ER8016 S

TASMANIA DEPARTMENT OF MINES

1971

GEOLOGICAL SURVEY EXPLANATORY REPORT

GEOLOGICAL ATLAS 1 MILE SERIES

ZONE 7 SHEET No. 22 (8016S)

TABLE CAPE

by R. D. GEE, B.Sc., Ph.D.

REGISTERED IN AUSTRALIA FOR TRANSMISSION BY POST AS A BOOK $1

№ 496

TASMANIA DEPARTMENT OF MINES

1971

GEOLOGICAL SURVEY EXPLANATORY REPORT

GEOLOGICAL ATLAS 1 MILE SERIES

ZONE 7 SHEET No. 22 (8016S)

TABLE CAPE

by R. D. GEE, B.Sc., Ph.D.

ISSUED UNDER THE AUTHORITY OF THE HONOURABLE
LEONARD HUBERT BESSELL, M.H.A.
MINISTER FOR MINES FOR TASMANIA

T. J. HUGHES, GOVERNMENT PRINTER, HOBART, TASMANIA

52221

FRONTISPIECE. Table Cape: A crinanite neck.

CONTENTS

LIST OF FIGURES

LIST OF PLATES

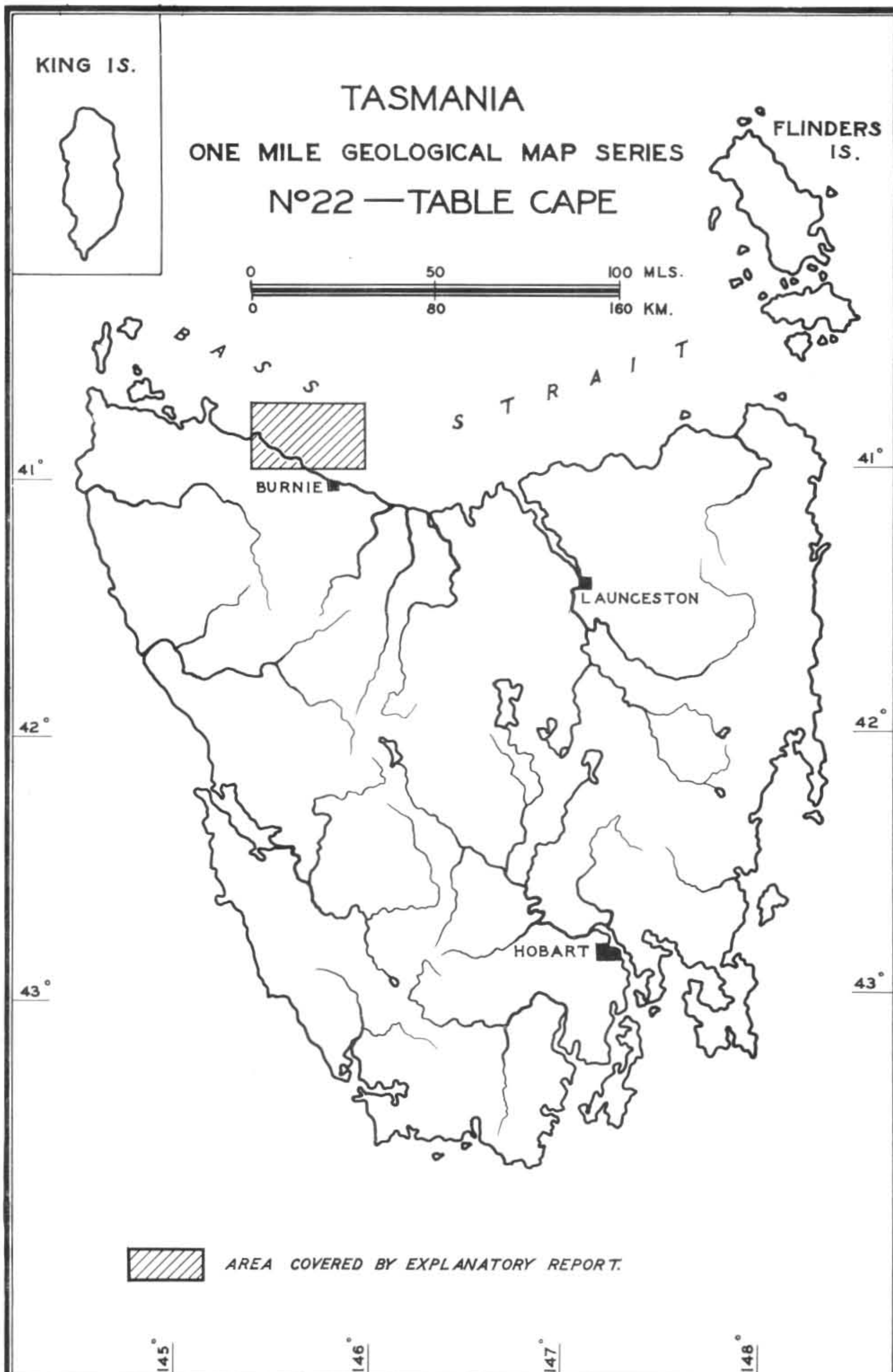
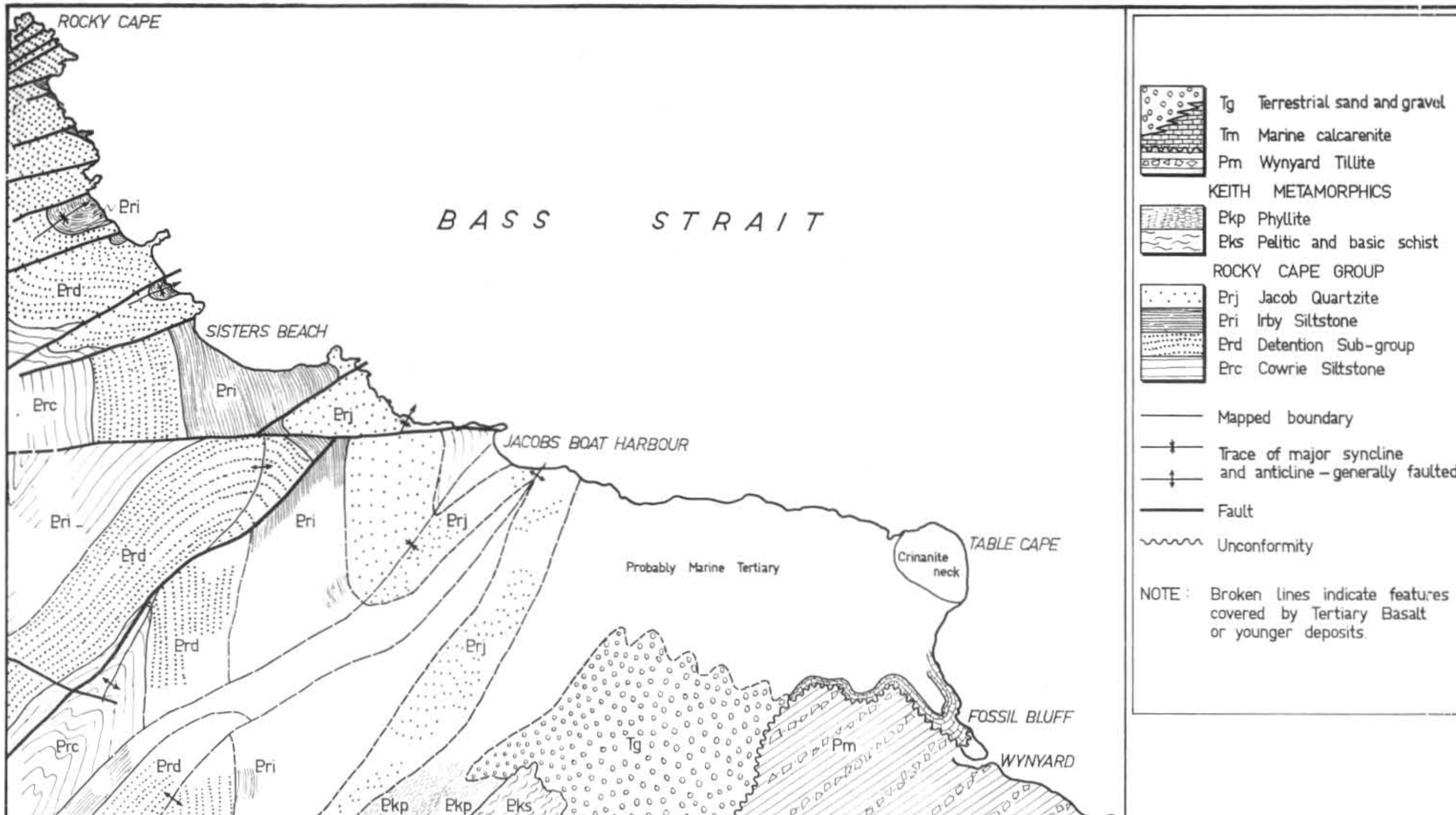


FIGURE 1. Location of the Table Cape Quadrangle.

5 cm



BEDROCK GEOLOGY TABLE CAPE QUADRANGLE

WITHOUT TERTIARY BASALT

0 1 2 3 4 Miles

0 1 2 3 4 5 6 Km.

FIGURE 2

R.D. GEE
GEOLOGIST

5 cm

INTRODUCTION

The Table Cape Quadrangle is delimited by latitudes 40° 45′ and 41° S, and longitudes 145° 30′ and 146° E. It is situated on the NW coast of Tasmania (fig. 1) and covers the area between Wynyard and Rocky Cape. Only 12% of the total quadrangle area is occupied by land: Tertiary volcanic rocks cover 44% of this, folded Proterozoic rocks cover 38%, and the remainder comprise superficial sediments, sub-basalt gravel and Permian bedrock.

The quadrangle has considerable geological interest: it contains the type area of the Proterozoic Rocky Cape Group, the basal tillite of the Tasmanian Permian sequence, the richly fossiliferous Tertiary marine beds at Fossil Bluff, and a crinanite neck.

The map sheet was published separately in 1966, at a scale of 1:63,360. An interpretation of the solid geology is given in Figure 2.

The Table Cape Quadrangle is essentially a rural area with Wynyard as the centre of population. The basalt slopes and alluvial flats are very fertile and are extensively cultivated: by contrast, the areas of Precambrian rocks are almost devoid of habitation and are not utilised.

PREVIOUS LITERATURE

The first geological account of the NW coast of Tasmania was by Strzelecki (1854) who recorded the Tertiary marine beds at Fossil Bluff. Stephens (1870) made observations on the Table Cape and Fossil Bluff rocks. He was the first to suggest that conglomeratic rocks beneath the Fossil Bluff bed were of glacial origin. He also noted the intrusive dolerite bodies in the folded Precambrian rocks.

The Fossil Bluff beds have attracted the attention of many workers: Johnston (1888) and Banks (1957) give comprehensive bibliographies. The Permian tillite also attracted a great deal of interest in regard to its age and origin, for example, Kitson (1902), David (1908), and Noetling (1910).

Around the turn of the century, traces of copper were discovered in the Precambrian dolerite dykes, and alluvial gold was found in the gravels near Wynyard. Montgomery (1896) reported on these prospects and appears to be the first to note the highly micaceous crystalline schist in the Inglis River. Twelvetrees (1903, 1905) described the old prospects, and broadly referred to the rocks W of Wynyard as the Rocky Cape Quartzite, which he considered to be of Precambrian age. Hills (1913) described the geology of the Wynyard district, and recognised the rock units that appear on the present geological map.

Since then very little geological work has been done in this part of Tasmania. Loveday and Farquhar (1958) produced a soils map which, in part, reflects the regional geology. Spry (1957) was the first to attempt the subdivision of the Precambrian rocks. This interpretation was revised (Spry, 1962; p. 11), and later expanded (Spry, 1964). The Proterozoic stratigraphy has been further revised (Gee, 1968) following extensive regional mapping in NW Tasmania.

PHYSIOGRAPHY

The Table Cape Quadrangle comprises two main physiographic units: the quartzite hills in the W and the basalt slopes in the E.

THE QUARTZITE HILLS

The hills in the Rocky Cape-Sisters Hills area owe their origin to the contrast between the hard massive quartzite and the surrounding siltstone. These hills have an average elevation of 180 m (600 ft) and rise to 300 m (1,000 ft) in the SW corner of the quadrangle where they continue as the northerly extension of the Dip Range. Two main rivers drain the area: the Detention River is superimposed directly across the strike of the quartzite ridge of the Sisters Hills, whereas Sisters Creek lies along a chain of structural wedges of siltstone between quartzite.

A combination of strongly acid soils and repeated burning has reduced much of this area to open grassy hills. The hills are mostly covered by thick peaty and sandy soils with abundant scree fragments. The depth of leaching is up to 10 m in some of the road cuttings and sand pits on the Sisters Hills. These sand pits [585551]* are actually *in situ* orthoquartzite with the cement completely leached. This suggests that the quartzite hills are an old landform.

Between Sisters Beach and Rocky Cape, the coastline is moulded against a broken strike ridge of quartzite which rises steeply from the shore line to heights of up to 130 m (400 ft). Narrow marine platforms are developed in places along this stretch of coastline, at altitudes of 8-15 m above sea level. These are located on in-folded and in-faulted wedges of siltstone.

Four raised sea caves are known in the cliffs between Rocky Cape and Jacobs Boat Harbour. These vary in height from 10-23 m above the present mean sea level. All show signs of having been used by the now extinct Tasmanian aborigines. One cave at Walkers Cove, near Breakneck Point, has been described by Jones (1965). The caves have been eroded along major joint intersections or bedding planes in the massive quartzite. They taper back into the cliff for distances in excess of 50 m.

One of the openings in the cave described by Jones appears to be eroded out of a fissure filled with silicified boulder bed material, the bedding dips 60° SE and the cave opening is controlled by a set of widely spaced planar joints dipping 70° NW. The roof and part of the floor of the cave is composed of the boulder bed which can be traced some distance further up the cliff, although it is not certain whether it extends all the way to the cliff top. The boulder bed is composed of well-rounded quartzite cobbles with a gritty silicified matrix. Large slabs of quartzite, up to 2 m in diameter wedged in the fissure, have probably fallen in during the filling of the fissure.

The sea caves are the result of wave action at a time when the sea level was up to 23 m higher than at the present day. They may be related to the period of marine platform development.

---

* All locations lie within kiloyard grid square 39, zone 7.

BASALT SLOPES AND RIVERINE FLATS

The eastern part of the quadrangle consists mainly of rolling slopes of decayed basalt which extend from the river and coastal flats up to an altitude 175 m a.s.l. The slopes are pock-marked with round-back springs and hummocky solifluction scars.

The best developed surface is the Wynyard Plain which varies from 2 m on the coast to 23 m a.s.l. further inland. It has a small erosional level cut into it at about 6 m a.s.l. along the coastline at East Wynyard. The Wynyard Plain is considered to be a pre-Oligocene-Miocene surface which was exhumed and covered with sediments, probably in the Pleistocene. This surface is also terraced at an altitude of 15 m a.s.l. by the Inglis and Flowerdale Rivers above their tidal reaches.

The coastline between Jacobs Boat Harbour and Wynyard is dominated by the prominent landmark, Table Cape. This is a round plug of volcanic rock which rises straight out of the water to a flat top at 175 m a.s.l.

STRATIGRAPHY

SUMMARY OF GEOLOGICAL HISTORY

PLEISTOCENE?	Sand, gravel and clay deposited on raised coastal erosional platforms.
MIOCENE-OLIGOCENE	Extensive basalt flows from volcanic centre at Table Cape. Fluvial quartz gravel deposited in main pre-basalt valley. Sandstone and limestone accumulated in shallow-water littoral environment.
	UNCONFORMITY
PERMIAN	Accumulation of glacial marine sediments in an erosional trough.
	UNCONFORMITY
PROTEROZOIC	Penguin Orogeny, accompanied by intrusion of albite dolerite and localised metamorphism to upper greenschist facies (Keith Metamorphics). Deposition of thick sequence of siltstone and orthoquartzite (Rocky Cape Group) in Proterozoic geosyncline.

PRECAMBRIAN

The Precambrian basement consists of a conformable sequence of siltstone, orthoquartzite with subordinate dolomite—the Rocky Cape Group. This group was first defined by Spry (1957, p. 81) but following the recognition of discrete sedimentary assemblages or groups in the Precambrian of Table Cape and Burnie Quadrangles, the Rocky Cape Group was restricted by Gee (1968) to include only one of those groups. All the formation of the redefined Rocky Cape Group crop out in the Table Cape Quadrangle, although some of the sections lie outside the area. The Rocky Cape Group is summarised thus:

	metres	*feet*
Jacob Quartzite	1,130	3,700
Irby Siltstone	760	2,500
Detention Sub-Group: Cave Quartzite, Port Slate, Bluff Quartzite	1,400	4,600
Cowrie Siltstone	2,440+	8,000+

Cowrie Siltstone

The Cowrie Siltstone is the oldest formation; its base is nowhere exposed. Good exposures occur in the Detention River where it flows across the Sisters Hills, and in the railway cuttings in the Sisters Hills. It is a cream to reddish brown, finely laminated siltstone, consisting of thin alternations of coarse-grained quartz, siltstone with 10% sericitic matrix, and medium-grained quartz siltstone with 70% matrix. It contains a well developed slaty cleavage, but lacks metamorphic recrystallisation. The passage upward into the Detention Sub-Group is exposed in the railway cuttings in the Sisters Hills [569547] over a vertical section of 30 m. The transitional beds consist of an alternation of fine-grained siltstone and fine-grained quartzose sandstone with up to 10% matrix. The bedding units are up to 1 m in thickness.

Detention Sub-Group

The Detention Sub-Group is the older of two thick, predominantly orthoquartzite formations each more than 1,200 m thick. In its type section at Rocky Cape on the W edge of the quadrangle, it consists of the Bluff Quartzite, the Port Slate and the Cave Quartzite. These units have previously been defined by Spry (1957) but are not mappable units and are not indicated on the geological map.

The quartzite is uniformly fine-grained with a granular to glassy texture depending on the degree of cementation. Typically, it consists of 99% quartz in the form of single-crystal quartz grains and quart cement; rounded and accessory grains of tourmaline, zircon, and hematite are also ·present. The quartzite in the Bass Highway road cuttings on top of the Sisters Hills (low in the Detention Sub-Group) are not as pure as usual, and contain up to 10% of orthoclase, microcline or chert, and up to 4% of a sericitic matrix in isolated lumps.

The texture is variable, even in the field of one thin section. The original grains, with a high degree of rounding and sphericity, are recognised by the quartz cement overgrowths in optical continuity and a fine dusty trail on the inner edge of the overgrowth (plate 1). In un-modified patches the grains show tangential or planar contacts. In patches of greater textural modification, there is an interlocking mosaic with sutured grain boundaries (plate 2).

The orthoquartzite is well bedded and characteristically cross-bedded in units from 5-40 cm thick. The cross-bedding occurs as grouped sets, each overlain by planar erosional surfaces. Each set is tabular or tapers gently back along the current direction. Complex soft-sediment deformational structures occur in the lower part of the Detention Sub-Group in the Sisters Hills railway cuttings, and these are discussed in a later section (p. 20).

Interbedded siltstone comprises about 10% of this sub-group. The siltstone is not regularly interbedded throughout, but occurs at definite horizons in beds from a few metres up to 80 m thick. Siltstone beds are of limited extent and pass laterally into the orthoquartzite by interdigitation rather than by simple lensing. The thickest of these horizons is the Port Slate which is exposed in the small bay on the E side of Rocky Cape [547623]. The bottom contact is gradational, the underlying thickly bedded orthoquartzite (Bluff Quartzite) passes

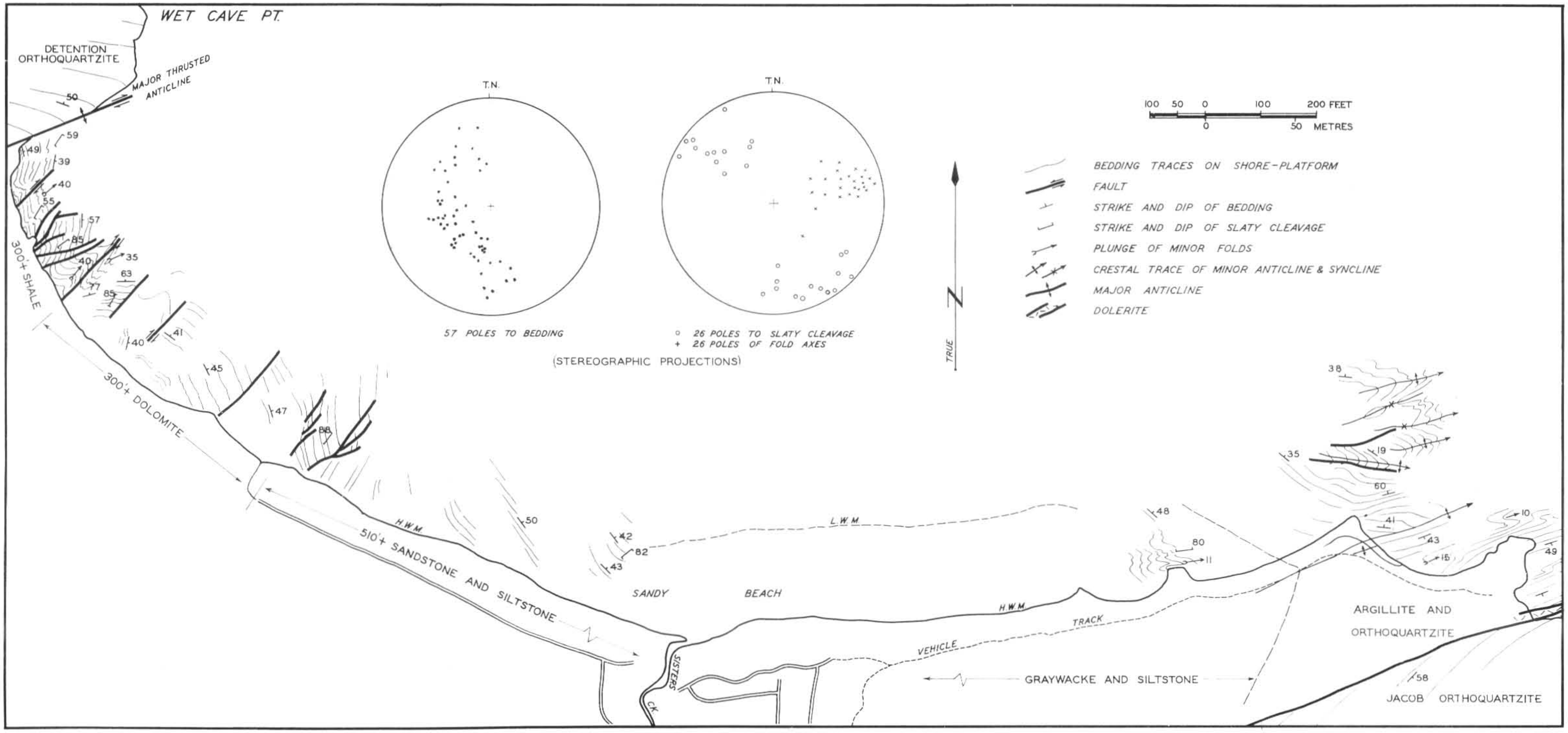


FIGURE 3. Structural map of the shore platform at Sisters Beach.

upward into a flaggy quartzite interbedded with thin layers of siltstone. The quartzite layers are cross-bedded lenses. The bulk of the Port Slate consists of abundant cross-bedded sandstone lenses in a grey siltstone (plate 3).

A well-cleaved horizon of similarly cross-bedded siltstone and sandstone within the Detention Sub-Group is exposed in the Bass Highway road cuttings on both flanks of the main anticline. This is probably the Port Slate.

Irby Siltstone

The Irby Siltstone contains subordinate black shale, dolomite, quartzite and sub-greywacke. A traverse from W to E (fig. 3) along Sisters Beach crosses the following units:

(*a*) black siltstone at, or near the base, with minor cross-bedded lenses of sandstone, at least 40 m thick;
(*b*) laminated and thickly bedded dolomite, at least 90 m thick;
(*c*) interbedded sandstone, siltstone and mudstone, at least 155 m thick;
(*d*) no outcrop: about 305 m, assuming a continuation of the structure;
(*e*) sub-greywacke and mudstone, at least 30 m thick;
(*f*) cream argillite, about 60 m thick;
(*g*) Jacob Quartzite on the eastern headland of the beach.

These units are bounded by faults, but the structural evidence (fig. 3) indicates that they form a sequence younging E. Some of these units are discussed in detail below.

Dolomite

The main part of the dolomite consists of buff-coloured dolomite beds in units from 30 cm to 120 cm thick, with minor interbedded dolomitic mudstone from 1-3 cm in thickness. The dolomite has a fine internal lamination which commonly shows small-scale cross lamination. In thin section the dolomite is of uniform (0.05 mm) grain size, studded with detrital quartz (0.05 mm) and minor detrital muscovite. These features suggest that it is a primary dolomite.

A chemical analysis of the massive dolomite from Sisters Beach by H. K. Wellington, is given below:

	%		%
SiO_2	40.9	MgO	11.5
Al_2O_3	4.7	K_2O	1.0
Fe_2O_3	0.8	Na_2O	Nil
FeO	2.2	H_2O+	1.5
MnO	0.06	H_2O-	0.14
P_2O_5	0.12	CO_2	22.0
TiO_2	0.16	SO_3	0.17
CaO	14.6	S	0.16

This analysis indicates that the molecular ratio of MgO/CaO is 1.10 so that the carbonate present is almost pure dolomite. The rock however contains over 40% of detrital quartz and is not a pure dolomite.

The lower part of the dolomite horizon is characterised by contorted sedimentary boudinage. On the shore platform weathering causes the dolomite boudins to stand out in relief, producing ' hieroglyphic ' markings (plate 5). The undeformed rock is a regularly laminated brown dolomite in layers from 5-15 mm in thickness, and black mudstone about 3 mm thick. The mudstone laminae are rich in sericite with about 10% of detrital quartz averaging 0.02 mm, about 10% anhedral dolomite grains, and about 3% detrital muscovite. The dolomite layers in thin section are petrographically the same as the more thickly bedded dolomite, although they contain irregular patches of recrystallised euhedral dolomite. The dolomite layers have a faint internal lamination which also shows fine cross-bedding.

The lower part of the boudinage zone shows various degrees of segmentation without disorientation. Where this segmentation is complete, the dolomite pieces are completely surrounded by mudstone, although the form of the original lamination is still apparent. The dolomite pieces have rounded edges, and are distinct from a breccia formed by the *in situ* fragmentation of brittle layers within a more plastic material.

The boudins are markedly elongate in a NE-SW direction, giving a conspicuous coarse lineation approximately parallel to the dip of the bedding. This lineation is also parallel to the regional fold axis (50° plunge at 060°), and to the axes of minor folds and related bedding-cleavage intersections in the nearby cleaved mudstones. The tectonic cleavage in the dolomite is expressed as sinuous and finely corrugated surfaces that are broadly planar. Corrugation is due to the fractures seeking out the nodes of the boudins (plate 5).

The boudins are crossed by hair-line tensional cracks (plate 6), perpendicular to the bedding and to the axis of elongation. These cracks are up to 0.5 mm wide and filled with the black mudstone material containing minute neo-crystallised dolomite rhombs. There has been a slight amount of movement along the fine cracks.

A fine microscopic flow-lamination is generally parallel to the bedding but bows into the nodes and encircles the rounded ends of the boudins. The sericite of the matrix and the detrital muscovite are orientated in the micro-foliation, and wrap around the detrital quartz. A strain slip micro-cleavage forms where the hair-line cracks intersect the mudstone layers.

Higher in the boudinage zone, the dolomite pieces are disorientated and the continuity of the original layering is lost. Many of the fragments are rotated into an edge-wise position at right-angles to the bedding, especially adjacent to the more prominent sinuous movement cracks. In these edge-wise pieces, the hair-line cracks are still at right angles to the slabs, showing that rotation occurred after micro-fracturing.

At the top of the boudinage horizon, the dolomite bodies are completely disorientated and twisted (plate 4). However, the gross aspect of bedding is still undisturbed showing there has been no bulk deformation, only *in situ* segmentation accompanied by independent internal rotation.

Immediately overlying the most complex bed is a bed of dolomite 2.6 m thick, with a few minor mudstone layers. Boudinage is absent, and the cleavage is manifest by a weak, planar, close-spaced jointing.

A sequence of development of these structures can be followed, starting with a plastic segmentation of dolomite layers and viscous flowage of mudstone, then micro-tension fracturing, followed by coarser fracturing and associated tilting and bending of the dolomite pieces. The round edges of the boudins, the micro-flow foliation in mudstone, and the twisting and rotation of dolomite bodies suggest these are preconsolidation structures. Recrystallisation of the dolomite was not an important process in boudinage formation.

Boudinage formation is generally explained by plastic deformation of a layered material under a triaxial stress field orientated with P_{max} normal to the layering, P_{int} parallel to the boudin elongation and P_{min} in the plane of the layering and normal to the boudin axis. These boudins may result from a directional shr.nkage in the plane of the bedding due to the preconsolidation movement down the local palaeoslope. The regional palaeoslope, determined from cross-bedding measurements in the enclosing orthoquartzites, is towards the NW and is in the required direction to give a NE-SW boudin axis.

The precise and consistent geometrical relationship between the boudin axis and the local lineation, and the clear relationship between the cleavage and the bending and tilting suggests a tectonic origin. In this case boudinage must have occurred under a load of at least 2,000 m of sediment since the conformably overlying Jacob Quartzite also participates in the folding. In the initial stages of concentric folding this superincumbent load would certainly be the P_{max} and P_{min} would be orientated in the bedding perpendicular to the fold axes. The presence of a plastic style of soft-sediment deformation with insignificant recrystallisation suggests a build-up of high internal pore water pressure. The petrographic evidence of the overlying Jacob Quartzite suggests that cementation occurred before compaction, so that this may have acted as a seal on the sedimentary pile.

Interbedded Sandstone, Siltstone and Mudstone

Overlying the dolomite is at least 150 m and possibly 305 m of an alternation of greenish grey siltstone, black mudstone and minor cross-bedded orthoquartzite. The siltstone is coarsely laminated due to irregular ribbons of coarser grained siltstone, and contains an abundance of small-scale wavy cross-bedding, scour-and-fill structures, cross-bedded lenses, and irregular erosional planes. Bedding is further complicated by load casting.

The orthoquartzite beds occur singly or in small groups. They are petrologically similar to the thick orthoquartzites.

Sub-Greywacke

The sub-greywacke unit near the eastern end of Sisters Beach consists of thickly bedded sub-greywacke, with thin alternations of fine-grained siltstone. The sub-greywacke is reddish brown in colour, varies in size from coarse silt to fine sand, and has about 20% matrix of iron-stained sericite and chlorite with abundant small hematite grains. The detrital grains are mainly quartz with about 5% plagioclase and muscovite. The fine-grained siltstone is composed mainly of sericite and chlorite. It is laminated, with glossy bedding surfaces, and has a weak oblique cleavage. These beds become thicker and more frequent at higher levels, and are the dominant rock type on the eastern headland of Sisters Beach.

Associated with the coarser sub-greywacke beds are thin interbedded hematite breccias. These are described in a following section (p. 23).

Jacob Quartzite

The Jacob Quartzite is a well-bedded, well-rounded and well-sorted pure quartz sandstone similar to the orthoquartzites of the Detention Sub-Group. It differs from the Detention Sub-group in its coarser grain size, thicker bedding and cross-bedding, fewer shaly layers, and abundance of ripples.

A gritty horizon occurs 2.5 km W of the headland at Jacobs Boat Harbour. The quartz grains vary up to 2 mm in size, covering five grades of the Wentworth scale. It is composed of 98% quartz in the form of single-crystal quartz grains and quartz cement in optical continuity.

Contorted stratification and slumping are present in the Jacob Quartzite. These are described in a later section.

Cross-Bedding Directions in the Orthoquartzite

A total of 283 measurements of cross-bedding directions, were made at thirteen stations over 13 km of coastline. In view of the early recognition of polymodal palaeocurrent patterns during the collection of data the following sampling procedure was used:

(i) Localities were selected at 1 km intervals where there was an abundance of cross-bedding.

(ii) Commencing at one cross-bed, and working stratigraphically up the section, every cross-bed was measured until no new mode appeared after ten additional measurements. Generally twenty sets and in one case fifty sets, have been measured.

The tilt-correction method of Norman (1960) for unrolling sedimentary lineations on plunging cylindroidal, flexural folds is followed. In this method tilt-correction is made in two steps, firstly a plunge correction along the shortest path to bring the tectonic axis to horizontal, and secondly a rotation about the fold axis to bring the bedding to horizontal.

The assumption is that the folds attained a plunge by a rotation about a horizontal axis at right angles to the fold axis. It is immaterial whether this results from two distinct phases or from two processes acting synchronously. Cummins (1964) showed that this simple method is incorrect if the plunge is due to a rotation about an axis which is not at right angles to the fold axis. The initial plunge correction is then not taken along the shortest possible path. This situation would be met with in repeatedly deformed areas, and a more refined method, taking into account the strain axis of each phase, is necessary.

The structure in the Rocky Cape Group is geometrically simple. Inland, the major and minor fold axes trend 060° and have a shallow plunge. Towards the coast the plunge steepens to 50° on the same general trend. The axial-planes remain vertical so that any rotation of the fold axes as they were formed must have been in the vertical plane. The additional plunge correction suggested by Cummins (1964) is therefore unnecessary.

Tilt-corrected azimuths for each station are grouped in 30° sectors and represented as rose diagrams in Figure 4. The polymodal patterns render this treatment more informative than a simple vector summation. Vector modes may however be used to determine the mean direction of each mode, and to collate the individual stations. These are obtained by the vector summation of azimuths which make up a single mode, and by neglecting sectors of 6% or less.

In general there are two types of rose diagrams: unimodal and diametrically opposed bimodal. In the Jacob Quartzite there are also two trimodal diagrams. The sampling procedure also shows that the cross-bedding is not of the 'herring-bone' type in which succeeding sets are oppositely directed, but of a clustered type in which sets of one mode are stacked, continuously one on top of the other.

The regional variation of the palaeocurrent direction is shown by the vector modes in Figure 4. In the Detention Sub-Group most of the sets point NW and are closely grouped. The only significant variation is the presence or absence of the diametrically opposed SE mode. The directions are more variable in the Jacob Quartzite. The NW mode is still present, but there are also modes to the SW, SE and NE.

Ripple marks are locally abundant in the Jacob Quartzite at localities where cross-bedding is uncommon or absent. These are of the transverse type, and both asymmetrical and symmetrical types occur. Axes of forty-four ripples from the Jacob Quartzite are included in Figure 4. The significant feature of the ripple mark diagrams is that the minimum direction corresponds to the total mean of cross-bedding directions. Ideally, transverse ripple marks are transverse to the dominant cross-bedding direction (Potter and Pettijohn, 1963, pp. 94-98), and each represent the palaeostrike and the palaeoslope respectively.

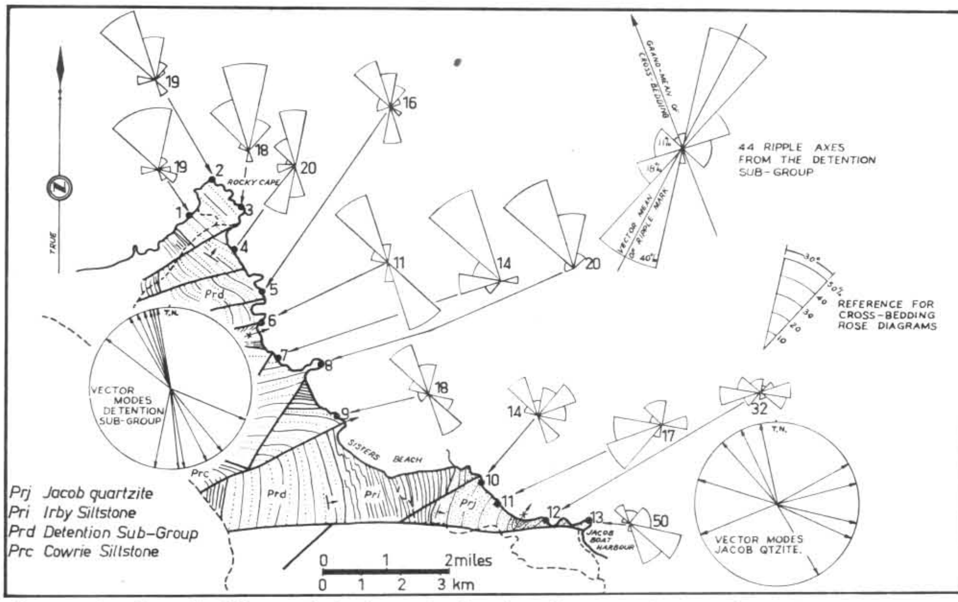


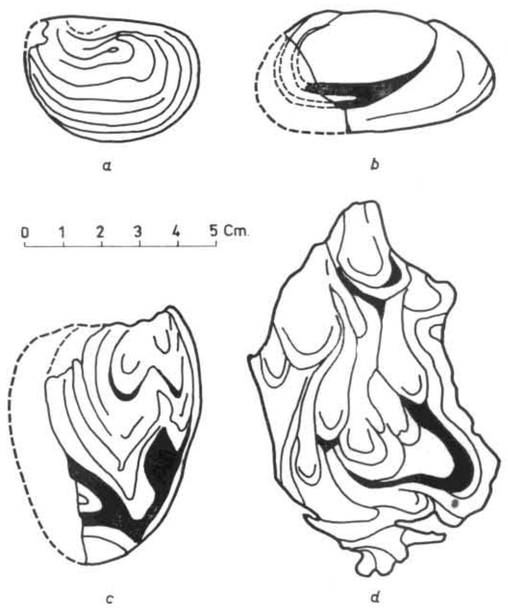
FIGURE 4. Cross-bedding and ripple mark directions in the orthoquartzites of the Rocky Cape Group.

Sedimentary Deformation Structures

Pseudo-Nodules

Examples of pseudo-nodules occur in the unassigned sandstone and siltstone formation above the Jacob Quartzite 275 m E of the headland at Jacobs Boat

Harbour. All stages can be observed in the disruption of a wedging sandstone unit. Load casting on the soles of sandstone beds grades into complete detachment when the sandstone bed thins to 15 cm. The detached bodies are ellipsoidal in cross section, and either cigar-shaped or equidimensional. Internally (fig. 5) they have a simple concentric structure of sandy laminae 2-5 mm thick, separated by paper-thin films of mudstone. These laminae form a continuous wrapping around the bottom, where they are thicker: they are generally absent at the top.



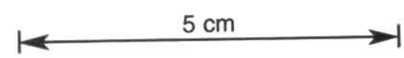


FIGURE 5. Sections of pseudo-nodules. *a; b; c:* Simple structure, from unnamed siltstone at Jacobs Boat Harbour. *d:* complex structure, from Cowrie Siltstone, western side of Rocky Cape. Lines and solid shading indicate thin claystone laminae.

More complex pseudo-nodules occur in the Cowrie Siltstone, on the W side of Rocky Cape, just outside the western boundary of the sheet. These each consist of a group of closely nestling downward-sagging droplet-shaped lobes of laminated siltstone (fig. 5d). This structure results from the sagging of several thin layers of sand separated by thin layers of mud, together contained within a thicker bed of mud.

The internal structure of the pseudo-nodules is an indication that vertical movement due to gravity was responsible. Kelling and Walton (1957) explained the origin of load casts by a hydrostatic adjustment of sand of density about 2.1, overlying silt of density about 1.4. Keunen (1958) experimentally produced an almost identical structure, by allowing sand to sink into thixotropic mud. Small irregularities in thickness of the sand load resulted in differential hydrostatic pressures along the sand-silt interface which are sufficient to cause adjustment in the unconsolidated sediment. The upward piercement of the finer grained material and the sagging of the coarser material results in the curling-up of the sandstone laminae.

Contorted Stratification in the Jacob Quartzite

A peculiar type of contorted stratification is found in the Jacob Quartzite on the headland at Jacobs Boat Harbour (fig. 6). The contorted stratification is confined to a bedding-contained zone 9 m thick. The zone can be traced for 730 m along the limb of the large syncline W of Jacobs Boat Harbour, and a contorted zone 2.75 km further W on the opposite limb of the syncline, is probably the same zone.

In profile the laminae are contorted, although the gross aspect of bedding is still apparent. The plications take the form of rounded synclinal depressions and sharp cuspate anticlines. The axial surfaces are generally perpendicular to the bedding, and there is no overturning.

When viewed from above, the bedding surfaces are patterned with amoeboid depressions, separated by ropy fold crests. The fold axes have a random orientation within the bedding plane but are commonly tilted at an angle to the bedding. The symmetry is therefore broadly polar, indicating upward diapiric movement. Cross-bedding is normally common in these rocks, but rare in the contorted zone.

The upper contact of the contorted zone is sharp, and follows the same stratigraphic interval over a distance of at least 60 m. The overlying bed is cross-bedded. At the lower contact the folds die out downward within the bottom 30 cm onto a thin bed of siltstone. There is no evidence of any plane of detachment at the base.

The following points may have a bearing on their origin: orthoquartzitic lithology, presumed littoral or sub-littoral environment, confinement of the layer parallel to bedding, preservation of gross aspect of bedding, rounded synclines and cuspate anticlines, polar symmetry, and the absence of cross-bedding in an otherwise cross-bedded sequence.

The deformation is considered to be due to the upward escape of interstitial fluids. No large-scale slumping or dislocation is involved. The sands were probably deposited in the quiet shallow water of a tidal lagoon where waves and currents were not sufficiently strong to form cross-bedding or ripple marks. This structure does not appear to be the result of simple load deformation due to density differences because there are no siltstone layers within the deformed zone.

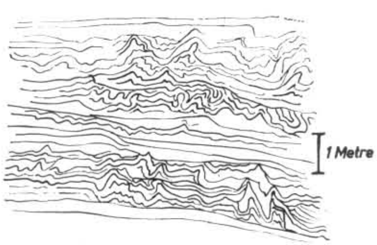


FIGURE 6. Contorted bedding in the Jacob Quartzite, Jacobs Boat Harbour.

5 cm

Stewart (1956) described similar contorted stratification in a modern coastal lagoon, thought to be due to air-heave. The sediments described by Stewart were deposited in a protected tidal lagoon during the flood tide, producing a layer of cavernous sand. On the ebb tide, air is sucked into the voids, and on the next flood tide the air is trapped in a narrow zone between the water above, and the rising water table within the sand. Stewart was able to show experimentally that this upward movement of entrapped air was sufficient to cause deformation. Because of the large thickness of sediment involved, this process must have operated continuously with a prolonged and delicate balance being maintained between the rate of sedimentation and the energy of environment. No counterpart of the miniature unconformities noted by Stewart is found in the rocks at Jacobs Boat Harbour.

The second, and more likely possibility is that deformation occurred while the sediment was in a state of temporary liquefaction caused by a collapse of unstable cavernous textures in newly deposited, waterlogged beds in a lagoonal environment (Terzaghi, 1957; Williams, 1960). Such a collapse would result in a momentary but substantial lowering of shear-resistance leading to flowage, expulsion of water, and the formation of a more closely packed and stable texture. In this state the granular aggregate would be dilatant so that the viscosity would markedly increase and deformation would be arrested.

Contorted Stratification in the Detention Sub-Group

Intraformational Disturbances resembling ball-and-pillow structures (Potter and Pettijohn, 1963) occur in the Detention Sub-Group in the railway cuttings through the Sisters Hills at the 138¾ mile marker [569538]. The rock is a flaggy sandstone with up to 10% matrix interbedded with thin siltstone. The disturbances are restricted to zones varying from 1-3 m in thickness and contain more than one sedimentation unit. The zones are parallel to the bedding and are separated by up to 15 m of undisturbed beds.

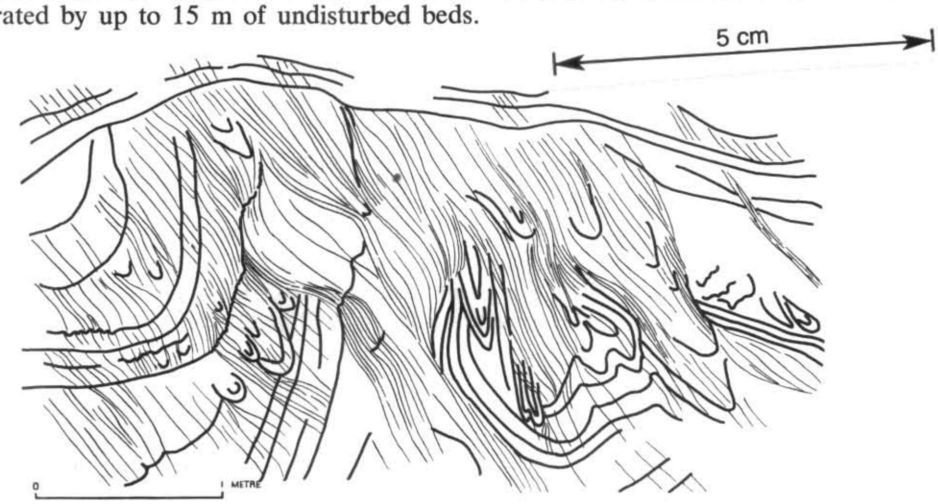


FIGURE 7. Contorted bedding at bottom of Detention Sub-Group, railway cutting, Sisters Hills.

The disturbed zones consist internally of tightly packed, often detached, downward lobate synclines (fig. 7). Corresponding anticlines are rare and when present are very sharp, and die out rapidly along the axis into planar bedding. In most cases the axial planes are constantly at a high angle to bedding. Within a single disturbed zone the fold axes are markedly variable in the mean axial plane, so that many of the folds are double conical lobes.

The larger, more open folds are concentric in style and affect several sedimentation units. The laminae within these units are deformed by smaller secondary isoclinal lobes, generally with smooth outlines. The laminae in the smaller lobes are thicker in the noses and thin rapidly up the limbs. The smaller lobes commonly occur in clusters, with the upper ones intruding down into the lower ones. The intruded lobes are not distorted, and there is no brecciation or slickensiding. The laminae within the sandstone, which are due to slight grain-size variations and small concentrations of heavy minerals, are usually well preserved. However, there are local patches of featureless granular sandstone in which the laminae have been obliterated. These pockets are fringed by patches of small irregular contortions where the laminae are still visible. The top boundary of the disturbed zones, which is overlain by continuous planar bedding truncates the upturned limbs of the lobes.

These disturbed zones in the railway cutting occur near the crest of the major Sisters Hills anticline, and consequently contain a strong tectonic cleavage. The cleavage is deflected around the rounded syncline and is channelled up into the cuspate anticlines, resulting in strongly sheared rock with an undulating cleavage enclosing un-sheared and detached synclinal fold cores. The cleavage is at a high angle to the bedding and has the same azimuth as the spread of lobe axes, consequently the cleavage lies close to the axial plane of the lobes (fig. 7). However, there are cases (fig. 8) where the cleavage cuts obliquely across the axial planes showing there is no genetic relationship.

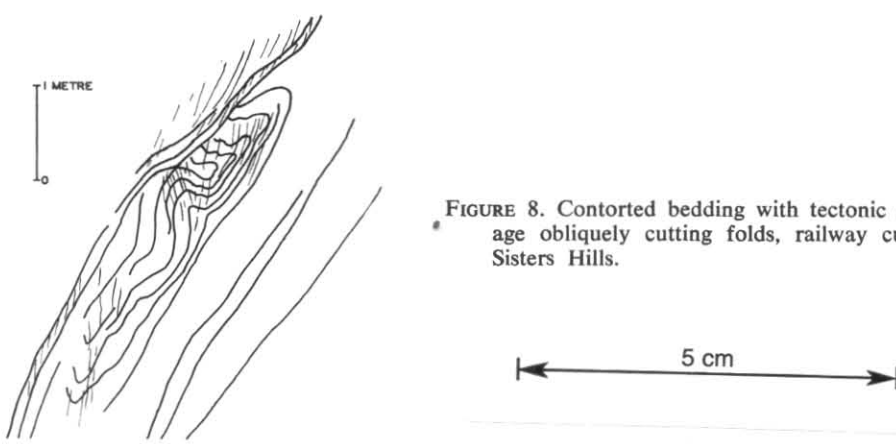


FIGURE 8. Contorted bedding with tectonic cleavage obliquely cutting folds, railway cutting, Sisters Hills.

The form and orientation of the structures show that mainly vertical movement is involved, and the top truncation shows that the structures formed before deposition of the overlying material.

The origin is probably similar to that suggested for the contortions at Jacobs Boat Harbour although the structures differ in some respects. At Jacobs Boat Harbour the gross aspect of bedding within the disturbed zone is still recognisable, the individual folds are smaller in size and the anticlines are still preserved.

The morphology and symmetry of the structures in the Detention Sub-Group indicates that they have also formed by the upward movement of interstitial fluids in newly deposited sediment during compaction. Selley *et al.* (1963) attributed similar structures to movement in ancient quick sands.

If the structures at Jacobs Boat Harbour and the Sisters Hills railway cuttings have a common origin then there must have been a difference in behaviour of the sediments. The deformations in the Sisters Hills were initially larger and proceeded further, suggesting a lower viscosity for longer periods. One possible explanation is that the rocks in the Sisters Hills railway cuttings contain up to 10% clay fraction. Boswell (1961, p. 74) notes that the addition of a small quantity of clay to a dilatant sand makes it thixotropic.

Block Slide in the Cowrie Siltstone

About 90 m from the top of the Cowrie Siltstone on the W side of Rocky Cape, just outside the western boundary of the sheet, is a block slide (fig. 9a). The block is 4 m thick, and is exposed over a length of 24 m, but the total length may be much greater. Bedding within the block is sharply discordant to the normal attitude of the bedding, showing a bodily rotation as well as a lateral displacement of the block. The sole plane of the main part of the block is smooth and parallels the bedding below. In detail the basal plane is made up of a nest of gently undulating surfaces which define a shear zone 5 cm in width.

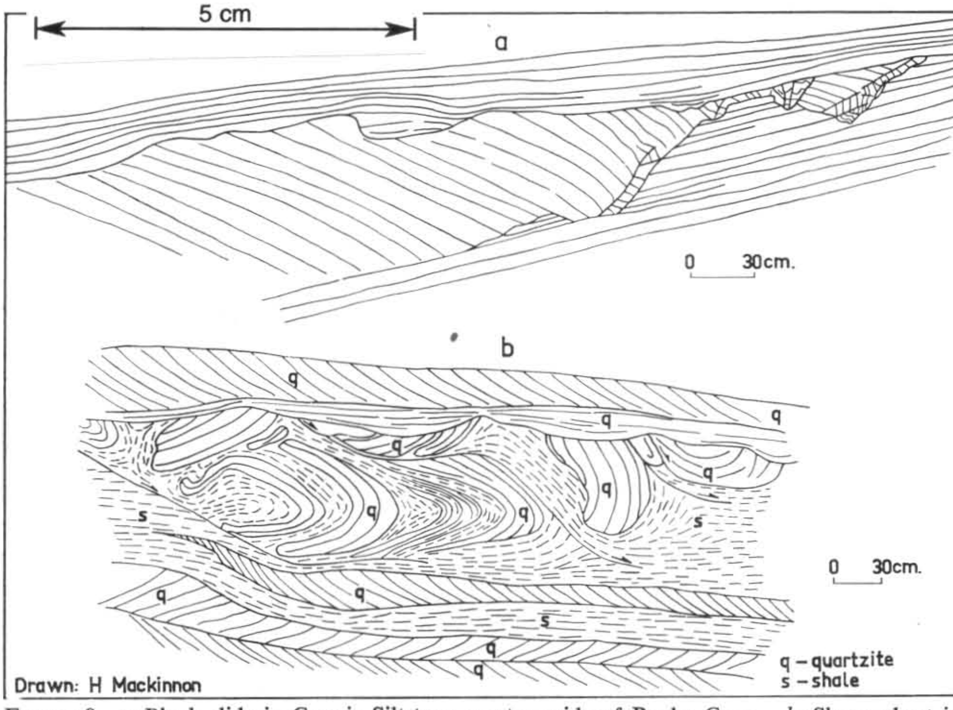


FIGURE 9. *a:* Block slide in Cowrie Siltstone, western side of Rocky Cape. *b:* Slump sheet in a silty layer within the cross-bedded Jacob Quartzite, 2.5 km west of Jacobs Boat Harbour.

Towards the heel, the basal slide surface turns up in a double shear circle. Still further back, the movement occurs on irregular surfaces that branch and transgress back up through the underlying beds. In this zone the bedding is fractured and crumpled. The deformed block is then truncated by the overlying beds. The upper surface is a slightly irregular plane upon which the overlying undisturbed beds were deposited with angular discordance. The overlying beds are of non-laminated cross-bedded siltstone and fine sandstone, distinct from the laminated mudstone in the displaced block.

The block has been displaced by a rotation of about 15° about an axis of 030° given by the line of intersection of bedding within the block and beneath the block. This is also the axis of curvature of the shear circles. The direction of movement is approximately NW, perpendicular to the axis of rotation. This structure has features similar to subaerial landslips, and is probably the result of downslope submarine block sliding under the influence of gravity. The palaeoslope was towards the NW approximately parallel to the palaeocurrent direction in the overlying orthoquartzite.

Slumping in the Jacob Quartzite

Figure 9b illustrates a slump sheet in siltstone bed in the Jacob orthoquartzite of Jacobs Boat Harbour. The slump sheet is confined to a siltstone bed 1.3 m thick containing thin sandstone lenses. The slump sheet consists of a series of small recumbent fold noses, and low-angle slide planes. The direction of movement is indicated by the facing of the recumbent fold noses. The top contact is a plane of erosion so that deformation is open cast. The immediately overlying bed is an irregular sheet of sandstone, which is in turn overlain by a typical bed of cross-bedded sandstone.

The fold axes lie parallel to the bedding and plunge SE. When the bedding tilt is corrected, a SW movement is indicated. Seventeen measurements of cross-bedding were also recorded at this locality (fig. 4, station 13), and these have a strong maximum in the SW quadrant. This does not imply deformation by current drag, but probably means that slumping was directed down the local depositional slope.

Fluxo-Turbidite in the Irby Siltstone

The sub-greywacke member of the Irby Siltstone at Sisters Beach [605604] contains intraformational hematite breccias up to 30 cm thick. These occur between laminated argillite below and massive arenite above (plate 7). This example has a scoured base and a smooth planar top. The breccia contains thin flakes of hematite 2 mm thick and up to 20 mm long, mostly orientated parallel in the bedding but occasionally oblique. There is no continuity of bedding lamination which would be expected from *in situ* fragmentation. The smaller hematite flakes are lozenge-shaped and wrapped around by a fine streaky flow-foliation in the matrix (plate 8). The matrix is a fine quartz siltstone heavily stained with limonite and containing abundant hematite grains.

These features suggest open cast, lateral movement in a high density silt-flow. The breccias may be termed fluxo-turbidites in the sense of Dżułyński *et al.* (1959).

Sedimentation in the Rocky Cape Group

The major part of the Cowrie Siltstone occurs to the W of the Table Cape Quadrangle in the vicinity of Cowrie Point. Here, it is a black pyritic shale with siltstone frequently occurring as finely cross-bedded layers, or as discrete cross-bedded lenses. A minimum of 2,450 m can be demonstrated; the base is not seen. The environment was a strongly reducing shallow basin, starved of detrital material.

Towards the top, as shown by those exposures in Table Cape Quadrangle, the Cowrie Siltstone contains a greater amount of detrital material, indicating an environmental change to a free circulating basin in which sedimentation slightly exceeded subsidence.

The depositional environment of the pure quartz sand is thought to be shallow water and probably marine in either the sub-littoral or neritic zones. Super-mature chemical composition, high sphericity, good rounding and size-sorting attest to the high energy of the environment. Multiple sets of planar cross-bedding and small-scale ripple marks are common. The bedding proper is planar and regular and interbedded lutites occur. These features, rule out an aeolian or fluvial environment.

The thick accumulation of quartz sand indicates a remarkably constant physical environment. This long standing stability was interrupted only when the interbedded lutites were deposited.

The thickest of these lutite beds (Irby Siltstone) consists of a sequence of a black pyritic shale with discrete cross-bedded lenses similar to parts of the Cowrie Siltstone, a bedded clastic dolomite, a horizon of interbedded orthoquartzite, siltstone and mudstone with abundant shallow water depositional structures and a sub-greywacke horizon with detrital hematite.

It is possible to reconstruct in broad terms the palaeogeography during the deposition of the orthoquartzites by considering the palaeocurrents and lithological associations. Other palaeogeographic indicators, such as facies changes, sand-shale ratios, grain size, isopachs and low-angle unconformities cannot be applied at this stage. Reconstruction based on palaeocurrents in the littoral environment is difficult because such currents may merely represent re-dispersal currents, and are not necessarily the primary transporting currents bringing material from source to basin. However in other areas of the world where the palaeogeographic indicators are well known, the dominant cross-bedding direction can be equated with the palaeoslope (Tanner, 1956; Pettijohn, 1957; Farkas, 1961; Potter and Pryor, 1961).

All the palaeocurrent patterns in the Detention Sub-Group (fig. 4) have a strong mode to the NW with a weaker diametrically opposed SE mode. With the exception of one station, the Jacob Quartzite always has a mode to the NW. It is therefore concluded that the regional palaeoslope dipped gently to the NW, and the strand line lay somewhere to the SE.

The diametrically opposed modes to the SE may also represent a transient palaeoslope in that direction. It thus appears that transverse dispersal currents were operative in the basin, which on extrapolation from the regional trend of the Proterozoic basin was orientated NE-SW. In the environment envisaged, namely a broad flat sandy plain under shallow water, these reversals may be achieved by slight differential subsidence. This in turn suggests a flanking foreland to the NW as well as the older Tyennan nucleus to the SE. The major structural evidence also supports the idea of a basement foreland to the NW. The relative strength of the respective modes then gives some indication of the relative stability of the flanking forelands.

The palaeocurrent indicators show that the dispersal currents were coming mainly from the SE where there is an older crystalline basement (Tyennan nucleus) composed of metasedimentary quartzites and schists. However the texture and mineralogy of the orthoquartzites rule out a source from the central Tyennan nucleus of Tasmania. About 99% of the grains are single-crystal quartz grains of medium to coarse-sand size, which is much coarser than even the coarsely crystalline metaquartzites. The ultimate source rock was primarily granitic or possibly gneissic and this is supported by the small quantities of well-rounded orthoclase and microcline in the Detention quartzite.

The tectonic significance of thick sequence of orthoquartzite is uncertain and even the thinner blanket sands present problems. A phenomenal total thickness of nearly 3,000 m of mature quartz sands was deposited in this basin. Well-sorted mature sandstones imply a tectonically stable environment with considerable wave and current action to winnow the finer material and round the residual quartz grains. Extensive blanket orthoquartzites are generally interpreted as continental transgressions of the shoreline. This interpretation is not applicable because of the extreme thickness involved. It would appear that the sands were laid down in a broad flat basin undergoing slow continued subsidence and maintaining a delicate balance with the rate of deposition, so that the position of the strand line and the depth of water remained approximately constant. The balance between accumulation and subsidence would be aided by continual re-dispersal of sand across the axis of the basin under the influence of the transverse currents. In this way the sand probably zig-zagged along the axis of the basin and became trapped in smaller subsiding sub-basins.

This environment is usually thought of as 'stable shelf', however these orthoquartzites belong to a thick sequence which may be considered thick basinal or geosynclinal. A thickness of nearly 3,000 m of sediment also demands long, gentle and continuous subsidence which is not altogether consistent with the concept of tectonic stability. This anomaly may be partly explained by postulating very long transportation of detritus that might offset the effects of large geosynclinal subsidence which normally produces immature sediments. However, tectonic stability over very long periods, perhaps as much as 100 million years appears necessary.

Keith Metamorphics

Small areas of metamorphic rocks occur in the valleys of the Flowerdale and Inglis Rivers, on the S border of the sheet. These rocks have since been mapped across the Burnie Quadrangle (Sheet 28), to correlate directly with the Keith Metamorphics (Gee, 1968) and the Keith Beds of McNeil (1960).

The stratigraphical relations of the Keith Metamorphics are not clear in Table Cape Quadrangle, but further S in the Burnie Quadrangle it can be shown that the unmetamorphosed Rocky Cape Group grades stratigraphically upwards across an overturned contact into the Keith Metamorphics.

Three main rock types occur in Table Cape Quadrangle: schistose quartzite, phyllite and basic schist.

Schistose Quartzite

This is best exposed under the road bridge across the Flowerdale River [631503]. The quartzite is a light brown rock with a strong foliation parallel or sub-parallel to the bedding. The anastomosing foliation encloses large quartz porphyroclasts which range from 0.1 to 1.3 mm.

In thin section the foliation is due to discontinuous anastomosing shreds of fine muscovite and minor biotite which enclose lozenge-shaped slices containing one or more quartz porphyroclasts (plate 9). Coarser muscovite and finer biotite have grown in the pressure shadows and penetrate the quartz. The porphyroclasts are slightly elongate (about 3:1) in the foliation, but some are rotated out of this plane producing oblique curved pressure shadows.

Mortar texture has begun to develop but appears to have been arrested by syntectonic recrystallisation. The larger parent grains show undulose extinction, fracturing, deformation bands and border granulation. The ground mass is composed of a fine, closely interlocking mosaic of granular (0.01 mm) strain-free quartz which suggests some post-tectonic (annealing) recrystallisation.

Some of the larger porphyroclasts have a zonal arrangement consisting of a large strained quartz grain with a sutured margin, a fringe of finely granulated quartz, and then a ground mass of quartz and micaceous material.

Phyllite

The phyllite is poorly exposed in the Table Cape Quadrangle. It consists typically of muscovite (50%), quartz (40%) with small amounts of chlorite (penninite?), tourmaline, zircon and sphene. The foliation is defined by the preferred orientation of fine muscovite, marked dimensional orientation of fine flattened quartz, and also in part by the segregation into muscovite- and quartz-rich layers. A late strain-slip cleavage is well developed in the phyllite (plate 10).

Pelitic and Basic Schist

Deeply weathered pelitic and basic schist occurs along Pages Road in the valley of the Inglis River. Fresh greenschist is found on the bend of the Inglis River at [662506]. This is a dark green, well foliated schist with abundant black idiomorphic magnetite and ilmenite visible in hand specimen. It is composed of approximately equal proportions of albite, quartz, epidote and tremolite. Albite and quartz occur in equant xenoblastic grains up to 0.5 mm, forming a mosaic which is abundantly studded with actinolite and granular epidote. The actinolite in places shows a faint blue-green pleochroism. The foliation is defined by strewn-out aggregates of sphene and leucoxene, shreds of granular epidote and dimensionally orientated sheaths of amphibole.

PERMIAN

Wynyard Tillite

The Wynyard Tillite, the lowermost formation in the Permian sequence in Tasmania, crops out along a 3 km strip of shore platform from Fossil Bluff E to the border of the sheet. It was first considered to be a tillite by Stephens (1870) and the history of thought regarding its age, origin and terminology has been reviewed by Banks, Loveday and Scott (1955) who first formally defined the formation with its type section at Wynyard.

Most of the Wynyard Tillite of the coastal strip actually occurs in Burnie Quadrangle, and more comprehensive descriptions will be given in the corresponding explanatory report. The coastal exposure is nearly continuous but neither top nor bottom are seen. David (1908) and Banks (1963) consider its thickness to be well in excess of 300 m.

In the Table Cape Quadrangle the formation consists of layers of tillite, pebbly mudstone and pebbly siltstone, laminated siltstone and sandstone, and some peculiar breccias. Typical tillite occurs in layers up to 10 m in thickness, generally with a crude stratification indicating that much of it is probably fluvioglacial. It contains a great variety of boulders that seem to represent every rock type in the Lower Palaeozoic of W and NW Tasmania. Faceted and striated boulders up to one metre in diameter occur in tillite on the point just E of Port Creek at East Wynyard. The matrix in the tillite is composed of strongly cemented, poorly sorted angular chips of quartz and slate, although in places there are irregular pockets of fine-grained, well sorted quartz sandstone.

The pebbly siltstone and pebbly mudstone are grey-coloured, generally non-laminated rocks containing scattered pebbles and boulders of the same diverse rock types that occur in the tillite. Some of the pebbles are well-rounded. The amount of exotic pebbles varies markedly over small distances, and in places there are small pockets of material very rich in pebbles. These pebbly beds contain some unusually contorted sandstone bodies, discussed below.

The laminated siltstone consists of thinly interbedded grey siltstone and fine-grained hard siliceous sandstone. The sandstone beds are up to 10 cm thick and have abundant rectilinear, asymmetrical ripple marks. Twenty-six measurements of current directions all fall in the sector 030°-100° (true), and the mode is between 40° and 50° (fig. 10). This current direction is parallel to the long axis of the basin of deposition as deduced from the distribution of the Permian rocks further S in Burnie Quadrangle.

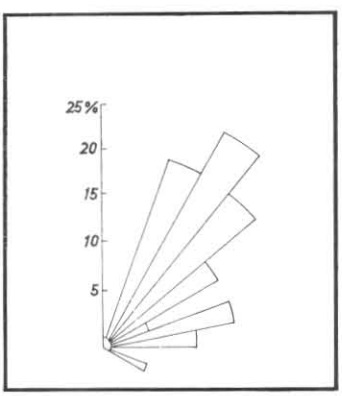


FIGURE 10. Rose diagram of twenty-six current directions from ripple marks in the Wynyard Tillite, Fossil Bluff.

5 cm

Various structures in the Wynyard Tillite at Fossil Bluff show that there has been pre-consolidation movement. The laminated and ripple marked siltstone contains broad and generally smooth undulations of the bedding with wavelengths up to 20 m and amplitudes of about one metre. They are irregular, non-cylindrical folds with a general axial trend to the NE. The folds have shallow plunges, and some are doubly plunging so that the bedding traces on the shore platform outline amoeboid or dome-shaped patterns. These look spectacular from the top of Fossil Bluff (fig. 11a).

These folds have a tendency towards a style of broad shallow synclines and sharp narrow anticlines. Complex small-scale folding and faulting is associated with the tight anticlines. These generally dip at less than 15°, but close to the crests the dips change rapidly to vertical or even overturned. There is no consistent sense of asymmetry and there is no approach to recumbent folds. Axial planes are mostly vertical.

Longitudinal joints and faults are common along the crests, and are accompanied by a multitude of small irregular and non-persistent faults oblique to the crests. Figures 11b and 11c illustrate some of these small faults. The faults are difficult to see in the fine siltstone and mudstone, and are only recognisable by off-sets in the fine sandstone beds.

The overlying pebbly siltstone unit shows soft sediment deformation of another kind. The siltstone contains some unusually large and intensely contorted root-less sandstone bodies (fig. 11d). The sandstone material is uniformly fine-grained and siliceous, with a faint internal lamination or a cross-lamination.

The sandstone bodies stand out in relief on the shore platform as isolated ' whale-backs ', twisted slabs and balled up lenses, varying in size from 30 cm up to 6 m. The actual folding is complex, some bodies are simply detached recumbent noses, others are irregularly crumpled slabs with turned up edges and others are completely involuted. The sandstone bodies are so common in some localities (e.g., on the point, 200 m E of Fossil Bluff) that the rock should be termed a breccia, or perhaps a megabreccia in the sense of Burns (1964, p. 53).

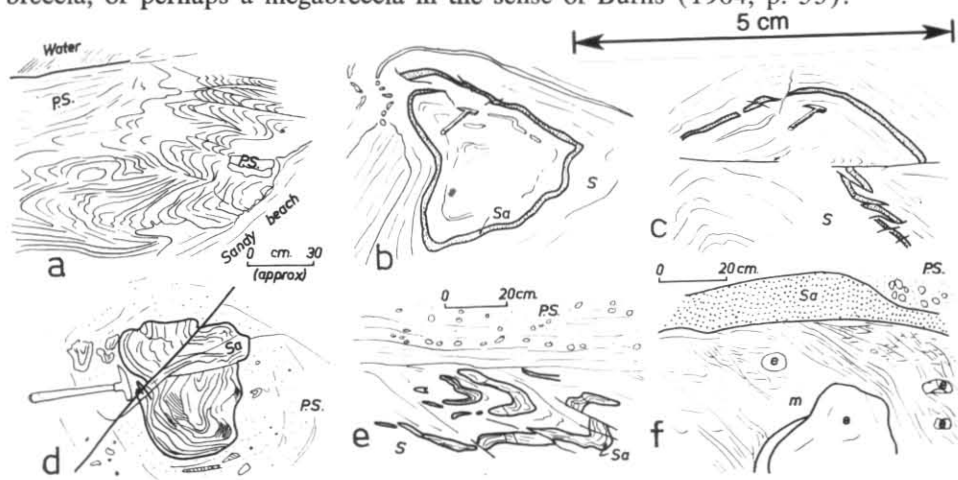


FIGURE 11. Structures in the Wynyard Tillite at Fossil Bluff (Explanation in text).

Some of the slabs contain cross-bedding, and may have originally been discrete cross-bedded lenses. The sandstone bodies are unlikely to be the result of *in situ* segmentation of a once continuous layer because there is no preservation of the gross aspect of the bedding. Many of the bodies have come from beds that were up to one metre thick. Some of the buckled slabs are terminated by clean sharp faces that look like faults. These faults do not occur in the pebbly siltstone ' matrix ', giving the impression of allochthonous blocks. The siltstone ' matrix ' does, however, have a coarsely spaced phacoidal fissility which is generally parallel to the bedding, but wraps around the pebbles and sandstone bodies. This suggests some soft-sediment flowage of the rock units.

The boundary between the laminated siltstone and the overlying pebbly siltstone is sharp, and appears to be a plane of movement. In the zone just below the boundary at a point just beneath the Tertiary unconformity on the eastern face of Fossil Bluff is a series of small recumbent slump-folds outlined by the fine sandstone beds (fig. 11e). Abundant small low-angle thrust faults are associated with the folding.

At other places in the same vicinity, this boundary truncates a set of closely spaced fractures in the underlying siltstone. These fractures are at a high angle to the bedding but near the contact they swing over to become more acute to the bedding (fig. 11f). Where the sandstone bodies are actually resting upon this contact large piercements (flames) of the underlying siltstone are squeezed up into the overlying unit between the sandstone bodies.

The type of sedimentary processes that are suggested for these structures is a lateral flowage of pebbly mud into a basin of shallow water in which fine sand and silt was being deposited and circulated. The folding in the laminated siltstone may then be the result of vertical adjustment due to sudden and unequal loading. The origin of the contorted sandstone bodies is problematical. They resemble the Cambrian megabreccia at Penguin in which Burns (1964, pp. 54, 158) considered gravitational sliding played an important part in mixing large exotic slabs of an alien sedimentary facies with *in situ* greywacke. In a glacial and fluvoglacial environment processes could be envisaged where well washed sediments may accumulate alongside poorly sorted sediments, both being susceptible to gravitational sliding.

TERTIARY

The Tertiary System is represented by the marine Table Cape Group, minor lacustrine clays, and extensive quartz gravels. These sedimentary rocks are overlain by Tertiary basalt.

Table Cape Group

The Tertiary marine beds at Fossil Bluff, Wynyard were first noted by Strzelecki (1845) and have since received considerable attention. The beds are notable for their abundant and varied fossil content which includes the oldest marsupial yet found in Australia, *Wynyardia bassiana,* and the toothed whale, *Prosqualodon*; the fauna is well documented in the geological literature.

Among the more notable contributions and reviews are those by Stephens (1870), Johnston (1888), Tate and Dennant (1896), David (1950), Banks (1957) and Gill (1962, pp. 233-235). The beds have been dated by Banks (1957) as Upper Oligocene, mainly on molluscan evidence. More recently Quilty (1966), on foraminiferal evidence has suggested a Lower Miocene age.

Freestone Cove Sandstone

This is the ' Crassatella bed ' of Johnston (1888). It is a coarse ferruginous sandstone 1.2 metres thick with shell fragments and pebbles and cobbles of quartzite and Permian rock fragments. It disconformably overlies the Permian rocks.

Fossil Bluff Sandstone

This is the ' Turritella bed ' of Johnston (1888). It is a well-bedded, light creamy brown, calcareous and glauconitic quartz sandstone, 24 m thick with beds of sandy limestone.

The Table Cape Group disconformably overlies the Permian Wynyard Tillite on the shore platform at Fossil Bluff at about high water level. The actual surface of unconformity is broadly planar, but irregular in detail, due mainly to differential erosion around the lenses and rolls of sandstone within the Permian siltstone. Small dyke-like lenses (Neptunian dykes) of calcirudite penetrate down into the tillite along cracks and bedding surfaces. The surface of disconformity is strewn with erratics and sandstone rolls shed from the tillite.

The beds dip at about 4° NW, and disappear under the basalt at sea level, immediately SE of Table Cape. The beds can be followed along the W bank of the Inglis River for 3 km, where they are seen in Mitchells Creek and again just W of the Bass Highway bridge over the Inglis River. Here they appear to be only about one metre thick, and probably thin rapidly against a small basement rise. The unconformity, although not exposed here, is about 8 m a.s.l.

The Table Cape Group also occurs further E at Doctors Rocks (in the Burnie Quadrangle). Thus the beds outcrop sporadically around the periphery of the Wynyard Plain, and it is probable that the whole of the Wynyard Plain was a marine embayment which received shallow water sedimentation in the mid-Tertiary.

Lacustrine Sediments

Approximately 6 m of probable lacustrine beds are exposed in the cutting, 2 km along the Calder Road from the Bass Highway [705513]. The sediments are poorly laminated and consist of poorly laminated, blue-grey claystone with scattered angular granules and sand-size chips of quartz. Carbonised plant leaves and stems are common.

The claystone overlies a small patch of deeply weathered albite schist (a small outlier of the Keith Metamorphics). The unconformity is approximately 38 m a.s.l. The relationship of the lacustrine sediments to the marine sequence is uncertain, it may either be a facies equivalent, or it may overly the marine sequence. The relative altitudes of the pre-Tertiary surface support the latter view; the marine sequence thinning onto the basement rises on the periphery of the marine embayment.

These sediments pass upward into the Tertiary sand and gravel.

Terrestrial Sand and Gravel

Substantial deposits of quartz gravel and sand, over 60 m thick, are exposed near the southern border of the sheet in the valley of the Inglis River, and in the many sand and gravel pits on the adjacent spurs. They consist largely of a round-pebble and granule conglomerate with a sand matrix. Isolated fragments of coal and wood occur in certain layers. Cement and fine matrix are absent, and the deposits are porous and friable. Variations in the sand matrix content produce a coarse and poorly defined stratification. Many of the layers are of well-sorted pure quartz sand. A finer stratification within these thicker units commonly shows festoon cross-bedding.

Their Tertiary age is shown by their marked dissection by the present drainage system, their occurrence around the hinterland of the Wynyard Plain, and their silicification by the overlying basalt. They occur in an elongate belt extending for 5 km SW into Burnie Quadrangle. This belt was the site of a large Tertiary valley.

QUATERNARY

Older Deposits on Coastal Platforms

These occur on the coastal plains at Wynyard and Sisters Beach. On the Wynyard Plain, these deposits consist of poorly stratified layers of unconsolidated sand, clay and gravel. They are commonly iron-stained and in places a lateritic hard-pan is developed. Carbonised wood and leaf fragments are present, and marine shell fragments have been recorded (Hills, 1913). The platform upon which these sediments were deposited is probably the exhumed pre-Tertiary marine surface of Permian rocks. The thickness of the sediments varies from an observable thickness of 7 m near the coast to at least 16 m inland. The environment of deposition is considered to be a lagoon (Gee, 1962) bounded to the N and W by basalt, and to the S by low cliffs of Permian rocks. Within the lagoon there was an accumulation of material brought down by the Flowerdale and Inglis Rivers (which probably occupied much the same position as they do today), plus material washed in from the sea.

There is an accumulation of dark peaty sand and clay on Irby Flats, behind Sisters Beach. A line of sand dunes occurs between the beach and the flats. On the beach, on the W bank at the mouth of Sisters Creek, recent wave erosion has exposed lignified stumps and branches of small trees in the dunes and carbonaceous sand beneath the dunes. The sediments on Irby Flats have accumulated on a raised shore platform, cut into the softer Irby Siltstone, at a level of 15 m above the present sea level.

Alluvium

Recent alluvial deposits derived from both the Tertiary gravels and the basalt have produced fertile flats in the lower reaches of the Flowerdale and Inglis Rivers. This material appears to have been deposited upon lower terraces cut into the older Quaternary sediments of the Wynyard Plain.

PRECAMBRIAN STRUCTURE

REGIONAL STRUCTURE

The regional structure of the Rocky Cape Group is shown in Figure 12. This is a composite section constructed from axial projection profiles and projected cross-sections with the inferred position before displacement along the major E-W fault passing through Jacobs Boat Harbour. The structure has been freely sketched in where it is obscured by younger rocks.

The main structural feature is a series of NE-SW trending folds which are tight and asymmetrical adjacent to the Keith Metamorphics, and become broad and symmetrical to the W. The folds have shallow to moderate plunges to the NE.

The strike ridge of Jacob Quartzite trending SW from Jacobs Boat Harbour is the E limb of the first anticline to the W of the Keith Metamorphics. Cross-bedding shows that the quartzite faces E and is in places overturned. It thus dips under the Keith Metamorphics. The exposures in Burnie Quadrangle confirm this relationship.

Between Rocky Cape and Sisters Beach, the Detention Sub-Group is regularly faulted by a series of high-angle oblique-slip thrusts with associated folding (fig. 12). The direction of movement on these faults is normal to the axis of rotation of the associated folds. As a result, the base of the Irby Siltstone which strikes out to sea is progressively stepped inland and appears as remnants in fault wedges and synclinal troughs. The fold axes pitch 40° NE in the axial planes, which generally strike NE-SW and dip 60°-80° NW.

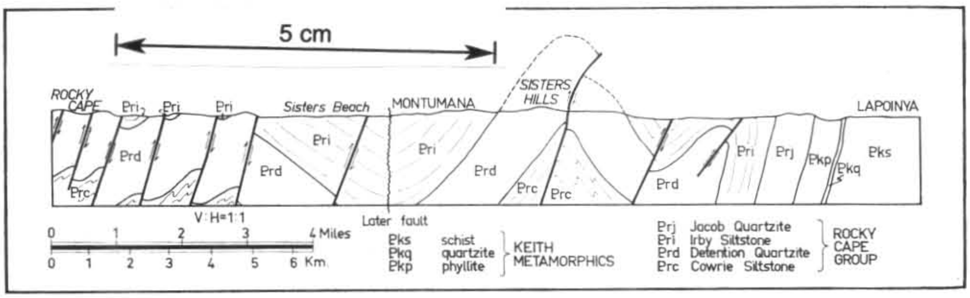


FIGURE 12. Composite section across the Proterozoic basement.

Oblique-slip faults are common in the Irby Siltstone, where they are exposed on the shore platform at Sisters Beach (fig. 3). These appear to have followed the minor folding, and in all instances are parallel to the slaty cleavage.

The anticline on the Sisters Hills is also broken by a thrust fault (fig. 12) with a displacement of 1,050 m. Cowrie Siltstone occurs in the core of the fold, and on the NW side of the fault it is planar and without minor folds; on the SE side of the fault there are abundant minor folds with a conspicuous slaty cleavage. It appears that movement along the fault in the quartzite was taken up by bedding plane slip in the Cowrie Siltstone on the western limb, and deformation by simultaneous slipping on the thrust and crumpling of the siltstone in the SE limb.

The cleavage in the siltstone in the core of this fold is due to anastomosing shreds of brown-stained sericite which define microlithons with a thickness of the order of size of the largest quartz grain. Detrital muscovite is crumpled but not preferentially orientated. However, within the axial-plane fault zone the cleavage is due to an alignment of large detrital muscovite (plate 11) without a pronounced development of the microlithons, or any indication of recrystallisation. The muscovite flakes (2 mm long) thus appear to have mechanically rotated through large angles within a granular matrix (average size 0.05 mm) which shows no evidence of fracturing or granulation. These features suggest great mobility of the rock during deformation, in which intergranular bonding and friction was at a minimum. This may have been attained by the generation of high internal pore-water pressures in the core of the major anticline.

Minor folds are generally lacking in the orthoquartzites but are common in the interbedded lutites. Examples of minor folds are well exposed in the Port Slate on the E side of Rocky Cape [547623], and also in the lutite bed within the Detention Sub-Group in the Bass Highway road cutting on the western side of Sisters Hills [567557]. These minor folds, when developed in siltstone containing discrete cross-bedded lenses, have a non-cylindroidal *en echelon* style.

A glossy, axial-plane, slaty cleavage is associated with these folds, and in places the rock is a phyllite. Plate 12 illustrates the slaty cleavage (in addition a later strain-slip cleavage) from a lutite bed in the Detention Sub-Group from a Bass Highway road cutting on the W flank of the Sisters Hills anticline. In the fine-grained laminae, the cleavage is due to a perfect planar orientation of minute crystalline muscovite which wraps quartz micro-augen. In the medium- to fine-grained siltstone laminae, the cleavage is due to the orientation of minute isolated sericite flakes between granular quartz.

A later strain-slip cleavage occurs at isolated localities in the interbedded lutite. One example is shown in Plate 12. It is later than the slaty cleavage, and is not related to any known period of folding. It appears to hold a more or less constant sub-horizontal attitude throughout the area. On the foreshore, in the core of the syncline, 1.5 km W of Jacobs Boat Harbour, the flat-lying strain-slip cleavage passes with unchanged orientation across 100 m of folded bedding.

MAJOR EAST-WEST FAULT

A major E-W fault, represented as a line of structural mis-match, extends from Jacobs Boat Harbour W to the edge of the quadrangle. This line has also been traced further W as far as the Black River in Smithton Quadrangle.

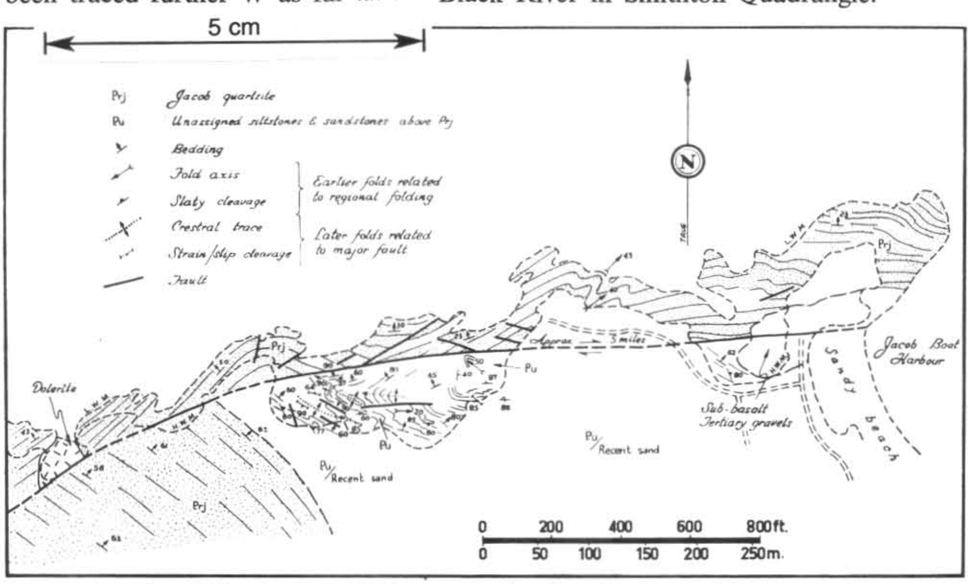


FIGURE 13. Map of Jacobs Boat Harbour area showing structures related to the transcurrent fault.

Complex re-folding occurs where siltstone is involved in the fault zone, for example, in the Sisters Beach road-cuttings, 2 km from the beach, and on the shore platform immediately W of Jacobs Boat Harbour. At the latter locality the line of the fault can be traced for 600 m along the shore platform, and the actual fault plane is observed in several places (fig. 13). No slickensides have been observed.

The late crumpling is restricted to the unnamed siltstone above the Jacob Quartzite and takes the form of *en echelon,* doubly-plunging anticlinal domes with a strain-slip axial plane cleavage. Some of the dome axes plunge at up to 90°. These structures refold the pre-existing minor folds and the slaty cleavage related to the regional folding. There is also a set of small-scale vertical shear planes trending WNW, expressed as axial planes of angular chevron folds in the siltstone and small sinistral transcurrent faults in the quartzite.

It is not possible to deduce the movement on the fault by reconstructing a coherent regional structure from the information within Table Cape Quadrangle; on regional considerations the best structural match suggests that this fault has a dextral transcurrent component of 8 km. There is thus a possibility that this fault may emerge, following further mapping, as one of the major fault structures of NW Tasmania.

The age of the fault is uncertain. It post-dates the regional folding in the Rocky Cape Group and is earlier than the Tertiary basalt. It does not fit in with the general structural plan of anything that is known about the tectonics of NW Tasmania. It is not a geomorphological feature and the associated crumpling distinguishes it from the Mesozoic or Cainozoic epeirogenic faults found elsewhere in Tasmania. Extrapolating further W into the Smithton area, it does not seem to affect the large N-S Cambrian structure (Gulline, 1959; Carey and Scott, 1953) running N-S through the township of Smithton. The fault is probably a Precambrian structure.

PRECAMBRIAN DOLERITE AND METADOLERITE

The dolerite dykes cropping out along the foreshore, between Jacobs Boat Harbour and Rocky Cape are part of the group that crops out sporadically from Sulphur Creek to Black River, called the Cooee Dolerite (Spry, 1957).

PETROLOGY

The dolerite is a hard, massive or well-jointed dark green, medium-grained rock. Most of the bodies are altered and sheared although in some of the larger masses (just W of Jacobs Boat Harbour, and W of Sisters Beach) some of the original minerals and the ophitic texture are still recognisable. Unaltered dolerites consist of randomly orientated and interlocking albite laths with euhedral to sub-hedral ophitic and intersertal clinopyroxene (augite). In places the clinozoisite has an alteration rim of tremolite. The more altered dolerites contain large patches of tremolite in a ground mass of clinozoisite, sericite, albite and sphene.

The metadolerite occurs in sheared dykes 1-8 m thick. These bodies generally have a planar sheet jointing with slickensides, as well as a weak but penetrative foliation. The augite and tremolite are mostly replaced by chlorite, and where it still remains, it is granulated. Fresh albite is uncommon, and has normally been altered to sericite. Abundant granules of clinozoisite are scattered throughout the chlorite-sericitic groundmass. The foliation, which is conspicuous in the hand specimen, is expressed in thin section as diffuse and indistinct anastomosing fracture planes with no apparent preferred mineral orientation. Small flakes of recrystallised chlorite and sericite occur within and across the fractures indicating that the alteration post-dates the shearing.

The very thin, sheared dykes from Rocky Cape (up to 50 cm thick) consist of a near-isotropic mass of chlorite and sericite, with some small granules of quartz, clinozoisite, ilmenite, sphene and leucoxene.

STRUCTURAL RELATIONS

The dolerite bodies in the Rocky Cape Group are steeply dipping tabular dykes. The majority occur in the NE trending, high angle thrust faults parallel to the axial planes of the folds.

The thin dykes are sheared, and show clear evidence of having been intruded during the period of folding. In the small bay on the E side of Rocky Cape, opposite the old port, the Port Slate is cut by a prominent set of faults trending 080°. A thin dyke 30 cm in width intruded along one of these faults exhibits a conspicuous shearing parallel to the dyke walls. Within a stratigraphic interval of 3 m there are twelve sills emanating from the dyke which intrude the enclosing flaggy quartzite and slate. The sills are folded along with the bedding and are cleaved parallel to the slaty cleavage in the siltstone. The sills are mainly concordant with the bedding, but some small cross-cutting dykes occur which penetrate along the cleavage planes in the siltstone or along rotational joints in the sandstone, and small disorientated joint blocks are completely encircled by sheared dolerite.

The shearing in the dolerite which is congruent with the cleavage development in the enclosing rock, together with the penetration of dolerite along faults, cleavage and rotational joints shows that the dolerite was intruded contemporaneously with the folding.

TERTIARY VOLCANIC ROCKS

Tertiary volcanic rocks occur in an elongate belt up to 8 km wide, stretching SW from the coast at Table Cape. The present outcrop belt of volcanics is the remnant of a once extensive sheet that was extruded on to a surface of moderate relief and with a NE drainage direction. At Fossil Bluff, the basalt flows are seen to be younger than the Upper Oligocene marine beds.

BASALT LAVAS

The lavas are represented by near-undersaturated and completely undersaturated alkali basalts. The maximum observable thickness of 130 m is exposed in the sea cliffs from the Table Cape to Jacobs Boat Harbour. Along this section individual flows are recognised by varying degrees of massiveness, weathering, and the presence or absence of basic xenoliths and amygdaloidal and scoriaceous layers. The layering dips at up to 5° W and in this 8 km long section the thickness of the lavas is probably in the order of 400 m.

The rock from the area between Fossil Bluff and Table Cape [746538], and from Chambers Bay just W of Table Cape [737567] is an olivine-labradorite basalt, containing small amounts of analcime. The rock has a holocrystalline, glomeroporphyritic texture containing about 10% olivine phenocrysts and lesser amounts of small phenocrystic pyroxene. Olivine is in equant anhedral rounded crystals (0.5 mm) and generally forming clusters up to 1.5 mm. These clusters appear to be partly disaggregated xenoliths. Optic axis sections of the olivine show zoning. The groundmass consists of small laths (0.2 x 0.05 mm) of plagioclase (labradorite), commonly orientated so as to show a flow foliation around the phenocrysts. Small intergranular anhedral clinopyroxene is present in the groundmass. The interstitial material consists of analcime, iron oxide, chlorite and fine apatite.

The basalt from the quarry on Tollymore Road [706574] is a more alkaline variety. It contains olivine, both as phenocrysts and in the groundmass. The olivine is stained along cracks and outlined by nearly opaque green chlorite. Clinopyroxene does not occur as phenocrysts, but is common in the groundmass. The pyroxene is faintly pleochroic Z = pale purple, X and Y reddish brown, and is thus a titanaugite. Plagioclase (labradorite) is uncommon in the groundmass, and the basalt is tending toward a limburgite. The groundmass is an allotriomorphic granular aggregate of olivine, clinopyroxene, analcime, iron oxides, apatite and sphene. Much of the analcime replaces plagioclase along cleavage and fractures. Much of the finer mesostasis material is clouded by turbid chlorite and leucoxene. Other secondary material includes a cavity-filling zeolite (cancrinite?) with moderate birefringence.

In Chambers Bay [737567] immediately W of the volcanic neck, a layer 18 m thick of scoriaceous and amygdaloidal lava underlies the main pile of lavas. Vesicles, vughs, and veins of aragonite, prehnite and zeolites are common. Within the scoriaceous basalt are irregular sheets of fresh fine-grained olivine basalt. Pillow-like bodies up to 1 m in diameter with chilled margins protrude from these sheets. The tachylytic margins are composed of a dirty greenish-brown glass containing subhedral olivine (0.5-1.0 mm) occasional plagioclase laths (0.1 x 0.04 mm), and small granules of a clinopyroxene (0.05 mm). Radiating natrolite occurs in amygdales and in irregular cavities.

CRINANITE PLUG

The prominent topographic feature, Table Cape, is a more or less circular volcanic plug with its northern face rising steeply from the sea to a height of 170 m a.s.l. (frontispiece). It is approximately 1.4 km in diameter, with a flat top, and stands about 70 m above the general level of the surrounding basalts. Its contacts with the surrounding basalts are not exposed because of the abundance of talus. The plug is composed of crinanite with some pegmatitic schlieren.

Several zones of different styles of jointing can be distinguished in the cliff face below the lighthouse:

110–160 m a.s.l.	widely spaced, generally sub-horizontal joints. This interval contains the pegmatitic schlieren.
80–110 m a.s.l.	short polygonal prisms of variable orientation.
40– 80 m a.s.l.	irregular blocky joints.
0– 40 m a.s.l.	close, sub-horizontal platy joints, with intervals of close, platy cross-jointing.

Most of the plug is composed of dolerite containing olivine, titanaugite, labradorite, sanidine, analcime and rare nepheline. Typically the rock is medium-grained, non-porphyritic with a sub-ophitic texture and a feldspathoidal mesostasis. Olivine occurs as anhedral rounded grains up to 0.5 mm, commonly with irregular cracks outlined by a dark green alteration product. Titanaugite occurs as small sub-hedral grains (0.2 mm) which are moulded against the olivine in stellate bundles, or as separate crystals sub-ophitic to the plagioclase. Normatively (Table 2), these have a composition of En_{32}, Fs_{16}, Wt_{52}. Plagioclase (An_{55-65}) generally occurs as laths 0.8 x 0.1 mm. In addition, phenocrysts of more sodic plagioclase up to 3 mm occur. The zoning within the main portion of a zoned crystal defines a perfect euhedral form, but the outer rim includes small laths of plagioclase and clinopyroxene, and is moulded into the interstices of the surrounding minerals. Except for the anhedral rim, these phenocrysts appear to have crystallised earlier than the plagioclase laths, yet are more sodic. Thin section determinations, using the extinction angle in sections normal to X, indicate that the euhedrally zoned portion is dominantly about An_{45} with sharp oscillatory reversals to An_{42}. The outer rim of the crystal shows a diffuse or gradual zonation to An_{20}.

The intersertal material consists of anhedral, untwinned alkali feldspar, slightly turbid analcime, small patches of radiating aggregates of ?natrolite and abundant fine needles of apatite. The analcime commonly occurs in pockets and seams replacing feldspar along cleavage. Skeletal grains and bladed aggregates of ilmenite up to 0.4 mm are moulded on to and partly enclose plagioclase and pyroxene.

Chemical analyses of five crinanite samples collected in sequence up the face of Table Cape, are listed in Table 1 and the CIPW norms in Table 2. The crinanite contains constant proportions of *or,* plagioclase, *di,* and *ol.* The type of olivine and augite is constant. The main systematic variations with increasing height include decrease in An ratio of the plagioclase, decrease in *ne,* and enrichment in *mt* and *il.* There is thus no marked differentiation trend in the exposed sequence.

The crinanite is chemically similar to that from Circular Head, 40 km to the W at Stanley (Edwards, 1941). The Circular Head mass showed a progressive decrease in MgO and FeO, and increase in Al_2O_3, Na_2O and K_2O. These trends are the reverse of those in the Table Cape Body.

Pegmatitic schlieren commonly occur as sub-horizontal tabular sheets in the upper, massive, interval of the neck. Below the lighthouse these dip gently S in a plane parallel to the main cooling joints. The schlieren vary in thickness from 2 cm to 2 m.

TABLE 1

CHEMICAL ANALYSES OF ALKALINE DOLERITES FROM TABLE CAPE

	1 %	2 %	3 %	4 %	5 %	6 %
SiO_2	45.4	44.4	45.0	45.2	44.7	45.7
TiO_2	2.2	2.3	2.2	2.0	2.1	2.9
Al_2O_3	15.4	15.i	14.7	14.7	14.2	16.7
Fe_2O_3	1.6	1.8	1.8	2.2	2.3	5.4
FeO	9.3	10.0	9.7	9.6	10.0	5.7
MnO	0.17	0.18	0.17	0.18	0.17	0.15
P_2O_5	0.50	0.47	0.49	0.46	0.48	0.87
CaO	8.8	8.8	8.6	8.6	8.8	7.4
MgO	9.7	10.9	10.1	9.7	9.9	3.2
Na_2O	3.6	3.3	3.4	3.2	3.1	5.2
K_2O	1.8	1.7	1.7	1.8	1.9	3.2
H_2O+ ..	0.84	0.45	1.0	1.4	0.88	1.8
H_2O- ..	0.87	0.79	0.74	0.90	0.98	1.4
CO_2	0.11	0.05	Nil	Nil	0.22	0.03

ANALYSES: J. FURST

1-5. Alkaline dolerite, face of Table Cape, below lighthouse: 1, sea level; 2, 37 m a.s.l.; 3, 73 m a.s.l.; 4, 110 m a.s.l.; 5, 134 m a.s.l.

6. Pegmatitic schliere, Table Cape, 135 m a.s.l.

TABLE 2

CIPW NORMS FOR ALKALINE DOLERITES FROM TABLE CAPE

	1 %	2 %	3 %	4 %	5 %	6 %
or	10.64	10.05	10.04	10.64	11.23	18.91
plagioclase	35.19 (An_{61})	32.52 (An_{67})	33.98 (An_{58})	35.48 (An_{58})	34.26 (An_{60})	33.20 (An_{39})
ne	8.24	8.94	7.92	6.52	5.40	12.68
di	15.52 $(En_{32}\ Fs_{16.5}$ $Wt_{51.5})$	15.30 $(En_{32}\ Fs_{16}$ $Wt_{52})$	15.91 $(En_{32}\ Fs_{16.5}$ $Wt_{51.5})$	15.60 $(En_{31}\ Fs_{17}$ $Wt_{52})$	16.16 $(En_{32}\ Fs_{17}$ $Wt_{51})$	14.32 $(En_{40}\ Fs_{7.5}$ $Wt_{52.5})$
ol	21.01 $(Fo_{64}\ Fa_{36})$	24.02 $(Fo_{65}\ Fa_{35})$	22.08 $(Fo_{66}\ Fa_{34})$	21.36 $(Fo_{63}\ Fa_{37})$	21.86 $(Fo_{63}\ Fa_{37})$	1.92 $(Fo_{83}\ Fa_{17})$
mt	2.32	2.61	2.61	3.19	3.34	7.83
il	4.18	4.37	4.18	3.78	4.00	5.51
ap	1.18	1.11	1.16	1.09	1.34	2.06
H_2O+	0.84	0.45	1.00	1.4	0.88	1.80
Cancrinite	—	—	—	—	0.53	0.07

For localities see Table 1.

The pegmatite consists of large pyroxene needle-like crystals of titanaugite up to 15 mm in length and feldspar crystals up to 1 cm in diameter; these occur in crystal aggregates in which ophitic textures are visible in hand specimen. These aggregates are set in a dull green feldspathoidal groundmass. The contacts of the schlieren are generally sharp but irregular, and have the features of dilational bodies. The actual contact is commonly marked by the arrangement of short pryoxene prisms (3 mm) and feldspar laths (2 mm) in comb structure perpendicular to the margin. Inside this marginal zone, is a zone up to 10 cm wide of randomly orientated feldspar and pyroxene displaying ophitic texture visible in hand specimen.

The essential components of the pegmatite include olivine (10%), titanaugite, plagioclase (An_{45}), sanidine, alkali feldspar, nepheline, analcime, and iron oxides. Small quantities of aegerine-augite, apatite and cancrinite occur. The proportion of olivine is much reduced (about 5%) in comparison with the normal crinanite, and occurs as slender crystals up to 4 mm long, or as tadpole-shaped subhedral crystals commonly with a core of alkali feldspar or cancrinite. The olivine is extensively cracked, and altered around the veins and along cracks by a reddish brown alteration product. The titanaugite occurs either as subhedral prisms with included apatite, and is partly replaced by iron oxide, or as small anhedral grains included in the plagioclase. Plagioclase, commonly zoned and with pericline twinning, occurs as interlocking laths up to 3 mm in length. These are generally altered to a slightly birifrigent analcime along cleavage and cracks. The alkali feldspar ($2V = 5\text{-}30°$) is thus probably largely sanidine and occurs as anhedral crystals up to 2 mm in diameter. It is characterised by abundant inclusions of euhedral hexagonal rods of nepheline (0.1 x 0.6 mm), arranged in a rectilinear or slightly radiating orientation, with a general tendency for the long axes of the rods to be orientated parallel to 010, and with hexagonal cross-sections visible on the 100 face. The nepheline thus appears to have crystallised early along with the sanidine, either eutectically or as an exsolution product. The mesostasis consists of small laths of untwinned plagioclase (no relief, straight extinction, $2V \cong 60°$, and thus probably oligoclase), anhedral indeterminate alkali feldspar closely intergrown with nepheline, analcime (both as an alteration product of nepheline and as interstitial material), and small granules of aegerine-augite. The dull groundmass consists of the same material as the mesostasis, but with abundant vugs of cancrinite, radiating natrolite, and is nearly opaque due to greenish-brown alteration.

The pegmatite, in comparison with the dolerite (Table 2), shows marked increase in normative *or, ne, mt, il* and *ap,* and reduction in plagioclase, *di* and *ol*. Both *di* and *ol* show a magnesium enrichment, contrary to the usual trend in late-crystallising pyroxenes.

ECONOMIC GEOLOGY

The mineral resources of the Table Cape Quadrangle are meagre, and only the non-metallics have been exploited.

SAND AND GRAVEL

Considerable reserves of high quality silica sand and gravel exist in the valley of the Inglis River, 5 km W of Wynyard. These are sub-basalt and are more than 70 m thick. They extend well S into Burnie Quadrangle where there has been greater exploitation. The deposits in the Table Cape Quadrange have been worked for railway ballast and road gravel.

CLAY

Extensive deposits of clay suitable for brickmaking occur in the Wynyard area (Gee, 1963). The clay is derived from Permian pebbly siltstone and varied claystone, and forms as a scree overburden or a talus wedge. Threader (1965, 1966) described similar deposits in the same vicinity, just S of the Quadrangle border.

Ceramic tests have been undertaken by the Mines Department Metallurgical Laboratories (Manson and James, 1964, 1965). Satisfactory results were obtained and the Wynyard Brick Company commenced operations in 1965. In the two years to December 1966 the company had quarried 13,623 m^3 (17,710 yd^3) of clay.

GEMSTONES

Zircon and occasional sapphire can be washed from many of the small creeks in the Sisters Creek and Boat Harbour area. Twelvetrees (1905, p. 17) states that unsuccessful attempts were made to commercially exploit the deposits when in 1896 the Shekleton Mining Syndicate sent a one ton sample to Europe. The deposits have since been worked mainly for gemstones, and then only on a small scale. Most of the stone appears to have been sold privately or cut for personal use.

There were two main areas for sluicing. One in the headwaters of Cassidys Creek (formerly called Shekleton Creek) where it flows off the Precambrian quartzite on to the basalt, and the second is in a similar geological position in the small creek that flows S through the hamlet of Sisters Creek, to join the Flowerdale River.

The zircon is derived from thin layers of sub-basalt sand and gravel. Some specimens washed by W. L. Matthews (pers. comm.) measure up to 3 mm in diameter, and have crystal faces showing varying degrees of rounding.

Their ultimate source is uncertain. They may have been shed from the Devonian Housetop granite during the Tertiary period of erosion and washed down the pre-basalt deep leads. Alternatively they may have been shed from the Precambrian orthoquartzite during a Tertiary period of deep leaching, and further concentrated by alluvial processes prior to the outpouring of the basalt. The orthoquartzite contains rounded accessory zircon although no large grains with good crystal faces have been observed.

COPPER

Small amounts of chalcopyrite with hematite and pyrite are found in the quartz veins associated with the dolerite bodies that intrude the Precambrian rocks. Twelvetrees (1905) reports that these have been prospected at several places, e.g., Lee Archer prospect 250 m W of Wet Cave Point, and King's prospect 2 km W of Jacobs Boat Harbour. These prospects were never mined.

GOLD

Small traces of gold can be washed from the sub-basalt gravels in the Inglis River. The gold is in too small a quantity to be of any economic significance, unless exhumed deep leads close to the surface can be found.

REFERENCES

BANKS, M. R. 1957. The stratigraphy of Tasmanian limestones, *in* HUGHES, T. D. Limestones in Tasmania. *Miner Resour. Tasm.* 10:39-85.

BANKS, M. R. 1963. Permian, *in* SPRY, A.; BANKS, M. R. (ed.). The geology of Tasmania. *J. geol. Soc. Aust.* 9(2): 189-215.

BANKS, M. R.; LOVEDAY, J.; SCOTT, D. L. 1955. Permian varves from Wynyard, Tasmania. *Pap. Proc. R. Soc. Tasm.* 89: 203-218.

BOSWELL, P. G. H. 1961. *Muddy sediments.* Heffer: Cambridge.

BURNS, K. L. 1964. One mile geological map series. K/55-6-29. Devonport. *Explan. Rep. geol. Surv. Tasm.*

CAREY, S. W.; SCOTT, B. 1952. Revised interpretation of the geology of the Smithton district of Tasmania. *Pap. Proc. R. Soc. Tasm.* 86: 63-70.

CUMMINS, W. A. 1964. Current directions from folded strata. *Geol. Mag.* 101: 169-173.

DAVID, T. W. E. 1908. The Permo-Carboniferous glacial beds at Wynyard, near Table Cape, Tasmania. *Rep. australas. Ass. Advmt Sci.* 11: 274-279.

DAVID, T. W. E. 1950. *The geology of the Commonwealth of Australia.* Vols. 1-3. Arnold: London.

DŻUŁYŃSKI, S.; KSIĄŻKIEWICZ, M.; KUENEN, P. H. 1959. Turbidites in flysch of the Polish Carpathian mountains. *Bull. geol. Soc. Am.* 70: 1089-1118.

EDWARDS, A. B. 1914a. The north-west coast of Tasmania. *Proc. R. Soc. Vict.* 53(2): 233-267.

EDWARDS, A. B. 1941b. The crinanite laccolith of Circular Head, Tasmania. *Proc. R. Soc. Vict.* 53(2): 403-415.

FARKAS, S. E. 1960. Cross-lamination analysis in the Upper Cambrian Franconia Formation of Wisconsin. *J. sedim. Petrology* 30: 447-458.

GEE, R. D. 1963. Report on clay in the Wynyard district. *Tech. Rep. Dep. Mines Tasm.* 7: 55-57.

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

GILL, E. D. 1962. Cainozoic, *in* SPRY, A.; BANKS, M. R. (ed.). The geology of Tasmania. *J. geol. Soc. Tasm.* 9(2): 233-253.

GRALEY, A. M.; LOVEDAY, J. 1961. Chemical and morphological data for soils in the Burnie-Table Cape districts, Tasmania. *Div. Rep. Div. Soils C.S.I.R.O. Aust.* 13/60.

GREENWOOD, R. 1960. Sedimentary boudinage in Cretaceous limestones of Zimapan, Mexico. *Rep. 21st Int. geol. Congr.* 18: 389-398.

GULLINE, A. B. 1959. The underground water resources of the Smithton district. *Undergr. Wat. Supply Pap. Tasm.* 5.

HILLS, L. 1913. The Preolenna coal field and the geology of the Wynyard district. *Bull. geol. Surv. Tasm.* 13.

JAMES, P. L. 1966. Ceramic investigations. R.485, R.488, R.491, R.500, R.501. Wynyard Brick Company. *Tech. Rep. Dep. Mines Tasm.* 10: 138-142.

JOHNSTON, R. M. 1877. Further notes on the Tertiary marine beds of Table Cape. *Pap. Proc. R. Soc. Tasm.* 1876: 79-90.

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

JONES, R. 1965. Observations on the geomorphology of a coastal cave near Wynyard. *Pap. Proc. R. Soc. Tasm.* 99: 15-16.

KELLING, G.; WALTON, E. K. 1957. Load-cast structures: their relationship to upper-surface structures and their mode of formation. *Geol. Mag.* 94: 481-490.

KITSON, A. E. 1902. On the occurrence of glacial beds at Wynyard, near Table Cape, Tasmania. *Proc. R. Soc. Vict.* 15(1): 28-35.

KUENEN, P. H. 1958. Experiments in geology. *Trans. geol. Soc. Glasg.* 23: 1-27.

LOVEDAY, J. 1955. Reconnaissance soil map of Tasmania. Sheets 22 and 28. Burnie and Table Cape area. *Div. Rep. Div. Soils C.S.I.R.O. Aust.* 14/55.

LOVEDAY, J.; FARQUHAR, R. N. 1958. The soils and some aspects of land use in the Burnie, Table Cape, and surrounding districts, north-west Tasmania. *Soils Land Use Ser. C.S.I.R.O. Aust.* 26.

MCCROSSAN, R. G. 1958. Sedimentary 'boudinage' structures in the Upper Devonian Ireton Formation of Alberta. *J. sedim. Petrology* 28: 316-320.

MCNEIL, R. D. 1961. Geological reconnaissance of the Arthur River area. *Tech. Rep. Dep. Mines Tasm.* 5: 46-60.

MANSON, W. ST C.; JAMES, P. L. 1964. Ceramic investigations. R.430. Clay from Wynyard; R.440 to R.448. Clays from Wynyard; R. 443-4; R.444-5, Reg. no. 2416. Clay and sand from Wynyard. *Tech. Rep. Dep. Mines Tasm.* 8: 227-242.

MANSON, W. ST C., JAMES, P. L. 1965. Ceramic investigations. R.465, R.466. Clay from Wynyard. *Tech. Rep. Dep. Mines Tasm.* 9: 185-186.

MONTGOMERY, A. 1896. Report on the mineral fields of the Gawler River, Penguin, Dial Range, Mount Housetop, Table Cape, Cam River, and portion of the Arthur River districts. *Rep. Secr. Mines Tasm.* 1895-6: i-xx.

NOETLING, F. 1910. Notes on the glacial beds of Freestone Bluff (Sandy Cove) near Wynyard. *Pap. Proc. R. Soc. Tasm.* 1909: 157-159.

NORMAN, T. N. 1960. Azimuths and primary linear structures in folded strata. *Geol. Mag.* 97: 338-343.

PETTIJOHN, F. J. 1957. *Sedimentary rocks.* 2nd ed. Harper & Bros: New York.

POTTER, P. E.; PETTIJOHN, F. J. *Paleocurrents and basin analysis.* Academic Press: New York.

POTTER, P. E.; PRYOR, W. A. 1961. Dispersal centers of Paleozoic and later clastics of the Upper Mississippi Valley and adjacent areas. *Bull. geol. Soc. Am.* 72: 1195-1249.

QUILTY, P. G. 1966. The age of Tasmanian marine Tertiary rocks. *Aust. J. Sci.* 29(5): 143-144.

SELLEY, R. C.; SHEARMAN, D. J.; SUTTON, J.; WATSON, J. 1963. Some underwater disturbances in the Torridonian of Skye and Raasay. *Geol. Mag.* 100: 224-243.

SPRY, A. 1957. The Precambrian rocks of Tasmania, Part I, Dolerites of the north-west coast of Tasmania. *Pap. Proc. R. Soc. Tasm.* 91: 81-93.

SPRY, A. 1962. The Precambrian rocks, *in* SPRY, A.; BANKS, M. R. (ed.). The geology of Tasmania. *J. geol. Soc. Aust.* 9(2): 107-126.

SPRY, A. 1964. Precambrian rocks of Tasmania, Part VI, the Zeehan-Corinna area. *Pap. Proc. R. Soc. Tasm.* 98: 23-48.

STEPHENS, T. 1870. Remarks on the geological structure of part of the north coast of Tasmania, with special reference to the Tertiary marine beds near Table Cape. *Pap. Proc. R. Soc. Tasm.* 1869: 17-21.

STEPHENS, T. 1909. Notes on the geology of the north-west coast of Tasmania, from the River Tamar to Circular Head. *Proc. Linn. Soc. N.S.W.* 33: 752-767.

STEWART, H. B. 1956. Contorted sediments in modern coastal lagoon explained by laboratory experiments. *Bull. am. Ass. Petrol. Geol.* 40(1): 153-161.

STRZELECKI, P. E. DE 1845. *Physical description of New South Wales and Van Diemen's Land.* Longman, Brown, Green & Longmans: London.

TANNER, W. F. 1955. Paleogeographic reconstructions from cross-bedding studies. *Bull. am. Ass. Petrol. Geol.* 39(12): 2471-2483.

TATE, R.; DENNANT, J. 1896. Correlation of the Tertiaries of Australia. Part III, South Australia and Tasmania. *Trans. R. Soc. S. Aust.* 20(1): 118-148.

TERZAGHI, K. 1957. Varieties of submarine slope failure. *Tek. Ukebl.* 43-44: 1-16.

THREADER, V. M. 1965. Brickmaking material near Wynyard. *Tech. Rep. Dep. Mines Tasm.* 9: 10-11.

THREADER, V. M. 1966. Clay reserves for Wynyard Brick Company, Wynyard. *Tech. Rep. Dep. Mines Tasm.* 10: 12-14.

TWELVETREES, W. H. 1903a. Trachydolerite in Tasmania. *Pap. Proc. R. Soc. Tasm.* 1902: 133-135.

TWELVETREES, W. H. 1903b. *Report on the Dial Range and some other mineral districts on the north-west coast of Tasmania.* Mines Department, Tasmania.

TWELVETREES, W. H. 1906. Report on north-west coast mineral deposits. *Rep. Secr. Mines* Tasm. 1905: 9-59.

WILLIAMS, E. 1960. Intra-stratal flow and convolute folding. *Geol. Mag.* 97: 208-214.

INDEX

PLATES 1-12

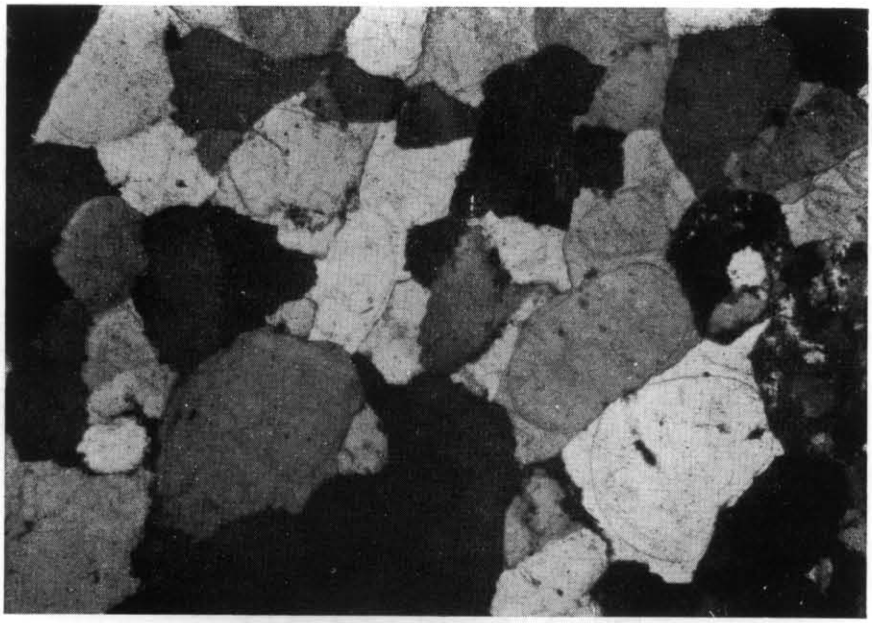


PLATE 1. Orthoquartzite with overgrowths on rounded quartz grains. x 28

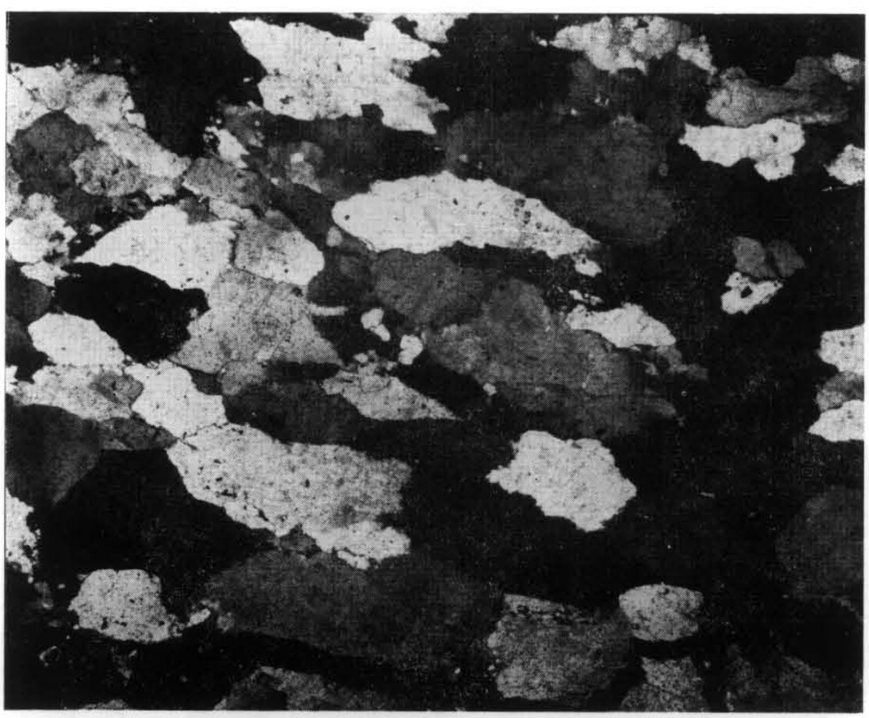


PLATE 2. Orthoquartzite with condensed fabric, sutured and elongate grains parallel to bedding. x 22.

5 cm

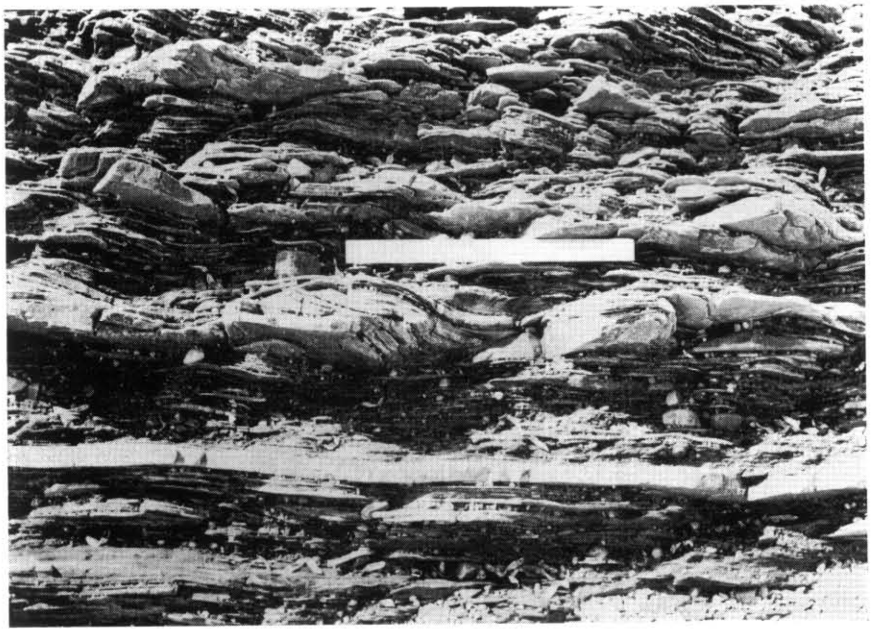


PLATE 3. Cross-bedded sandstone lenses in siltstone, Port Slate, Rocky Cape.

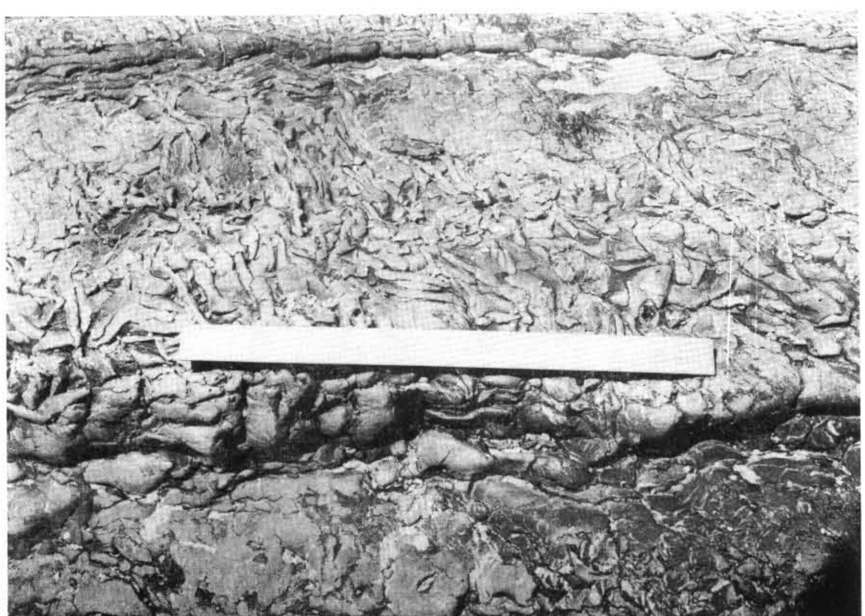


PLATE 4. 'Hieroglyphic' markings in dolomitic siltstone, Sisters Beach.

5 cm

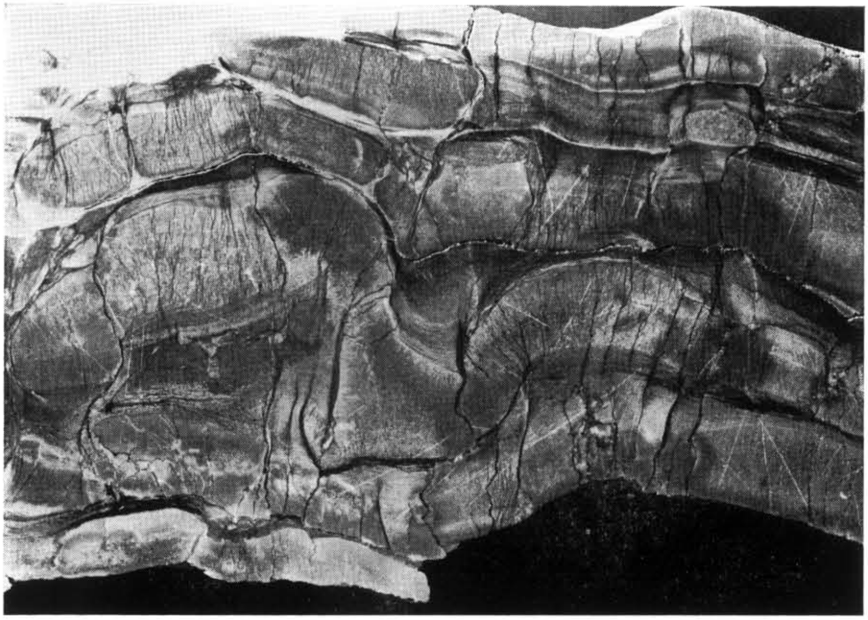


PLATE 5. Sedimentary boudinage in interlaminated dolomite and siltstone, Sisters Beach. x 1.

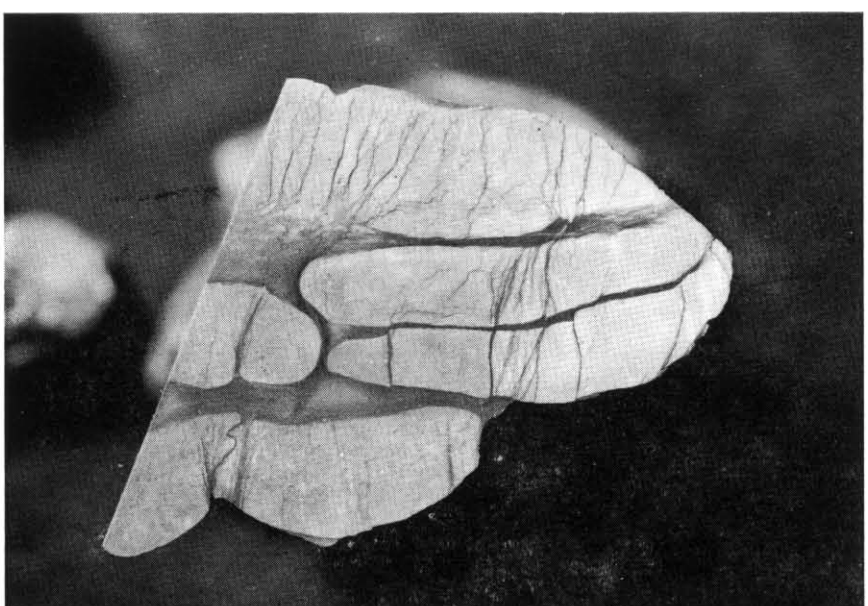


PLATE 6. Dolomite boudins showing transverse hair-line cracks, Sisters Beach. x 2.

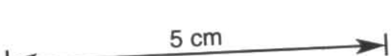


PLATE 7. Hematite breccia showing scoured base and conformable top. Top of Irby Siltstone, Sisters Beach.

PLATE 8. Details of hematite breccia (above). x 4.

5 cm

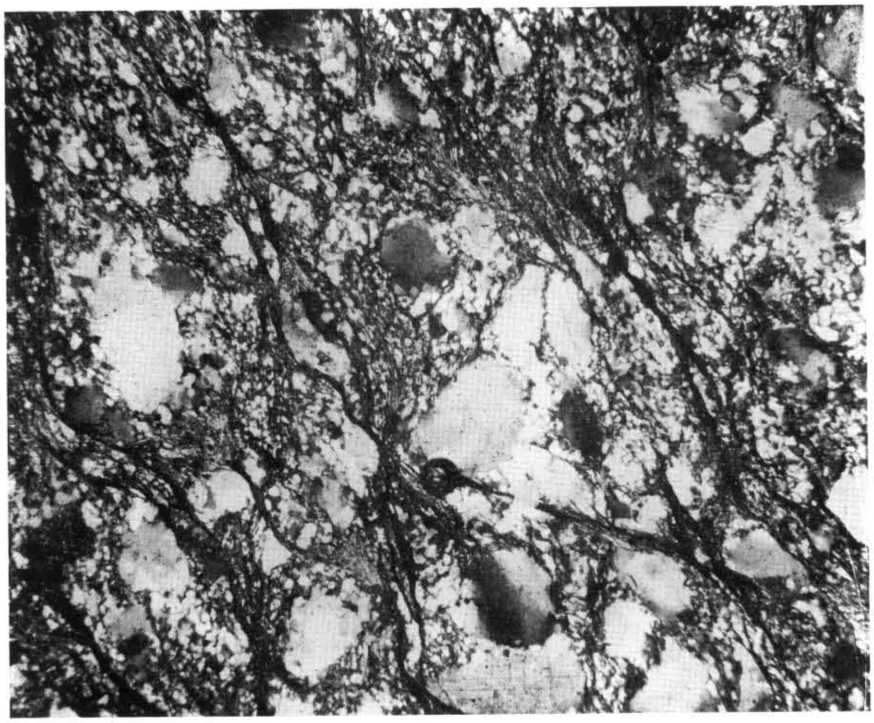


PLATE 9. Mortar texture in quartzite, showing partly granulated porphyroclasts, Keith Metamorphics. x 100.

PLATE 10. Crenulated phyllite, western margin of Keith Metamorphics. x 23.

5 cm

PLATE 11. Cleavage in Cowrie Siltstone, due to alignment of detrital muscovite, core of regional anticline Sisters Hills. Bedding is approximately perpendicular to cleavage. x 75.

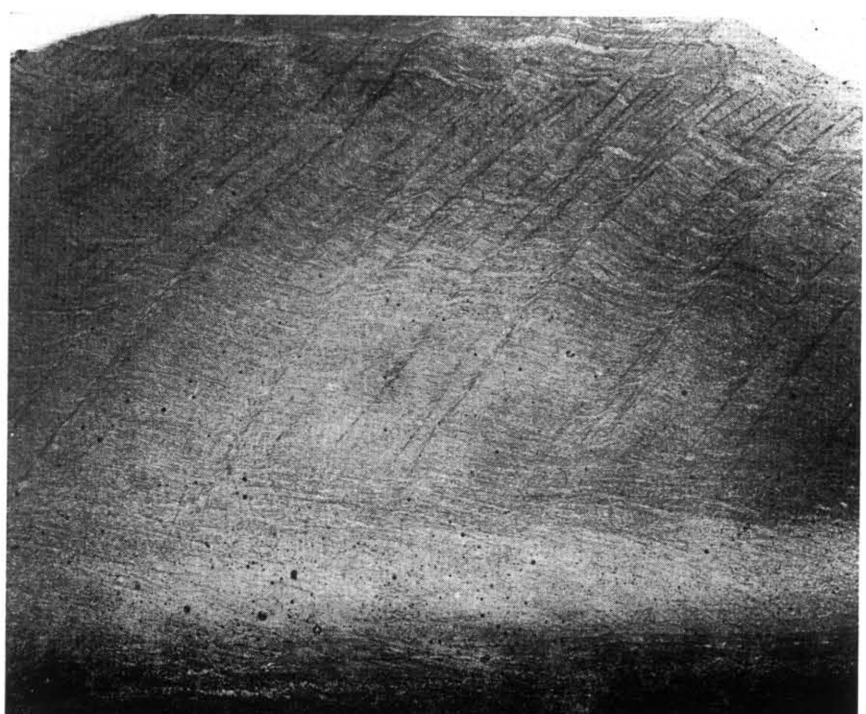


PLATE 12. Slaty cleavage oblique to bedding lamination, and late strain-slip cleavage. Silty layer in Detention Sub-Group, Sisters Hills. x 2.

5 cm