Petrology

The petrology of the basalts has been described in detail by Sutherland (1969, 1971). His conclusions are briefly summarised below.

The two basalt layers in the Bell Bay - Beauty Point area are near-undersaturated olivine alkaline basalts. Each unit probably consists of several individual flows. Further south at Deviot, the lowest exposed basalt is a nepheline basanite having a glassy mesostasis containing nepheline and analcine. The volcanic centres are unknown.

The coarse-grained basalt, or basanitic dolerite in the Craigburn - Whirlpool Reach - East Arm - Rowella area consists of olivine, labradorite and augite in a mesostasis containing sodic feldspar, analcine and glass. Textures range from intergranular to ophitic and intersertal. Pegmatitic schlieren occur. The coarse-grained basalt is at least 200 m thick and is confined by a steep-walled, pre-basalt valley. The unit appears to be a single body and some differentiation is evident. A volcanic centre may be inferred.

SEDIMENTARY ROCKS

Pre- and intra-basalt sediments

Sequences of fresh water (fluvial and lacustrine) sediments occur below and within the basalt horizons in both the Tamar and Port Sorell troughs. The pre-basalt sediments in both troughs have thicknesses of more than 300 m and are lithologically similar. They consist of brown sandy clay which is in places lignitic, and subordinate siliceous granule conglomerate and argillaceous sand.

The deposits are fairly well exposed in the Lower Tamar Valley, and have been the subject of many engineering geological investigations (see p. 65). The deposits have previously been described by Johnston (1888), Gill (1962) and Sutherland (1971).

These deposits contain carbonaceous and limonitic remains of fossil wood and leaf impressions, worm tubes and the freshwater mussels *Prohyria johnstoni* (Etheridge) and *Alathyria tamarensis* (Etheridge) (McMichael, 1957), which indicate a Middle Eocene age.

Ironstones

Various types of ferruginous deposits are associated with the Cainozoic sediments of the Tamar trough.

Perhaps the oldest of these is the concretionary and pisolitic hematite and goethite ironstone locally developed on the Andersons Creek ultramafic complex which is partly overlain by post-basalt gravel at Beaconsfield. Its age is uncertain, and Green (1959) suggests it may even be of Cretaceous age. The ironstone occurs as discontinuous blankets up to 25 m thick, lapping on to small basement topographic irregularities. Its concretionary nature, and the lack of any sedimentary structures suggest it represents a period of *in situ* laterisation of the ultramafic rocks which were perhaps exposed during the early stages of Tertiary sedimentation. These deposits have been described by Twelvetrees and Reid (1919), and Nye (1930) in connection with early attempts at economic exploitation.

Other types of ferricrete occur within the Tertiary sediments. These are represented on the geological map by the symbol (+++) superimposed on other rock units. Two main types occur, a sandy ironstone, commonly pisolitic, and probably of Tertiary age; and a pisolitic, non-sandy ironstone probably of Quaternary age. It is not implied that these two types mark separate episodes of ferricrete formation, but are probably the result of processes that continued throughout Cainozoic times.

The probable Tertiary ironstone is similar to that described in the Pipers River Quadrangle (Marshall, 1970) and in the Launceston Quadrangle (Longman, 1966). They occur as *in situ* spongiform or pisolitic patches of ferruginous cemented silt and sand. They are commonly peripheral to basalt flows or dolerite basement. Some appear to form by impregnation of the sands by iron hydroxide derived from the basalt. However, other patches occur at distinct levels in the Cainozoic sequence, and appear to have formed by *in situ* growth of pisoliths. In some cases they may result from mechanical accumulation. For example, the matrix of the dolerite boulder beds is rich in pisoliths, and Sutherland (1971, p. 14) has noted that some pisolite-rich patches contain fragments of the underlying rocks. Such features suggest periods of sub-aerial weathering and laterisation of the dolerite and from basaltic extrusive rocks.

The probable Quaternary ironstone occurs as patches of friable, uncemented 'buck-shot' gravel in the present zone of weathering. They commonly contain fragments of the underlying rocks. These are interpreted as residual or transported accumulations of remnants of the older lateritic profiles within the Cainozoic sequence.

Dolerite boulder beds

These are composed of sub-angular pebbles and boulders of Jurassic dolerite in a matrix of clay and ferruginous pisoliths. They are well exposed in road cuttings near the East Tamar Highway - Batman Bridge Road junction.

Johnston (1888) regarded these as tuff breccias and agglomerates, however Carey (1947) considered that the boulders were redistributed fault-scarp debris. The distribution of the beds is closely related to the wall of Jurassic dolerite that forms the eastern margin of the Tamar graben. Sutherland (1971) has reported fragments of olivine basalt in the conglomerate beds; this suggests an intra-basalt age.

Post-basalt sediments

Extensive blankets of semi-consolidated quartz gravel and clean sand occur in the Tamar trough, where they transgressively overlie the basalt-sediment sequence. These gravels are similar in lithology to those in the intra-basalt and sub-basalt sequences, however in the Bell Bay and Beaconsfield area, the gravel constitutes a major sedimentary unit above the basalt. Similar deposits, not demonstrably immediately post-basalt, occur at Port Sorell Inlet, Lefroy and Beechford. These may not all be entirely post-basalt in age, and are referred to as Cainozoic gravels.

Johnston (1888), Carey (1947), Green (1959) and Sutherland (1971) have described the deposits in the Tamar trough. The gravel consists mainly of sub-rounded fragments of vein quartz and quartzite. Chert fragments also occur in the gravel north of Beaconsfield township. Much of the rounding is attributed to recycling of rounded pebbles from the Ordovician conglomerates and the Permian pebbly siltstone formations. Good sorting, stratification and cross-stratification, and lenses of sand within the gravel indicate terrestrial fluvial deposition.

Old talus deposits

Most of the hills that form the hinterland to the flat plains of the lower Tamar area are covered by talus. Those talus deposits mantling the Precambrian and Ordovician hills are thick, stabilised and are being eroded by the present drainage systems. In some places they interfinger with the Cainozoic sediments. Such deposits could date back to the early phase of Tertiary sedimentation.

STRUCTURE

Both the Tamar (graben) trough and the Port Sorell trough are fault controlled structures. The other areas of extensive Cainozoic sedimentation are merely spill-overs from the troughs, partly accumulated in pre-basalt deep leads. Carey (1947) first described the close relationship between faulting, sedimentation and volcanism in the Launceston trough, which he regarded as a graben. Longman (1966) developed this idea, but considered the Launceston Basin to be a fault wedge structure involving regional south-east tilting of the Permo-Triassic rocks, and NNW-SSE faulting with the down-throw to the south-west.

The Tamar trough in the Beaconsfield Quadrangle is clearly a symmetrical graben. The Permo-Triassic rocks on each side dip gently but uniformly towards the trough. To the east, the Permo-Triassic rocks dip off the structural high of the Mathinna fold belt, and to the west dip off the high of the Precambrian fold belt. Two elongate remnants of the Jurassic dolerite sill that caps the Permo-Triassic rocks mark the confines of the graben. The two main faults are recognised by the steep palaeoslopes against which the Tertiary sediments were deposited.

Sutherland (1971) recognised that the half-graben of the Launceston trough changes northward into a graben near Rosevears (9 km south of the Beaconsfield Quadrangle). This change corresponds to the southern termination of the Asbestos Range structural high. This shows that the direction of Tertiary faulting is controlled by the 'grain' of the Palaeozoic and Precambrian basement, and suggests that the Tertiary basins are located by fragmentation of the basement along the boundaries of major structural provinces.

Block faulting is more in evidence in the Port Sorell trough, although here there is not the same clear relationship between faulting and sedimentation. The major fault directions are NNW-SSE and ENE-WSW. Regionally, the Port Sorell trough occurs on the eastern side of the Mersey graben (Burns, 1965, p. 201). The NW-trending fault that can be intermittently mapped along Port Sorell Inlet, throws the Cambrian and Permian sequences together. This is probably the easternmost fault of the structure. The Permian rocks dip gently, but uniformly south-west, away from the structural high of the Asbestos Range.

QUATFRNARY

Recent and Pleistocene deposits are distinguished by their complete lack of consolidation and their intimate relationship to the present cycle of erosion and deposition. Strictly speaking Quaternary deposits are present over much of the area, but their inclusion on the map is determined by whether they form a geomorphological unit obscuring the underlying geology, that can be represented conveniently at a scale of 1:63,360.

River alluvium and marsh deposits (Qa)

This unit includes the silt, sand and clay on the flood plains of streams, the estuarine mud and silt of the Tamar and Rubicon Rivers, and the humic muds that accumulate on the low-lying poorly drained coastal areas.

Beach and active dune sand (Qbd)

The coastline is characterised by a series of beaches up to 9 km long, separated by rocky promontories. These beaches have a longitudinal sand ridge at the back of the beach, which feed easterly trending blow-out dunes. The beaches do not usually represent old persistent features, so that the sand dunes encroach upon older Tertiary deposits rather than on stranded beach ridges.

The beaches are predominately composed of quartz grains and between 0.5 and 3% of heavy minerals. Local patches of highly concentrated heavy minerals occur in the tidal zone east of Five Mile Bluff [822462]. Fractions of over 90% of garnet, zircon, ilmenite, rutile and topaz occur.

Stabilised beach ridges (Qbr)

A series of parallel, sparsely vegetated beach ridges lie behind the present beach line at Bakers Beach and at Greens Beach. These represent older beach ridges related to a receding strand-line, and may be Pleistocene in age.

Reworked silt, sand and clay (Qs)

The alluvial deposits, particularly on Cimitiere Plain, pass into veneers of unconsolidated silt, sand and clay. Although this material usually overlies Tertiary sediments, from which it is derived, it also obscures Tertiary basalt, Permian rocks and Mathinna Beds.

A similar reworked type of deposit (Qp) but with rounded exotic pebbles of granite, porphyry, quartzite, conglomerate and schist occurs in several places along Cimitiere Creek and the upper reaches of the Curries River. These deposits lap on to the southern limit of the Mathinna Beds and result from weathering and local transport of the pebbly layers of the Lower Permian sequence.

Windblown and locally derived sand (Qw)

Unconsolidated sand forms a broken blanket over much of the low-lying areas east of the Tamar Estuary. On the Cimitiere Plain it occurs as E-W linear ridges separated by linear depressions occupied by silt (Qs) and occasional basalt rubble. These structures represent old longitudinal sand dunes formed by the prevailing westerly wind, that have ceased to move due to removal by erosion of source material and the growth of vegetation. They are being eroded by the present-day streams. A granule sand variety occurs on the seaward (westward) edge of the linear system at Cimitiere Plain. This may represent the fossilised winnowed fraction of the dune system.

Similar but smaller deposits occur on the West Tamar in the coastal area between West Head and Badger Head. These have a linear trend in an ESE direction and extend inland for nearly 6 km. They are vegetated and are cut by the present day drainage system, and are being overridden by the present-day dunes coming from Badger Beach.

Talus deposits

Talus deposits of various degrees of stability and various origins occur. Basalt talus (Qtb) is common in the Hillwood area where it results from the under-cutting in the Tertiary clays and consequent land slipping. These are the most recent deposits. Dolerite talus (Qtd) occurs as a distinct unit on the northern slopes of the Tippogoree Hills. It contains both fresh and weathered fragments, and the slopes are well vegetated with established timber.

ENGINEERING GEOLOGY

P.C. Stevenson

LANDSLIPS

The Tertiary sediments and associated basalts of the Tamar Valley are subject to landslip on slopes of more than about 10°. This problem has been recognised for many years (Friend, 1848) and has had an impact on development.

The phenomenon of landslip occurs where soft plastic clay, eroded into steep slopes is acted on by water which has been concentrated either by natural springs or by human agency. The basalts commonly cause a spring line and so the clay/basalt association is important. Human agency is of course more marked in settled areas and written accounts have dealt mainly with landslips as hazards to settlements.

Landslips commonly take the form of rotational slumps or block glides* in plastic clay with subsiding sand and basalt. In this phase, back tilting often induces disturbance of drainage and ponding. This leads to a second phase marked by lateral spreading failure of the slip foot and a slow overturning earthflow at the toe. Marked horizontal tension has been noted in most house failures.

Many of the salient features of the landslip process are exemplified by a quasi-natural slip in open country 2 km north-west of Batman Bridge. A notable group of uncontrolled landslips is to be seen along the shore south of the Comalco plant at Bell Bay, and the wharf area at Bell Bay (Skeats, 1922) and its railway access has been constructed in the knowledge of a similar problem.

Jennings (1964*a*) indicated the size and nature of the Beauty Point landslip and gave a map and section. He also proposed an area of restricted building which was afterward codified in the *Beauty Point Landslip Act 1970*. This Act, modelled on the *Lawrence Vale Landslip Act 1961* gave restricted compensation to persons whose houses were destroyed by earth movements.

Subsequent reports have dealt with landslips at Beauty Point (Jennings, 1971; Stevenson, 1973*a*), a hazard at George Town (Stevenson, 1973*b*) and a landslip at Deviot (Stevenson, 1971), the last being the subject of an extension of the Beauty Point Act as the *Beauty Point Landslip Act 1971*.

The landslip problem is currently the subject of a detailed programme of investigation by the Department of Mines and reports are published from time to time.

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*For nomenclature see Varnes, D.J. 1958.

ECONOMIC GEOLOGY

A.J. Noldart
V.M. Threader

The area covered by the Beaconsfield map sheet contains a variety of mineral occurrences of which the most significant have been the goldfields of Beaconsfield and Lefroy. At Beaconsfield the Tasmania mine, closed since 1914, remains the largest single producer of gold in Tasmania with a recorded production of some 26 580 kg. At Lefroy the largest producer was the New Pinafore mine with a production of 1570 kg of a total of nearly 5200 kg from this area.

Comparisons with other gold producing districts in Tasmania show productions of over 8400 kg from Mathinna, 19 900 kg from the Mt Lyell copper mines and 16 080 kg from the Rosebery-Mt Reid lead/zinc complex. Gold production from the last two areas is as a by-product from base metal mining.

Some of the earliest known mining activities in Tasmania, with the exception of some coal mining and the extraction of stone for building purposes, were based on the pisolitic hematitic iron ores at Andersons Creek, and the production of burnt lime for agricultural requirements.

Current mining activities are restricted to the extraction of detrital silica from the western slopes of Cabbage Tree Hill for the manufacture of silico-manganese and ferro-silicon, the exploitation of sand and gravel for construction purposes, and the treatment of small quantities of silica sand from Port Sorell for the moulding industry.

Prospecting and exploration is currently being carried out to determine the feasibility of reopening the Tasmania gold mine; to determine the potential of the asbestos deposits at Andersons Creek; and to treat detrital chromite deposits in the same locality.

HISTORY AND PREVIOUS INVESTIGATIONS

The earliest reference to mineral occurrences in the Beaconsfield Quadrangle was by the then Surveyor General G.W. Evans (1822) when he reported:

'Within a few miles of Launceston there is a most surprising abundance of iron. Literally speaking there are entire mountains of this ore, which is so remarkably rich that it has been found to yield 70 per cent of pure metal. These mines have not been worked;...'

The occurrence of the iron and other mineral deposits however, were known almost from the start of the settlement at York Town in 1804. F.G. Duff (1888), in an article reprinted from the Launceston Examiner reported:

'...in 1804 Colonel Paterson...formed the first settlement in northern Tasmania, and founded the township of York Town...The deposits of iron ore, sandstone, asbestos, and serpentine in the vicinity of York Town were soon discovered...'

Later attempts (1872-1875) to produce commercial iron from these and other deposits were not successful.

The utilisation of limestone and other calcareous deposits in the district was apparently one of the earlier mining activities, but there is no information available on these activities except comments by Gould (1866) to the effect that '...the lime which has been for many years past an article of export from the district.'

'The blue limestone has been worked for many years past, and in several localities.'

'The calcareous bands found by the existence of these fossils are in places sufficiently important to be working as sources of lime; and at various periods kilns have been in operation in the district for that purpose.'

The earliest reference to gold discoveries is also by Gould (1864) when he stated:

'Gold has, indeed, been found in small quantities at many points throughout the district, and in some instances the character of the gold has been such as to indicate its source near at hand...Among the places in which gold has already been obtained may be enumerated..., Nine Mile Springs,...'

Nine Mile Springs was the early name for a small township near Lefroy. The major producer in the district, the Tasmania mine, was not discovered until 1877.

Other mineral occurrences to be exploited on a limited scale are the asbestos deposits at Andersons Creek; serpentinites from Andersons Creek for terrazzo requirements; ochre from Andersons Creek for paint manufacture and gas purification; leached sandstone from Brandy Creek for the manufacture of sandsoap, etc., and small amounts of white clay for pottery manufacture.

In more recent years attention has been focused on the possibility of utilising pyritic shales at Port Sorell as a source of sulphur; residual clays overlying the serpentinite at Andersons Creek for nickel and cobalt; and on the search for heavy mineral concentrations in Recent coastal deposits.

Gravel and sand deposits have been worked for many years, mainly for road repairs, but construction demands in recent years have created a major industry operating over large areas.

All old mine openings are collapsed or in a general state of disrepair, most other workings obscured by scree and regrowth, and reports by early workers form the only source of information on these workings. Miscellaneous reports by Thureau (1882, 1883*a*, 1883*b*, 1884), Montgomery (1891, 1896, 1897) and Twelvetrees (1900, 1902, 1903*a*, 1903*b*) contain the basic data used by later investigators on the Beaconsfield, Salisbury and Lefroy goldfields; and a report by Just (1891) outlines the history of the iron deposits.

Examinations were later carried out on the asbestos deposits by Twelvetrees (1917) and Reid (1919) during a resurgence of interest in these deposits and by Broadhurst (1935) in the Lefroy district. There are numerous reports by other workers on specific mines or prospects, by officers of the Department of Mines made in the course of mineral resources investigations, and by mining and exploration company personnel.

With respect to the older mining ventures the authors have relied entirely on the earlier reports. Some sections of these are quoted without change in order to retain the original writer's concepts on specific aspects as pertaining at the time they were written.

Metallic minerals

GOLD

Gold has been the only mineral produced from the area in significant economic quantities. By far the greatest production has been from the Tasmania line of lode in the Beaconsfield goldfield, with moderate production from some of the mines in the Lefroy goldfield notably the Pinafore, Chum, Volunteer and Native Youth lines of lode. Minor production is recorded from other lodes in these districts and from the Salisbury area. Minor amounts of gold have also been recovered from small Tertiary to Recent detrital deposits in the three districts.

Production

There is no complete record of production during the early days of mining in Tasmania, particularly where detrital gold deposits were exploited. This is marked in the goldfields lying within the Beaconsfield map sheet, where the only information available is a comment by Commissioner Bernard Shaw (1873) where he stated, in reference to the Lefroy field, that 'the value of the gold found in alluvial deposit during the year 1872 was £8000.'

Nothing is known of production from other centres but although the deposits were significant in holding prospectors in the fields the deposits were too small to have contributed anything but a very small proportion of the overall production.

Production from lode mining was better documented through mine managers' reports etc., particularly for the larger mines, but many of the smaller mines of the early period have no recorded production. From descriptions of the underground workings by early investigators it is unlikely that any significant amount of gold was recovered from these workings.

The following table lists gold production data from the main reefs and lode formations in the Beaconsfield and Lefroy goldfields.

Goldfield	*Reef or Lode Formation*	*Production kg*	*Mining Commenced*	*Mining Ceased*
Beaconsfield	Tasmania	26 580	1877	1914
Lefroy	New Pinafore	1 712	1890	1896
Lefroy	Chum	1 313	1881?	1896
Lefroy	Volunteer	1 277	1891	1904
Lefroy	Native Youth	749	1877?	1888
Lefroy	New Golden Point	60	1881?	1903
Lefroy	Morning Star	37	1883	1903
Beaconsfield	Moonlight-Cum-Wonder	32	1898	1903
Beaconsfield	North Tasmania	31	1898	1911

The production figures for the Tasmania and New Pinafore lodes include production from retreatment of battery sands etc., after the cessation of mining activities.

There is a total recorded production of 49 kg gold from a number of other small mines in the Lefroy field.

BEACONSFIELD GOLDFIELD

The Beaconsfield goldfield lies 39 km by road northerly from Launceston and 3 km west of the Tamar estuary. The main deposits were found immediately west of the Beaconsfield town site on the eastern flank of the Cabbage Tree Hill. Several smaller deposits were found to the north-west and south-east along a narrow belt centred on the crest of the ridge line of the Cabbage Tree Hill. Further to the south the extension of this ridge forms the Blue Tier ridge with the Salisbury goldfield located at its southern extremity.

All the workings are inaccessible with the exception of the Garfield adit on the west flank of the hill. Remnants of the surface works of the Tasmania mine such as the remains of chimney stacks, massive concrete surrounds of the Harts and Grubbs shafts, and the still standing brickwork of the winding houses and boiler rooms servicing the shafts form a prominent landmark in the town and have become a focal point for tourists.

History

Reef gold was first discovered high on the eastern flank of the Cabbage Tree Hill by the Dally brothers in 1877. This find stimulated interest in the area resulting in the tracing of the initial discovery downslope, and the location of other small occurrences along the crest of the ridge to the north and south.

Numerous mining companies sprang into existence including the Tasmania Gold Mining Co. (on the original discovery), the Golden Gate Gold Mining Co., and the Florence Nightingale Gold Mining Co., on the line of the Tasmania reef and the Lefroy Gold Mining Co., exploring immediately to the east of the Florence holdings.

Along the crest of the ridge discoveries were made by the Moonlight and Little Wonder Gold Mining Companies to the north of the Tasmania find, the Garfield further north, and the Dundee and Excelsior (Brandy Creek mines) to the north of Brandy Creek. To the south prospecting by the Phoenix, Leviathan, Cosmopolitan and Rising Sun companies disclosed further small auriferous quartz reefs.

The Tasmania and Golden Gate companies merged shortly after the commencement of operations followed in 1888 by the further amalgamation of these mines with the Florence Nightingale and Lefroy companies with the object of a combined effort to control water intake into the mines. A later reorganisation of the group resulted in the formation of the Tasmania Gold Mining and Quartz Crushing Co., under which name the mine operated until its closure.

During this period surface prospecting and underground development of the Florence mine indicated the presence of a deep extensive channel infilled with clays and gravels occurring to the east of the mines. The potential of this channel was recognised early and several efforts were made to explore and mine detrital gold contained in the sediments. The Ophir, Denmark and later the Ballarat companies were the main groups but extremely hazardous mining conditions and heavy water intake resulted in the failure of all attempts at deep mining.

Exploration and mining on the smaller properties continued sporadically but by 1891 virtually all operations were dormant with the exception of the Moonlight-cum-Wonder amalgamation. The discovery in 1898 of the North Tasmania mine revived some interest but closure of these two mines came in 1903 and 1911 respectively.

The end of the mining industry at Beaconsfield came with the closure of the Tasmania mine in 1914. Retreatment of battery sands and tailings from the Tasmania Gold Mining and Quartz Crushing Co. treatment plant continued for several years after the cessation of mining. These sands are currently under investigation for potential economic extraction of gold residues.

Subsequent activities were restricted to prospecting of localised detrital deposits by individuals and small syndicates with little attention paid to deeper exploration until 1962 at which time the Department of Mines commenced an investigation into the auriferous potential of the Beaconsfield district.

Surface investigations and extensive literature research failed to indicate any near-surface prospects but suggested that a potential economic ore body could exist below the bottom levels of the Tasmania mine, and a deep exploratory diamond drilling programme was instigated in 1964 and completed in 1967.

Significant auriferous mineralisation was intersected but low gold prices deterred private company expenditure on the prospect. The area was later released to Allstate Explorations N.L. for further investigations. Two diamond drilling programmes were completed with the further intersection of significant mineralisation in the second programme. Investigation of the prospect is continuing.

Lode Deposits

Tasmania Mine

Discovered in 1877, the Tasmania auriferous quartz reef remained in production until 1914 at which time the economics of mining forced closure of the underground workings. Subsequent operations were concentrated on the retreatment of mine tailings dumps until the final plant shutdown in 1924. Overall production from the Tasmania reef, inclusive of tailings retreatment, was 26 580 kg of gold from 1 084 690 t of ore, for an average gold recovery of 24.7 g/t. The gold won was valued at £3,613,000 of which £772,072 was distributed in dividends to shareholders. No dividends were paid after 1903 when the mine was taken over by a company based in England.

The underground workings are now inaccessible and the following information has been obtained from old literature. The main references are those by Thureau (1883*a*), Montgomery (1891), Anon. (1898), Twelvetrees (1903*b*), and Cundy and Fawcett (1914).

Closure of the mine was due to a combination of factors involving fall in grade, economics associated with depth, increased metallurgical problems, excessive water intake etc. It was reported (Hudson, 1923) that in 1913, the last year of normal mining and development, almost 86 400 *kl* of water was raised from the mine and it was estimated that an additional 313 300 *kl* would be encountered for each metre of extra sinking undertaken.

In the latter stages of the life of the mine employer-employee relations deteriorated rapidly and, with closure of the mine in April 1914 by the management, the then Government of Tasmania assumed control of the mine in an endeavour to avoid a shutdown. On the employees' assurance that mismanagement was mainly responsible for the projected closure the Government then subsidised a tributing party of about 150 mine employees to continue mining activities. The mine was reopened in June 1914, but the venture proved unsuccessful and final closure occurred on 21 November 1914.

The workings. Underground mine plans, cross sections and longitudinal sections of the mine are available at the Department of Mines and a full description of the underground workings is not considered warranted here. Briefly, the Tasmania reef was worked from the surface to about 145 m from the 'Golden Gate' and 'Florence Nightingale' shafts. Subsequent to the amalgamation of the original companies, mining activities were extended to 450 m by a succession of deeper shafts: namely the 'New Main Shaft' (300 m) 'Hart's Shaft' (420 m), and 'Grubb's Shaft' (450 m). The last named shaft was sunk partly in the deep lead and, due to movement in this section, was later restricted to use as a general service shaft. All heavy haulage operations were directed through the more stable 'Hart's Shaft'.

Stoping was consistent over the full 395 m of the orebody to a depth of 380 m but below that level the stoping limits, as indicated on the longitudinal sections, were progressively reduced on the 1375 foot (420 m) and 1500 foot (450 m) levels to a final stope length of 290 m. This sharp reduction in stope length is due to the economics of mining at depth and does not represent an actual decrease in the size of the orebody (Cundy and Fawcett, 1914).

The orebody. The Tasmania reef is a fissure reef striking about N50°E with the quartz emplaced on a pre-existent fault zone. The movement on the fault is shown on old plans as about 30 m north side east. The reef has been itself displaced by two major fault zones and numerous smaller movements. The major faults were termed the 'main cross course' (easternmost fault) with a strike of N30°W dipping steeply south-west and No. 2 fault striking N45°W also dipping steeply south-west. East of the 'main cross course' the reef maintains a fairly constant strike of about N50°E with a slight swing to N45°E west of the fault. The reef in these sections of the mine transgresses almost all units of the previously termed Caroline Creek Sandstone sequence and lies entirely within that succession. The overall dip of the reef here is about 50-55° SE and the two sections are obviously dislocated portions of the same reef.

West of the No. 2 fault, however, the reef as mined shows a marked swing northerly to about N55°W with a dip to the south-west. This section of the mine lies entirely within the massive conglomeratic quartzites underlying the above sandstone sequence of the Cabbage Tree Formation. The sharp swing in strike together with a marked change in the mineralisation pattern and strength has raised strong doubts as to this section actually being the western continuation of the Tasmania reef. The orebody in this portion of the mine proved to be inconsistent and very 'bunchy', ranging in size from mere threads to lenses up to one metre in width. Mineralisation was weak, with values considerably lower than in the main Tasmania reef, and mining operations were only continued to about the 100 ft (30 m) level.

Movement on the 'main cross course' appears to be west side north with a displacement of about 70 m on the orebody. However, a simple lateral movement cannot fully explain the displacement as the enclosing strata appear to have been displaced by some 300 m as distinct from the smaller movement in the orebody. It is apparent that a considerable west side up movement has occurred with a lateral component of about 150-180 m. A similar type of movement appears to have occurred in the 'No. 2 fault' but the displacement here cannot be ascertained due to the doubtful identity of the reef mined west of this fault.

A comprehensive discussion of the effects of the faulting on the Tasmania reef and an outline of the possible positions that the reef could have assumed west of the 'No. 2 fault' are given by Montgomery (1891).

The main Tasmania reef has an overall length of about 395 m. The strike averages N50°E with a dip of 50-60° to the south-east. Stoping outlines as shown on the mine longitudinal sections and plans indicate an overall plunge of the orebody to the north-east at 55° with individual shoots within the orebody also trending north-east but with shallower plunges ranging from 35° to 50°. With the overall plunge indicated, the 90 m of main reef lying to the west of the 'main cross course' at the surface thus becomes progressively shorter with depth, finally plunging away from the between faults block at about the 180 m level. Below this level the entire stope length of the orebody lies to the east of the 'main cross course'.

The reef varies in width from several centimetres to more than 8 m in some lenses with an overall stoping average of about 2-2.5 m. Gold values in the reef are reported to have been fairly consistent along the length of each individual level but varied considerably with depth. From the surface to about the 400 foot (120 m) level an average grade of 38 g/t was maintained but average grades over the next 90 m dropped to about 25 g/t. Still further reductions in grade occurred with greater depth dropping to as low as 3.8 g/t at the 1370 foot (415 m) level. A considerable improvement to an average grade of up to 20 g/t over a stoping length of 285 m was reported from the bottom, 1500 foot (450 m), level.

Gold quality is also reported to have changed with depth, the gold obtained from the richer upper levels consisting mainly of free milling auriferous quartz, readily amalgamated. Changes in mineralisation below about the 400 foot (120 m) level showed the presence of pyrite, chalcopyrite, sphalerite, galena, etc., in increasing amounts with a considerable proportion of the gold intimately associated with the sulphides necessitating more specialised and expensive treatment methods.

Following studies and research by the Department of Mines in 1962-1963 (Noldart, 1964) a departmental diamond drilling programme was successful in three intersections (B4, B4A, B4B) of the ore body, some 75 to 90 m below the 1500 ft (450 m) level on the plane of the ore body. Details of this programme are given by Noldart (1968) and only the ore body is discussed here.

The ore body in each intersection was found to be composed of a quartz reef impregnated with sulphides in variable concentrations from very minor to dense, and containing visible gold in some sections. The sulphide mineralisation was predominantly pyrite with blebs of chalcopyrite and minor galena, sphalerite and arsenopyrite. Tetrahedrite has been recorded by previous workers but was not observed in the drill core. The main gangue was siderite and some country rock assimilation was evident.

The visible gold ranged in size from minute specks to flakes up to 2 mm scattered randomly in the core. The sporadic distribution is well demonstrated in intersection B4 where the gold content over regular 0.6 m assay intervals ranged from a low of 2.6 g/t to a high of 904.6 g/t. Most of the free gold sighted occurred in quartz carrying only minor to negligible sulphides with some specks noted in moderate sulphide concentrations.

Mine plans and sections show frequent 'splits' in the ore body as on the 1500 ft (450 m) level where a split has developed parallel reefs 12 to 15 m apart over a length of 100 m. Examination of the ore intersections shows an 0.5 m inclusion of country rock in B4, and a 3.3 m section of massive carbonate gangue in B4B suggesting the development of a strong hanging wall lode and a weaker footwall lode common to the ore body in the mine.

Composite assay values of the diamond drill intersections are as follows:

Hole No.	*Depth (m)*	*Au g/t*	*Ag g/t*	*Cu %*	*As %*	*Pb %*	*Zn %*	*Mn %*	*S %*
B4	514.8-520.0	92.14	7.19	1.06	1.49	1.10	0.80	0.49	7.5
B4A	512.1-519.5	64.44	10.10	0.91	0.43	0.03	0.16	0.36	4.9
B4B	525.3-528.9	41.02	16.84	1.10	0.05	0.10	0.03	0.39	3.58

Other mines

Moonlight-cum-Wonder mine. This mine comprises the old 'Moonlight', 'Little Wonder', 'Olive Branch' and 'Amalgamated West Tasmania' mines, all of which operated to some extent on the same line of lode.

Situated near the crest of the Cabbage Tree Hill, the mine was developed entirely in the massive conglomeratic black quartzites of the lower sections of the Cabbage Tree Formation. The overall strike of the orebody is N55°-60°W. The general dip is to the south-west although a reversal of dip is reported from the deeper levels in the northern section.

The auriferous quartz in these workings was not confined to one ore channel with occasional splitting of the reef, as was the case in the Tasmania reef, but was reported to have been distributed in a number of parallel or sub-parallel veins, often in broken ground and subject to rapid variation in size both along strike and down dip. In some areas, as in the 'Olive Branch' section, the veins were too small to be mined individually but were rich enough and numerous enough to encourage attempts at bulk open cut mining.

Generally good values were obtained in the older shallow workings to depths of about 75 m but values diminished rapidly below this depth. The orebody was tested to the 800 foot (245 m) level with exploration drives at the 400, 500, 600 and 800 foot (120, 150, 180 and 245 m) levels without success. The ore channels are reported as varying from threads up to 0.5 m in width with occasional lenses up to 2.75 m in thickness. Values did not improve with size of the reefs and were often reported as richer in the narrower zones. Thureau (1883a) recorded: "very rich 'shoots' of gold in the reef dip as from a common centre both east and west..." in the 130 foot (40 m) level of the 'Little Wonder' mine. It is probable that these are small saddle reefs reflecting one of the minor flexures in the strata of Cabbage Tree Hill.

The mineralisation pattern in these reefs is almost identical with that in the western section of the Tasmania mine and it is probable that the two reef systems are located on the same fissure zone.

Tonnage and grades of ore from these reefs are not available but records of the Department of Mines show a gross recovery of 32 kg of gold from these mines.

Smaller mines. Very little is known about the smaller mining operations in the district. Innumerable small shafts and costeans cover the eastern slopes of Cabbage Tree Hill but only a very small proportion of the smaller workings encountered payable reefs.

Travelling north along Cabbage Tree Hill from the Middle Arm Creek water gap the more significant of these workings south of the Tasmania reef are: The 'Rising Sun; mine immediately above Middle Arm Creek, and the 'Cosmopolitan', 'Leviathan', 'Bonanza', 'Star' and 'Phoenix' mines, all located on the eastern flank of the ridge. The 'Garfield' mine is also located on the eastern flank of the ridge but is north of the Tasmania reef towards the northern spur of Cabbage Tree Hill.

All these mines were designed to test possible occurrences of the 'Moonlight-cum-Wonder' type reef formations with but little success. Some minor copper/silver type mineralisation was encountered in the 'Rising Sun' mine, and small irregular auriferous reefs were encountered in the other mines. The gold values in each case were insufficient to encourage further exploration. The 'Phoenix' mine, although originally worked on a reef similar to the other small mines, was ultimately deepened to intersect the Tasmania reef to become part of the main workings.

Immediately to the north of Brandy Creek, on a low ridge extension of Cabbage Tree Hill, moderately payable gold reefs of the 'Moonlight-cum-Wonder' type were worked in the 'Brandy Creek' mine (Dundee and Excelsior mines) but again values did not persist with depth. A similar type mineralisation also occurred in the 'North Tasmania' mine located some 395 m further north along the strike.

These two mines appear to have been the only ones other than the Tasmania and Moonlight-cum-Wonder mines where payable gold mineralisation was encountered. Full records of production are not available but the North Tasmania is recorded as having produced 31 kg of gold.

As far as can be determined the mineralisation in all of the smaller mines was similar in all respects to that of the Moonlight-cum-Wonder reefs; *i.e.* surface enrichment in narrow, irregular quartz veins, rapidly diminishing in value with depth.

Detrital Deposits

The Deep Lead

The deep lead running along the eastern flank of Cabbage Tree Hill has been investigated by several shafts and drill holes. No records are available of any testing having been carried out on the true bottom of the lead although an attempt was at last report being made by the Ophir Gold Mining Company.

The last information available on this mine, (Twelvetrees 1903*a*), was that a shaft had been sunk to a depth of 123 m with the upper *c.*84 m sunk through the material of the deep lead. Levels were driven eastwards into the lead at depths of 90 m and 120 m. From the 400 foot (120 m) level a winze was sunk in the west wall of the lead to a depth of 18 m (138 m from the surface). A level was then driven eastwards from the bottom of the winze through 56 m of sandstone followed by some broken ground and finally limestone. This drive appears to be below the bottom of the lead.

Future plans to rise from this level into the bottom of the lead do not appear to have been put into effect.

All payable material obtained before 1903 appears to have come from the western wall of the lead, known locally as the 'high reef' zone, and from minor workings on false bottoms at intermediate levels. Both the western wall zone and a false bottom of 'black ligneous clay' at a depth of 34 m were reported to be 'fairly payable'.

Two bores sunk to bedrock through the deep lead by the Ophir Company were reported to give good values. Montgomery (1891) quotes a report submitted to the Company by one of the Directors, where he stated that the first bore to a depth of 114 m on the western wall, encountered:'...gravel containing gold at two ounces to load,...' at 73 m, and '...9 feet [2.7 m] of wash with gold at the rate of 4 ounces to the load.' In the second bore to a depth of 87 m in the eastern wall, 'about 12 feet [3.7 m] wash, giving returns at 2 ounces to load.' Montgomery then commented: 'If these results are reliable the richness of the lead would be phenomenal', but the term 'load' is not defined in the reports available.

Very little core was obtained in the course of the drilling and the above reported values can only be taken as indicative that the deep lead is auriferous in part, particularly in the lower levels.

Other portions of the lead were tested in the Tasmania mine adit (No. 2 level, 90 m of drive); the lower Cosmopolitan adit (125 m of drive); and from the No. 4 and 5 levels of the old Florence Nightingale workings at depths of 82 m and 100 m respectively. No payable values are reported from any of these workings but it is probable that any enrichment from south of the Tasmania workings would necessarily be weak, and that the level drives would be too far south to intersect any enrichment from the main Tasmania reef.

From the evidence available it appears that the main enrichment has been from the flanks of the Cabbage Tree Hill and north of the surface expression of the Tasmania reef. The deposits worked on the western wall required crushing indicating that the bulk of this material is merely eluvial detritus shed from the auriferous quartz reefs. This would suggest a fairly localised concentration of this type of material with finer alluvial gold dispersed throughout wash horizons.

Other alluvial deposits

Small deposits of alluvial gold have been worked along Brandy Creek downstream of the Brandy Creek mines and on the flats to the east of the townsite but all occurrences are small and of little economic value.

Other deposits worked on the east flank of Cabbage Tree Hill north of the surface outcrop of the Tasmania reef occur as fillings in depressions and embayments in the hill slope and are probably perched remnants of a higher level of deep lead fill most of which has since been removed by erosion.

Ore Prospects

Tasmania Reef

Unfortunately no geological information is available on the Tasmania reef after 1903 so that nothing is known of the limiting factors controlling the extremities of the orebody at depths below about 210 m. A summary of such information as is available to that depth is given below.

On the eastern end the Tasmania reef is reported to have feathered out into a series of thin stringers on entering brecciated zones in the previously titled Caroline Creek Sandstone close to the footwall of Gordon Limestone Correlate. Twelvetrees (1903*b*) discussing the 700 foot (210 m) level, wrote as follows:

'Behind the limestone, conformable with it and underlying it, the level passed through a bed of dense, tenacious clay...This clay band is known in the mine as 'the dyke'. Westwards it merges gradually into a zone of what can best be described by the term 'broken formation', or 'broken country'. This consists of sandy material showing lines of false deposition, and containing angular fragments of sandstone, giving place to the west to more solid shattering and disintegration *in situ*. Hard blocks of sandstone are met with, having the sandy material between them for a length of about 60 ft [18 m]. It is noteworthy that the reef in this section of the level became irregular, splitting and jumping up and down. The reef tails out just where the broken formation begins; its track goes into the broken *[sic]* for a little way and then disappears.

In the level above the 600 feet [180 m], the reef behaves in the same way when the broken country is entered'.

And further with reference to the 700 foot (210 m) level, the deepest then being worked, he recorded the following:

'The actual appearance of the reef in the east end of the 700 foot [210 m] level is sufficient to cause anxiety. It feathers out when entering the broken country. It has no appearance of having been sheared off by a fault, and there is no track or channel in the limestone'.

The limiting factor on the eastern end of the orebody down to the 700 foot (210 m) level is evidently lack of continuity of the reef through zones of brecciation and it is probable that similar conditions restrict the orebody at depths below that level. Longitudinal sections of the mine do in fact show a marked steepening of the eastern stope limits between the 700 foot (210 m) and 1250 foot (810 m) levels suggesting that the bounding control at this end of the orebody is structural and not lithological.

On the western margin of the orebody a different set of conditions exists. As mentioned previously the western extension of the Tasmania reef past the 'No. 2 fault' is questionable, but from the information available it is doubtful if the main Tasmania reef as such ever extended any distance into the up faulted members of the conglomerates and black quartzites west of the fault. It is apparent from the longitudinal sections that the western limit of the Tasmania orebody fairly closely follows the attitude of the bedding planes of the country rocks. At no stage were the workings continued into the underlying conglomerates and black quartzites, the mineralisation dying out on all levels at a point where it could be expected to approach these beds.

It would appear that conglomerates and black quartzites are not in themselves very favourable to ore deposition and that they have acted as a bounding influence on the western limits of the orebody.

Montgomery (1891), with reference to the country rocks, made the following observations:

'The Tasmania reef has been auriferous throughout all the strata traversed by it. The richest stone is found in a number of distinct 'shoots' or 'chutes',....Outside of the 'shoots' however, the quartz has been generally payable...The strata that have proved 'favourable country' for gold in the mine may be said to be all those between the lower beds of grits and conglomerates and the main limestone bed...In the mines on the Moonlight line of reef rich stone has been got in the upper levels of all, and as long as the quartz was found in the light coloured grits and sandstone, but on getting down into the black country the stone has become unpayable in every case...'

The inconsistency of the reefs in black quartzites and conglomerates is due in a large measure to the relative competencies of the beds involved, resulting in poorly defined fissures in the harder beds with the development of multiple fracture patterns and consequent dispersal of mineralisation along a number of more or less poorly defined channels.

These rocks then cannot be considered as offering good prospects for extensive gold mineralisation.

With regard to the Tasmania mine at depth, it is known that good values recurred on the bottom 1500 foot (460 m) level, over a stoping length of about 285 m. Whether or not this represents the true length of the orebody at this depth or whether the orebody continues to maintain an overall length of about 400 m is questionable, but the possibility must be considered that the restriction indicated on the mine plans is due to economic limits rather than mineralisation limits. If so, a good gold prospect lies below the present known workings with good chances of permanency with further depth.

If, however, the bounding controls of lithology on the western limits and country fracturing on the eastern limits, continue to control the orebody at depth, then the limits of the orebody below the 1500 foot (460 m) level could be expected to contract fairly quickly with depth. Any such contraction would greatly reduce the potential of the orebody, possibly to the extent of unpayability.

Other mines

The prospects of the smaller mines on the field are not promising. The Moonlight-cum-Wonder reef system was fairly extensively prospected during the life of the mine, particularly at depth, with no success. Too little is known about other mines such as the North Tasmania and Brandy Creek mines, to be able to suggest any exploration programme, and the still smaller mines such as the Leviathan, Cosmopolitan, etc., are too small to warrant testing. Any mineralisation on this belt would be small and patchy and restricted to near surface depths. The best exploration for this type of mineralisation would be surface costeaning over large areas, a method commonly used by early prospectors in the district.

Two mines not previously mentioned due to their position are the 'East Tasmania' mine and 'Dally's United' mine. Neither of these mines were active producers but were sunk as prospecting ventures attempting to intersect any extension of the Tasmania reef east of the Gordon Limestone correlate. Should the line of fissure persist east of the Gordon Limestone correlate, then comparatively small 'shoots' of ore could occur in the sandstone members of the succession overlying the Gordon Limestone correlate, but any mineralisation found would be repetition on a small scale and not a continuation of the Tasmania orebody as such.

Some small quantities of 'alluvial' gold may still be won from the thin Tertiary gravel beds on the lower slopes of Cabbage Tree Hill, and on the plain east of the Beaconsfield township, but large accumulations cannot be expected.

SALISBURY DISTRICT

The Salisbury goldfield is situated at the southern end of Salisbury Hill 6 km SSW of Beaconsfield and is in effect an extension of the Beaconsfield goldfield. There is no information on the discovery of the field except for the comments by Duff (1888, p.3) suggesting that very little time elapsed between the discovery of the Tasmania reef and the deposits at Salisbury.

By 1883 the Victoria workings had been completed after driving an adit 185 m into the east flank of the hill and a further 180 m northerly along a lode formation and all mining had ceased. A short revival of interest occurred in 1893-96 with further work in the Victoria mine and on sluicing operations at the nose of the southern spur but the field again became dormant until the sinking of the Salisbury shaft in 1903.

The main workings were the Salisbury, also known as the Victoria; and the Duchess of York, also called the Gladstone and Santa Claus, mines. Both mines were explored by a combination of shafts and adits from the eastern flank of the ridge. The workings are roughly in the same position respective to the strata as the Cosmopolitan mine on the eastern flank of Cabbage Tree Hill. Some open cut, hydraulic sluicing workings are located in the nose of the southern spur of the ridge.

The mineralisation in these mines differs markedly from that of the Cabbage Tree Hill mines in that the majority of gold occurrences in the near surface workings occurred as 'coarse lumps of gold' and 'patches of free gold met with in sugary quartz and soft seams of pug'. In several instances the gold had a superficial coating of black manganiferous oxides giving rise to the so called 'black gold' of the locality.

In the deeper levels of the adits all the gold was reported to be intimately associated with sulphide mineralisation. Occurrences of nickel and chromium minerals are recorded from the main adits closely associated with an intrusive body of basic rock.

High grade concentrations or 'pockets' of eluvial/alluvial gold occurred in the talus on the cresh of the south spur and in the talus/alluvium admixture at the foot of the spur. Gold values in these deposits was also reported to be extremely 'patchy' with high grade pockets interspersed with large areas of almost barren material.

No production figures for the Salisbury district are available.

LEFROY GOLDFIELD

The Lefroy goldfield is situated 40 km north of Launceston, and 15 km east of George Town. Some 30 auriferous formations occur in the field the majority occurring en echelon in a NNW-trending zone 4 km long centred on the township of Lefroy.

All the workings are inaccessible and the only evidence of mining is the old dumps, remains of foundations and collapsed shafts.

History

Gold was known to occur in the Lefroy district prior to 1864 (Gould, 1864) and possibly as early as 1853. Reef gold was first discovered at Specimen Hill by S. Richards and party in 1869 resulting in the opening of the Reward mine. Further prospecting soon located the eastern extensions of the Land-O'-Cakes and Volunteer reef systems and the township of Nine Mile Springs sprang up centred on these workings. Later prospecting to the west and north resulted in the discovery of the Golden Point and Native Youth orebodies and the township of Lefroy grew around these mines.

The field had a history of sporadic activity as the gold on each new discovery was exhausted. The early finds were soon worked out and the field lapsed until the discovery of the Chum, Golden Era and extensions of the Land-O'-Cakes orebodies in 1880 but again gold values declined sharply at about 120 m and 1884 the field again collapsed.

The discovery of the Pinafore and reopening of the Volunteer in 1890-91 revived interest and by 1895 some 20 companies were working in the Lefroy field, the main producers being the New Pinafore, Volunteer and later West Volunteer mines. A further slump in 1896 saw the New Pinafore and Volunteer mines engaged in deep sinking and exploration to depths of 380 m with little success except for occasional isolated patches of pyritic ore carrying high gold values but too small to sustain mining operations.

Altogether about 50 mines operated in the area on some 30 lines of reef but in no case did payable values extend in depth; a general cut out occurring about the 120 m level or shallower on the smaller mines. Total production from Department of Mines statistics has been estimated at 5170 kg of gold, mostly prior to 1900 with only 230 kg recovered since that date. An estimated 155 kg has also been recovered from alluvial deposits.

Previous investigations

The area was first examined by Thureau (1882, 1883*b*) who recommended deep drilling on the main lines of lode. Montgomery (1897) after an extensive study also recommended prospecting at greater depths in the existing mines.

The deep development of the Volunteer mine was examined by Twelvetrees (1900) to the depth of 380 m and, although no payable lode was found below 140 m, recommended still deeper prospecting. Twelvetrees (1908) later drew attention to the possibility of gold occurring in the district between the Lefroy and Back Creek goldfields.

Nye (1925) examined the Golden Zone mine but no major work was carried out until Broadhurst (1935) undertook a general survey of the field. This investigation drew attention to the possible importance of the sub-basalt deep leads.

Hughes (1953) later summarised the known information on the area but again no work was carried out until Groves (1965) made a detailed study of the area to determine prospecting targets.

Diamond drilling was carried out by the Department of Mines on the deep leads in 1883, 1892 and later in 1935 (Blake, 1938), and a series of 23 holes was drilled in 1935-37 mainly on reef targets at depths ranging from 37-245 m.

Lode Deposits

Groves (1965) fully described the deposits and his descriptions are given below:

'The extent and formation of the gold-bearing lodes have been discussed previously. The fractures can be traced on the surface for about 1.5 km and proved continually to a depth of 380 m*. The gold, however, is limited in economic quantities both laterally and at depth although present in trace amounts throughout the fractures.

The gold is generally associated with vughy quartz on the footwall and/or hanging wall of the fractures. It is found in association with stibnite and cervantite, a mixed antimony oxide formed by oxidation of stibnite,

*Groves figures have been converted to metric units.

and more rarely with pyrite, chalcopyrite and arsenopyrite. Vitreous white quartz is common, particularly in fault zones and small fractures but is generally non-auriferous. The association of gold with sulphides was most clearly shown in the Clarence mine where free gold was extremely rare but pyrite assayed up to 673 g/t of gold. A small pocket of pyritic ore at the 800 foot (240 m) level in the New Pinafore mine is reported to have assayed 50.5 g of gold per tonne, and represents the only concentration of gold found below 120 m in the mines.

The predominant feature of the mining field is the consistent decline in gold values below the 90-120 m levels, and, in many of the smaller mines, the marked decrease at only 30 m, although quartz may fill the lode channel. The New Pinafore and Volunteer mines were extended to a depth of 370 m and 380 m respectively but yielded very little gold although the lode channel in each case was distinct. Gold values generally declined from about 30 g/6 in the upper levels to less than 3 g/t at depth.

The decline in gold values was attributed to a process of surface enrichment by Broadhurst (1935) who quoted figures showing a marked decrease in fineness, *i.e.* increase in impurities, of the gold with depth. Broadhurst calculated that at least 600 m of the upper lode must have been eroded and much of the gold from this lode carried down in solution to attain the gold values encountered between 0-120 m. This is dependent also on the relative rates of erosion and solution of the gold, the rate of the latter essentially being the greater. Broadhurst also suggested that the gold was precipitated from solution by the sulphides and that pyrite, which is fairly common in the lodes, formed ferric sulphate which was a solvent for gold. However, both Krauskopf (1951) and Cloke and Kelly (1964) have since shown that the solubility of gold is negligible except in acid chloride solution in the presence of a strong oxidising agent.

Surface enrichment of gold is poorly documented but examples given by Lindgren (1933, p. 859) indicate that there is little enrichment of gold in oxidised zones or as at Mt Morgan, Queensland, deposition of supergene gold occurs only in the lower part of the oxidised zone. Enrichment in gold values to the extent suggested at Lefroy does not appear to be supported by the literature. The presence of free sulphides and general absence of oxidised minerals other than cervantite in the upper levels is also unusual for an enriched zone, although decrease in quality of the gold with depth is usually indicative of increase in sulphides, as at the Tasmania Mine, Beaconsfield (Noldart, 1964). However, gold enrichment is not recorded from the upper levels at Beaconsfield although it is probable that surface oxidation has taken place. It would therefore appear that special conditions must have prevailed if surface enrichment has resulted in the recorded distribution of gold values at Lefroy.

Many of the lodes contained satisfactory gold values at the surface but were only worked at very shallow depths, presumably due to a rapid decline in gold values below 30 m. These include the Old Comrades, Perpetual, Equilla, White Pinafore, Welcome, Nugget, Australasian and McIvor, Prince of Wales, Brisbane, Tablier, Monkland, Windermere, Rifleman and Leefloyd Reefs. These were all described in some detail by Montgomery (1897) and Broadhurst (1935). A brief description of the larger mines and exploration carried out since Broadhurst (1935) is given below.

Chum Reef

The Chum Reef is one of the longest and most continuous reefs in the Lefroy field and consists largely of gold-bearing quartz with minor pyrite and stibnite. It has been worked to a maximum depth of 150 m and from the mine plans appears to have been stoped out almost continually over the explored length and depth. Three boreholes were drilled by the Department of Mines in 1935 to intersect the lode along its proved length at a depth of 240 and 275 m with very little success: 2.4 m of core at 250 m in No. 1 bore assayed 0.6 g of gold and 0.4 g of silver per tonne and No. 3 and 4 bores intersected only a trace of gold.

Pinafore Reef

The Pinafore Reef comprises a series of quartz veins in a wide fault zone, and is generally obscured by overlying Tertiary gravel and basalt. It has been worked extensively to a depth of 90 m with fair success. The reef was tested in depth by underground mining to 370 m, small pockets of fairly rich ore occurring at 240 and 330 m. Extensive driving and crosscutting was carried out at 370 m and five lodes were intersected, all proving unpayable. Small amounts of gold were found in the Pinafore lode at this level but were uneconomic.

Golden Era Reef

This reef has been worked to a maximum depth of 73 m where gold values were high in the east drive on the main lode. The auriferous quartz extended underfoot but the mine was closed due to water problems and lack of capital. Four boreholes were drilled by the Department of Mines in 1936-37 to intersect this lode at depths ranging from 53-106 m, generally with poor results. Borehole No. 11, however, intersected one metre of pyritic material at 101 m assaying 11.2 g gold and 10.4 g silver to the ton.

Clarence Reef

Broadhurst suggested that the Clarence Reef has been faulted to form two main branches, the North Clarence and South Clarence Reefs. The North Clarence Reef has been worked from the Clarence Shaft to a depth of 64 m and two small patches of ore stoped out to the east of the shaft. The gold was associated with pyrite which assayed up to 685 g/t. The South Clarence Reef has been worked from the East Clarence and Golden Heart Shafts to a maximum depth of 67 m. In the East Clarence Mine the main ore shoot pitches shallowly to the west and several good crushings have been taken from this shoot.

Morning Star Reef

This reef has been worked to a depth of 130 m in the Morning Star Mine. Satisfactory gold values were obtained to the east of the shaft in the upper levels and to the west in the lower levels. The available information suggests a west plunging orebody which became unpayable at the 420 foot (130 m) level. Four boreholes were drilled by the Department of Mines to intersect the orebody along the probable extension of the westerly plunge. Results of the drilling were not encouraging, borehole No. 4A intersecting the only gold recorded, which occurred in a zone 10 m wide averaging 0.75 g of gold and 0.26 g silver per tonne at a depth of 171 m.

New Native Youth Reef

The New Native Yough Reef was one of the richest in the field and included the City of Launceston, New Native Youth and Excelsior mines. The reef, a hard quartz lode, was investigated to a depth of 240 m. Stoping was carried out along its length to a depth of 120-150 m but below this the lode proved uneconomic. A few small patches of gold are recorded from the 800 foot (240 m) level.

Golden Point and Crown Reef

This reef is unusual as it trends NE. It is a short reef and occurs in strongly fractured siltstone and slate, with numerous irregular quartz veins. The longitudinal section of the reef indicates two near-vertical shoots of ore to a maximum depth of about 100 m. It is not recorded whether the reef was investigated at a greater depth.

Land-O'-Cakes Reef

This line of lode has been traced for nearly 1.5 km on the surface but was only worked to any extent in the Land-O'-Cakes Mine. It was stoped to a depth of about 60 m, exploration down to the 400 foot (120 m) level indicating a rapid decline in gold values. Four boreholes were drilled by the Department of Mines in 1938, three to test the lode at depth and one to test the western extension of the lode. A trace of gold was found in most of the boreholes but the results were not encouraging.

Volunteer Reef

The Volunteer Reef has been worked over a length of about 1220 m and lodes probably continuous with the reef have been cut over a greater distance. The main workings were the Volunteer, West Volunteer and East Volunteer Mines which worked the lode to a depth of about 190 m although the better gold values occurred above 140 m, with the richest ore between 70 and 90 m. The lode was explored at depth by underground mining to 380 m but only very small quantities of gold were found at this depth. The longitudinal section of the reef indicates a fairly shallow westerly plunge. A possible extension of the ore along this plunge was drilled by the Department of Mines in 1936-37, two boreholes failing to intersect any gold-bearing lode.'

Detrital Deposits

Diamond drilling in the Sludge Creek-Blanket Creek area indicated the presence of two main basalt flows separated by up to 15 m of sediments with a thickness of up to 27 m of sediments below the lower basalt flow. The sediments consist of gravels, sandstone and clay containing fossilised tree stumps and lignite. Depths of more than 95 m were indicated in the main channel by the 1937 drilling programme.

An apparent stream bank slope of 1 in 2 and the presence of huge boulders of sandstone described in mine workings by early investigators suggest that steep river gradients and gorge-like conditions were a feature of the early history of the Lefroy deep lead.

Tertiary leads

Several leads have been traced on the surface to the point where they appear to pass beneath the basalt, at which point the workings have generally been discontinued. The leads of this type include the Pinafore, Golden Point and Native Youth Leads.

The Pinafore Lead has been worked from just east of the Pinafore main shaft to where it passes beneath the basalt near the Lefroy Deep Leads Company shaft. Some coarse gold was obtained from the gravel. Broadhurst suggested that the gravel passes beneath one of the higher basalt flows, but with precipitous conditions existing it is possible that it passes steeply beneath the lowest basalt. A similar lead runs along the east side of Sludge Creek and again appears to pass beneath the basalt north of the Native Youth lode.

Sub-basalt leads

The basal lead beneath the earliest basalt flow has been worked from several shafts, generally on the western branch of the pre-basalt stream. The East Pinafore workings intersected gravel and clay on the western bank of the old stream bed and fairly high gold values were obtained in the gravel. The old stream bed was intersected in the Golden Era workings and very coarse gravel was found containing coarse gold and giving satisfactory pan prospects on the western bank. The stream bed was also investigated in the New Golden Heart workings where coarse gravel was intersected containing 20 g/t of alluvial gold, with subsidiary gold in vein-quartz pebbles and boulders. The Pinafore Company shaft, about 200 m north of the Morning Star Shaft, also intersected the old stream bed which was filled by at least 8 m of boulder gravel containing samples of free gold up to 3.8 g. In this mine, work proved unpayable due to the immense boulders which hampered mining operations. Alluvials were also investigated in the Morning Star Mine by the King Prospecting Association but no gold was found.

Diamond drilling of the deep leads has been largely unsuccessful, except in delineating the old stream beds. The No. 4 bore (1883) is reported to have intersected a basal gravel some 2 m thick which contained some gold. A further bore No. 4 (1892), was sunk 10 m south-east of the No. 4 (1883) bore but no gold was found. Two boreholes drilled in 1937 intersected gold-bearing gravel filling the old valley floor. Bore No. 14 intersected 76 cm of coarse gravel assaying 3.76 g/t gold at 80 m and Bore No. 16 a trace of gold at 90 m. Blake (1938) indicated that all the sediments below the lowest basalt were assayed for gold in the 1937 boreholes although the sediments between flows were not assayed.

The drilling results, although not very encouraging, indicate the presence of gold in the sub-basalt gravel. The prospects encountered in the workings where the alluvials were investigated were far better than those reported from the boreholes although mining conditions were difficult. This suggests that results from the old boreholes should not be taken as a true indication of the quantity of alluvial gold but rather as a guide to its presence.'

Post-basalt leads

In some localities gold-bearing gravels occur in present day streams and probably represent a certain amount of reworking of old Tertiary leads and Recent/Quaternary deposits.

OTHER OCCURRENCES

In 1889 Commissioner Glover of the Northern and Southern Division reported:

'Further discovery has been made during the past year of a gold-bearing reef, whilst a party were boring for coal, about 10 miles [16 km] west of Lefroy and four miles [6.4 km] from George Town. The borings obtained from this reef having given exceedingly rich prospects, a shaft has been sunk...'

The geology of the area where two gold leases were pegged in this locality in 1889 (cancelled in 1890) comprises Upper Palaeozoic rocks intruded by dolerite and it is likely that the mineral seen would be a pyritic mineral common in some Permian rocks.

No other occurrences of gold are known in the Beaconsfield Quadrangle except for minor quantities associated with the Andersons Creek iron deposits.

CHROMITE

The presence of chromite associated with the iron deposits at Andersons Creek has been known since 1872-73 when it was found to be a serious contaminant in iron and steel produced from the deposits. Chromates were also recognised in ochre deposits worked in the same locality prior to 1888 for the manufacture of paints and pigments.

No significance was attached to the occurrence of chromite until 1958 when investigation of the nickeliferous clays of the area was being undertaken by the Ben Lomond Mining Company. The presence of a chromite fraction in these clays was recognised as a potentially economic source of Cr_2O_3 and exploration was undertaken to attempt to locate payable concentrations of detrital chromite.

The chromite derived from the underlying serpentinous rocks of the Andersons Creek untramafic complex (see p. 32). The mineral mostly occurs as numerous small grains (up to 1 mm in diameter) in the serpentinite but it has also been noted in local concentrations in the form of veinlets up to 5 cm wide in the host rock. Occasional disseminations and thin bands of chromite grains also occur in the lower sequences of the overlying Ordovician sediments.

Exploration undertaken by the Department of Mines in 1961-1962 located significant concentrations of chromite in two distinct environments, *i.e.* Tertiary quartz gravel and Recent surface gravel and soil.

The Tertiary deposits occur as a remnant of a deep lead system capping a small hill on the east bank of Andersons Creek. The upper portion of the hill is covered with white quartz gravel ranging in thickness from a few centimetres to more than 6 m at the hill crest. Immediately below the gravels the ultramafic rocks have been leached to a compact, very plastic, greenish brown to brown clay. The chromiferous concentrations occur immediately above the clay surface extending upward into the lower gravel beds. The thickness of the chromiferous zone ranges from a few centimetres to about 2.5 m. A small chromite fraction up to 5% by weight is contained in the underlying clay. Preliminary investigations by Noldart (1963) indicated reserves of about 7500 tonnes Cr_2O_3 for an average thickness of one metre over an areal extent of 5-5.5 ha. Further sampling and exploration by Northern Chromite Pty Ltd upgraded the reserves to an indicated 35 000 t of 55% concentrate and a further inferred 6700 t of 55% concentrate.

Four main areas of surface gravel containing significant chromite concentrations were located south-east of the Tertiary deposits. They are located on the slopes of tributary drainage channels and range from 2.5 ha to 5 ha in extent. The gravels range from a few centimetres to one metre in thickness with an indicated chromite content of 5% by weight, average grade. Together the four deposits are tentatively estimated to contain a total of 6000 t of concentrates over an area of approximately 14 ha. Other small pockets may occur in this area and small occurrences at Simmonds Hill and Leonardsburg have not been fully investigated.

COPPER

Minor occurrences of copper are recorded in the Precambrian succession in the vicinity of Badger Head and Little Badger Head. In July 1876 A.W. Loane found specimens of chalcopyrite near Badger Head and in 1877 submitted a sample for assay which yielded 21.5% Cu. By 1878 exploration was being carried out on several prospects but most operations were unsuccessful.

Loane and party were reported to be investigating a lode one metre in width carrying ore 'of the peacock variety, however the prospect was under water at high tide and the venture failed. Duff (1888) stated 'at Badger Head one company spent about £11,000 in endeavouring to develop a copper lode...' but did not identify the company.

Copper is also associated with gold mineralisation in the district. The old Rising Sun mine above Middle Arm Creek at the southern end of Cabbage Tree Hill was reported to contain high copper values and in the Report of the Secretary for Mines for 1897-98, Commissioner Glover reported 'a mine which was established a few years ago, known as the North Tasmania, as a gold mine, has developed into a silver and copper mine, the assays from the lodes of which are reported to afford highly favourable prospects,...'

Recent deep drilling of the Tasmania reef at Beaconsfield intersected auriferous quartz reefs carrying an average of 1.02% Cu.

IRIDOSMINE

There is only one reference to the occurrence of iridosmine, (commonly termed osmiridium in Tasmania) in the area. Reid (1919) stated that 'osmiridium, a natural alloy of iridium and osmium, in varying proportions, has been recovered from the alluvial drifts of Andersons Creek. It is usually accompanied by gold in small quantities.'

IRON

The superficial iron deposits of the Beaconsfield district have been the subject of sporadic exploration activities since the first settlement at York Town in northern Tasmania. With the exception of coal reported at South Cape Bay by French explorers in 1793 these deposits were the earliest known mineral deposits recorded in Tasmania.

Mention of the deposits were made by Evans (1822) and Bigge (1823) and geological descriptions were given by Gould (1866). Further reports by Just (1891) and Twelvetrees (1903*a*) deal with the history of the deposits, in particular the attempts at exploitation of the deposits, and only a brief outline will be given here.

Earliest records indicate that subsequent to the settlement at York Town by Colonel Patterson in 1804 his ship, the *Lady Nelson* returned to England in 1805 with a cargo (ballast?) of a few tons of iron ore. Nothing further was heard of this shipment regarding assaying, metallurgical or other investigations. Gould pitted and trenched the deposits in 1865-66 and submitted a favourable report.

In 1872 the Tasmanian Charcoal Iron Company was floated to exploit the Mt Vulcan deposits and the foundation stone for the first furnace was laid in December of that year. The furnace was erected at which is now Redbill Point on the West Arm of the Tamar and connected to the deposits by a wooden tramway some 7 km in length.

This attempt at smelting was not successful and in 1876 the British and Tasmanian Charcoal Iron Company was refloated from the original company and work commenced on the erection of a blast furnace. A new jetty 180 m in length was built and the tramway replaced with a standard gauge, 1.34 m (4 ft 8½ in), railway. Difficulties were soon encountered in disposal of the furnace product due to a high chromium content in the pig iron making it unsuitable for most purposes and the plant was closed in August 1877.

Twelvetrees (1903*a*) records that about 10 000 t of pig iron was produced in these operations.

During this period two other companies operated small furnaces in the district. The Ilfracombe Iron Company was formed in the early 1870s to work a small deposit on the western flank of Peaked Hill 5-6 km SSW of Mt Vulcan. The operations were not successful and the plant closed after a series of trials. The remains of this furnace are still standing on the river flats near the deposits. In the first half of 1875 the Tamar Hematite Iron Company mined a small deposit on the west bank of Brandy Creek one kilometre north of Beaconsfield but produced only 500 t of pig iron. The quality of this material was reported to be excellent but poor markets and low production rates forced closure.

No further exploration was undertaken until the Department of Mines undertook a drilling programme on the Andersons Creek deposits. Nye (1930) reported a total of 21 holes drilled in 1929 but no deposits with economic potential were located. Broken Hill Pty Co. Ltd were the last to carry out work in the area with a number of percussion holes drilled during 1966-67 in conjunction with investigations of the chromite and nickel bearing laterites. Gebert (1967) reported that only low grade material was located during the programme. Five percussion holes drilled by this company on the Peaked Hill deposits did not locate significant mineralisation.

The Andersons Creek deposits are composed of concretionary and pisolitic hematite-goethite material with subsidiary magnetite. They occur as shallow cappings on Scotts Hill, Mt Vulcan and Barnes Hill ranging in thickness from 1-25 m and overlying ultramafic rocks. Soft limonitic and ochreous deposits flank the ironstones to the west and north and all evidence suggests that they are residual mantles resulting from *in situ* laterisation of the ultramafic rocks. Magnetite and chromite are common constituents of the ultramafic rocks and contaminants in the ironstone. The chromium content is variable and appears to increase with depth. A typical assay from the Mt Vulcan quarry (Twelvetrees and Reid, 1919) gave:

Fe	53.06%	Cr_2O_3	5.90%
Si	5.40%	Al	4.30%
S	0.13%	Loss on ignition	7.30%
P	Trace		

The deposit on the flank of Peaked Hill is small but similar in all respects to the above where examined, but is reported by Twelvetrees (1903a) to be free of any chromium content. The origin of the deposit and relationship to underlying rocks cannot be determined.

The deposit at Brandy Creek is also of limited extent consisting of a bed of ironstone about one metre in thickness underlain by pebbly gravel and overlain by up to 2 m of impure brown hematite. This deposit is also free of chromium and may represent weathering products of a thin basalt flow similar to the basalts to the north.

LEAD

Thureau (1883*a*) recorded the occurrence of galena associated with a quartz vein system on the west bank of Middle Arm Creek approximately 320 m downstream from the present West Tamar Highway. Detrital galena 'up to several pounds in weight' was found in gravel on the banks and bed of the creek and further search uncovered a metalliferous vein 'composed of iron pyrites, carbonates of iron, and galenite.' The vein is described as 'moderately interspersed with galenites.' No mention is made of lead mineralisation occurring in the remainder of the quartz vein system.

No further information is available on this occurrence except an indication by Montgomery (1891) on Plan No. 1 of two quartz veins in this locality. Recent search failed to locate the veins.

NICKEL

Thureau (1883a) first recorded the occurrence of nickel associated with ultramafic rocks in the workings of the old Victoria mine at the Salisbury goldfield and Twelvetrees (1903a) later noted the occurrence of nickeliferous quartz veins in the nearby Duchess of York mine but these occurences were of mineragraphic interest only.

The first investigations specifically for nickeliferous mineralisation was commenced by the Ben Lomond Mining Co. in 1955 and widespread mineralisation was indicated by sampling over the ultramafic complex at Andersons Creek. Initial investigations were concentrated on the possibility of mineral concentrations in the weathered ultramafic rocks and, or, in association with rodingite. This work was unsuccessful but further sampling disclosed a significant concentration within the overlying clay/clay-soil profile.

In 1957 Enterprise Exploration Co. Pty Ltd undertook further work on the project and carried out a limited sampling programme on the south-eastern section of the ultramafic rocks. Grades and tonnages outlined were disappointing and the project was abandoned. Following mineragraphic studies by the C.S.I.R.O. the Department of Mines drilled one hole to test for any nickel-rodingite association. No significant mineralisation was located.

King Island Scheelite (1947) Ltd commenced a detailed sampling programme of the weathering profile in 1967 and by the end of 1968 had completed a total of 37 diamond drill holes. The reserves estimated at the completion of the programme comprised four localities totalling 6 million tonnes with an average grade of 1.04% Ni and 0.06% Co, based on a cut off grade of 0.70% Ni with little prospect of discovering further large reserves. The project was not considered viable and was allowed to lapse.

A recognisable profile developed over the ultramafic rocks was indicated by the drilling. There is a gradation downward from a surface capping of hard pisolitic grains of iron with a red clay matrix to a ferruginous red clay zone followed by a limonitic yellow to orange coloured clay. This in turn grades into a mottled zone of mixed red, brown, yellow and purple clays.

Underlying this is a zone termed the 'transition zone' composed of soft, highly decomposed ultramafic rock with occasional patches of red clay. This zone gives way to bleached pale yellow-green ultramafic rocks of variable hardness grading downward into fresh rock. Profile thicknesses range from 1-20 m.

The strongest mineralisation occurs in the 'transition zone' and the upper section of the bleached ultramafic rock. Grades are extremely variable with individual sections carrying up to 2.25% Ni and 0.08% Co. No nickel mineral has been identified in the profile. Electron probe microanalyses indicate that the bulk of the total nickel is included in the lattice of the clay mineral smectite and with secondary iron oxides in the 'transition zone'. In the bleached zone it is divided between the clay mineral, the ultramafic rocks and iron oxide.

The secondary mineral garnierite occurs in association with opaline silica as thin layers along fracture planes and on slickensides in the ultramafic rocks particularly near rodingite occurrences. Assays of fresh samples from the drilling programme indicate a general nickel content of between 0.2% and 0.3% in the ultramafic rocks with occasional higher figures (up to 0.70%).

OSMIRIDIUM (See IRIDOSMINE)

PYRITE (See SULPHUR)

SILVER

Silver is only present in the area as a subsidiary of other minerals. Thureau (1883*a*) indicated silver to be present with galena occurrences (see Lead), and it is present in the auriferous quartz reefs in the area. Assay results of Department of Mines drilling show a silver content ranging from 7.5 g/t to 17.1 g/t in the Tasmania auriferous quartz reef where intersected.

SULPHUR

Slaty mudstones of Cambrian(?) age exposed at Branchs Creek on the South East Arm of Port Sorell carry a significant quantity of syngenetic pyrite and were the focus of exploration activities by the Ben Lomond Mining Co. during 1953-55.

Initial sampling of the slates was favourable and further trenching and bulk sampling were carried out. Channel sampling of the trenches show the sulphur content to be very variable across the strike of the slates with results ranging from 0.2% to 23.1% sulphur. Following stage two a diamond drilling programme of 5 holes was completed to investigate the deposits at depth.

Hughes (1955) reported that the drilling and trenching indicated three or four horizons within the slate sequence contained better than 10% sulphur over thicknesses of from 6 to 20 m. Metallurgical and beneficiation investigations were not encouraging and the project lapsed. Further sampling and metallurgical investigations were carried out by the Electrolytic Zinc Co. of Australasia Ltd but the project was again abandoned due to uneconomic recoveries of the available sulphur.

OTHER MINERALS

Reconnaissance offshore sampling by Placer Metals Ltd in 1967 and sampling of coastal and inland dunes by Placer Gold Ltd also in 1967, located minor pockets of heavy minerals containing low concentrations of ilmenite, rutile and zircon. No concentrations of economic significance were located.

Non-metallic minerals

ASBESTOS

Asbestos was first recorded in the Beaconsfield district by Gould (1866) as occurring in the ultramafic complex at Andersons Creek but no significance was placed on the occurrence. Interest in the deposits has since been sporadic with several attempts at exploration and, or mining.

The Inspector of Mines Report for 1882 records exploration by the Asbestos Mining Company during that year but apparently without success. In

1899-1900 an attempt was made to exploit the deposits by the Australasian Asbestos Company. Twelvetrees (1900) describes the early operations of the company and gives the first geological report on the area. A further report by Twelvetrees (1903*a*) indicated that the material extracted by this company consisted of 'asbestiform rock intended to be used in the manufacture of asbestic, and incombustible plaster,': 375 tonnes were shipped to Melbourne.

The next serious attempt to exploit the deposits was by the Durabestos Company of Sydney in 1917. Options were taken over leases held by C.B. Buxton and after close examination and assessment of the area the company undertook active development. A milling plant, the first such plant established in Australia, was erected and operated successfully for some two years until the fibre content, always variable, became too low. During 1918 operations were transferred to the Wunderlich Company Limited. Overall grades for this period were low and only carried economic consideration due to war-created shortages. Taylor (1955) states that 'from 48,854 tons of rock quarried, 4,414 tons were selected for milling from which 441 tons of fibre valued at approximately £10,000 (in 1918) were extracted.'

No further interest was taken in these deposits until recent years except for a few tonnes produced in 1937-38.

In 1971-72 Allstate Exploration N.L. undertook a comprehensive evaluation of the deposits. Fifteen diamond drill holes totalling 2000 m were completed and several thousand metres of trenching carried out to facilitate mineral occurrence investigations. Samples of drill core were submitted to the Quebec Department of Mines laboratories in Canada for milling and recovery evaluations based on the Quebec Standard Tests.

Results of this work were disappointing and although numerous pockets of fibre are scattered over the area, mapping, trenching and drilling failed to locate an orebody of sufficient size or grade to be economically viable. Most of the areas where fibre was prominent at surface were drilled but the fibre content was patchy at depth as on surface. The project was abandoned.

The ultramafic complex is fully described both in this publication (p. 30), and also by Taylor (1955) who deals with the structural features of the fibre vein systems in considerable detail.

Fibre occurs as cross and slip fibre. Cross fibre chrysotile is generally short with fibre lengths of 35 mm and under and is by far the most abundant. Fibre lengths up to 100 mm are present in moderate quantities in some localities but longer fibre is rare. Occasional veins up to 250 mm in width occur but internal fibre partings reduce the individual lengths to about 35 mm. The Canadian tests indicate that the cross fibre stands up to milling but is variable in value, ranging from group 4D to group 7B.

Slip fibre is common in the area in veins up to 0.3 m, but more commonly about 25-30 mm, in width. The fibre is parallel to the strike of the veins and consists mostly of amphibole asbestos but some chrysotile does occur in the slip form. Fibres are deceptive in length, often apparently very long but when examined prove to be about 13 mm in actual length with short bunches of fibres loosely held together end to end. Milling tests indicate that this type of fibre breaks down very rapidly and has practically no value as a fibre.

Large quantities of fibrous material noted in the drill cores and thought to be possibly chrysotile proved to be predominantly brucite and of no economic interest.

COAL

Two thin lignitic beds up to 30 cm in thickness and of limited lateral extent occur on the lower south-eastern slopes of Mount George. Opinions on the age of the deposits vary; Twelvetrees (1904) considered them to be Tertiary, Hills *et al.* (1922) Triassic and Hughes (1949) Permian. Diamond drilling carried out in 1935 was inconclusive as the holes appear to have been sited stratigraphically below the outcrops.

GRAPHITE

Graphite has been reported from the Rubicon estuary. Although black clay derived from Cambrian sediments which crop out on the east bank does occur, the colouration is due to the presence of carbonaceous impurities in the sediments and is of no economic significance.

LIMESTONE

Gould (1866) reported the quarrying of two types of limestone 'locally distinguished as the blue and the white limestone' stating that the white limestone had only been quarried at one locality whilst the blue variety had been worked 'for many years past'. The locality of the white variety, also referred to as the marble quarry, occurs on Salisbury Creek immediately east of the West Tamar Highway-Flowery Gully road junction. It is of limited extent and can only be located by the water filled pit.

The blue variety occurs on Middle Arm Creek about 500 m west of the highway where three quarries were worked for burnt lime over many years from the middle 1800s to about 1900. These quarries are in members of the Gordon Limestone correlate of Ordovician age. There is no current exploitation of limestone in the Beaconsfield Quadrangle, all operations being confined to the Flowery Gully district to the south.

Prior to the discovery of these limestone beds lime was obtained from several localities in the district where outcrops of fossiliferous calcareous mudstone of Permian age were utilised. Gould (1866) states 'The calcareous bands found by the existence of the fossils are in places sufficiently important to be worth working as sources of lime; and at various periods kilns have been in operation in the district for that purpose'. One such kiln, built by the Government still stands on the east bank of Middle Arm Creek about 500 m below the Beaconsfield-Kayena road bridge.

Minor occurrences of impure Permian limestone occur near Boats Crew Point on the West Arm and on Andersons Creek about 800 m upstream from West Arm.

OCHRE

Considerable quantities of chromic iron oxides occur at Andersons Creek in association with the secondary iron deposits and have been utilised in the past on a small scale.

Initial sampling undertaken about 1887 indicated that the oxides were suitable for the manufacture of oxide paints and in 1888 the chromate and Asbestos Paint and Gold Mining Company Limited was formed to work the deposits. Little work was done by this company and in 1890 the venture was taken over by the Native Paint and Oxide Proprietary. A mill was erected and over the next two years some 500 tonnes of oxides were produced principally for gas purification.

No further interest was taken in the deposits until the leases were taken over by the Serpentine Paint Company in 1918. A paint factory was established in Launceston and production recommenced on the old workings on the west flank of Scotts Hill; operations continued on a small scale until 1928.

The workings are still accessible and consist of a long narrow open cut approximately 4 m wide by 75 m long. The cut was driven from about creek level to a face some 8 m in depth. Early testing indicates a further 4-5 m below the floor of the cut. The deposits occur as a surface mantle covering the flanks of both Scotts Hill and Mount Vulcan and where exposed in the workings are highly variable in colour. Yellow, red, green and brown layering is prominent. The oxides are mostly fine-grained with only minor grit or pebble material.

SERPENTINE

Large areas of Cambrian serpentinised pyroxenite occur west of Beaconsfield. The rock is attractive in appearance but it is highly sheared and therefore its fragmentary nature makes it unsuitable for use an an ornamental stone. It was extracted by the Tasmanian Greenstone Company for building stone prior to 1917 and by the Tasmanian Terrazzo Pty Ltd, in 1939, crushed into chips and used for terrazzo paving. It is also used by hand carvers for ornaments. The fragments rarely exceed 10 cm in size.

TALC

This mineral has been found in secondary deposits in the Rubicon estuary area associated with Cambrian dolomite. No deposits of economic value are known in the area but several high values were detected in samples from a proline auger prospecting programme (Threader, 1973). Pure talc contains about 32% magnesia; values approaching 27% have been recorded which represents 85% talc but the distribution of high values was too irregular to encourage further prospecting by the company.

CONSTRUCTION MATERIALS

For the purposes of this study the area has been divided into four physiographic units: A - Coastal Plains, B - Asbestos-Dazzler Ranges, C - Dolerite Hills flanking the Tamar Valley and D - Hills of Lower Palaeozoic Sediments (fig. 23).

The occurrence of construction materials is summarised in Table 2 and details of localities and economic potential are given in the appropriate section of the text.

CLAY

Of the five types of clay recognised on the basis of industrial use, only brick clay and possibly bloating clay are known to occur in the Beaconsfield Quadrangle. The clay resources consist of:

Tertiary sediments of Units A1, A3, A4.
Triassic sediments of Unit C.
Permian sediments of Units A3, A4.
Lower Palaeozoic sediments of Units D1, D2.

Tertiary

Units A1, A3 and A4 contain considerable thicknesses of continental deposits consisting mainly of clay and sandy clay with some lignitic horizons. In the Port Sorell area, the thickness of the Tertiary sequence ranges from 0-366 m. The following details are taken from bore hole logs.

Bore hole	*Depth (m)*	*Depth to dolerite (m)*
Burgess	356.62	354
Parsons	351.10	351
Isles	338.33	-
Sulzberger No. 1	306.02	178
Sulzberger No. 2	381.00	332
Sulzberger No. 3	335.28	256
Sulzberger No. 4	381.00	366
Hermitage	207.26	138

For economic purposes, only the top 20 m of Tertiary sediments need be considered at present as this is more or less the practical quarrying limit. In the Port Sorell area the sediments are stated to be interbedded with Tertiary basalt and detailed prospecting would therefore be necessary to prove a working area of clay.

Unit A2 has not been drilled to any great depths and thicknesses of Tertiary sediments are not known. The Tertiary sediments of the Launceston and Longford basins are known to exceed 300 m in thickness and a similar thickness is to be expected for Units Al and A2. Leaman (1973*a*) has suggested a maximum thickness of about 350 m for the Port Sorell deposits from geophysical data.

Unit A4. Tertiary sediments are here overlain by late Cainozoic sandy deposits and would not form an economically useful clay resource, except in the George Town-Bell Bay area where several good road exposures have been noted.

Two unusual occurrences of cream and white clay have been recorded by Hughes (1954, 1958*a*) one at the mouth of Sheepwash Creek on the eastern shore of Port Sorell and the other on the property of W.C. Leonard 1.5 km from Beaconsfield on the Holwell road. The exact localities are not known but the clays are both of Tertiary age and may be small lagoonal deposits of higher quality than the normal Tertiary sediments. Similar deposits may occur in the Tertiary succession in the area. As detailed logging of about sixty water bores in the Longford, Quamby Lake River and Launceston Quadrangles by W.L. Matthews has not revealed any it is unlikely that large deposits exist.

Some of the Tertiary clay adjacent to dolerite masses has a high content of rock fragments and is unsuitable as a ceramic material. This is notably so along portions of the East Tamar highway.

Much of the land occupied by Tertiary sediments is valuable agricultural or pastoral land and as such would be unavailable or too costly for the brick industry which requires a high bulk, low cost raw material. A solution to this problem may lie in the utilisation of disused gravel pits. Most of the gravel deposits are on elevated land and would therefore be ideal locations for quarrying. All that would be required would be to remove the organic-stained silcrete gravel bottom to expose the clay, once prospect drilling drilling had established that the quality and quantity of clay were adequate.

Lignitic clay has been found in the George Town area (Twelvetrees, 1904; Hills *et al.*, 1922). These beds may prove to be a suitable raw material for expanded aggregate (bloating clay). These beds were not located

Table 2. SUMMARY OF NON-METALLIC MINERAL RESOURCES

Unit	Locality	Rock Type	Age	Use
A1	West bank of Rubicon estuary	Dune sand	Quaternary	Well-sorted sand suitable for silica brick manufacture; the limited size range makes it unsuitable as fine aggregate.
		Beach shingle	Quaternary	Shingle has been extracted in the past for roadworks, concrete aggregate, drains, etc., but its removal is now prohibited.
		Terrestrial clay and sandy clay	Tertiary	Large reserves of ceramic clay of brick making quality. Some small superficial sand deposits are worked for concrete aggregate.
		Basalt at surface and interlayered with Tertiary clay	Tertiary	
		Dolerite	Jurassic	
		Undifferentiated sandstone and mudstone	Permian	See under Unit A2.
A2	East bank of Rubicon estuary	Estuarine sand	Quaternary	Sand deposits on tidal flats of the estuary are screened to produce foundry sand, filtration sand, aggregate and pebbles.
		Terrestrial sediments	Tertiary	Gravel deposits, some are worked (fig. 22). Clay and sandy clay - shallower than in Unit A1 as indicated by the prevalence of L. Palaeozoic outcrops. Thicker Tertiary accumulations may occur behind the coastal dunes at or near sea level. White clay has been reported from the mouth of Sheepwash Creek.

Table 2 (continued)

Unit	Locality	Rock Type	Age	Use
A2	East bank of Rubicon estuary (continued)	Dolerite	Jurassic	Portview Hill and Dolgarth Hill: outcrops of fresh dolerite suitable for crushing for aggregate.
		Mudstone and sandstone	Permian	Very limited in extent. Some areas may be suitable for brick manufacture.
		Mainly slate, siltstone and sandstone	Cambrian	Weathered lutite horizons are suitable for brick manufacture.
A3	Tamar Plains	Dune sand	Quaternary	See under Unit A1.
		Terrestrial sediments	Tertiary	Quartz- and ironstone gravels and sand deposits are extensive and have been worked for many years. Clay: see under Units A1 and A2.
		Mudstone and sandstone etc.	Permian. Mainly Masseys Creek Group	Large areas of mudstone, some pebbly, are suitable for ceramics.
		Quartzite and slate	Ordovician	Scree slopes on the flanks of Peaked Hill, Salisbury Hill and Cabbage Tree Hill provide high grade silica which is used for metallurgical purposes at Bell Bay and screen undersize is used as road making and concrete aggregate. Lutite beds (slate and phyllite) underlying the quartzite are suitable for use in brick manufacture.
		Ultramafic rocks	Cambrian	Serpentinised pyroxenite has been mined for ornamental purposes but it is so highly jointed that blocks larger than 15 cm are unobtainable. It has been crushed and used in the preparation of terrazzo paving and is sometimes used for ornament carving.

Table 2 (continued)

Unit	Locality	Rock Type	Age	Use
A3	Tamar Plains (continued)	Ultramafic rocks	Cambrian	Limonite, derived from serpentinite has been used for paint pigments (Blake 1928)
A4	Cimitiere Plains	Windblown sand including older and newer dune formations	Quaternary	A highly sorted sand (see A1).
		Gravels and partly consolidated conglomerate	Tertiary	Concrete and road aggregate.
		Clay and sandy clay		Ceramics (notably in the Bell Bay area).
		Dolerite	Jurassic	
		Sandstone and mudstone	Permian and Triassic	
		Quartz sandstone (predominantly Mathinna Beds)	Siluro-Devonian	
B	Asbestos Range	Sandstone, quartzite, slate, phyllite	Precambrian	None known, but lutites may be of use in ceramics if deeply weathered zones are present. There is no current demand.
C	Flanking hills of the Tamar graben	Dolerite	Jurassic	Fresh rock is suitable for crushing as in A1 and A2. A secondary deposit of ironstone gravel owes its origin to leaching of dolerite but the product is discussed under Tertiary and Quaternary gravels.
D1	Peaked Hill Salisbury Hill Cabbage Tree Hill	Predominantly sandstone and quartzite	Ordovician	See gravel deposits (scree) in A3.

Table 2 (continued)

Unit	Locality	Rock Type	Age	Use
D2	Lefroy Hills	Greywacke, sandstone and slate/phyllite	Ordovician-Devonian	The beds are predominantly arenaceous. Some lutites are present but there is no likelihood of their use in the foreseeable future as better and more accessible materials are available.

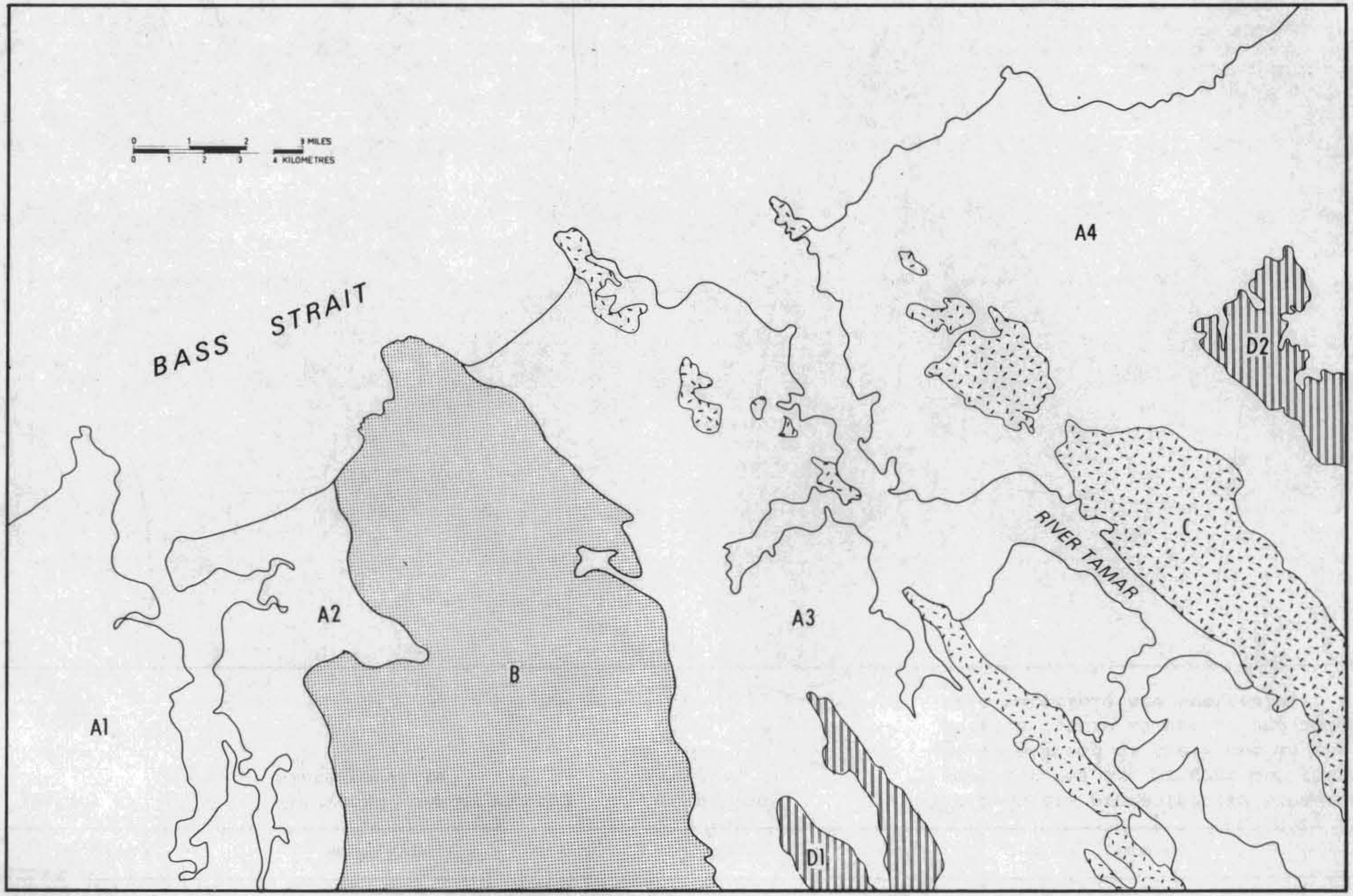


Figure 23. *Physiographic regions (see Table 2, p. 92-95)*

during the present survey but similar beds on the West Tamar highway, south-east of Legana (Launceston Quadrangle) warrant investigation if there is a local demand for light weight concrete which utilises this type of material.

Triassic

Triassic sediments crop out on the eastern flanks of the Tippogoree Hills which are prominent dolerite outcrops of Unit C. The beds are imperfectly exposed due to dolerite scree and are not at present easily accessible. Triassic mudstone is frequently used as a brick making material in Hobart but is not plentiful in the north of the State and unlikely to become popular there as other superior materials are more abundant.

Palaeozoic

Permian. Most members of the Permian succession contain too high a sand content to be suitable for use in ceramics. A sample (C2) of a West Arm Group sediment was collected on the Bell Bay-Bridport highway. It had the appearance and texture of a suitable ceramic material but on testing proved to have a non-clay content exceeding 50%. Lower Permian clay (sample C3) from the Massey Creek Formation in the vicinity of West Arm gave a more satisfactory result.

A brick works once operated at Loira, 12 km south-east of Beaconsfield. The clay used was a weathered pebbly mudstone of Upper Permian age. It is currently used for the manufacture of glazed tiles. This locality is in the Frankford Quadrangle.

Lower Palaeozoic. The Mathinna Beds in Unit D2 are predominantly arenaceous and as such are unsuitable for brick making. A sample (C8) of Mathinna lutite, which was collected from a road cutting near the Lefroy turn-off, fabricated well and produced a test brick of pleasing colour and adequate strength. The brick lacked green strength and the lutite would have to be blended with a more clayey material to have practical economic application.

A sample of weathered Cambrian lutite from a road cutting on the West Tamar highway at the Flowery Gully junction has been tested for ceramic properties with satisfactory results.

Another weathered Cambrian lutite on the eastern shore of Port Sorell (sample C6) has proved to be an unsatisfactory ceramic material and did not bond at 1000°C. It may be a suitable refractory clay but no tests have been done to determine its suitability.

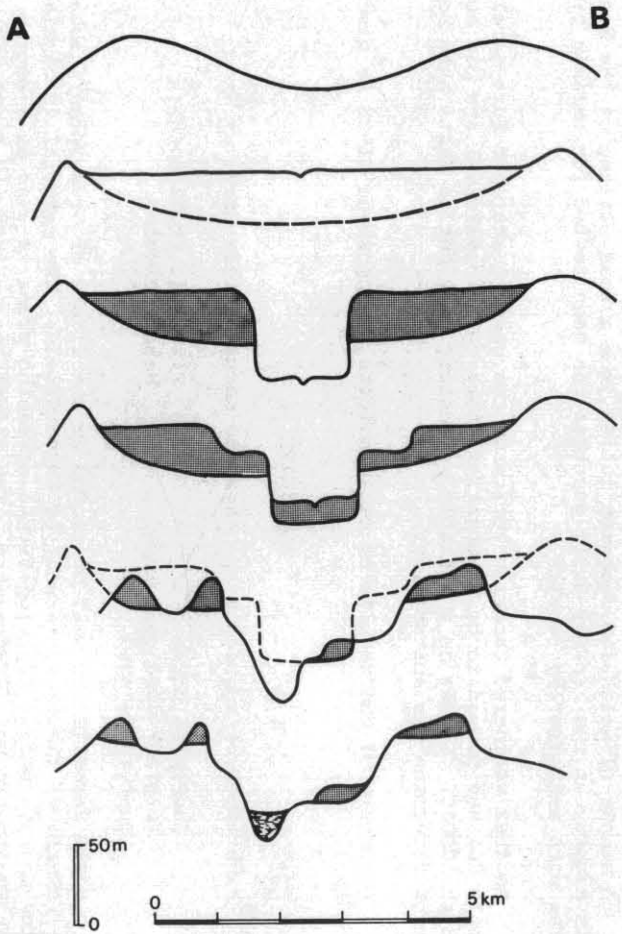
A summary of the results of ceramic tests on Specimens C1-C8 is given in Table 3.

AGGREGATE

Five types of aggregate are known to occur in this area:

- Quartzite scree
- Tertiary sand and gravel
- Quaternary sand
- Pisolitic ironstone
- Beach shingle

Scree deposits are well developed on the flanks of Ordovician (Cabbage Tree Formation) ridges south-west of Beaconsfield. The material is of high purity and the coarse fraction from a screening plant is used as a source of silica to produce ferrosilicon. The undersize, $<\frac{3}{4}$ inch (18.8 mm), is used as road and concrete aggregate. Reserves are estimated to cover 2.6 km^2



1. An early stage in the development of Andersons Creek valley.

2. Valley fill in flood plain of valley.

3. Rejuvenation leading to cutting of new valley in old flood plain.

4. Deposition of alluvium on floor of new valley and partial erosion of older alluvium leaving paired terraces.

5. Rejuvenation leading to the deepening of the valley and partial removal of alluvium leaving terraces at both levels.

6. Eustatic rise in sea level causing drowning of the valley and the formation of West Arm.

Figure 24. *Suggested development of river terraces at West Arm.*

5 cm

Table 3. SUMMARY OF CERAMIC TESTS.

Sample No.*	ANG Ref.	Material	Silt and clay fraction (%)	Firing tests at 1000°C
C1	895246	Tertiary sandy clay	55, 74	No bond
C2	863362	Permian sandy mudstone	85	No test
C3	705299	Lower Permian mudstone	38	Good bond
C4	765236	Lower Palaeozoic sediment	92	Good bond
C5	794337	Tertiary sandy clay	53	Good bond
C6	536272	Lower Palaeozoic sediment (the above materials warrant further investigation as a possible refractory clay)	54, 53	No bond
C7	771355	Tertiary sandy clay	29	No bond
C8	890357	Lower Palaeozoic sediment (poor green strength)	39	Good bond

and to average 2 m in thickness to give a volume of about 5 million m^3. A sample of -3 inch (76.2 mm) material was screened. The grain size distribution was approximately 25% >¾ inch and 75% <¾ inch.

The *in situ* material ranges in size up to almost 1 m across and a sizing analysis of -3 inch scree is therefore not indicative of the real size distribution. It is estimated that the +3 inch scree would constitute more than half and possibly three-quarters of the total. The reserves of +¾ inch scree would therefore range between 3 and 4 million m^3 and of the -¾ inch scree between 1 and 2 million m^3. The distribution is shown on Figure 22 with adjusted proportions after removal of +¾ inch material. The material is poorly sorted and would therefore be more suited for road making than for concrete preparation.

Tertiary sand and gravel deposits are widespread in the Tamar and Rubicon valleys. They were briefly described by Blake (1928*a*) and more fully by Reid (1929) who considered that they were deposited prior to the last upward land movement. The rejuvenation which followed this movement removed all but a few remnants of these gravels which now remain as river terraces. Reid gave the reserves at two of the localities as:

Beauty Point - Thickness 10-50 ft (3-15 m)
Average 30 ft (9m)
Volume 7 600 000 yd^3 (5 000 000 m^3)

Deviot - Average thickness 15 ft (4.5 m)
Volume 600 000 yd^3 (460 000 m^3)

These areas were held under mining leases by Cementoid Silica Ltd which intended shipping aggregate from Beaconsfield to Melbourne for construction purposes. Reid (1929) stated that the deposits lay between the 200 ft (61 m) and 275 ft (84 m) contours. More accurate information is now available and it is now known that the full range is from near sea level to 450 ft (137 m). This range indicates that more than one terrace level is involved and suggests that the various deposits may not be contemporaneous. Reid's remarks referred to the Beauty Point and Deviot deposits which he related to terrace levels of the River Tamar and concluded that they are remnants of huge terraces which flanked the Tamar estuary.

Prominent and continuous gravel-capped terraces are not in keeping with

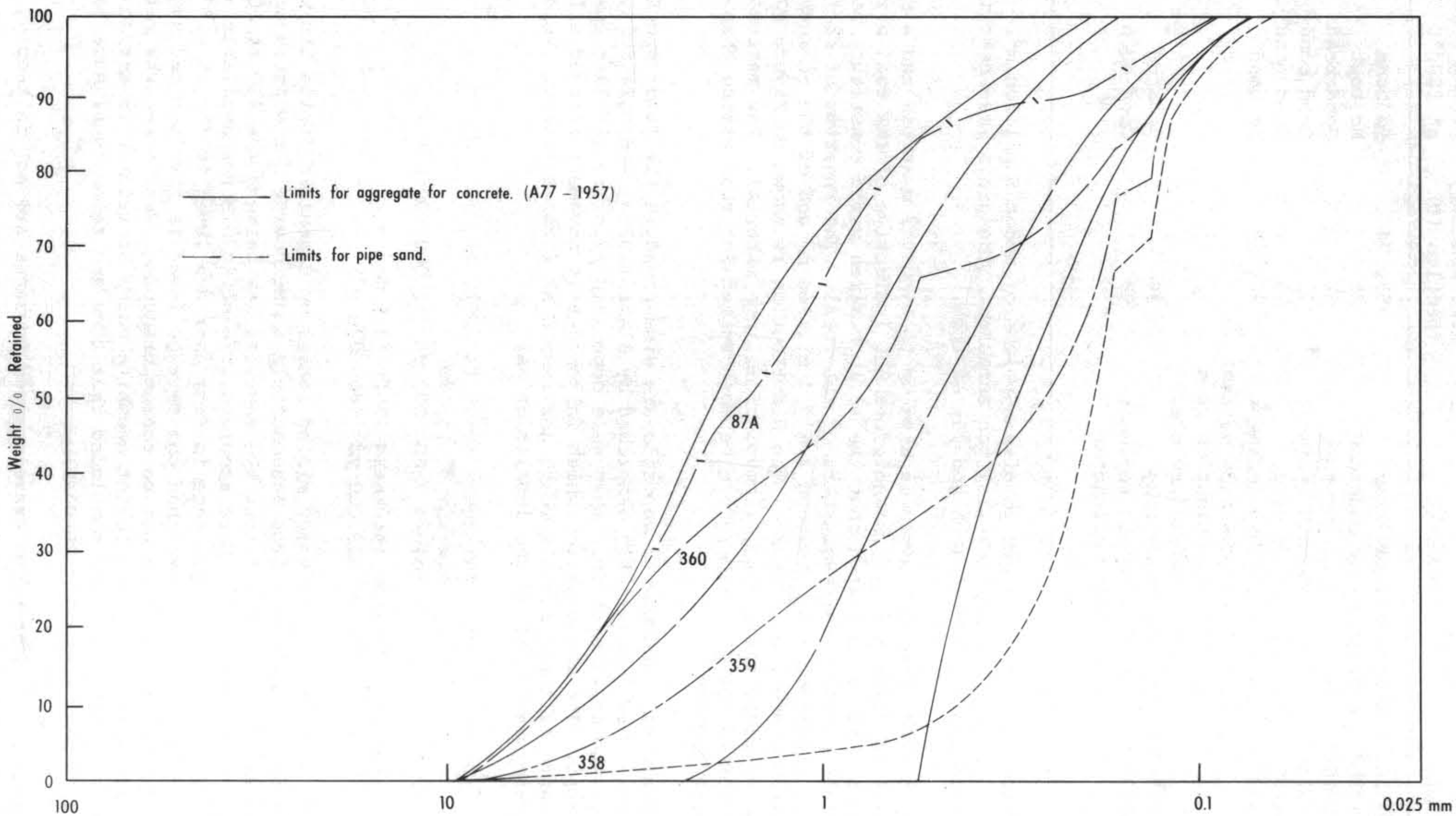


Figure 25. *Particle size frequency distribution of samples collected from shallow pits on the property of Major Rooms, Deviot (after Blake, 1928).*

5 cm

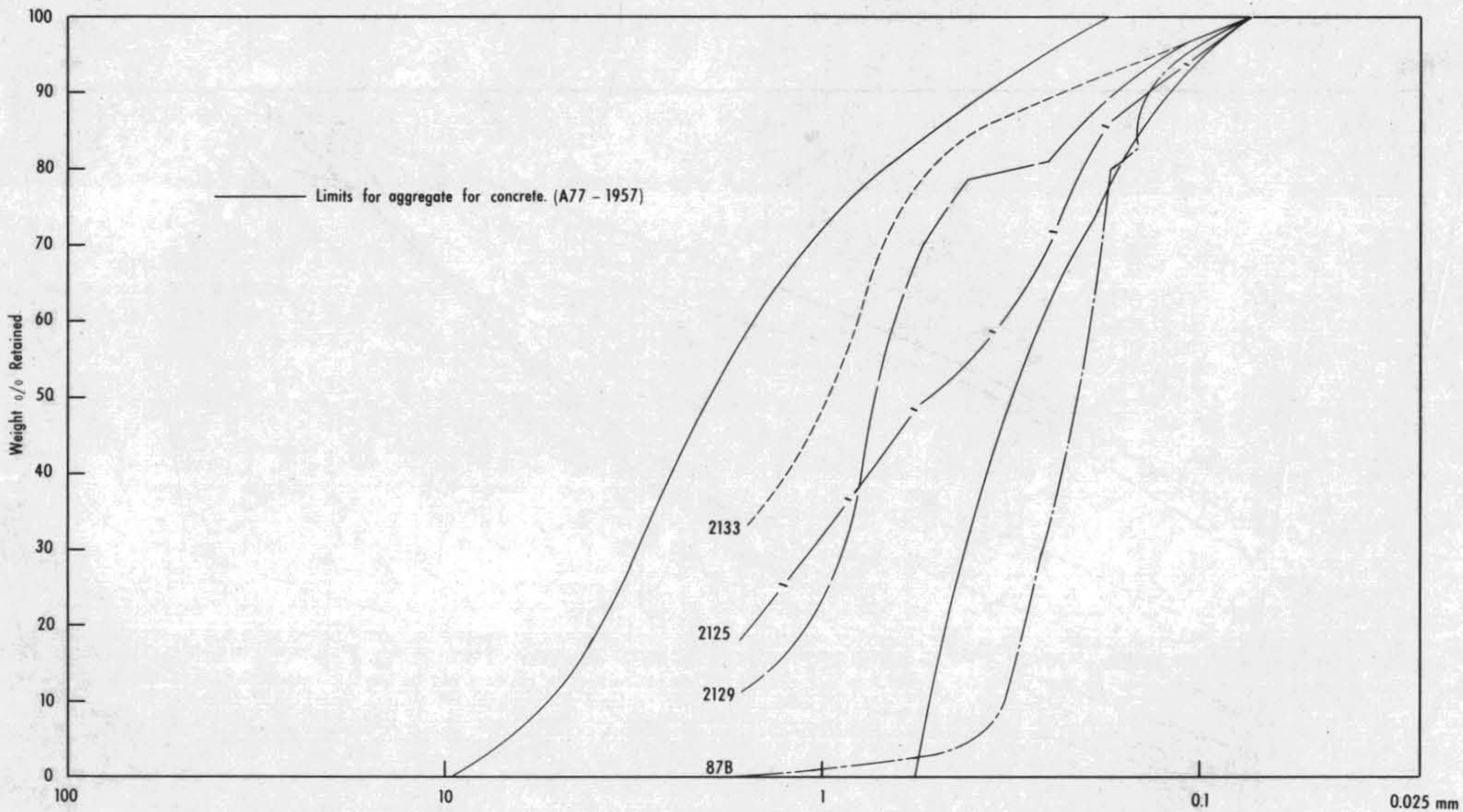


Figure 26. *Particle size frequency distribution of aggregate from Beauty Point (after Reid, 1929).*

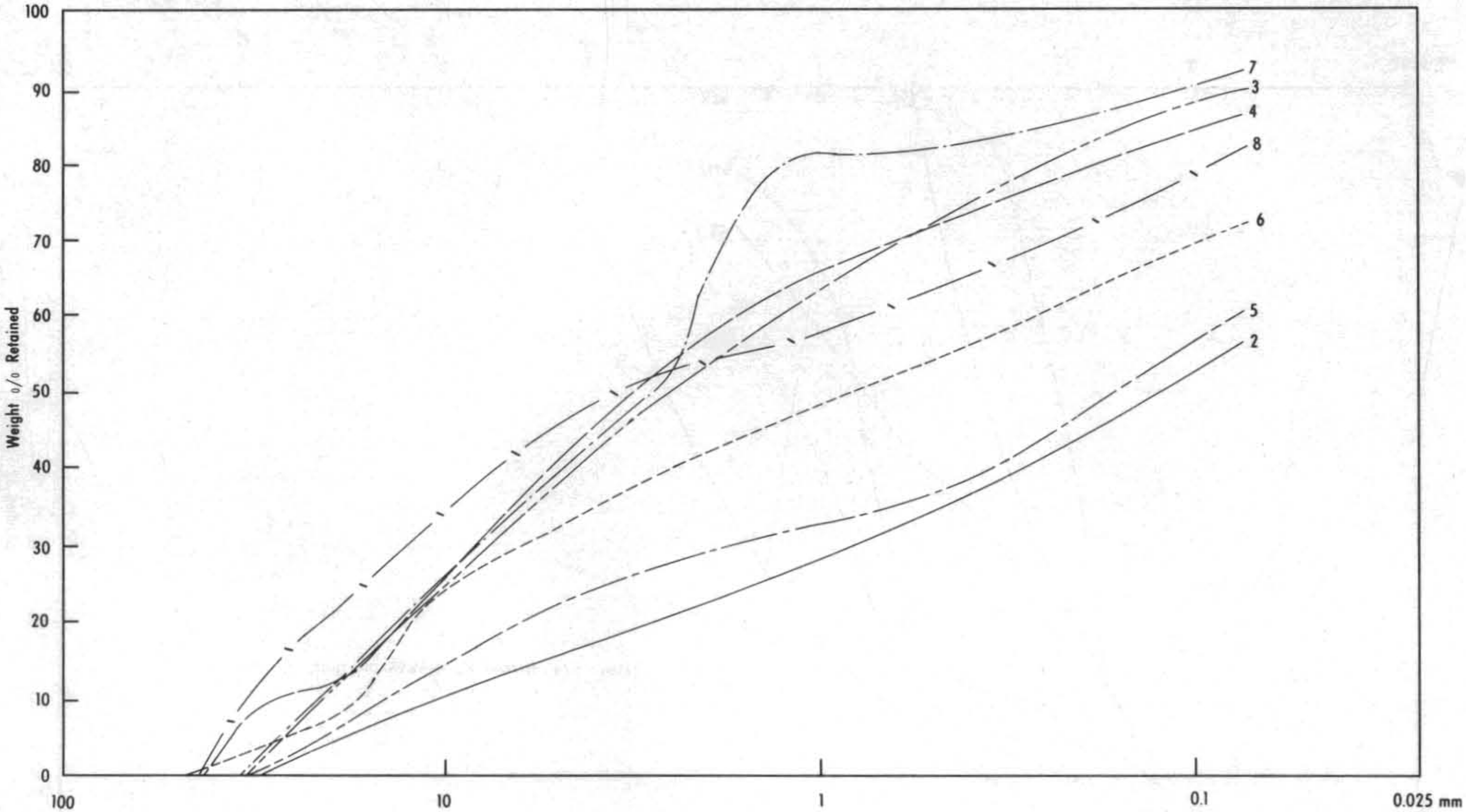


Figure 27. *Particle size frequency distribution of samples 30-2 to 30-8, Kelso area.*

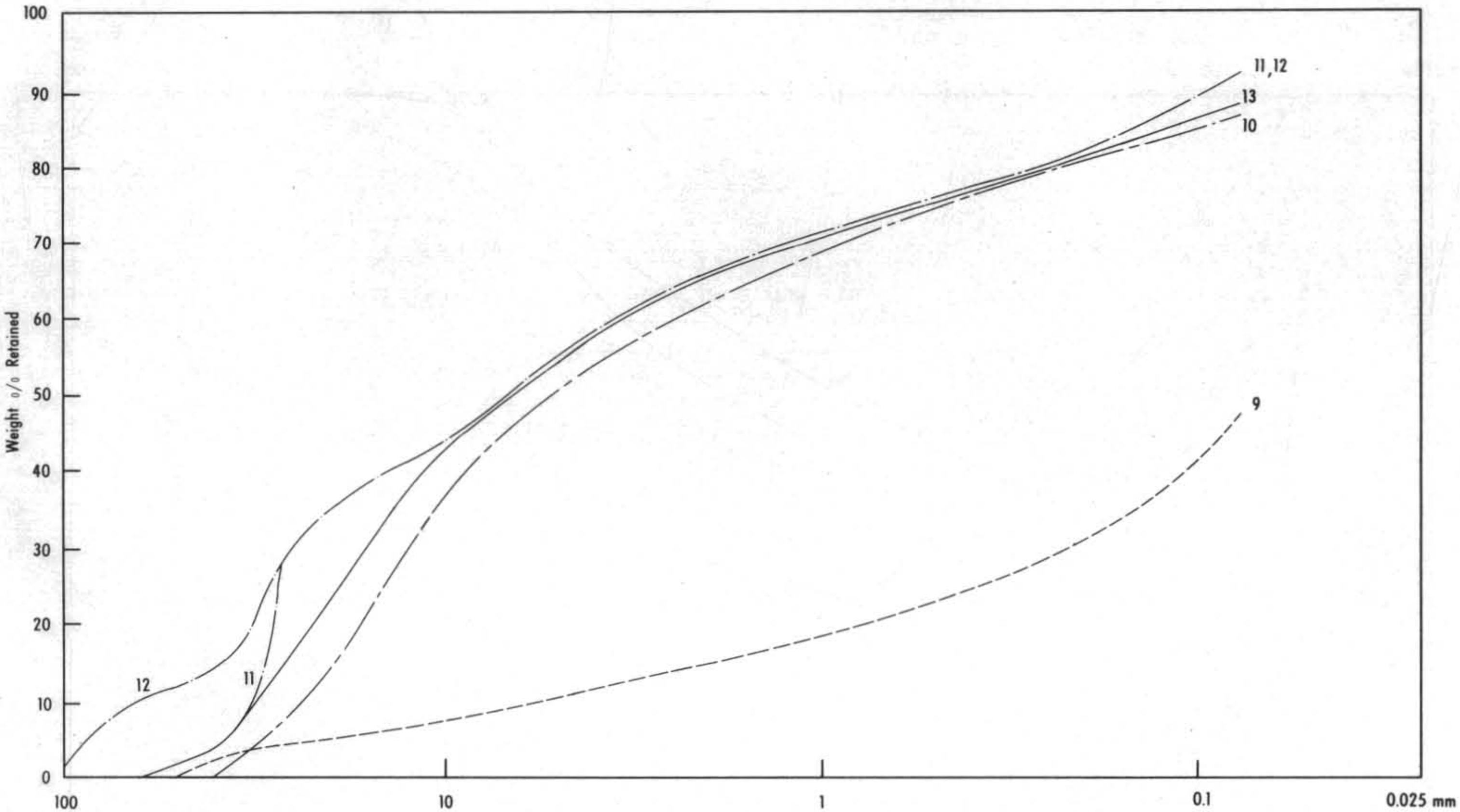


Figure 28. *Particle size frequency distribution of samples 30-9 to 30-13, Beaconsfield area.*

5 cm

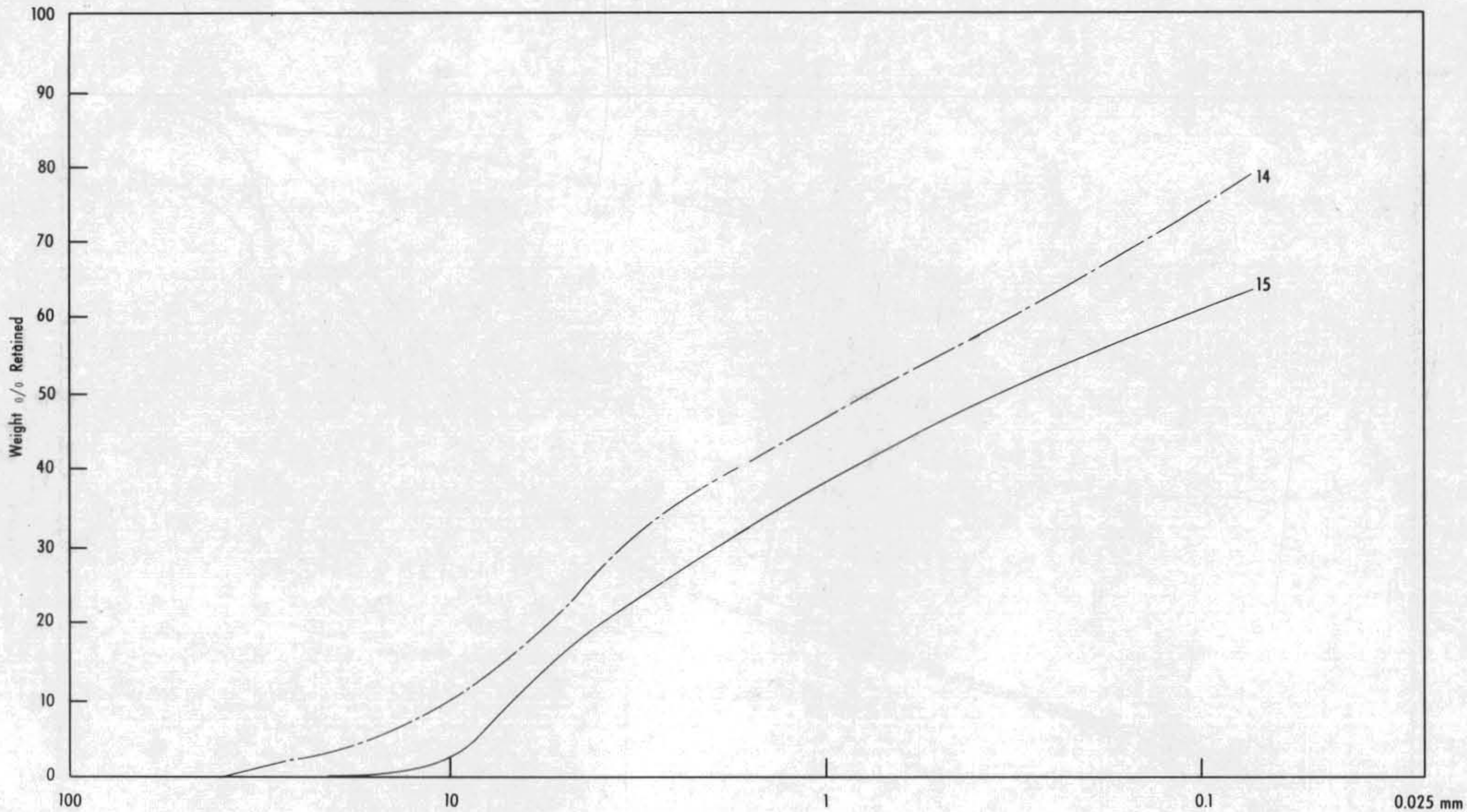


Figure 29. *Particle size frequency distribution of samples 30-14, 30-15, Deviot.*

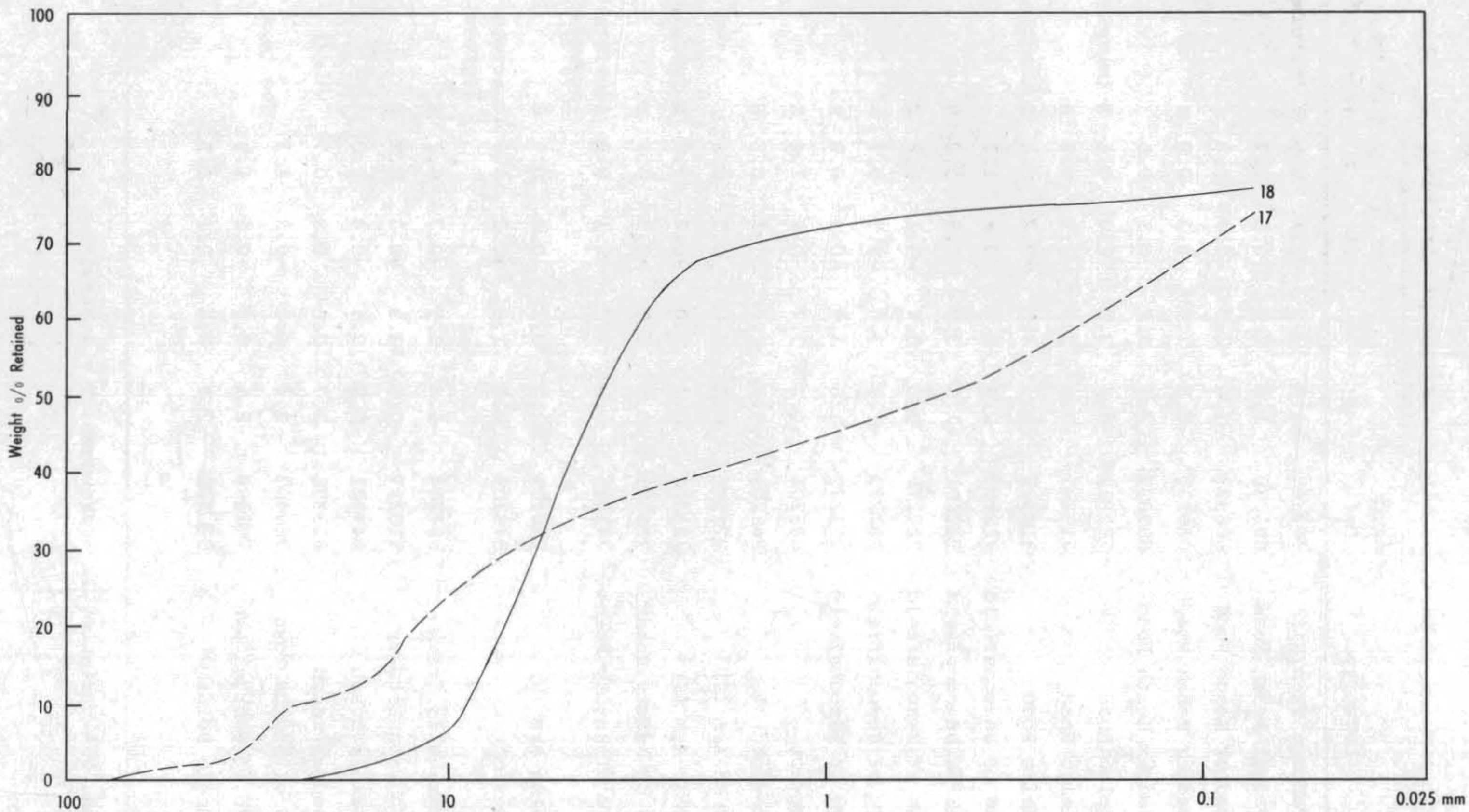


Figure 30. *Particle size frequency distribution of samples 30-17, 30-18, West Arm area.*

Table 4. AGGREGATE: PHI VALUES OF SIZING PARAMETERS, AND SUITABILITY.

			ϕ values of sizing parameters*				
Sample No.	Locality	ANG Ref.	M	σ	Sk	K	Suitability (see Table 5)
30-1	Cabbage Tree Hill	747248	-0.6	3.7	-0.1	0.6	B (marginal)
30-2	Badger Beach Road	683339	1.6	2.9	0.6	0.7	-
30-3	Badger Beach Road	686333	-1.6	2.3	-0.1	1.3	C
30-4	Badger Beach Road	686333	-0.8	2.9	-0.3	0.8	B
30-5	Badger Beach Road	689333	1.3	3.2	0.5	0.6	-
30-6	Kelso Road	722352	0.2	3.3	0.01	0.6	D (marginal)
30-7	Kelso Road	719347	-0.8	3.3	-0.3	0.8	B
30-8	Kelso Road	714339	-0.7	3.5	-0.3	0.6	B (marginal)
30-9	NW of Beaconsfield	722283	2.4	2.7	0.8	1.2	-
30-10	NW of Beaconsfield	730281	-1.3	3.2	-0.5	0.8	B
30-11	NW of Beaconsfield	727278	0.6	3.4	-0.1	0.8	D
30-12	NW of Beaconsfield	732273	-1.9	3.5	-0.3	0.7	B
30-13	NW of Beaconsfield	732270	-1.6	3.3	-0.4	0.8	B
30-14	Deviot	846205	-0.3	3.2	-0.7	1.4	E
30-15	Deviot	846205	1.2	2.7	0.1	0.5	F
30-17	West Arm (S)	722316	0.2	3.6	0.2	0.6	-
30-18	West Arm (S)	733320	0.3	3.0	-0.2	0.8	E (marginal)
30-27	W of Beauty Point	732301	-0.9	3.7	-0.3	0.8	B
30-28	SW of Beauty Point	741295	1.0	2.2	-0.1	0.9	concrete fine aggregate
30-29	West Arm (N)	716325	-1.2	3.2	-0.4	0.9	C
30-30	Deviot	844209	0.8	1.8	-0.2	1.0	concrete fine aggregate
30-31	Marshalls Creek	557264	-1.4	3.5	-0.7	0.7	B
30-32	Rubicon Estuary	516227	-0.9	3.3	-0.3	0.9	C
S1	Bakers Beach	549321	2.7	0.5	-0.4	1.0	See text
S2	Badger Beach	623376	2.7	0.5	0.2	0.7	See text
S3	N of George Town	760407	2.4	0.7	-0.2	1.3	See text
S4	NE of George Town	791404	2.1	0.7	-0.2	1.9	See text
S5	Eagle Point	530260	2.1	0.5	0.2	1.5	See text

*M = mean, σ = variance, Sk = skewness, K = kurtosis.

estuarine environment and a more local source is suggested. It appears more likely that these deposits are remnants of tributary terraces of more limited extent and the source of material is probably the Precambrian rocks of the Asbestos Range with contributory material from Ordovician quartzite from Cabbage Tree and Salisbury Hills.

The gravel areas are shown in Figure 22 and their orientation of their 'shoestring' shape and reduced levels of bottom indicate the direction of movement. The terrace remnant on the west bank of the Rubicon and the east bank of the Tamar indicate the limits of the ancient flood plains. At the time of gravel deposition, the dolerite hills on the west bank of the Tamar would not have been sufficiently prominent to exercise any influence on the distribution of gravel. They do not rise above 90 m and are capped by gravel in places.

A section has been drawn across Tamar West Arm which divides the two largest gravel deposits (fig. 22). Sections 1-6 (fig. 24) depict the sequence of events leading to the present profile. At least three fluvial cycles are evoked to account for the two terrace levels and finally a eustatic sea level rise of 15 m which retarded the final cycle. Correlation of terrace remnants has been based on continuity and relative elevation of paired remnants. Samples collected on individual terraces do not possess particle size distributions of value for correlative purposes. The reason for this may lie in insufficient sampling to ascertain intra-terrace variation. A more detailed sampling of these gravel deposits may yield useful data for correlative purposes, but as the deposits have been exploited for at least half a century, it would not be possible to obtain representative material. Analyses quoted by Reid (1929) are of more highly sorted gravels than those now obtainable (fig. 26).

For comparison with the sizing parameters for the Beaconsfield gravels (table 4), the specifications in current use by the Department of Public Works have been expressed in the same units (ϕ values) and are presented in Table 5. As the parameters define the frequency curve, they can be used instead of curve matching to determine the suitability of a material for a specific purpose.

Table 5. P.W.D. ROAD MATERIAL SPECIFICATIONS: SIZING PARAMETERS EXPRESSED AS PHI VALUES.

Road Material Specification	Range of ϕ values of sizing parameters							
	Mean		Variance		Skewness		Kurtosis	
A	-3.1	-1.3	1.8	2.8	-0.6	-0.4	1.5	0.8
B	-2.5	-0.5	2.6	3.3	-0.7	-0.4	1.2	0.6
C	-2.1	-0.3	2.6	3.0	-0.7	-0.4	1.2	0.7
D	-1.2	0.9	3.0	2.7	-0.5	-0.3	0.7	0.6
E	-0.9	1.6	2.3	1.9	-0.6	-0.2	0.9	0.7
F	-0.2	2.2	2.5	1.8	-0.3	-0.16	0.7	0.8
Concrete Fine aggregate	-0.73	1.8	1.4	0.9	-0.1	-0.3	0.9	1.1

Specifications A and B are suitable base course materials and Specifications C to F are suitable surface course materials.

Quaternary sand. Patches of windblown and locally derived sand occur throughout the coastal plain. The deposits rarely exceed one metre in thickness and are well sorted and fine-grained. The material is extracted from small pits and used locally as a concrete sand. Supplies are limited and application restricted.

Dune sand is abundant at Northdown, Greens, Badger and Bakers Beaches but is not at present exploited. Dune sand should not be mined within 100 m of high water mark but in some sections of coastline in Beaconsfield Quadrangle the dunes are one kilometre in width so that huge reserves of mineable sand occur outside the limits of the coastline environment.

Sand is pumped from the east bank of the Rubicon estuary at Eagle Point and screened to produce aggregate, moulding, filtration and blasting sand and pebbles. This material is probably derived from the Tertiary gravel which now remains as terrace remnants (see earlier). The bulk of the deposit at Eagle Point is a fine sand.

The sizing parameters of these sands are set out in Table 4 (S1-S5). They are all too fine and too highly sorted for use as fine aggregate in structural concrete.

The output from the Industrial Sands Pty Ltd plant at Eagle Point was 5371 t in 1972.

Beach shingle. Shingle occurs over a distance of 25 km on beaches between Ulverstone and Point Sorell. Northdown Beach is the easternmost portion of this line and contains the last untouched remnant of shingle in the entire deposit. The beaches have been extensively mined in the past for construction purposes but are now closed to mining with the exception of hand selection of grinding pebbles by Mineral Supplies of Ulverstone. This material was derived from Precambrian, Cambrian and Lower Palaeozoic terrains transported down the Mersey and Forth valleys by post-glacial melt waters. The deposition was effected by east flowing currents in Bass Strait. At this time the sea level was 3 m higher so that the shingle is now lying above the reach of present day normal wave action. It is not known how far inland the shingle extends, but it presumably covered the shore platform existing at the time of deposition and could be expected to occur beneath the dunes which extend from the berm inland for distances of up to hundreds of metres.

The deposit is currently under study by government officers for the purposes of assessing accretion, erosion and formulating environmental controls.

Pisolitic ironstone (buckshot gravel). Ironstone gravel deposits occur on the flanks of Mt George and Bullock Hill in the East Tamar region. This material originates from meteoric water which dissolves iron from the dolerite and deposits it in the 'B' horizon of a soil profile as nodules or at the water table to form a hard ferricrete layer. During dry periods, capillary action could perhaps cause similar deposition in soils over dolerite or basalt but similar deposits occur in Tertiary sediments north and east of the Great Western Tiers where the only iron-rich source is the dolerite capping the Tiers.

Deposits of this nature rarely exceed 0.5 m in thickness and in the Beaconsfield area are restricted in extent. The material is used for road construction, mainly as a surface course on unsealed roads.

A similar deposit occurs in the Mt Vulcan area but is not available for use as an aggregate as it is classed as a low grade iron ore.

Terminology. The terminology in common use for aggregate is inadequate for the purposes of this report. The terms and units which have been used, and their inter-relationships are set out in Table 6.

Aggregate requirements for different purposes have been determined by appropriate authorities. Generally speaking they all require a range of particle sizes such that on compaction, a minimum of voids is produced. For ease of presentation the particle size frequency distributions have been given in graphic form as cumulative curves. Steep curves indicate a high degree of sorting which is desirable in concrete aggregates. Flat curves indicate poor sorting which is desirable in road making aggregates.

The parameters which define the frequency curve are the mean, variance, skewness and kurtosis (peakedness). The following general remarks are given as a guide to the parameter values.

Mean (M). Positive values represent material ranging from sand = 0-4, silt 4-8, and clay 8-12.

Variance (σ) is a measure of dispersion, values of less than 0.5 indicate a high degree of sorting, 0.5-1 moderate sorting, 1-2 poor sorting, and values of more than 2 very poor sorting.

Skewness (Sk) is a measure of the symmetry of the frequency curve. The absolute mathematical limits are -1 to +1 with zero representing perfect symmetry of the distribution. Negative values indicate relative abundance of fine particles and positive values a relative abundance of coarse particles.

Kurtosis (K) is a measure of the peakedness of the frequency curve, a normal curve has a value of one. Values in excess of one indicate that the central area of the distribution is better sorted that the 'tails'.

NOTES ON TABLE 6.

NAASRA: National Association of Australian State Road Authorities (1968).

WENTWORTH-UDDEN: Particle size terminology which has been generally accepted (see Lane *et al.*, 1947).

ϕ: $\phi = -\log_2 d$, where d is the diameter of the particle in millimetres. The term was employed by Krumbein (1936) to convert diameters in the Wentworth-Udden grade scale to a simple whole number series.

BSS: British Standard Sieve. These screens are in use in the laboratories of the Departments of Mines and Public Works. The series given forms a 2× geometric progression which is sufficient for most purposes. The full series forms a $\sqrt[4]{2\times}$ progression and is necessary for the sizing analysis of highly sorted sediments such as dune sand. With the exception of the extreme particle sizes, the table has been set out on a logarithmic scale so that the screens in general use form a whole number series.

SCREEN NUMBER: This term gives the number of apertures per lineal inch of screen and is now obsolete. Screens larger than No. 7 were designated by actual aperture in inches.

Table 6. TERMINOLOGY USED TO DESCRIBE AGGREGATE.

NAASRA Term	Wentworth-Udden Term	Range of particle diameters (mm)		Range of particle diameters ϕ values		BSS Particle diameter (mm)	BSS No.	BSS ϕ
	Boulder	>256		<-8				
	Cobble	64	256	-6	-8			
Coarse aggregate						76.2	3 in	-6.27
						37.6	$1\frac{1}{2}$ in	-5.27
(Retained on 2.38 mm screen)	Pebble	4	64	-2	-6	18.8	$\frac{3}{4}$ in	-4.27
						9.4	$\frac{3}{8}$ in	-3.27
						4.7	$\frac{3}{16}$ in	-2.27
	Granule	2	4	-1	-2			
						2.38	7	-1.27
Fine aggregate	Very coarse sand	1	2	1	-1			
						1.2	14	-0.27
(Retained on 0.42 mm screen)	Coarse sand	$\frac{1}{2}$	1	1	0			
						0.6	25	0.73
	Medium sand	$\frac{1}{4}$	$\frac{1}{2}$	2	1			
						0.3	52	1.73
	Fine sand	$\frac{1}{8}$	$\frac{1}{4}$	3	2			
Binder						0.15	100	2.73
	Very fine sand	$\frac{1}{16}$	$\frac{1}{8}$	4	3			
(Passing 0.42 mm screen)						0.075	200	3.73
						0.038	400	4.73
	Silt	$\frac{1}{256}$	$\frac{1}{16}$	8	4			
	Clay	$<\frac{1}{256}$		>8				

GROUNDWATER

W.C. Cromer

Groundwater constitutes only a small proportion of the overall water usage in the Beaconsfield Quadrangle. All the major population centres are supplied from regional reticulated systems, and because much of the area is unsuitable for intensive small-scale farming, rural land owners prefer to rely on surface water rather than underground sources. With the exception of small towns such as Port Sorell, Greens Beach and Kelso, which have recently investigated the possibility of town groundwater supplies, there would seem to be little future demand for groundwater.

All of the groundwater used in the quadrangle is extracted from Tertiary and Quaternary rocks, despite the fact that some of the older sequences (especially the fractured Precambrian, Cambrian and Ordovician rocks) are potentially good aquifers. These remain unexplored because agricultural development has largely been confined to the less rugged and more productive areas. The only available reference to groundwater in pre-Tertiary rocks is that of Stevenson (1975), who reported on groundwater conditions in the Tasmania Mine at Beaconsfield.

GROUNDWATER IN TERTIARY SEDIMENTS

There are few successful bores in the Tertiary sediments and recent investigations by the Department of Mines and private drilling contractors have demonstrated that rapid lateral and vertical lithological changes in these sediments make selection of suitable drilling sites difficult. Future successful holes will be more the result of luck than sound geological practice.

The most productive holes in these sediments occur in the Port Sorell Basin (Cromer, 1977), a thick succession of clay, sand and basalt up to 350 m thick extending south from Port Sorell to Harford. One of the bores drilled at Parkers Ford yielded 270 *l*/min of good quality water which is presently supplementing the Port Sorell town supply (Cromer, 1975) and a second was pump-tested by private contractors at more than 1000 *l*/min. These are unusually high yields and over 20 holes drilled subsequently in similar rocks in the Port Sorell area were failures. The overall success rate throughout the region is probably less than 20%. The water quality from successful holes is good (<500 mg/*l* total dissolved solids) which contrasts strongly with the usually poor-saline (>1500 mg/*l* TDS) groundwater in Tertiary sediments elsewhere in Tasmania.

Tertiary sediments were recently investigated as a possible source of groundwater for the Greens Beach town supply (Cromer and Sloane, 1976) in the Greens Beach and Badger Beach areas. Results were discouraging; yields from shallow spear bores were usually less than 10 *l*/min, and while the overall salinity of the water is acceptable (<500 mg/*l* TDS) the water often contains large amounts of suspended solids and unacceptable dissolved iron levels. The rocks were discounted as useful aquifers.

Sloane (1977, pers. comm.) has conducted a stratigraphic drilling programme in the landslip affected areas of Beauty Point. In the course of the investigations some of the holes in Tertiary sand and clay produced yields of up to 10 *l*/min.

GROUNDWATER IN TERTIARY BASALTS

Throughout Tasmania, basalts have proved to be reliable sources of good-medium quality groundwater. The overall success rate for holes drilled is probably greater than 90%; yields are rarely less than 50 *l*/min and some holes deliver more than 1000 *l*/min.

Port Sorell Basin

The Tertiary succession in the Port Sorell and neighbouring Wesley Vale and Sassafras Basins is:

top	Moriarty Basalt
	Wesley Vale Sand
	Thirlstane Basalt
base	Harford Beds

The Harford Beds are deeply buried and are hydrologically unproductive. The Wesley Vale Sand is composed predominantly of clayey sand and clay and is an unreliable aquifer. Both basalt units are good suppliers of groundwater, but the exposed Moriarty Basalt is extensively and deeply weathered, which results in some bore failures. Much of the Thirlstane Basalt is buried beneath a thin veneer of Wesley Vale Sand. Because of this, it remains relatively fresh and unweathered. This, together with the fact that it contains numerous highly vesicular horizons and is more than 150 m thick in places, has produced a reliable, productive aquifer of very large storage. Fewer than 5% of water bores drilled in this rock are failures and most of the abandoned holes would have been successful if drilled deeper. Invariably, yield increases with depth in this rock type.

Yields in the Moriarty and Thirlstane basalts range from about 50 *l*/min to more than 1500 *l*/min. Water quality is invariably good (<300 mg/*l* TDS)

Greens Beach area

Two investigation water bores were drilled by the Department of Mines in the Tamar basalts at Greens Beach and Kelso. Water was obtained from vesicular zones in otherwise hard, fresh basalt at depths between 17 and 30 m, with yield increasing with depth. One of the holes drilled 150 m from the coast intersected poor quality water (2000 mg/*l* TDS) and was pumped at 240 *l*/min. The aquifer is obviously contaminated with diluted sea water at this site. The second hole, drilled at Kelso, yielded 110 *l*/min of medium quality (1000 mg/*l* TDS) water.

Elsewhere in this area,basalts are considered to be favourable aquifers. The same conclusions apply elsewhere in the quadrangle, but individual sites should be geologically investigated prior to drilling.

GROUNDWATER IN QUATERNARY SEDIMENTS

Many Quaternary deposits, especially marine and aeolian coastal sands, are reliable low-yielding aquifers containing good-medium quality groundwater. Previous investigations in the quadrangle have been concentrated largely in coastal areas and the region possesses extensive tracts of Quaternary sediments which are potentially useful aquifers.

Table 7. SUMMARY OF WATER BORE DATA, BEACONSFIELD QUADRANGLE

Rock type	Water bore success rate (%)	Average yield (*l*/min)	Average water quality (mg/*l*)	Calculated aquifer properties S*	T (m^2/day)†
Tertiary sediments	<20	0->1000	250-1500	10^{-4} -- 10^{-5}	100-120
Tertiary basalts	>90	50->1500	<300	n.d.	n.d.
Quaternary sand	>95	20-50	<500	0.20	*c*.70

* Storage coefficient or specific yield; dimensionless

† Transmissivity, m^3/day/m (m^2/day)

Areas east of George Town

Leaman (1973b) reported briefly on groundwater from unconsolidated sediments in the George Town district. He estimated available water reserves in aeolian sands between Low Head and Five Mile Bluff as 39 x 10^6 m^3, with an annual recharge of 6 x 10^6 m^3. A test bore in unconsolidated aeolian sand at Beechford yielded medium quality water (800 mg/*l* TDS) at 26 *l*/min.

Port Sorell

Small areas of Quaternary sediments occur in the vicinity of Port Sorell township, where they overlie Tertiary sand and clay. A test bore at the Shearwater Golf Club (Cromer, 1974) drilled to a depth of 15 m in Quaternary (?) sand and quartz grit, yielded 450 *l*/min of medium quality water (1200 mg/*l* TDS).

Greens Beach

The aeolian and marine sand bordering Greens Beach has been the subject of detailed investigations aimed at establishing a reliable town supply (Cromer and Sloane, 1976). The aquifer is 9 m thick and overlies stiff green clay thought to be derived from weathering of the underlying basalt. A 13-day pump test conducted on a circular 12-spear bore array yielded 240 *l*/min (20 *l*/min/spear) of good quality (510 mg/*l* TDS) water (Cromer, 1978, in press). The installation presently supplies a neighbouring golf club and caravan park with drinking water and will later form part of the permanent town supply. Additional arrays are planned as consumer demand increases.

Other coastal areas

Potentially the most promising coastal aquifer is the aeolian and marine sand bordering Badger Beach, between Badger and Wentworth Heads. The sand extends up to one kilometre inland and could in future supply large quantities of groundwater.

A narrow strip of coastal sand less than 100 m wide and 2 m thick has been used for many years as a source of groundwater by householders at Kelso. There are a total of 27 shallow wells about 2-3 m above high water mark extending over a distance of one kilemetre. Yields are variable and low (<10 *l*/min) and the presence of abundant shelly bands in the sand renders the medium-quality (1500 mg/*l* TDS) water hard and unsuitable for most household purposes.

REFERENCES

ANONYMOUS 1898. Beaconsfield. The Tasmania mine, *in* Tasmania and its mineral wealth. 2 ed. *Aust.min.Stand.* Spec.ED.:49-54.

BAKER, G. 1957. Further occurrences of nickel and chromium minerals from Anderson's Creek area, northern Tasmania. *Mineragr.Invest.CSIRO* 722.

BAKER, G. 1959. Rodingite in nickeliferous serpentinite, near Beaconsfield, northern Tasmania. *J.geol.Soc.Aust.* 6:21-35.

BAKER, G.; EDWARDS, A.B. 1957. Nickeliferous serpentinite and rodingite from Anderson's Creek, near Beaconsfield, northern Tasmania. *Mineragr. Invest.CSIRO* 682.

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

BHATTACHARJI, S.; SMITH, C.H. 1964. Flowage differentiation. *Science* 145: 150-153.

BIGGE, J.T. 1823. Report of the Commissioner of Inquiry, on the state of agriculture and trade in the colony of New South Wales. *House of Commons Pap.U.K.* 1823(136).

BLAKE, F. 1928a. Clay and sand deposits of Tasmania. *Unpubl.Rep.Dep.Mines Tasm.* 1928(2):45-50.

BLAKE, F. 1928b. Paint materials procurable in Tasmania. *Unpubl.Rep.Dep. Mines Tasm.* 1928(2):39-44.

BLAKE, F. 1938. Supplementary report on drilling at Lefroy. *Unpubl.Rep. Dep.Mines Tasm.* 1938:61-63.

BLAKE, F. 1960. Geology of proposed bridge site at Longreach, River Tamar. *Tech.Rep.Dep.Mines Tasm.* 5:124-126.

BLAKE, F. 1961. Landslips at Beauty Point. *Tech.Rep.Dep.Mines Tasm.* 5:194-196.

BROADHURST, E. 1935. Lefroy and Back Creek goldfields. *Bull.geol.Surv.Tasm.* 42.

BURNS, K.L. 1965. One mile geological map series. K/55-6-29. Devonport. *Explan.Rep.geol.Surv.Tasm.*

CAREY, S.W. 1947. Geology of the Launceston district. *Rec.Qn Vict.Mus.* 2(1):31-46.

CLARKE, M.J. 1968. A reappraisal of a Lower Permian type section, Golden Valley, Tasmania. *Rec.geol.Surv.Tasm.* 7.

CLARKE, M.J. 1969. Preliminary notes on the occurrence of the Alandale and Ulladulla faunas in Tasmania. *Tech.Rep.Dep.Mines Tasm.* 13:128-138.

CLOKE, P.L.; KELLY, W.C. 1964. Solubility of gold under inorganic supergene conditions. *Econ.Geol.* 59:269-270.

CROMER, W.C. 1974. Groundwater investigations at the Shearwater Golf Club, Port Sorell. *Unpubl.Rep.Dep.Mines Tasm.* 1974/73.

CROMER, W.C. 1975. Hydrology of the Tertiary sediments near Port Sorell. *Tech.Rep.Dep.Mines Tasm.* 19:110-127.

CROMER, W.C. 1977. Deep drilling in Tertiary basins east of Devonport. *Tech.Rep.Dep.Mines Tasm.* 20:45-52.

CROMER, W.C. 1978. Groundwater from coastal sands; Greens Beach, Northern Tasmania. *Bull.geol.Surv.Tasm.* 57.

CROMER, W.C.; SLOANE, D.J. 1976. Geology and hydrology of the Tertiary and Quaternary sediments near Greens Beach, Northern Tasmania. *Unpubl.Rep. Dep.Mines Tasm.* 1976/24.

CUNDY, W.H.; FAWCETT, L. 1914. [*Report on Tasmania gold mine*]. (Consultants report to Minister for Mines for Tasmania).

DAVIES, J.L. 1959. High level erosion surfaces and landscape development in Tasmania. *Aust.Geogr.* 7:193-203.

DUFF, F.G. 1888. *Mineral deposits of the West Tamar.* Launceston Examiner. (Reprinted from *Launceston Examiner* 48(252):[3], (253):[3]).

EDWARDS, A.B. 1950. Petrology of the Cainozoic basaltic rocks of Tasmania. *Proc.R.Soc.Vict.*N.S. 62:97-120.

EVANS, G.W. 1822. *A geographical, historical, and topographical description of Van Diemen's Land.* Souter : London.

FRIEND, M.C. 1848. On the landslips which have recently occurred on the west bank of the River Tamar, Van Diemen's Land. *Tasm.J.nat.Sci.* 3:358-360.

GEBERT, H. 1967. Report on exploration licences 3/65 and 14/65, Beaconsfield, Tasmania. *Unpubl.Rep.Broken Hill Pty Co. Ltd.*

GEE, R.D. 1968. A revised stratigraphy for the Precambrian in north-west Tasmania. *Pap.Proc.R.Soc.Tasm.* 102:7-10.

GILL, E.D. 1962. Cainozoic, *in* SPRY, A.H.; BANKS, M.R. (ed.). The geology of Tasmania. *J.geol.Soc.Aust.* 9:233-253.

GILL, E.D.; BANKS, M.R. 1956. Cainozoic history of Mowbray Swamp and other areas of north-western Tasmania. *Rec.Qn Vict.Mus.* N.S. 6.

GLOVER, W.H. 1889. [Reports of Commissioners]. *Rep.Secr.Mines Tasm.* 1888-1889:6.

GLOVER, W.H. 1898. [Reports of Commissioners]. *Rep.Secr.Mines Tasm.* 1897-1898:12.

GOULD, C. 1864. Report upon the geological structure of part of the County of Dorset. *House of Assembly Pap.Tasm.* 1864(46).

GOULD, C. 1866. Geological Surveyor's report of the country near Ilfracombe, in the West Tamar district. *House of Assembly Pap.Tasm.* 1866(76).

GREEN, D.H. 1959. Geology of the Beaconsfield district, including the Andersons Creek ultrabasic complex. *Rec.Qn Vict.Mus.* N.S. 10.

GROVES, D.I. 1965. Geology of the Lefroy goldfield. *Tech.Rep.Dep.Mines Tasm.* 9:58-76.

HELBY, R.J. 1972. A palynological reconnaissance of the Golden Valley borehole. *Unpubl.Rep.geol.Surv.N.S.W.* 72/1.

HILLS, L.; REID, A.M.; NYE, P.B.; KEID, H.C.W.; REID, W.D. 1922. The coal resources of Tasmania. *Miner.Resour.geol.Surv.Tasm.* 7.

HOWLAND-ROSE, A.W. 1965. Beaconsfield deep lead gravity survey, Tasmania 1964. *Rec.Bur.miner.Resour.Geol.Geophys.Aust.* 1965/139.

HUDSON, J.O. 1923. Tasmania mine. *Unpubl.Rep.Dep.Mines Tasm.* 1923.

HUGHES, T.D. 1949. Coal at Georgetown. *Unpubl.Rep.Dep.Mines Tasm.* 1949:74.

HUGHES, T.D. 1953. The Beaconsfield and Lefroy goldfields. *Publ.5th emp. min.metall.Congr.* 1:1233-1241.

HUGHES, T.D. 1954. Geological report on country east of Port Sorell. *Unpubl.Rep.Dep.Mines Tasm.* 1954:12-18.

HUGHES, T.D. 1955. Pyrite prospect, Branch Creek (3rd Report). *Unpubl. Rep.Dep.Mines Tasm.* 1955:149-157.

HUGHES, T.D. 1957. Nickel near Beaconsfield. *Tech.Rep.Dep.Mines Tasm.* 1: 19-22.

HUGHES, T.D. 1958a. Clay deposit of W.C. Leonard, Beaconsfield. *Tech.Rep. Dep.Mines Tasm.* 2:42-43.

HUGHES, T.D. 1958b. Proposed bridge over Tamar River at Whirlpool Reach. *Tech.Rep.Dep.Mines Tasm.* 2:111-113.

HUGHES, T.D. 1959a. Supplementary report on proposed bridge site, Whirlpool Reach, Tamar River. *Tech.Rep.Dep.Mines Tasm.* 3:121.

HUGHES, T.D. 1959b. Further samples from Beaconsfield nickeliferous clay. *Tech.Rep.Dep.Mines Tasm.* 3:67-70.

HUGHES, T.D. 1962. Nickel in serpentine near Beaconsfield. *Tech.Rep.Dep. Mines Tasm.* 6:38-40.

IRVINE, T.N.; SMITH, C.H. 1967. The ultramafic rocks of the Muskox intrussion, Northwest Territories, Canada, *in* WYLLIE, P.J. (ed.). *Ultramafic and related rocks:* 38-49. Wiley : New York.

JENNINGS, D.J. 1967. Geological atlas 1 mile series. Zone 7 Sheet 23 (8316S). Noland Bay. *Department of Mines, Tasmania.*

JENNINGS, I.B. 1964a. Slope stability at Beauty Point. *Tech.Rep.Dep.Mines Tasm.* 8:92-99.

JENNINGS, I.B. 1964b. Proposed extensions, Inspection Head Wharf. *Tech. Rep.Dep.Mines Tasm.* 8:99-100.

JENNINGS, I.B. 1971. Inspection of proposed subdivisions Beauty Point. *Tech.Rep.Dep.Mines Tasm.* 14:77-79.

JENNINGS, J.N. 1959. The coastal geomorphology of King Island, Bass Strait, in relation to changes in the relative level of land and sea. *Rec.Qn Vict.Mus.* N.S. 11.

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

JUST, T.C. 1891. Notes on the iron ore deposits of the Tamar District, Tasmania and on the manufacture of pig iron therefrom. *Tasm.Off.Rec.* 1891:457-470.

KRAUSKOPF, K.B. 1951. The solubility of gold. *Econ.Geol.* 46:858-870.

KRUMBEIN, W.C. 1936. Application of logarithmic moments to size frequency distribution of sediments. *J.sediment.Petrology.* 6:35-47.

LANE, E.W. *et al.* 1974. Report of the subcommittee on sediment terminology. *Trans.am.geophys.Un.* 28:936-938.

LEAMAN, D.E. 1973a. Devonport-Port Sorell gravity survey. *Tech.Rep.Dep. Mines Tasm.* 16:97-105.

LEAMAN, D.E. 1973b. Underground water prospects from unconsolidated aquifers in the George Town area. *Tech.Rep.Dep.Mines Tasm.* 16:216-217.

LINDGREN, W.L. 1933. *Mineral Deposits.* McGraw-Hill : New York.

LONGMAN, M.J. 1966. One mile geological map series. K/55-7-39. Launceston. *Explan.Rep.geol.Surv.Tasm.*

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

McKELLAR, J.B.A. 1957. Geology of portion of the Western Tiers. *Rec.Qn Vict.Mus.* N.S. 7.

McMICHAEL, D.F. 1957. A review of the fossil freshwater mussels (Mollusca, Pelecypoda) of Australasia. *Proc.linn.Soc.N.S.W.* 81:222-244.

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

MATTHEWS, W.L. 1966. Possible building sites at George Town. *Tech.Rep.Dep. Mines Tasm.* 10:87-90.

MONTGOMERY, A. 1891. Report on the geological structure of the Beaconsfield goldfield. *Rep.Secr.Mines Tasm.* 1890-1891:43-57.

MONTGOMERY, A. 1896. Geological survey of the Lefroy goldfield. Progress Report. *Rep.Secr.Mines Tasm.* 1895-1896:xxxix-xl.

MONTGOMERY, A. 1897. Lefroy goldfield, Tasmania. Report on the geological structure and mining development. *Rep.Secr.Mines Tasm.* 1896-1897: i-xxxviii.

NATIONAL ASSOCIATION OF AUSTRALIAN STATE ROAD AUTHORITIES. 1968. *Guide to the selection and testing of gravel for pavement construction.* NAASRA: Sydney.

NICHOLS, K.D. 1960. Erosion surfaces, river terraces, and river capture in the Launceston Tertiary basin. *Pap.Proc.R. Soc.Tasm.* 94:1-12.

NOLDART, A.J. 1963. Alluvial chromite deposits, Andersons Creek area, Beaconsfield goldfield. *Tech.Rep.Dep.Mines Tasm.* 7:69-76.

NOLDART, A.J. 1964. Notes on auriferous deposits, Beaconsfield goldfield. *Tech.Rep.Dep.Mines Tasm.* 8:10-22.

NOLDART, A.J. 1968. Exploratory diamond drilling, Tasmania gold mine, Beaconsfield goldfield. *Tech.Rep.Dep.Mines Tasm.* 12:27-36.

NYE, P.B. 1924. Report on cement materials in the Beaconsfield and Flowery Gully districts. *Unpubl.Rep.Dep.Mines Tasm.* 1924:138-162.

NYE, P.B. 1925. Report on the Golden Zone mine, Lefroy. *Unpubl.Rep.Dep. Mines Tasm.* 1925:41-43.

NYE, P.B. 1930. Report on the boring operations undertaken in connection with the Beaconsfield chromiferous iron ore deposits. *Unpubl.Rep.Dep. Mines Tasm.* 1930:59-63.

RALEIGH, C.B.; PATERSON, M.S. 1965. Experimental deformation of serpentine and its tectonic implications. *J.geophys.Res.* 70:3965-3985.

REID, A.M. 1919. Asbestos in the Beaconsfield district. *Rep.geol.Surv.Tasm.* 8.

REID, A.M. 1929. Tamar Sands. *Unpubl.Rep.Dep.Mines Tasm.* 1929:114-128.

SCOTT, J.B. 1930. Report on boring at Beaconsfield. Victoria drilling plant. *Unpubl.Rep.Dep.Mines Tasm.* 1930:140-141.

SHAW, B. 1873. George Town and Waterhouse goldfield. *House of Assembly Pap.Tasm.* 1873(57).

SKEATS, W. 1922. Report on the geological conditions at the Bell Bay site, Tamar estuary, as affecting the question of its suitability as a future deep water port for Launceston. *Daily Telegraph, Launceston* 42(161):8. (Report to Marine Board, Launceston).

SLOANE, D.J. 1977. The Beauty Point landslip area. *Unpubl.Rep.Dep.Mines Tasm.* 1977/7.

STEVENSON, P.C. 1971. A mud spring and a landslip at Deviot. *Tech.Rep.Dep. Mines Tasm.* 14:79-82.

STEVENSON, P.C. 1973a. Examination of a landslip at Beauty Point. *Tech. Rep.Dep.Mines Tasm.* 15:61-63.

STEVENSON, P.C. 1973b. Foundation conditions at Tamar Avenue, George Town. *Tech.Rep.Dep.Mines Tasm.* 15:64-66.

STEVENSON, P.C. 1975. Groundwater conditions at the Tasmania Mine, Beaconsfield. *Tech.Rep.Dep.Mines Tasm.* 18:138-141.

SUTHERLAND, F.L. 1966. The Tertiary volcanics of the Tamar Valley, northern Tasmania - a preliminary report. *Aust.J.Sci.* 29:114-115.

SUTHERLAND, F.L. 1969. The mineralogy, petrochemistry and magmatic history of the Tamar lavas, northern Tasmania. *Pap.Proc.R.Soc.Tasm.* 103:17-34.

SUTHERLAND, F.L. 1971. The geology and petrology of the Tertiary volcanic rocks of the Tamar trough, northern Tasmania. *Rec.Qn Vict.Mus.* 36.

TAYLOR, B.L. 1955. Asbestos in Tasmania. *Miner.Resour.geol.Surv.Tasm.* 9.

THREADER, V.M. 1967. *The geology of the Mangana-Waterhouse goldfields with particular reference to structure and mineralisation.* M.Sc. thesis. University of Tasmania : Hobart.

THREADER, V.M. 1973. Prospecting for talc near Marshalls Creek, Rubicon estuary. *Tech.Rep.Dep.Mines* 15:16-18.

THUREAU, G. 1882. Report on the mineral resources and permanency of the Lefroy gold field. *House of Assembly Pap.Tasm.* 1882(118).

THUREAU, G. 1883a. Report on the future prospects as regards productiveness and permanency of the Beaconsfield and Salisbury mining districts. *House of Assembly Pap.Tasm.* 1883(51).

THUREAU, G. 1883b. Report on the future prospects of deep mining of gold-bearing quartz lodes at Lefroy. *House of Assembly Pap.Tasm.* 1883(126).

THUREAU, G. 1884. Carbonaceous and associated mineral deposits near Beaconsfield. *Parl.Pap.Tasm.* 1884(96).

TWELVETREES, W.H. 1900. Report on the asbestos deposits, Anderson's Creek, near Beaconsfield. *Rep.Secr.Mines Tasm.* 1889-1900:xxxi-xl.

TWELVETREES, W.H. 1902. Report on deep sinking at the Moonlight-cum-Wonder gold mine, Beaconsfield. *Rep.Secr.Mines Tasm.* 1901-1902:269-280.

TWELVETREES, W.H. 1903a. *Report on the mineral resources of the districts of Beaconsfield and Salisbury.* Mines Department, Tasmania.

TWELVETREES, W.H. 1903b. *Report upon the present position of the Tasmania mine, Beaconsfield.* Mines Department, Tasmania.

TWELVETREES, W.H. 1904. *Report on coal near George Town and slate near Badger Head.* Mines Department, Tasmania.

TWELVETREES, W.H. 1908. Back Creek. *Rep.Secr.Mines Tasm.* 1907:65.

TWELVETREES, W.H. 1917. Asbestos at Andersons Creek. *Miner.Resour.geol. Surv.Tasm.* 4.

TWELVETREES, W.H.; REID, A.M. 1919. The iron ore deposits in Tasmania. *Miner.Resour.geol.Surv.Tasm.* 6.

VARNES, D.J. 1958. Landslide types and processes, *in* ECKEL, E.B. (ed.). Landslides and engineering practice. *Spec.Rep.Highway Res.Bd Wash.* 29: 20-47.

WARD, L.K. 1912. The origin of certain contact rocks with a high content of lime and magnesia. *Rep.Aust.Ass.Advanc.Sci.* 13:176-187.

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

APPENDIX 1

Andersons Creek Bore Holes

M.J. Clarke

In the Andersons Creek area two diamond drill holes, which were originally programmed for economic investigations, have provided stratigraphic details of the lowermost parts of the Masseys Creek Group. The positions of the two drill holes are indicated on the published geological map. Both holes were drilled vertically and were fully cored. Details are given in Tables 1 and 2.

Important conclusions are:

(1) Correlation between the two holes is good, although it is evident that the thicknesses of individual units show significant variations.

(2) The intervals containing the glauconitic beds encountered in both holes, closely resemble a sequence exposed in Andersons Creek 180-190 m below the Liffey Sandstone. If this correlation is valid, the Masseys Creek Group has a total thickness in this area of about 290 m.

(3) D.D.H. 1 was collared 16 m above D.D.H. 2, yet encountered basement 9 m below the level in D.D.H. 2. Assuming a regular basement surface (by no means probable) the basement slopes gently to the south. However, the detailed facies variations between the two sequences drilled, tend to suggest that deeper water conditions prevailed to the north. Basement slopes to the east and west must be steeper since Cambrian ultramafic rocks are exposed around the Permian outcrop little more than 35-45 m below the collars of the bore holes. Overall the data indicate a relatively small and localised pre-Permian valley which now slopes gently to the south, and with relatively steeper walls to the east and west. Originally the valley may have deepened to the north.

(4) Macrofossils are present in both bore holes except for the first 60 m above basement. They are insufficiently abundant or diverse to permit a precise age allocation other than indicating a broad Allandale Fauna age. However, in Andersons Creek well-preserved faunas are intermittently developed throughout the Masseys Creek Group, and three more precise divisions of a more broadly conceived Allandale Fauna can be recognised in superposition. Since the lowest of these three faunas partly overlaps the collars of the two bore holes, it is evident that no part of the bore hole sequences can be younger than the oldest recognisable assemblage in Andersons Creek.

(5) Samples at approximately 9 m intervals in D.D.H. 1 were processed for palynological examination. Dr R.J. Helby (pers. comm.) reports 'the presence of abundant and well-preserved early Stage 2 microfloras throughout. They are almost identical with assemblages associated with the lowest Allandale macrofauna in the Cranky Corner Basin, New South Wales.' This supports the more detailed subdivision of the Allandale Fauna based on macrofossils, since late Stage 2 microfloras occur in association with the main Allandale *Eurydesma cordatum* assemblage at Golden Valley (Clarke, 1968; Helby, 1972).

Table 1. ANDERSONS CREEK D.D.H. 1 [49/709213]

Depth (m)	Thickness (m)	Description
0	34.38	Siltstone and fine sandstone with some fenestellids. Essentially ill-sorted and with worm burrows and rare pebbles in places. Occasional coarser gritty layers with fragments of *Grantonia*, *Eurydesma* and *Stenopora*.
38.38	9.10	Coarse-grained glauconitic and shelly siltstone and sandstone. Very pebbly. Fossils comprise mostly *Grantonia* sp. nov. with some *Strophalosia*, *Eurydesma*, *Stenopora* and fenestellids. Bryozoal mudstone without pebbles (1.22 m) between 41.45 and 42.67 m.
43.58	6.20	Dark, monotonous pyritic and carbonaceous mudstone with rare small pebbles (hereafter termed 'Quamby type'), except for 38 cm of ill-sorted sandstone with many pebbles and shell fragments at 48.37-48.75 m.
49.78	2.03	Ill-sorted pebbly and shelly siltstone and sandstone.
58.81	29.57	'Quamby type' mudstone with rare thin pebbly bands which contain *Grantonia*, *Eurydesma* and other shelly debris.
81.38	9.14	Ill-sorted pebbly siltstone and sandstone with sparse shelly debris. Bryozoal mudstone (3.66 m) with few pebbles between 83.51 and 87.17 m.
90.52	27.49	Ill-sorted siltstone and mudstone with smaller pebbles and little fossil debris. Rare thin gravelly horizons.
118.01	3.91	Very pebbly, ill-sorted sandstone.
121.92	4.71	'Quamby type' mudstone.
126.63	11.29	Ill-sorted siltstone with scattered pebbles. Uppermost 60 cm very gravelly.
137.92	6.25	'Quamby type' mudstone. Basal 22 cm consists of an ultramafic gravel.
144.17	8.39	Unconformity. Cambrian ultramafic rocks.
153.56		Hole completed.

Table 2. ANDERSONS CREEK D.D.H. 2 [49/709217]

Depth (m)	Thickness (m)	Description
0	9.75	Dark siltstone, no fossils.
9.75	7.62	Ill-sorted, pebbly and shelly glauconitic siltstone and sandstone with *Grantonia* sp. nov. and *Eurydesma*. Bryozoal mudstone (2.33 m) between 14.32 and 16.65 m.
17.37	17.07	Essentially 'Quamby type' mudstone with rare gravelly layers with *Grantonia* and *Eurydesma*. Rare calcareous concretions.
34.44	1.37	Ill-sorted pebbly siltstone with shelly debris.
35.81	24.38	'Quamby type' mudstone with occasional thin layers of pebbly siltstone with *Grantonia* and *Eurydesma*.
60.19	2.90	Bryozoal mudstone with some pebbles.
63.09	29.87	Ill-sorted pebbly siltstone and mudstone.
92.96	3.66	'Quamby type' mudstone.
96.62	14.07	Very pebbly, ill-sorted siltstone (tillite?).
110.69	7.11	'Quamby type' mudstone.
117.80	1.75	Ultramafic conglomerate.
119.55	6.55	Unconformity. Cambrian ultramafic rocks.
126.10		Hole completed.

APPENDIX 2

Transformation of grid references

The Australian National Grid (ANG), in which coordinates are given in yards, is used on the Beaconsfield geological map sheet and ANG references are given in this report. The ANG is now obsolete and has been superseded by the metric Australian Map Grid (AMG). When using this report in conjunction with later maps printed with the AMG the equivalent references may be found by consulting the following table:

ANG 100-yard reference	*AMG 100-metre reference*	*ANG 100-yard reference*	*AMG 100-metre reference*
49/516227	DQ633360	49/732273	DQ830405
49/529226	DQ645360	49/732301	DQ830430
49/530260	DQ645391	49/733272	DQ831404
49/534250	DQ649382	49/733320	DQ830448
49/535240	DQ650372	49/734199	DQ832337
49/536272	DQ651402	49/741295	DQ838425
49/549321	DQ662447	49/741333	DQ837460
49/557264	DQ670395	49/747248	DQ844382
49/558292	DQ671420	49/747259	DQ844392
49/623376	DQ729498	49/750254	DQ847387
49/683339	DQ784464	49/760236	DQ856371
49/686333	DQ787459	49/760407	DQ854527
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49/689333	DQ790459	49/767235	DQ862370
49/694277	DQ795408	49/767298	DQ862428
49/694278	DQ795409	49/769258	DQ864391
49/695277	DQ796408	49/771355	DQ865480
49/696261	DQ797393	49/774283	DQ868414
49/696271	DQ797402	49/774286	DQ868417
49/697223	DQ798359	49/774835	DQ862919
49/699272	DQ800403	49/777218	DQ872355
49/701254	DQ802387	49/779217	DQ873354
49/702313	DQ802441	49/791404	DQ882525
49/705299	DQ805428	49/794337	DQ886464
49/706288	DQ806418	49/816376	DQ906500
49/708239	DQ808373	49/819377	DQ908501
49/713315	DQ813443	49/822462	DQ910578
49/714317	DQ813445	49/844209	DQ933347
49/714339	DQ813465	49/846205	DQ935344
49/716310	DQ815438	49/853364	DQ939489
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49/718220	DQ818356	49/868360	DQ953486
49/719347	DQ817472	49/874358	DQ959484
49/720325	DQ818452	49/874359	DQ959485
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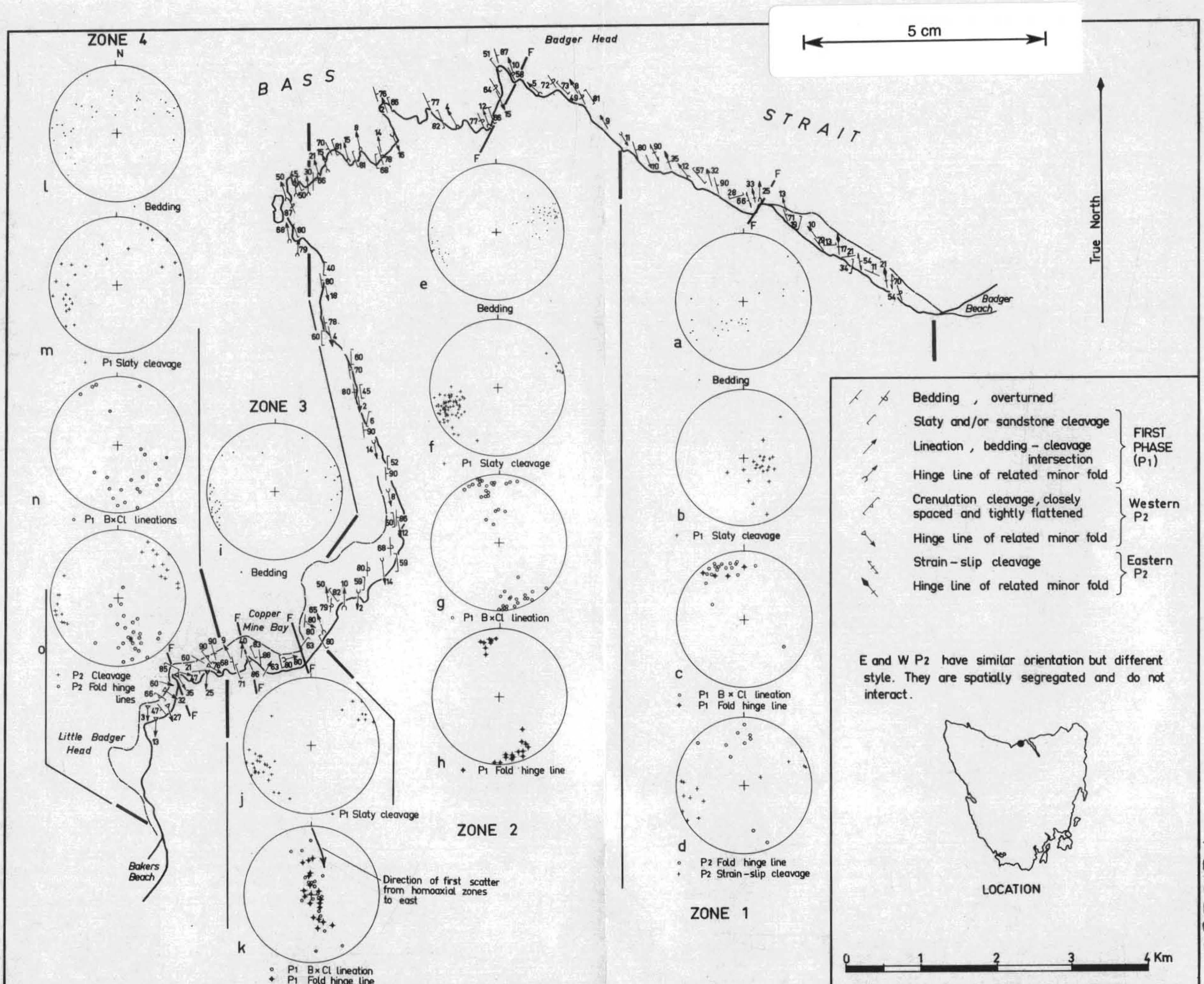

Figure 3. *Structural data, Precambrian rocks, Badger Head.*

Beaconsfield Explan.Rep.

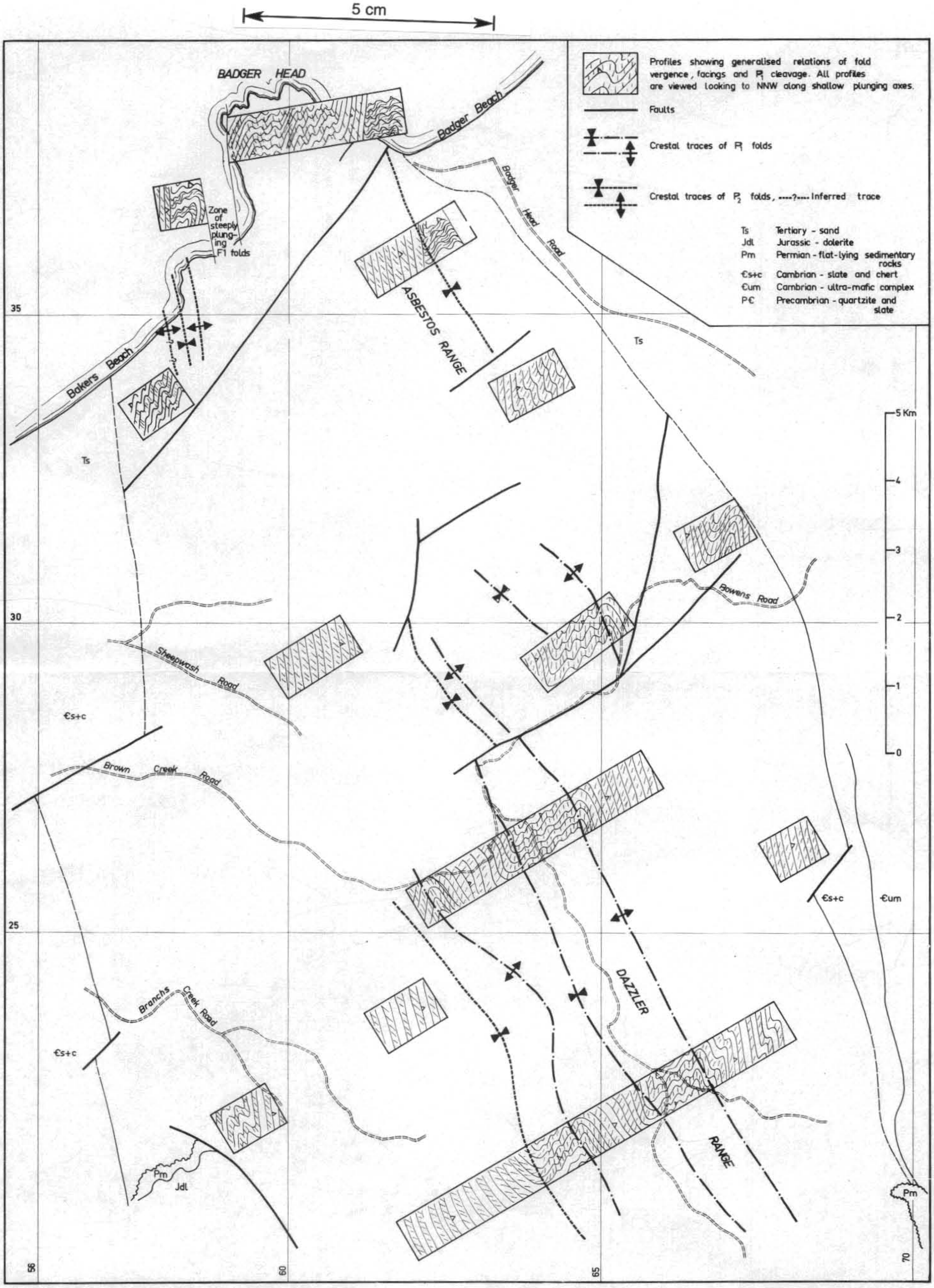

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Figure 6. *Structure of the Asbestos-Dazzler Ranges.* Beaconsfield Explan.Rep.

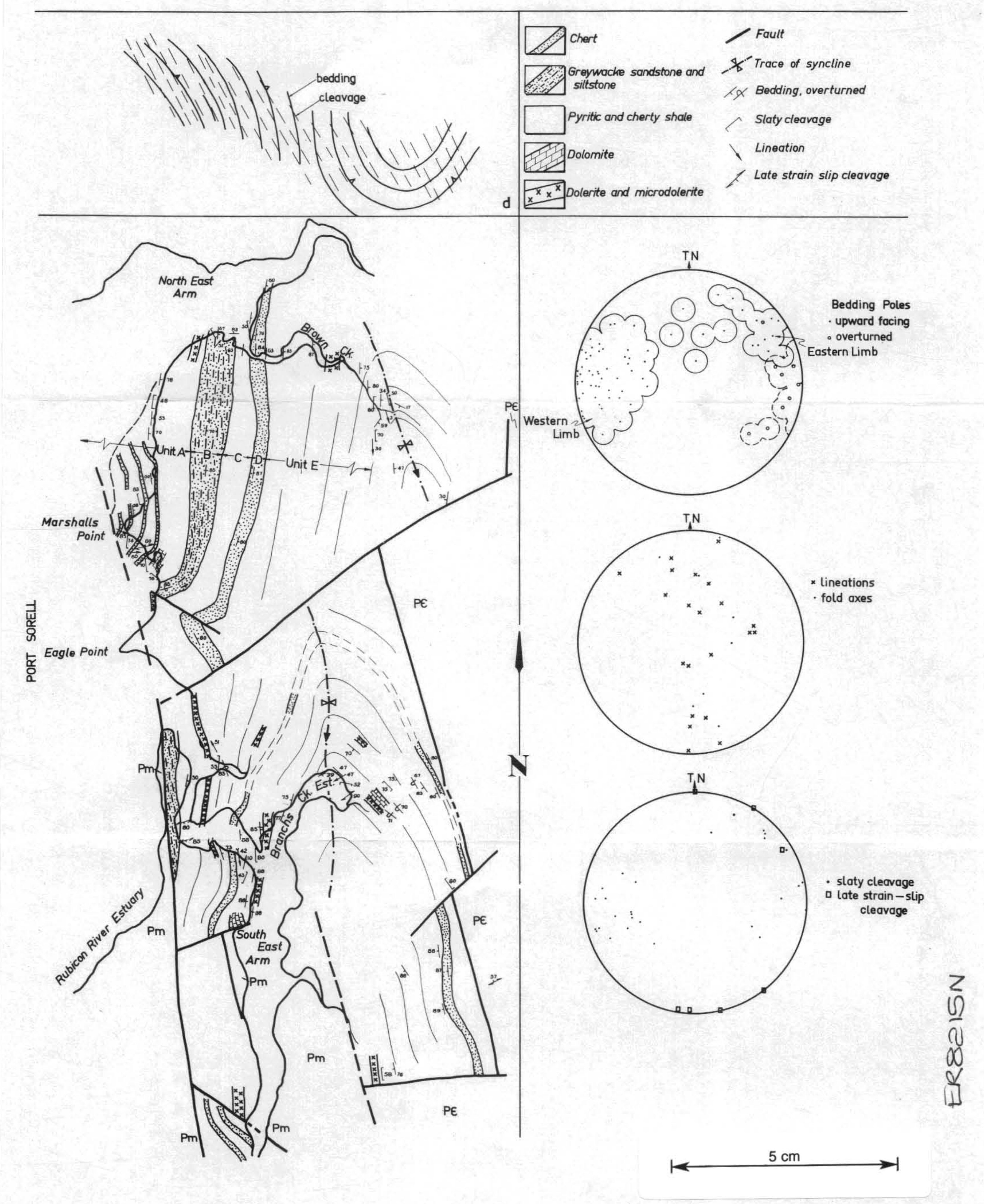


Figure 8. *Cambrian geology, Port Sorell inlet.*

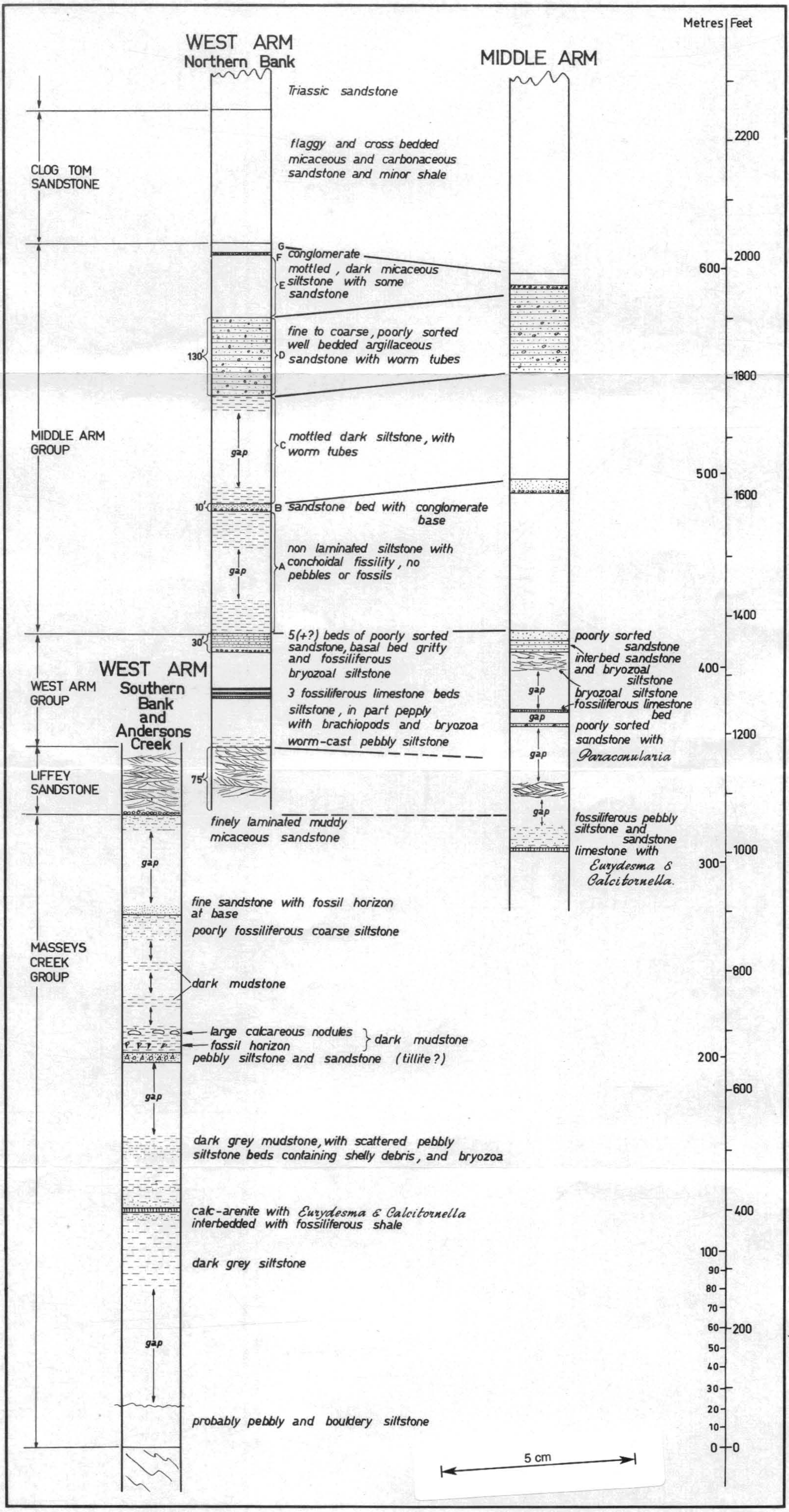


Figure 15. *Permian sections, West Tamar.*

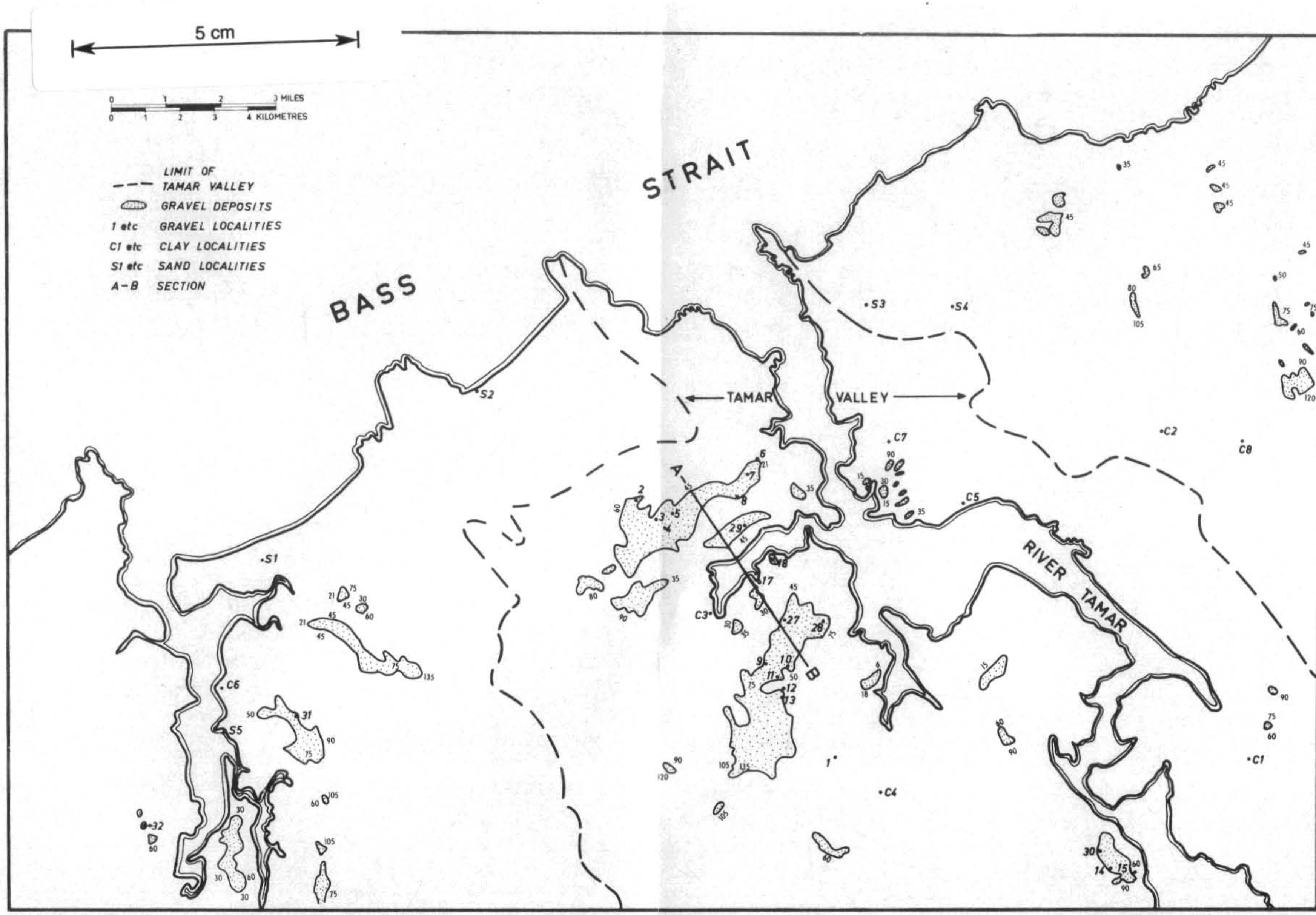
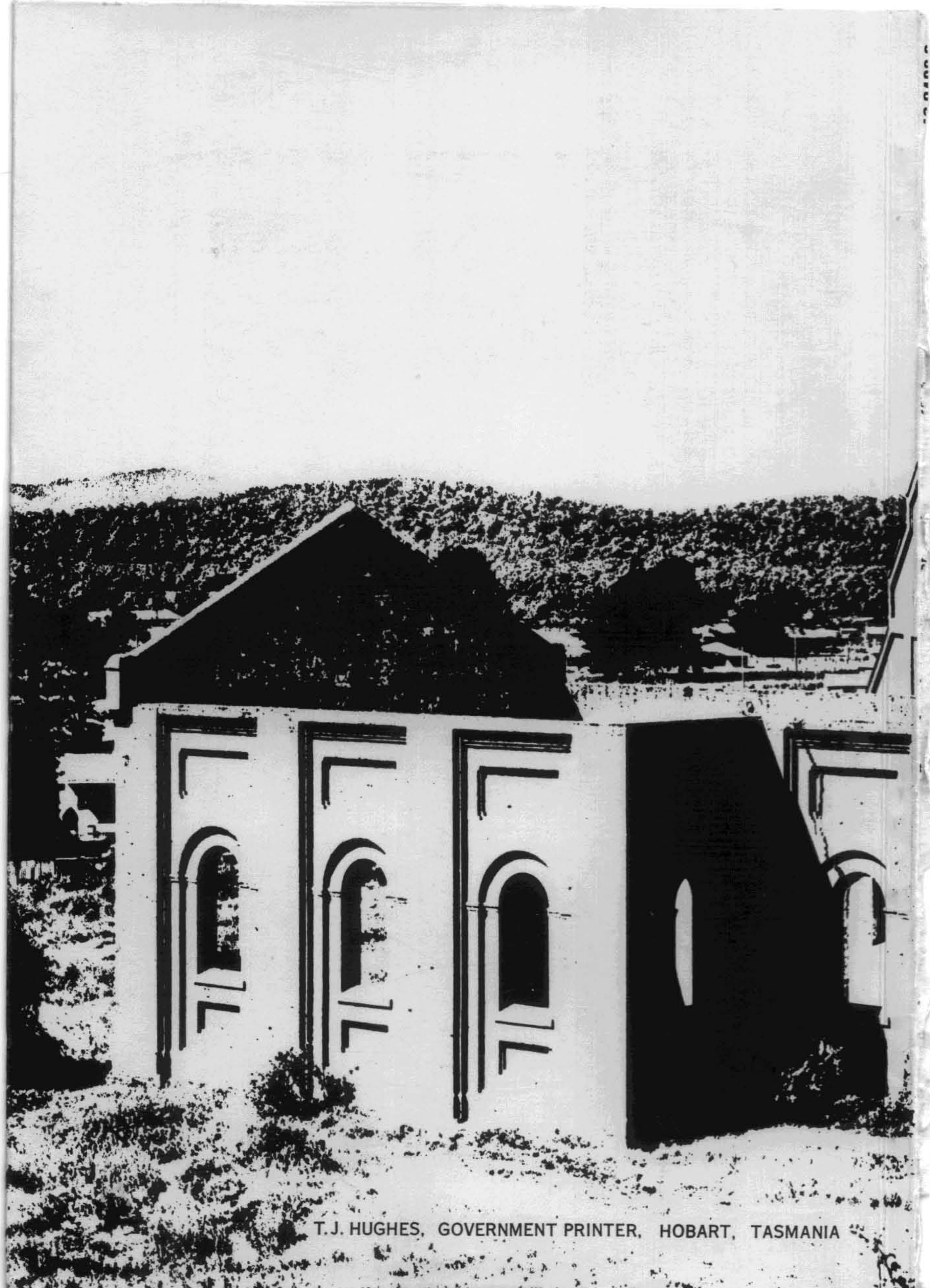


Figure 22. *Distribution of gravel deposits, and clay and sand sample localities. Heights in metres.*

[Beaconsfield Explan.Rep.]



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