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BURNIE

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PREFACE

These explanatory notes describe the geology and mineral resources of the Burnie geological atlas 1 mile map sheet published in 1967. The Burnie Quadrangle extends from the north coast around Burnie to the township of Riana in the south-east and to the picturesque gorge of the Hellyer River in the south-west.

Apart from the urban and industrial activities of the Burnie area, agriculture and forestry provide the main employment in the region. Sands and gravels are an important mineral resource, whereas metallic mineral deposits have only been mined to a very limited extent.

Geological features of the region include a cross-section of the Precambrian sequences, comprising one of the important tectonic elements of Tasmania, and the oldest beds of the Parmeener Super-group in the State.

J.G. SYMONS, Director of Mines

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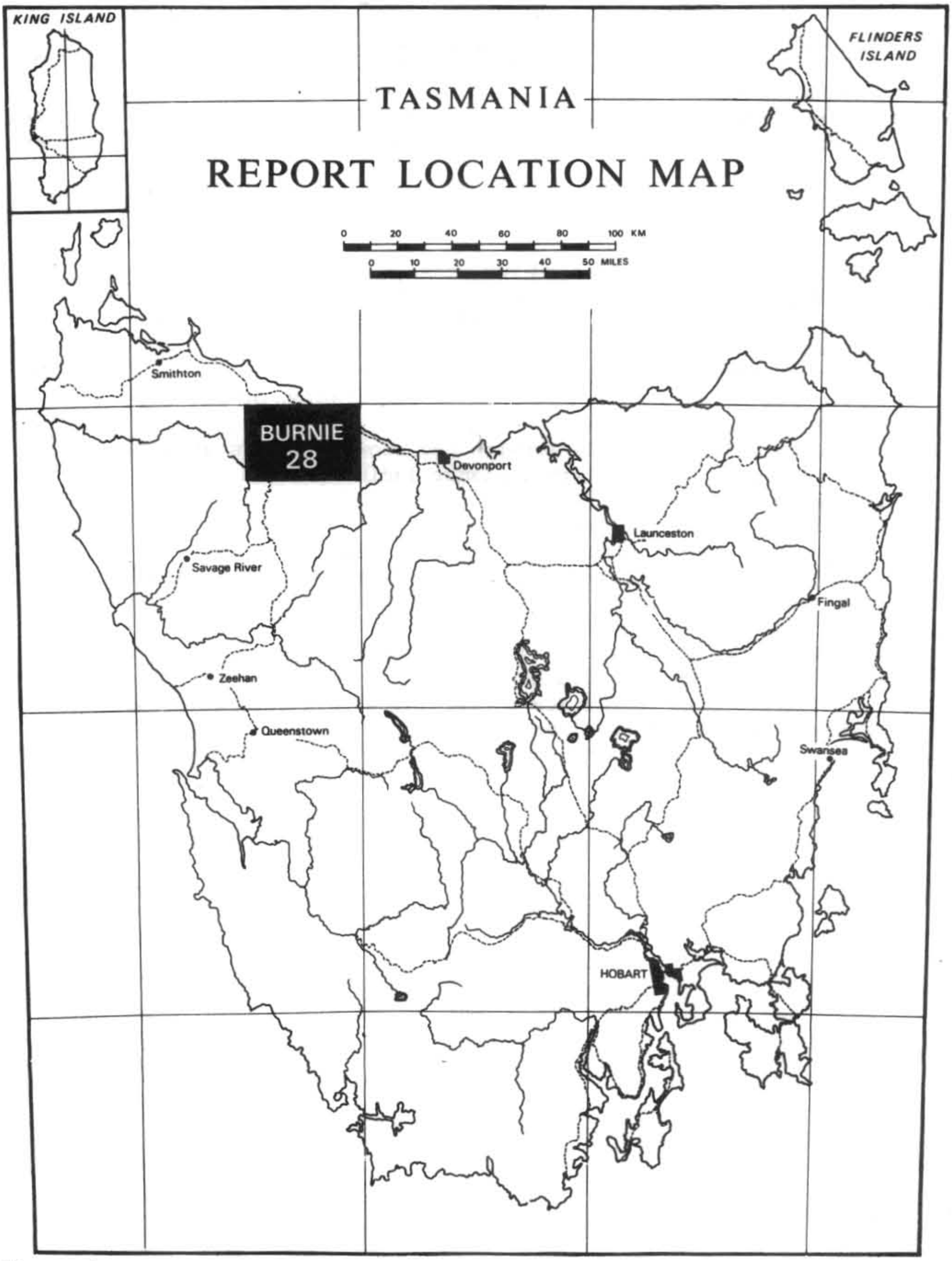


Figure 1. *Location of Burnie Quadrangle.*

5 cm

INTRODUCTION

The Burnie Quadrangle is situated on the North West Coast of Tasmania and is bounded by latitudes 41°15' and 41°S, and longitudes 145°30' and 146°E. It includes the coastal section between Blythe River Heads and Doctors Rocks (fig. 1).

The quadrangle includes the important urban centre of Burnie, which serves as an outlet for the nearby pulp and paper factory, the titanium pigment factory, the sulphuric acid plant and for base metal concentrates from the mineral fields of the West Coast. Much of the quadrangle is under close cultivation and the basalt slopes and Permian siltstone hills are extensively forested with hardwood and softwood timbers. Sand and gravel are the most important mineral resources, while deposits of iron ore, copper and tin are known but have only been mined to a limited extent.

The map sheet was published in 1967 at a scale of 1:63 360. An interpretation of the bedrock geology is given in Figure 2. The most important geological feature is a cross-section of the Proterozoic Rocky Cape Geanticline, one of the important tectonic elements of Tasmania.

PREVIOUS LITERATURE

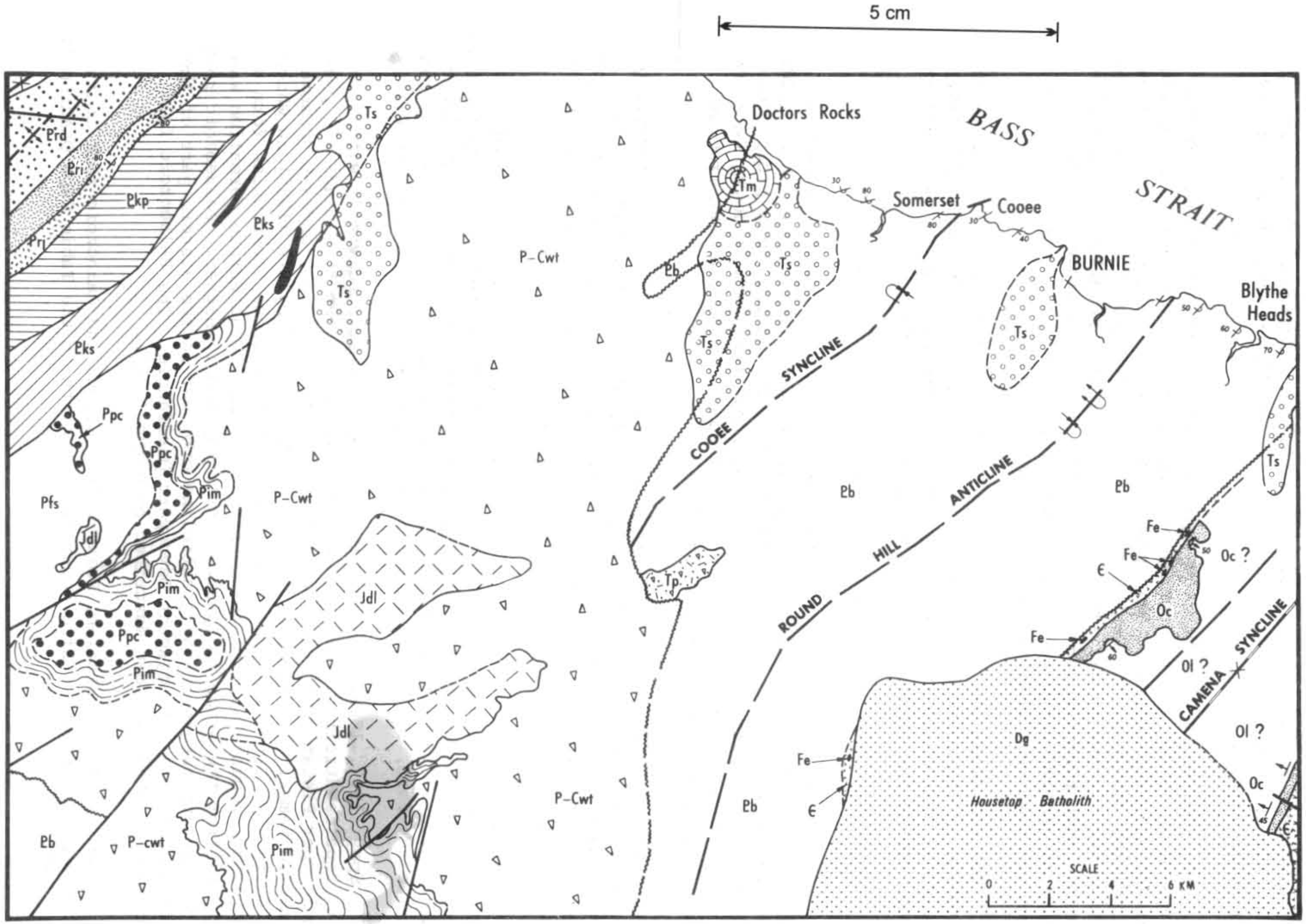
Strzelecki (1845, p. 93) first mentioned the contorted siliceous and argillaceous slates west of Emu Bay, while Stephens (1870) noted these folded rocks and also dolerite dykes. These dykes attracted the early prospectors, and traces of copper were found at several localities between Rocky Cape and Penguin. Traces of gold were found on the coastal plains and an iron ore deposit was discovered in the Blythe River.

Montgomery (1894, 1896) visited the area to report on these fledgling mineral fields which had not lived up to early hopes. Twelvetrees (1903, 1906) made the first worthwhile observations in reports on the mineral fields of the North West Coast, and Hills (1913) also visited the area to assess the coal potential of the Permian rocks in the Wynyard area.

Following the delineation of the mineral belts of the West Coast, the barren rocks to the north-west emerged as an important tectonic element, which Carey (1953) defined as the Rocky Cape Geanticline. With the recognition of flanking fossiliferous Middle Cambrian rocks at Smithton to the west and Penguin to the east, the geanticlinal rocks were regarded as late Precambrian.

Spry (1957, 1962, 1964) attempted stratigraphic subdivision within the Rocky Cape Geanticline. He defined the Rocky Cape Group to include all presumed upper Precambrian rocks between Penguin and Smithton, and set up some formation names. A revised stratigraphy was outlined by Gee (1968) in which the Rocky Cape Group was redefined to include only those rocks which form a continuous sequence west of the geanticlinal axis. The Burnie Formation was excluded from the Group and placed stratigraphically higher. Palaeozoic rocks on the eastern margin of the geanticline crop out in the eastern part of the quadrangle and in the adjacent Devonport Quadrangle. The Palaeozoic fold belt in this area has been described by Burns (1965).

Some of the Precambrian, Permo-Carboniferous and Cainozoic rock units in the Burnie Quadrangle also occur further north in the Table Cape Quadrangle (Gee, 1971).


5 cm
Doctors Rocks
BASS STRAIT
Somerset
Cooee
BURNIE
Blythe Heads
COOEE SYNCLINE
ROUND HILL ANTICLINE
CAMENA SYNCLINE
Housetop Batholith
SCALE
0 2 4 6 KM
Ts
Tm
Tp
P-Cwt
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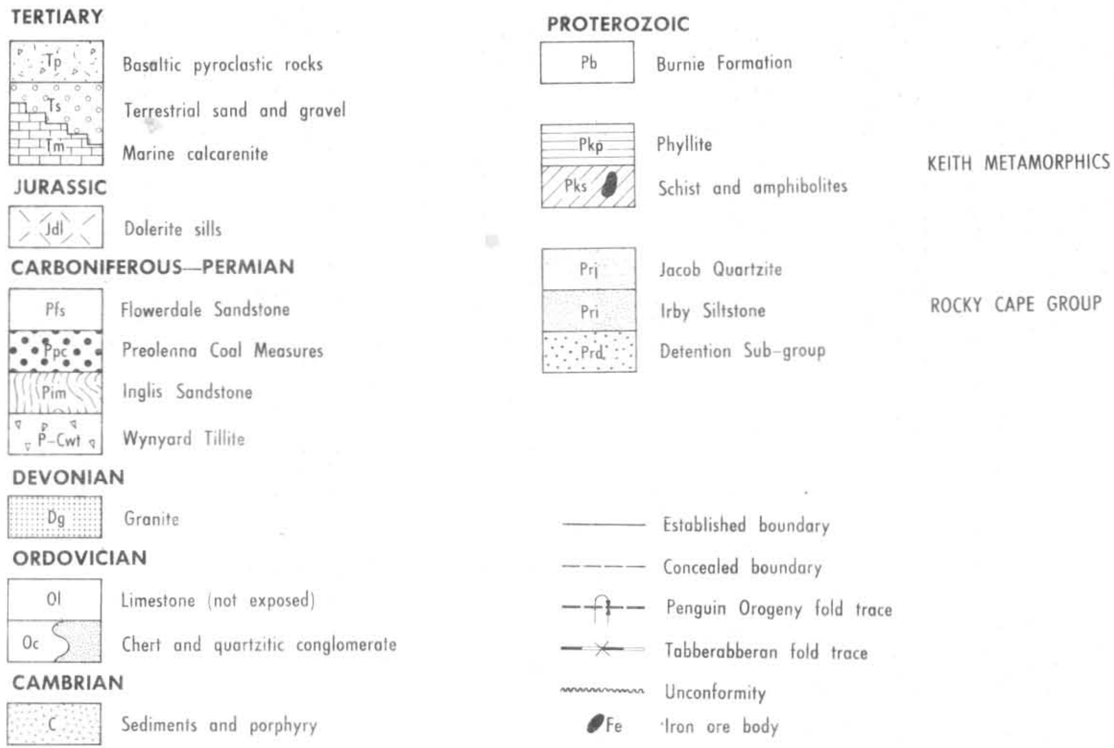


Figure 2. *Bedrock geology, Burnie Quadrangle.*

PHYSIOGRAPHY

The most conspicuous topographic feature is a remnant erosional surface that slopes gently seaward from about 450 m to 75 m above sea level. This corresponds to the Lower Coastal Surface of Davies (1959). Most of this surface is underlain by Tertiary basalt, but Tertiary gravel, Jurassic dolerite, Permian siltstone and Precambrian rocks also occur. Round Hill (Precambrian greywacke), the dolerite peaks south of Henrietta, and the Dip Range (Rocky Cape Group quartzites) in the north-west corner of the quadrangle all stand above this surface. Burns (1965) suggests a Pliocene age for this surface.

The Lower Coastal Surface is dissected by the Flowerdale, Inglis, Cam, Emu and Blythe Rivers which flow northwards, in narrow incised superimposed gorges that are nearly at grade for the lowermost 13 km of their courses. The surface rises to the south-west to a maximum altitude of 550 m in the West Takone-Oonah area, then drops steeply to approximately 150 m a.s.l. This tract of country forms the water divide between the northerly flowing rivers mentioned previously, and the westerly flowing Arthur and Hellyer Rivers, one of the major drainage systems of Tasmania.

A low-level coastal platform is developed intermittently along the coastline below the scarp of the Lower Coastal Surface. The platform, on which the towns of Burnie and Somerset are built, is probably an emerged marine erosional surface of Pleistocene age, which has subsequently been covered with Quaternary sand.

Both the scarp between the narrow coastal surface and the Lower Coastal Surface and the steep gorge walls of the rivers that dissect the latter surface are currently the sites of active landslides and solifluction.

SUMMARY OF GEOLOGICAL HISTORY

PLEISTOCENE(?)	Sand gravel and clay deposited on raised coastal erosional platforms.
MIOCENE-OLIGOCENE	Extensive basalt flows, deposition of fluvial quartz gravel and carbonaceous clay. Accumulation of clastic limestone in a littoral environment (Table Cape Group).
	Unconformity
JURASSIC	Intrusion of dolerite.
PERMIAN	Accumulation of basal glacio-marine beds (Wynyard Tillite), marine pebbly siltstone (Inglis Siltstone) and fluvial sandstone (Flowerdale Sandstone) and coal measures (Preolenna Coal Measures).
	Unconformity
DEVONIAN	Orogenic folding and post-tectonic intrusion of granite.
ORDOVICIAN	Deposition of siliceous conglomerate (Sulphur Creek Conglomerate).
CAMBRIAN	Deposition of siltstone and porphyry (Radford Creek Group) and hematitic siliceous siltstone.

Unconformity

PRECAMBRIAN (PROTEROZOIC)	Penguin Orogeny, accompanied by intrusion of albite dolerite (Cooee Dolerite) and localised metamorphism to upper greenschist facies (Keith Metamorphics).
	Deposition of subgreywacke, slate and minor pillow lava (Burnie Formation).
	Deposition of thick sequence of orthoquartzite and siltstone (Rocky Cape Group).

STRATIGRAPHY

Proterozoic

ROCKY CAPE GROUP

The Rocky Cape Group has been redefined (Gee, 1968) following Spry (1957, 1962) to include that sequence of orthoquartzite siltstone and mudstone that crops out on the coast between Boat Harbour and Black River and to include the Cowrie Siltstone (stratigraphically low), Detention Sub-Group, Irby Siltstone and Jacob Quartzite (stratigraphically high). Overlying the Jacob Quartzite, and in transitional contact, is a sequence of metasiltstone, pelitic schist and greenschist called the Keith Metamorphics.

All these units occur in the Burnie Quadrangle, but exposure is poor and some contacts are dislocated by axial-plane thrust faults. Lithological descriptions and stratigraphic thicknesses are given in the Table Cape Explanatory Report (Gee, 1971). The Cowrie Siltstone is normally a finely laminated pyritic shale, but in the eastern part of its outcrop (the extreme north-west corner of Burnie Quadrangle) it is a medium-grained laminated siltstone. The Detention Sub-Group is a well-bedded orthoquartzite with some shaley layers. The Irby Siltstone is a siltstone in the Burnie Quadrangle, although it contains sub-units of greywacke, dolomite and orthoquartzite in the Table Cape Quadrangle, while the Jacob Quartzite is a thick orthoquartzite.

The Rocky Cape Group is characterised by great thicknesses of laminated shale and orthoquartzite, these lithologies being indicative of extremely quiet geosynclinal subsidence. Lithologies that indicate rapid sedimentation are almost completely absent. The sedimentary history of the group is outlined in Gee (1971, p. 23-25).

BURNIE FORMATION

The Burnie Formation crops out along the coastline between Doctors Rocks and the eastern edge of the Burnie Quadrangle, and forms the basement over a large portion of the quadrangle. It is considered to be younger than, and deposited in a different basin to, the Rocky Cape Group.

LITHOLOGY

The Burnie Formation consists of at least 5 000 m of a monotonous alternation of well-bedded black slaty mudstone with quartz-wacke of siltstone and sandstone grade. Minor pillow lava is recorded from two localities.

The arenite has a typical greywacke texture with poorly sorted quartz grains and minor muscovite, in a sericitic and chloritic matrix. Single-

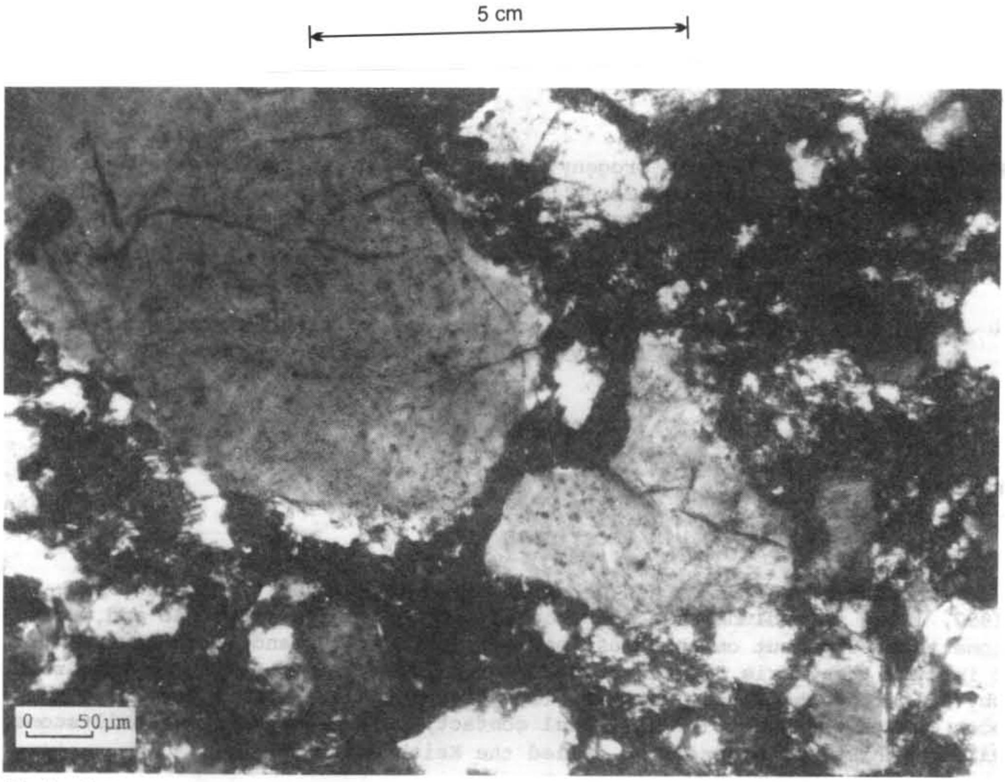


Plate 1. *Photomicrograph of corroded overgrowths on initially rounded quartz grains, coarse arenite, Burnie Formation, Sulphur Creek.*

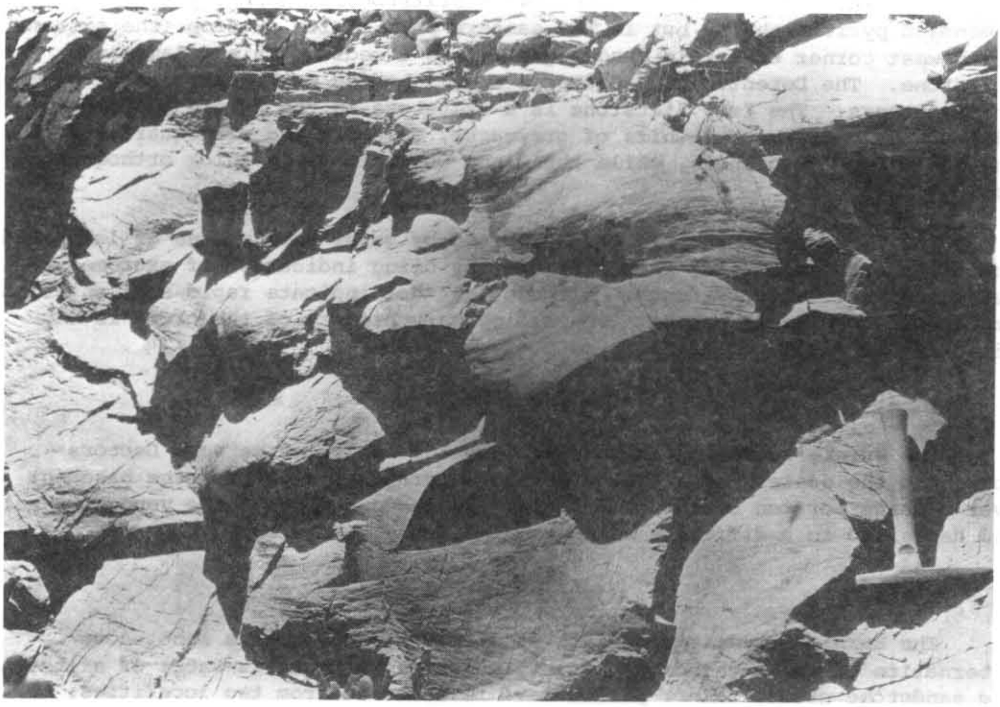


Plate 2. *Underside view of festoon cross-bedding, railway cutting 400 m east of Chasm Creek.*

crystal quartz grains form the major clastic component while fragments of once-rounded grains are common in coarser arenites at Blythe Heads [986412]*. Clear evidence of recycling is shown by overgrowths on once-rounded grains, that are now partly corroded by the matrix (plate 1). Minor rock fragments include chert and claystone, but no detrital feldspar has been observed.

The arenites are characterised by up to 40% matrix, textural immaturity, and apparent mineralogical maturity. They are not sub-greywackes in the sense of Pettijohn (1957, p. 301) as they contain more than the permissible 15% matrix, but are termed quartz-wacke, a subdivision of greywacke (Dott, 1964).

The interbedded lutite varies from dark featureless mudstone to grey glossy slate, containing a variety of cleavages indicative of polyphase deformation.

DEPOSITIONAL FEATURES

Festoon cross-bedded scoops are common in the quartz-wacke in the area of Round Hill [955417]. These appear as undulating concentric shear joints in the deformed rock, which Burns (1965, p. 148) termed pseudo-boudins. They can however be recognised as current structures by the smooth downward curving parting, the sharp upward-pointing cusps, and the cross-laminae infillings (plate 2). These structures are confined to the middle of the arenite bed and are thus not directly attributable to bottom scour by turbidity currents. They may be interpreted either as scour and fill structures, or as linguoid ripples, and thus provide a palaeocurrent trend, but not a confident palaeocurrent vector. Observations from many localities on the coastline east of Burnie indicates a palaeocurrent direction at a high angle to the mesoscopic axial tectonic structures. Despite the structural complexity, these axial structures always trend NNE, parallel to the major axis of folding and the trend of the basin of deposition of the Burnie Formation. This implies that the current structures resulted from transverse currents.

Rectilinear ripples occur on the top of some arenite beds at Round Hill (plate 3). These are regular corrugations with wavelengths from 5 to 12 cm and amplitudes of 2 to 5 cm. Three examples observed have axes exactly parallel to the tectonic lineation while cross-laminae infillings in the overlying siltstone beds prove a sedimentary origin. These ripples also indicate transverse traction currents. Flute marks (plate 4) are developed on the base of some arenite beds, and these markings are invariably modified by load casting and cleavage development. Small-scale scouring of a mudstone at the base of an arenite bed is well illustrated in Plate 5.

No systematic orientation data has been collected for these markings because of the uncertainties in unwinding sedimentary vectors through large angles about steeply plunging axes, in which there has been a flattening component to deformation. With reference to the tectonic axis that is uniformly directed NNE, these scouring currents are axially orientated.

The arenite beds in the rhythmically alternating arenite-mudstone association generally show an upward grading from coarse to fine. The bases of the arenite beds are sharp and the underlying lutite is scoured (plate 5). Gradation through the arenite beds is achieved by a fine planar lamination, in which successive laminae are finer and each lamination is graded. Small-scale wavy cross-lamination occurs in the top few centimetres of the arenite beds, and in places the laminae are convoluted.

Mudstone inclusions in the arenite are locally abundant. These are

*All localities lie within kiloyard grid square 39, Zone 7.

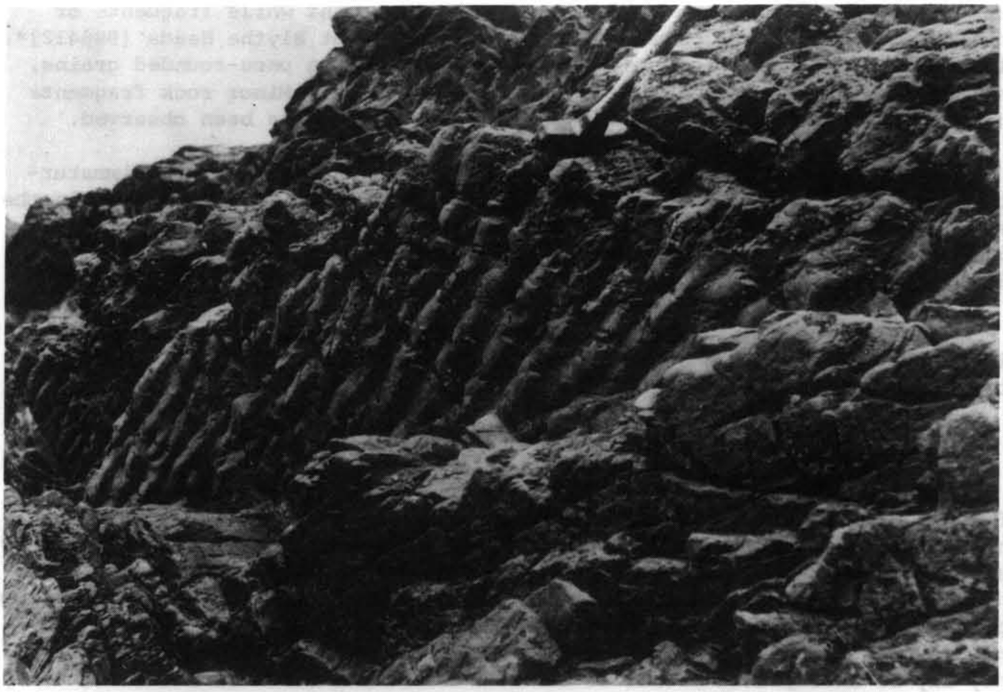


Plate 3. *Rectilinear transverse ripples, Round Hill Point.*

Plate 4. *Sole marking on an arenite bed showing penetration of cleavage into flames, Chasm Creek.*

usually elongate, vary in size up to 25 cm, and generally lack preferred orientation. Torn edges and twisted flakes are common. These inclusions are probably due to scouring of newly deposited lutite, followed by transport and deposition with the material that forms the arenite bed.

Many of the above structures occur in a sequence within the one arenite bed. The thinner arenite beds up to 10 cm have a sharp basal contact, while there may be a rapid passage into normal featureless quartz-wacke immediately above the base. Following this is an interval of small-scale wavy lamination that passes upward into lutite by fine repetitious micrograding. Thicker arenite beds, up to 2 m thick, also have a sharp basal contact. The bulk of the bed contains either a weak planar lamination, or large-scale festoon cross-bedding, above which is an interval of planar lamination passing sharply upward into lutite.

The depositional features indicate that the arenite beds comprise two lithogenetic types, a traction deposit characterised by large-scale festoon cross-bedding, and a turbidite deposit characterised by graded bedding, bottom scouring; and small-scale cross lamination. Both types are petrographically similar.

SEDIMENTATION

The Burnie Formation is a thick flysch-type deposit that accumulated in a basin between the Rocky Cape Group to the west and the older Precambrian metamorphic basement to the east (the latter cropping out in the Devonport Quadrangle and described by Burns (1965)). The present distribution of the Burnie Formation suggests an elongate NNE-SSW basin.

Many of the sedimentary features observed are those commonly attributed to deposition by turbidity currents. The sequence observed within some of the arenite sedimentation units is similar to that outlined by Bouma (1962). However the larger scale traction structures indicate the presence of strong bottom currents that reworked the sediment. These currents are unrelated to turbidity currents.

The environment envisaged is a dominant regime of deep, quiet water in which black, faintly laminated mudstone was deposited. Incursions of dense currents laden with sand, silt and clay occurred at frequent and regular intervals, deposition occurring mainly by dropping from suspension associated with secondary currents as a result of the passage of the turbidity currents. During and after deposition, the sediments were reworked by independent bottom currents although no significant resorting occurred.

Much of the quartz-wacke, although texturally immature, contains recycled quartz grains, suggesting some derivation from the Rocky Cape Group to the west. Occasional grains of well-rounded tourmaline also indicate a provenance, in part, from more mature sediments. Derivation from the older polycrystalline Precambrian basement to the east does not appear to have been important. A dual system of sediment dispersal may be postulated from palaeocurrent indicators. It is probable that axially directed currents brought in poorly sorted material from a distant and unknown source of dominantly sedimentary terrain, while transverse currents may have introduced texturally mature detritus.

INTERBEDDED PILLOW LAVAS

Pillow lavas occur on the foreshore west of Somerset [802487] and also 1.5 km west of the headland at Sulphur Creek in the Devonport Quadrangle [49/011396].

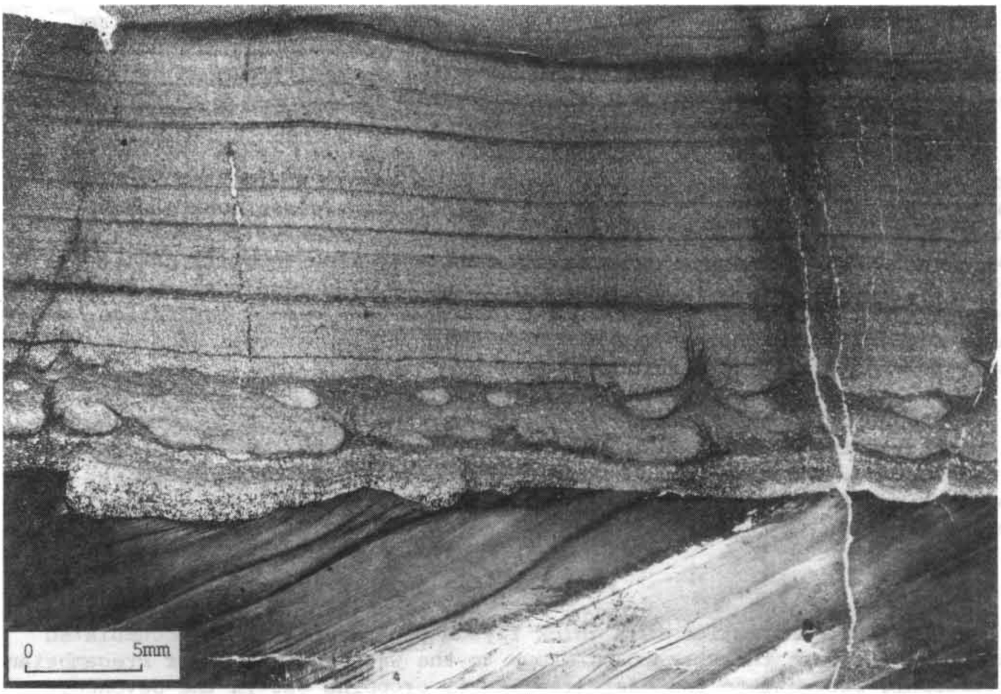


Plate 5. *Photomicrograph of a single arenite bed showing scours at base, grading, load casts, internal planar lamination and cross-lamination. Round Hill Point.*

Plate 6. *Pillow lavas, Burnie Formation, Sulphur Creek. Top to right.*

At Sulphur Creek, the volcanic rocks are strongly altered, deeply weathered and deformed, but the bun shapes, concentric vesicles and inter-pillow chloritic mudstone are still clearly recognisable (plate 6). Three horizons are recognisable, all of which are repeated several times by folding.

The volcanic rocks are light green to buff in colour, with numerous small discoid bodies up to 3 mm in diameter. In thin section, they are composed of a fine, near-isotropic mass of sericite, chlorite, epidote, leucoxene, quartz and calcite. Laths of "saussurite", presumably after original plagioclase, define a flow banding.

The rocks west of Somerset are less altered but more deformed than those at Sulphur Creek. They occur in two concordant bodies each about 10 m thick. Ovoid bodies up to one metre in diameter are visible, separated by ribbons of chloritic material, although no definite pillow forms are recognisable. In thin section, fragmental crystals of clinopyroxene, and sheaths of tremolite are set in a fine chlorite-sericite-epidote matrix. Skeletal ilmenite crystals are present.

STRUCTURAL ANALYSIS

A well-exposed complexly folded section of the Burnie Formation crops out on the foreshore between Doctors Rocks and the eastern margin of the Burnie Quadrangle. This section allows reconstruction of the polyphase history of the Penguin Orogeny, and enables a composite profile to be constructed.

The structure is complex on all scales due to repeated mesoscopic folding or cleavage formation, involving five phases of penetrative deformation. The individual phases are all nearly coaxial, and the mesoscopic folds of one generation occur in zones which are spatially segregated from zones of other generations. However, determination of the sequence of deformation by structural analysis is possible in zones of overlap. The segregated nature of the mesoscopic folding in relation to the major structure is shown in Figure 3. The phases of deformation are designated P_1, P_2, P_3 etc. in chronological order. This terminology refers to the area as a whole, and not to the sequence at any one point. Because of the segregated nature of folding, the situation can arise where the P_3 phase may be the first developed at one locality, but at another locality the same phase may be superimposed on P_1 or P_2 structures. Burns (1965, p. 144) recognised two phases of folding in the Burnie Formation at Sulphur Creek (Devonport Quadrangle) which he designated P_1 and P_2. The P_1 of Burns corresponds with P_1 in this discussion while the P_2 of Burns corresponds to the P_5.

The entire shore platform has been mapped at various convenient scales (1:1 200 or 1:3 000) and composite structural maps on a scale of 1:4 800 are presented in Figures 4, 5, 6 and 7. The coastal structural section is divided into five regional zones which are homogeneous with respect to important properties, such as facing of strata and folds, vergence of folds, and orientation of enveloping surface.

The *facing* of a fold (Shackleton, 1958, p. 363) is the direction of stratigraphic younging of the beds, measured in the axial plane, normal to the fold axis. The *enveloping surface* (Turner and Weiss, 1963) is the imaginary line drawn tangentially to the crests of successive antiforms (or synforms) developed on a single folded surface. The *vergence* (Wood, 1963) is the sense of asymmetry of "drag folds" which is expressed diagrammatically in Figures 8, 9, 10, 11 and 12. The term *coupled fold* is used in preference to the word "drag fold".

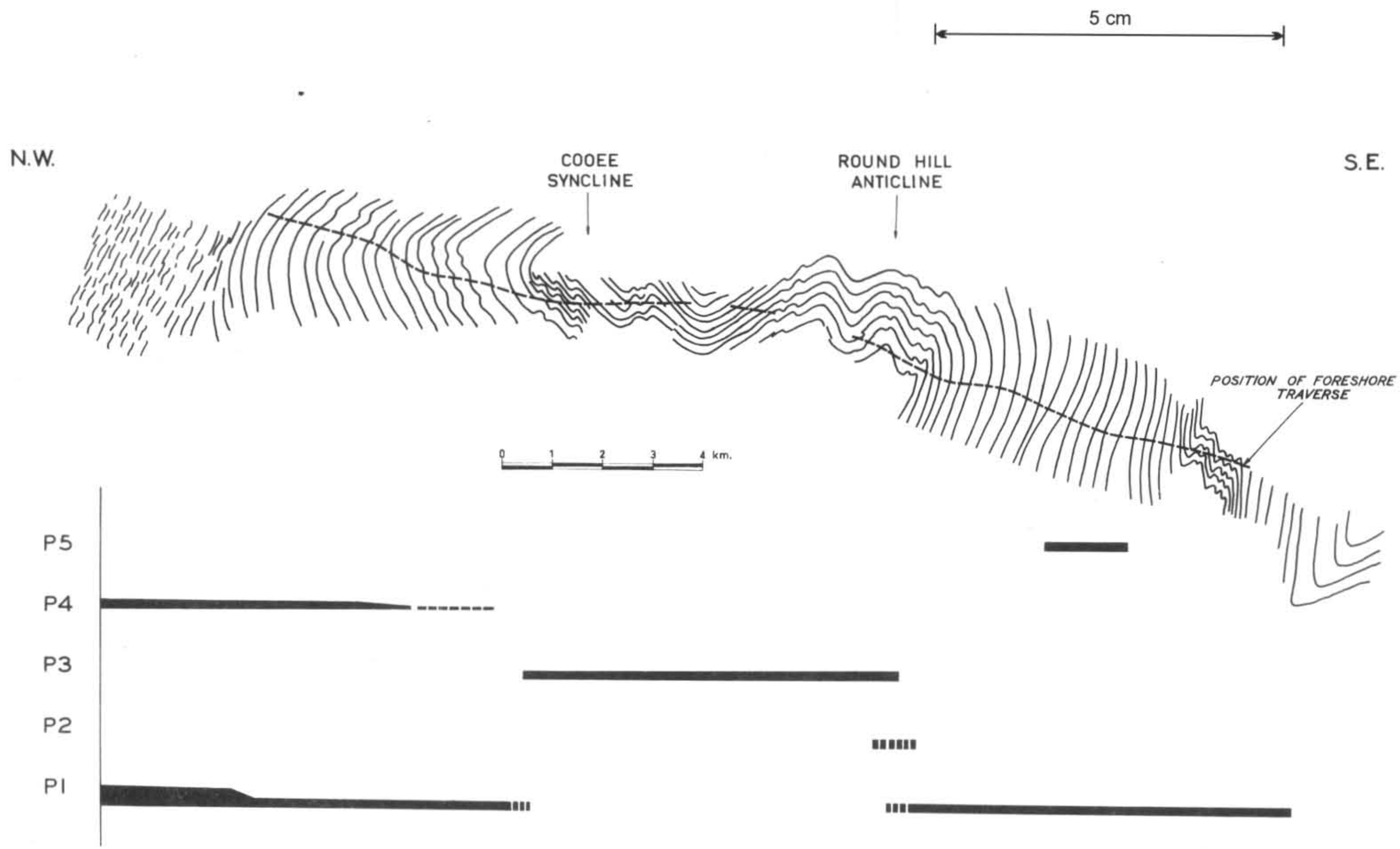


Figure 3. *Distribution of individual deformation phases, Burnie Formation.*

The five major structural belts, from west to east are:

(1) Somerset Overturned Belt (probably adjacent to the Keith Metamorphics).
(2) Cooee Hinge Zone.
(3) Parklands Flat Belt.
(4) Round Hill Hinge.
(5) Blythe Overturned Belt.

Orientation data and diagrammatic summaries for each of these belts are presented in Figures 8, 9, 10, 11 and 12.

Somerset Overturned Belt

This belt occurs along the coastline between the unconformity with the unfolded Permian rocks near Doctors Rocks [806483], and the Cam River [848457] (fig. 8). The bedding is completely overturned and numerous recumbent P_1 folds with a mean axis plunging gently toward 290° and with mean axial planes dipping 20° S are developed in this zone. These P_1 folds face down to the south. The P_1 axial plane cleavage is strongly developed especially in the vicinity of Doctors Rocks where it is difficult to recognise bedding.

The P_4 folds and associated strain-slip cleavage, are strongly developed at Doctors Rocks but decrease in intensity and abundance to the east. The P_4 structures are characterised by concentric fold style, strain-slip cleavage, and an axial orientation that is distinct from other generations. Excellent examples of refolding of P_1 structures by P_4 folds occur.

Cooee Hinge

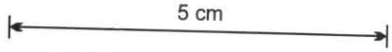
This zone lies between the Cam River [848457] and Cooee Point [890450] (fig. 9). The bedding and P_1 enveloping surfaces are steep, with a mean strike of 078° with the bedding facing south-east. The P_1 fold axes plunge 10° towards 248° while the P_1 axial planes have a mean strike of 330° and dip 10° south-west. The P_1 slaty cleavage is generally perpendicular to the bedding. The P_1 folds face nearly horizontally to the south-east, and the vergence is generally nil. This zone is the nose of a large recumbent syncline of which the Somerset Overturned Belt is an upper limb.

The P_3 folds make their first appearance here. These are coupled folds of a concentric style, without cleavage and are disharmonic, often passing into axial-plane thrusts, or dying out along the axis by convergence of the complex axes. The P_3 folds form in zones of planar vertical bedding, away from the P_1 mesoscopic folds, and die out against the earlier folds by a convergence of axes. They have a constant vergence with an anticline to the south-east and a syncline to the north-west, indicating a south-east side-up movement.

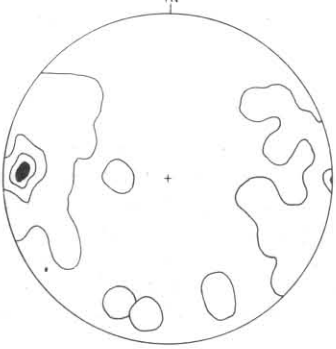
The easterly continuation of the P_4 cleavage is sporadically developed. It has the same orientation as in the Somerset Overturned Belt, but is not accompanied by folding. It cuts across the P_3 folds without deviation.

Parklands Flat Belt

The Parklands Flat Belt extends from Cooee Point [890450] to Burnie [909445] (fig. 10), and is characterised by the disappearance of P_1 structures, the increase in frequency of P_3 structures, and the presence of intrusive dolerite bodies.

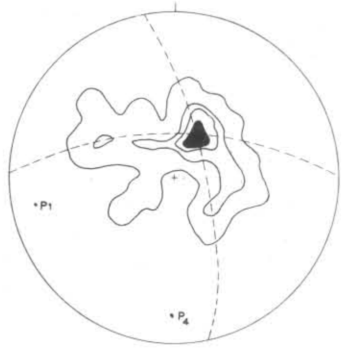


a



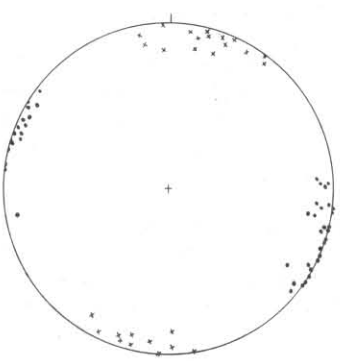
75 poles of P1 fold axes
contours 1-3-6-9%
mean axis 258/14°

b



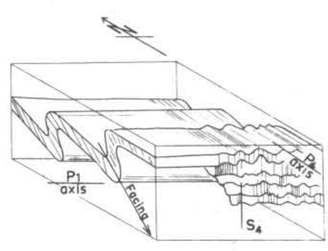
75 poles to P1 axial surfaces
Showing position of P1 and P4 axes.
contours 1-3-6-9%

c



• 44 poles to P4 strain-slip cleavage
× 27 poles of P4 fold axes

d



Diagrammatic representation of vergence and facing of P1 folds.

Figure 8. *Structural data, Somerset Overturned Belt.*

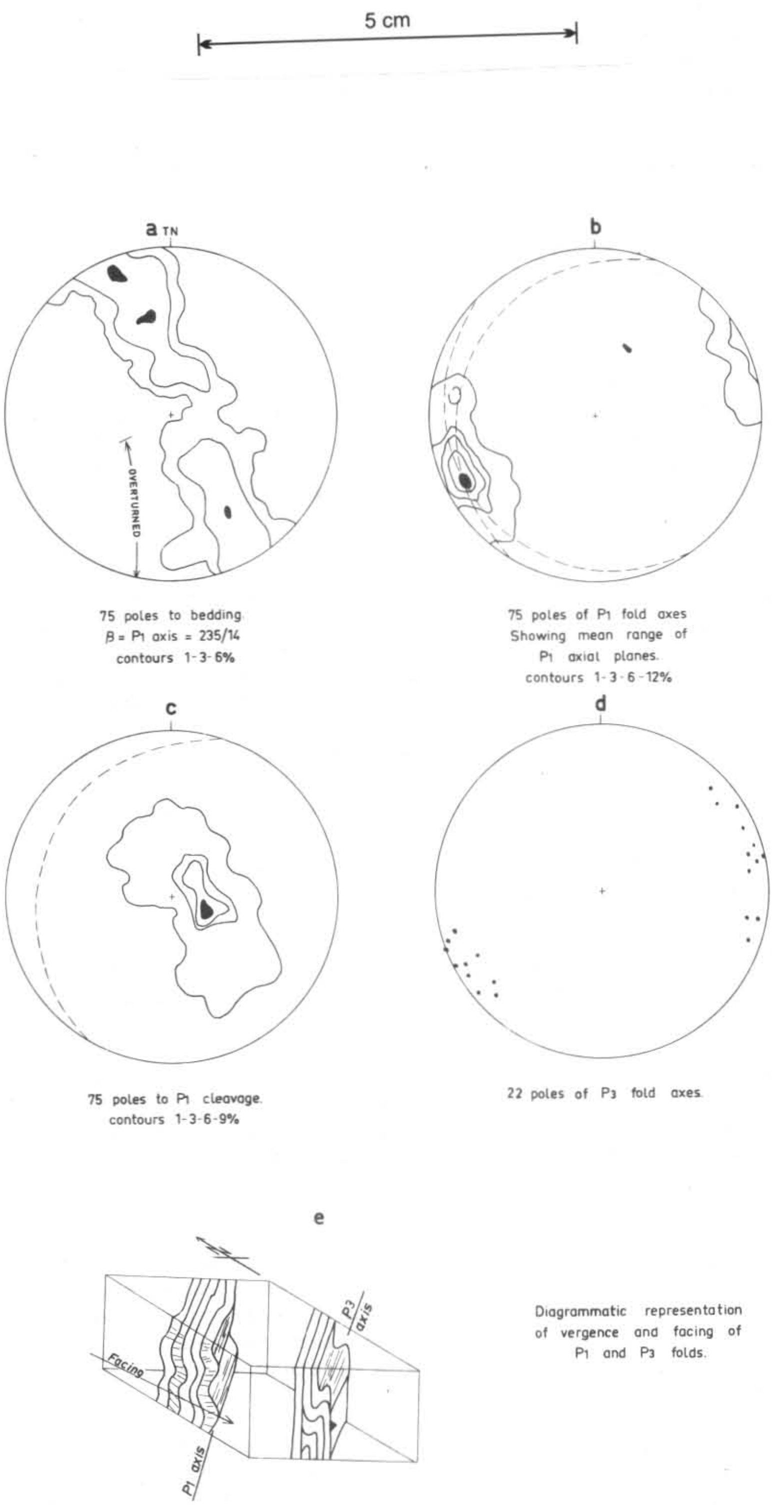


Figure 9. *Structural data, Cooee Hinge.*

On the western side of Cooee Point, the P_1 cleavage is still visible as a coarse anastomosing sandstone cleavage and a weak slaty cleavage, with the P_1 cleavage being clearly refolded by P_3 folds. Only three examples of mesoscopic P_1 folds are known in the Parklands Flat Belt.

The mean attitude of bedding and P_3 enveloping surface is generally flat and upward facing. The plot of P_3 fold axes shows two maxima, one plunging gently north-east and the other south-west. This is due to an *en echelon* arrangement of folds manifest by divergent plunges on oppositely coupled folds. The P_3 folds are concentric in style and are without cleavage.

Round Hill Hinge

A break in the structural record occurs between Blackmans Point at Burnie and Wivenhoe. Between Wivenhoe [945420] and the navigation light on Round Hill Point [965422] is a major anticline, called the Round Hill Hinge (fig. 11). Although the structural geometry is simple the deformational history is complex. The P_1, P_2 and P_3 structures are all present and are developed about approximately the same axis.

First generation folds with moderate plunges to the south-west occur on both flanks of the anticline (fig. 11b). The folds on the eastern limb are upward facing, while those on the western limb have an identical orientation, but are downward facing. The vergence of the P_1 folds is incorrect for them to be related to the P_3 anticline (fig. 11f) as the folds on the western limb appear to have been rotated about the P_3 fold axis.

The P_2 event is a relatively unimportant phase of cleavage development in the interval between P_1 and P_3. It occurs only at Round Hill Point and is not known to be related to any folding. The cleavage is confined to mudstone beds where it takes the form of either a well-developed crenulation cleavage if there is a pre-existing P_1 cleavage, or a weak slaty cleavage if the P_1 cleavage is undeveloped.

The P_2 cleavage intersects the bedding to produce a lineation that is very close to the P_1 and P_3 axes. In zones free of P_3 folding, the P_2 cleavage strikes north-east and dips 30° north-west but is dispersed about the P_3 axis (fig. 11d).

Mesoscopic P_3 folds are the dominant feature of the Round Hill Hinge (plate 7). The fold axes cluster at a maximum of 240°, plunging 20° and with vertical axial planes. These folds are open and concentric in style, with axial-plane cracking simulating cleavage in some places.

Blythe Overturned Belt

This belt extends eastward from Round Hill [965422] to the end of the basement outcrop at Sulphur Creek (Devonport Quadrangle, 49/026386). It is characterised by the abundance of P_1 folds with moderate to steeply dipping axes, steeply dipping to overturned bedding, and the localised appearance of the P_5 phase of folding (fig. 12). The greatest thickness of strata (4800 m) occurs in this belt.

The axial planes of the P_1 folds strike 010° and dip 60°W which is shallower than the mean attitude of the bedding. The P_1 fold axes have a systematic variation in plunge, plunging 30-40°SW in the western section, but increasing to 60-70°SW east of the Blythe River. The folds thus vary from plunging inclined folds to reclined folds. Fold profiles are well revealed, and are of a flattened concentric style. A slaty cleavage is

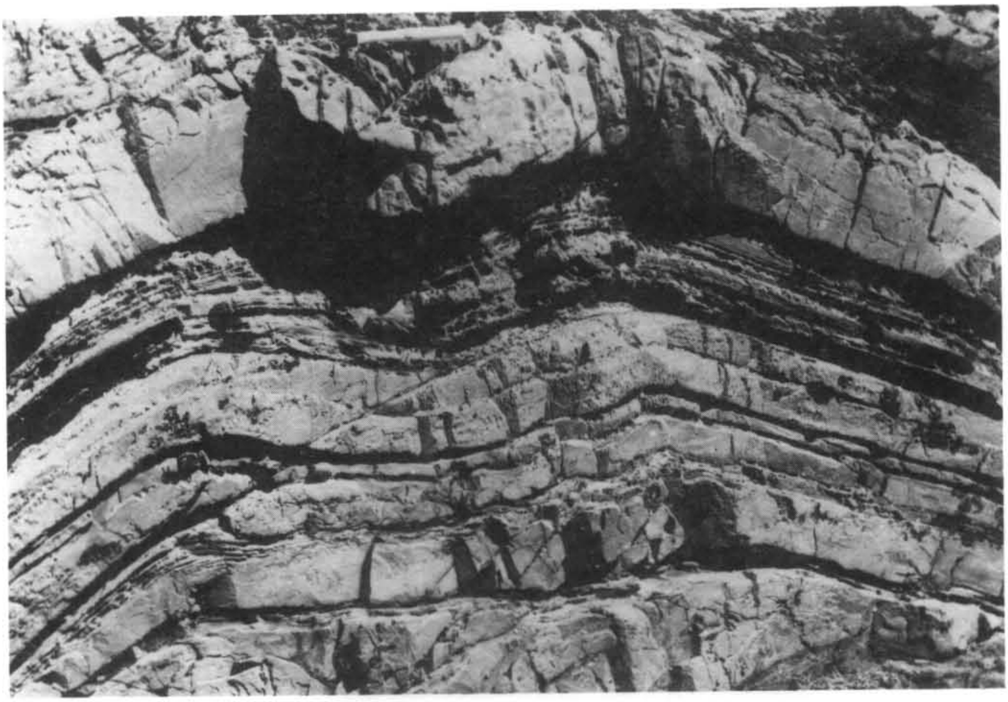


Plate 7. *P_3 fold near crest of major P_3 anticline, Round Hill Point.*

Plate 8. *P_5 fold showing refolding of earlier P_1 cleavage, 3 km west of Howth railway station.*

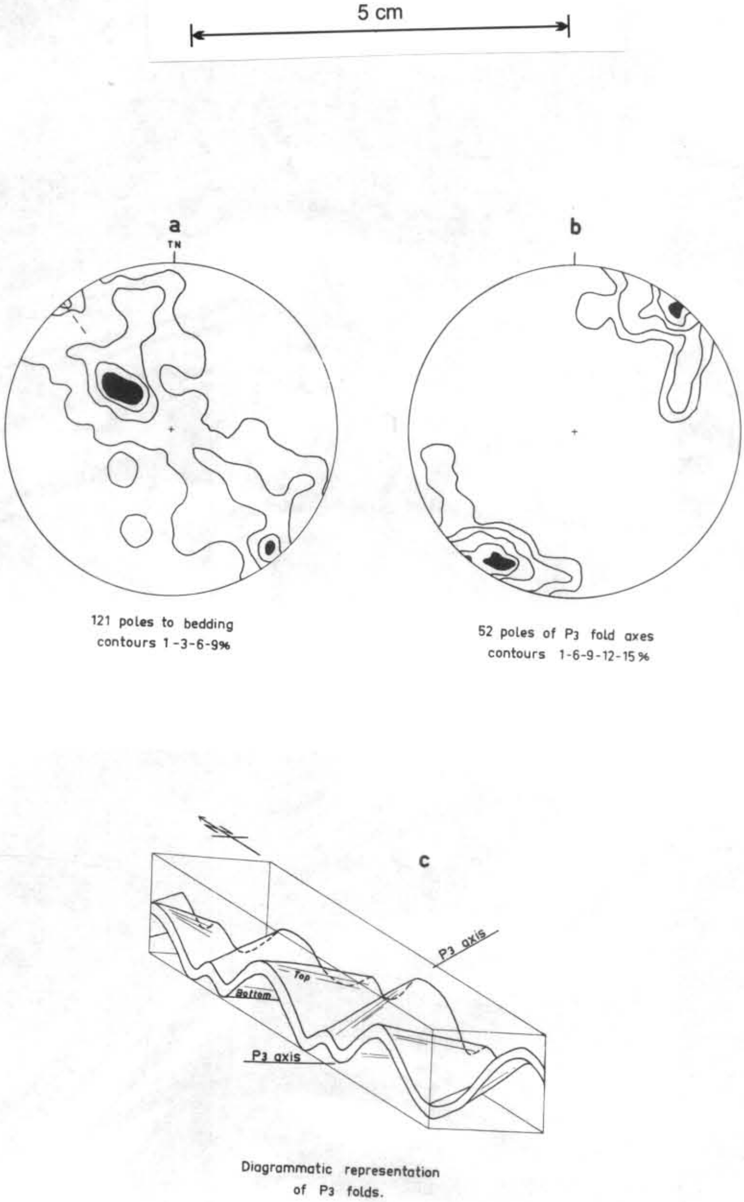


Figure 10. *Structural data, Parklands Flat Belt.*

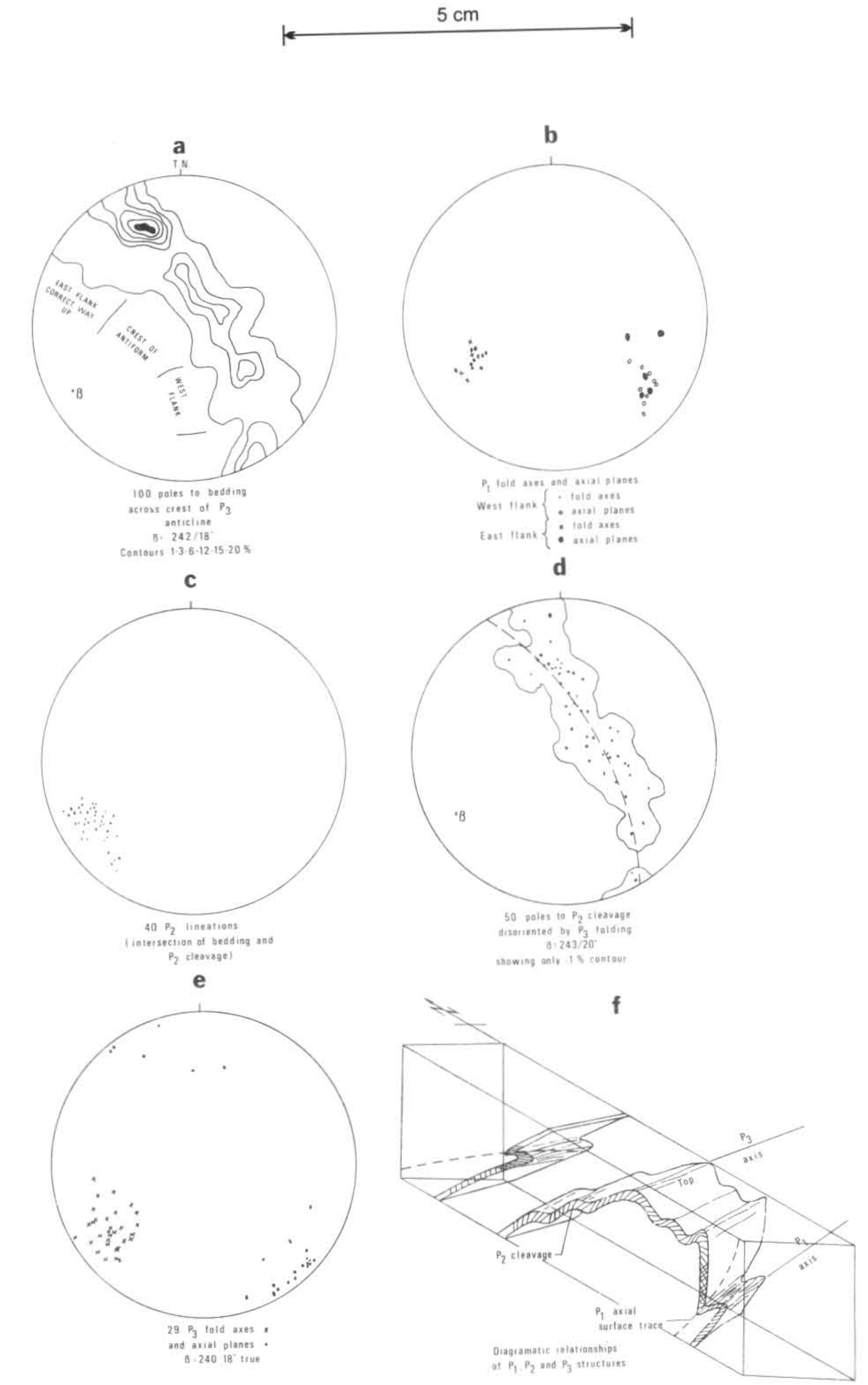


Figure 11. *Structural data, Round Hill Hinge.*

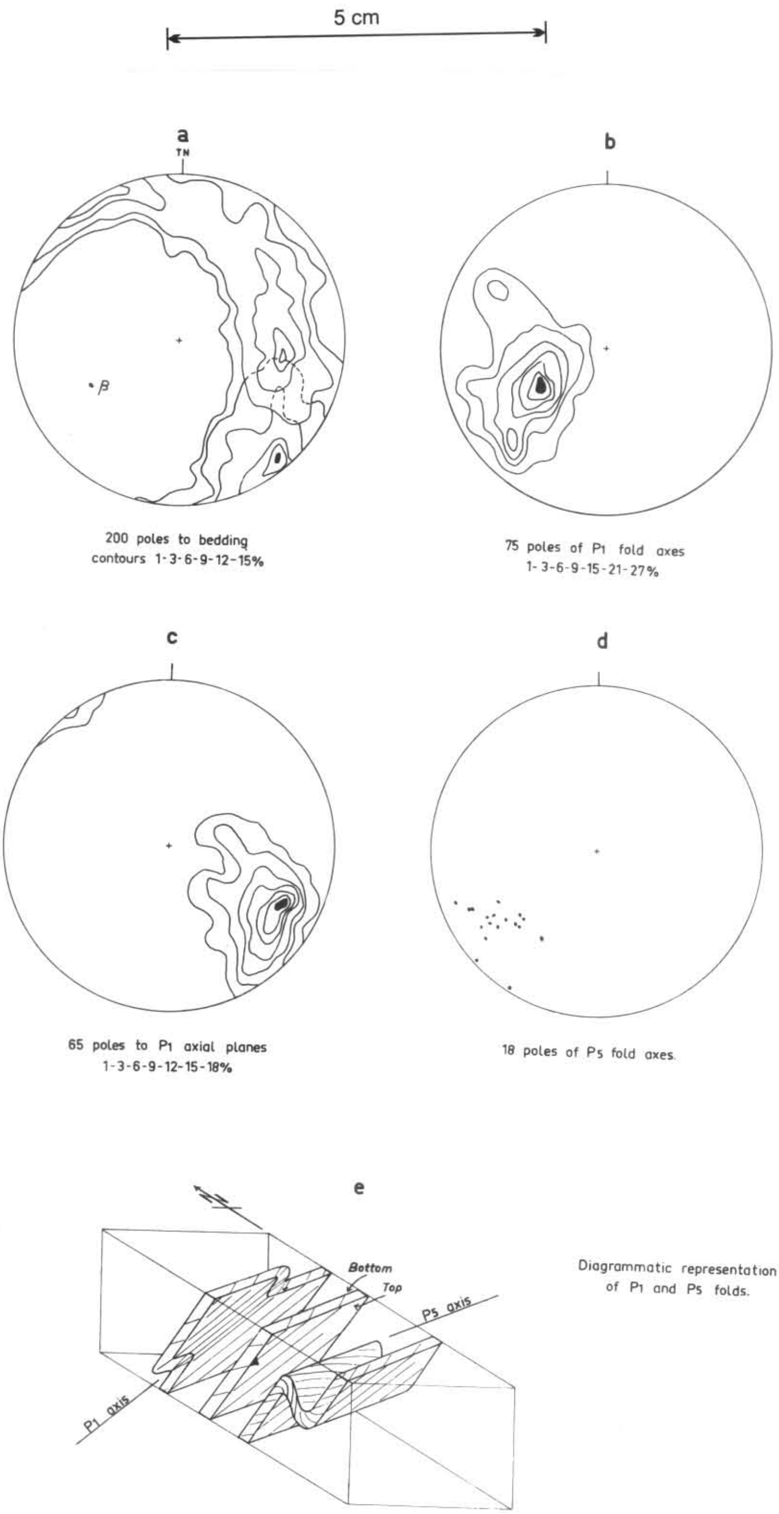


Figure 12. *Structural data, Blythe Overturned Belt.*

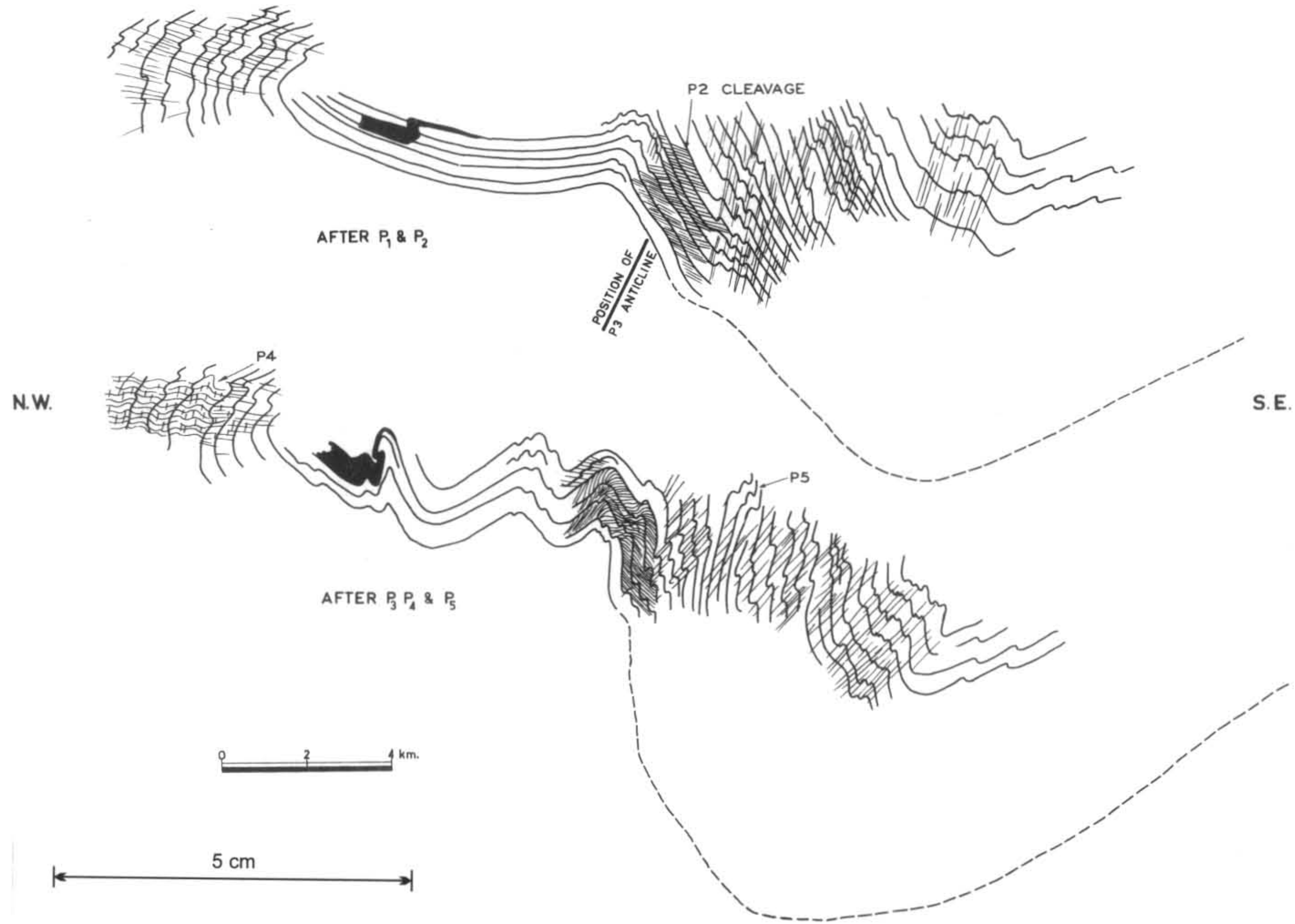


Figure 13. *Two main stages in the evolution of the major structure of the Burnie Formation.*

present in the lutite beds and a fanning sandstone cleavage in the arenite beds.

Powell (1974), in a detailed analysis of folds and cleavage in five small areas of Burnie Quartzite and Slate near Sulphur Creek, found that the slaty cleavage could be interpreted as an essentially planar structure initiated in a short interval during protracted folding. Cleavage initiated late during folding appears to be largely superimposed on fold profiles and may cut across the profile from one limb to the other where rotation of early folds had occurred. Cleavage initiated part way through folding is refracted in sandy beds to form cleavage fans, the largest cleavage-fan angles developing in folds where cleavage was initiated early in folding.

The P_1 folds are always coupled, and face upward to the SSE, although the mean bedding faces down to the south-east. The vergence is constant.

The P_5 folding occurs only in the area east of Blythe Heads and is of minor regional significance. In style, the P_5 folds resemble the P_3 folds further west, but have an incorrect vergence to be related to the major hinge at Round Hill. The sense of coupling is such that there is always an antiformal crest immediately to the west of a synform. They are thus truly downward facing, with the common limb completely overturned.

The exact position of the P_5 event in the structural sequence is not clear. The P_5 folds are clearly later than P_1 (plate 8), are not related to the P_3 event, and are tentatively assigned to a younger and separate act of deformation. They do not fit into the overall picture of continued lateral shortening in a NW-SE direction although they are developed about the same axis. It is possible that they are gravity collapse structures on the overturned limb of the regional anticline.

STRUCTURAL EVOLUTION

Before discussing the structural evolution of the Burnie Formation it should be noted that another major structural belt, the Penguin Reversal, can be recognised further east, between Beecraft Point and Penguin in the Devonport Quadrangle (Burns, 1965). This belt is upward facing, and a major syncline is thus postulated between Sulphur Creek and Penguin.

The unusual feature of the structure of the Burnie Formation is the overall geometric simplicity despite the polyphase deformation. This arises partly because of the nearly coaxial deformations, and also because of the spatial segregation of the individual phases. The P_1 and P_3 structures are the only persistent structures across the deformed belt, the P_3 folds being most abundantly developed in zones unaffected by P_1 folding. The area of overlap of the zones is small (or non-existent), and the overall structural sequence is determined by superposition involving the intermediate phases in a few critical localities.

The two main stages in the evolution of the fold belt are shown in Figure 13. The primary structure is the result of large-scale tectonic transport to the south-east producing the recumbent Cooee syncline and an asymmetrical anticline near Wivenhoe. The location of this primary anticline is not known, but it must lie to the west of the present Round Hill anticline because the vergence of the P_1 folds on the western limb of the Round Hill anticline shows that they are rotated about this hinge. The primary anticline must be east of the eastern edge of the Parklands Flat Belt.

During the P_1 folding, the flat belt between the primary hinges behaved passively and remained virtually undeformed. The third phase of deformation resulted in continued lateral shortening by concentric folding in this flat belt, and a tightening of the primary anticline by the development of a secondary hinge (Round Hill anticline) immediately to the east.

KEITH METAMORPHICS

The Keith Metamorphics (Gee, 1968, 1971) form a belt of low-grade regional metamorphic pelitic schist and amphibolite that separates the Rocky Cape Group from the Burnie Formation. The rocks are derived partly from the surrounding sediments, and partly from syntectonic basic intrusions that are considered equivalent to the Cooee Dolerite. The belt is about 4 km wide and has been followed from Wynyard on the coast, south-west to the Arthur River and probably extends further south.

The few exposures are generally deeply weathered except in the beds of the Inglis and Flowerdale Rivers. The main rock types are pelitic and calcic schist, greenschist amphibolite, phyllite and schistose quartzite. The last two rock types have been described by Gee (1971) and will not be discussed further here.

PETROLOGY

Pelitic and Calcic Schist

These are medium- to coarse-grained, well foliated and often crenulated schists containing quartz and muscovite, with variable amounts of calcite and albite. Metamorphic segregation into quartz-calcite rich layers and muscovite-albite rich layers is common. Minor amounts of penninite chlorite, epidote, zoisite, sphene, tourmaline and magnetite are present. Albite occurs as microporphyroblasts up to 1.5 mm in diameter. Trails of quartz inclusions in the albite are straight or gently curved, and are continuous with the mica foliation. Chemical analyses of a pelitic schist (analysis 1) and an albite-calcite pelitic schist (analysis 2) are given in Table 1.

Greenschist Amphibolite

These vary from well foliated greenschists, to weakly foliated, massive, dense, dark green rocks. They are characterised by the abundance of albite, the presence of blue-green actinolite, a high Na_2O content and, in places, remnant dolerite textures.

Specimen 33241 (table 1, analysis 3) is a typical schistose amphibolite. It contains albite (An_0-An_3) 50%, blue-green tremolite 20%, epidote 15% and minor quartz 10%. Albite and quartz occur in equant xenoblastic grains up to 0.5 mm, forming a mosaic abundantly studded with actinolite and granular epidote. The foliation is defined by strewn-out aggregates of sphene, leucoxene and very fine epidote.

The more dense, massive amphibolites are albite rich. Specimen 33237 (table 1, analysis 4) is a dark grey-green rock with a weak foliation due to lighter coloured albite-rich layers and darker chlorite-tremolite layers. It is composed of about 70% albite (An_0) in equidimensional grains (0.5-1.0 mm) forming a xenoblastic mosaic. The albite contains abundant inclusions of quartz, calcite, chlorite and magnetite. Calcite, quartz, tremolite and green biotite are the other main constituents. Magnetite and ilmenite form about 5% of the rock.

Albite-rich amphibolites, showing remnant dolerite textures, crop out in the Inglis River one kilometre downstream from the Calder-Preolenna road

Table 1. CHEMICAL ANALYSES OF KEITH METAMORPHICS AND COOEE DOLERITE

Analysis	Keith Metamorphics				Cooee Dolerite				
	1	2	3	4	5	6	7	8	9
SiO_2	73.4	55.0	46.2	57.6	44.44	58.32	54.64	54.0	48.5
Al_2O_3	11.2	12.0	10.8	10.2	17.97	15.03	15.22	14.0	15.6
Fe_2O_3	4.0	2.1	10.1	4.4	1.74	0.96	1.17	0.5	3.7
FeO	2.0	5.1	7.7	4.2	8.32	2.60	7.81	10.0	8.3
MgO	2.0	5.7	6.0	4.8	4.74	4.36	5.39	5.1	7.4
CaO	0.20	5.6	8.4	4.8	9.42	8.46	7.96	8.3	6.3
Na_2O	0.07	1.1	3.4	3.9	2.86	3.24	1.69	1.9	2.6
K_2O	3.4	2.8	0.60	1.2	3.04	1.41	2.23	1.9	1.0
H_2O_-	0.15	0.20	0.17	0.14	0.26	0.14	0.02	2.6	4.3
H_2O_+	2.5	3.0	2.6	1.5	3.53	5.04	2.85	0.26	0.21
CO_2		7.5		5.8				0.10	
TiO_2	0.46	0.36	3.0	0.61	3.00	0.41	0.68	0.74	1.2
P_2O_5	0.06	0.07	0.22	0.32	0.72	0.12	0.12	0.10	0.16
MnO	0.01	0.12	0.31	0.06	0.22	0.11	0.13	0.17	0.16
SO_3	0.08	0.16	0.21	0.09					
S	0.03		0.19						
Total	99.56	100.81	99.90	99.62	100.26	100.20	99.91	99.67	99.43

1. Fine-grained pelitic schist, Hilders Timber Road, Arthur River; 33247*.
2. Quartz-muscovite-calcite-albite schist, Flowerdale River; 33239*.
3. Greenschist amphibolite, Flowerdale River; 33241*.
4. Greenschist amphibolite, Flowerdale River; 33237*.
5. Coarse dolerite, Burnie; 4864 (Spry, 1957).
6. Dolerite, Detention River; 4852 (Spry, 1957).
7. Leucocratic dolerite, Burnie; 4861 (Spry, 1957).
8. Coarse dolerite, Detention River; 33358*.
9. Sheared dolerite, the Port, Rocky Cape; 33359*.

*Analysis: H.K. Wellington, Department of Mines Laboratories, Launceston.

bridge [641428]. These are fine-grained, dense, massive, dark green rocks with diffuse pink spots and veins of albite visible in hand specimen. They lack foliation but are well jointed and appear to be near-vertical tabular bodies concordant with the foliation in the enclosing pelites.

These rocks are mineralogically similar to the schistose greenschists. Specimen 33231 contains about 40% albite occurring both as randomly oriented interlocking laths up to 0.4 mm, and as irregular grains in a mosaic. Remnants of ferro-magnesian minerals form columns (0.5 mm) of interlayered fibrous calcite, amphibole, green biotite and chlorite, resembling pseudomorphs of the original pyroxene. Small flakes of chlorite are interstitial to the albite laths. Apatite needles up to one millimetre long, skeletal ilmenite and sphene occur as accessory minerals. Similar textures are found in some altered but unsheared dolerites at Cooee.

The albite-epidote-chlorite-actinolite-sphene-calcite and less commonly albite-epidote-biotite mineral assemblage indicate a lower to middle subfacies of greenschist regional metamorphism. Hornblende amphibole and garnet are absent and there is no mineralogical or textural evidence of polymetamorphism or repeated deformation. This contrasts with the polyphase history of the older Precambrian basement in the Frenchmans Cap area described by Gee (1963) and Spry (1963).

The remnant dolerite textures, the presence of skeletal ilmenite and needles of apatite, and the relatively high proportions of FeO, Fe_2O_3, TiO_2 and Na_2O indicate an igneous origin. There is also a close similarity in geochemistry between the Cooee Dolerite and the albite amphibolite (table 1).

TRANSITIONAL NATURE OF THE WESTERN CONTACT

The western contact between the metamorphic rocks comprising the Keith Metamorphics and the unmetamorphosed Rocky Cape Group is gradational across strike with the rock types in this zone including phyllite and schistose quartzite. For the purpose of mapping, the first appearance of mesoscopically visible albite was taken as the boundary between the schist and phyllite.

The transition is expressed in two ways:

(1) A gradation in metamorphic grade from unmetamorphosed orthoquartzite and siltstone, through slate, phyllite, albite-chlorite schist to schist with biotite.

(2) A gradation in micro-fabric from rocks showing no penetrative deformation on the granular scale, through slightly cleaved arenite, through mortar-textured quartzite, into crystalline schists showing metamorphic banding.

This gradation is seen on the Forestry Commission road (Hebe Road) south of Lapoinya, near the confluence of the Hebe and Flowerdale Rivers [557413]. The passage across the "albite line" from phyllite to schist is seen in the Flowerdale River, 3 km upstream from the Pages Road Bridge [636492].

STRUCTURE

Mesoscopic Structure

The metamorphic belt is dominated by a strong, parallel striking, near-vertical regional schistosity. In the pelitic schist and phyllite the folded surface is a diffuse mesoscopic layering which is considered to be bedding. The intersection of these two surfaces produces a near horizontal lineation. Orientation data are given in Figure 14.

A near vertical late crenulation and strain-slip cleavage is developed in the phyllite (Gee, 1971, plate 10). This cleavage (figure 14) is similar in style and orientation to the P_4 cleavage found in the more lustrous slates of the Burnie Formation near Doctors Rocks.

Major Structure

The strike of the foliation in the metamorphic rocks on the western contact is parallel to the regional strike of bedding and fold axes in the sedimentary rocks to the west. The strike ridge of unmetamorphosed orthoquartzite (correlate of Jacob Quartzite) that flanks the western contact is vertical or slightly overturned, and faces downward to the south-east. Facings are obtained from the cross-bedded orthoquartzite 1.5 km south-west of the Forestry Commission house at Lapoinya [483476].

This regional facing shows that the Rocky Cape Group stratigraphically underlies the Keith Metamorphics although it partly overlies the Metamorphics in a structural sense. Bedding-cleavage relationships in cleaved arenite in the transition zone indicate a downward facing to the south-east and there is no evidence of a reversal of facing.

The eastern contact against the Burnie Formation is covered by Permian

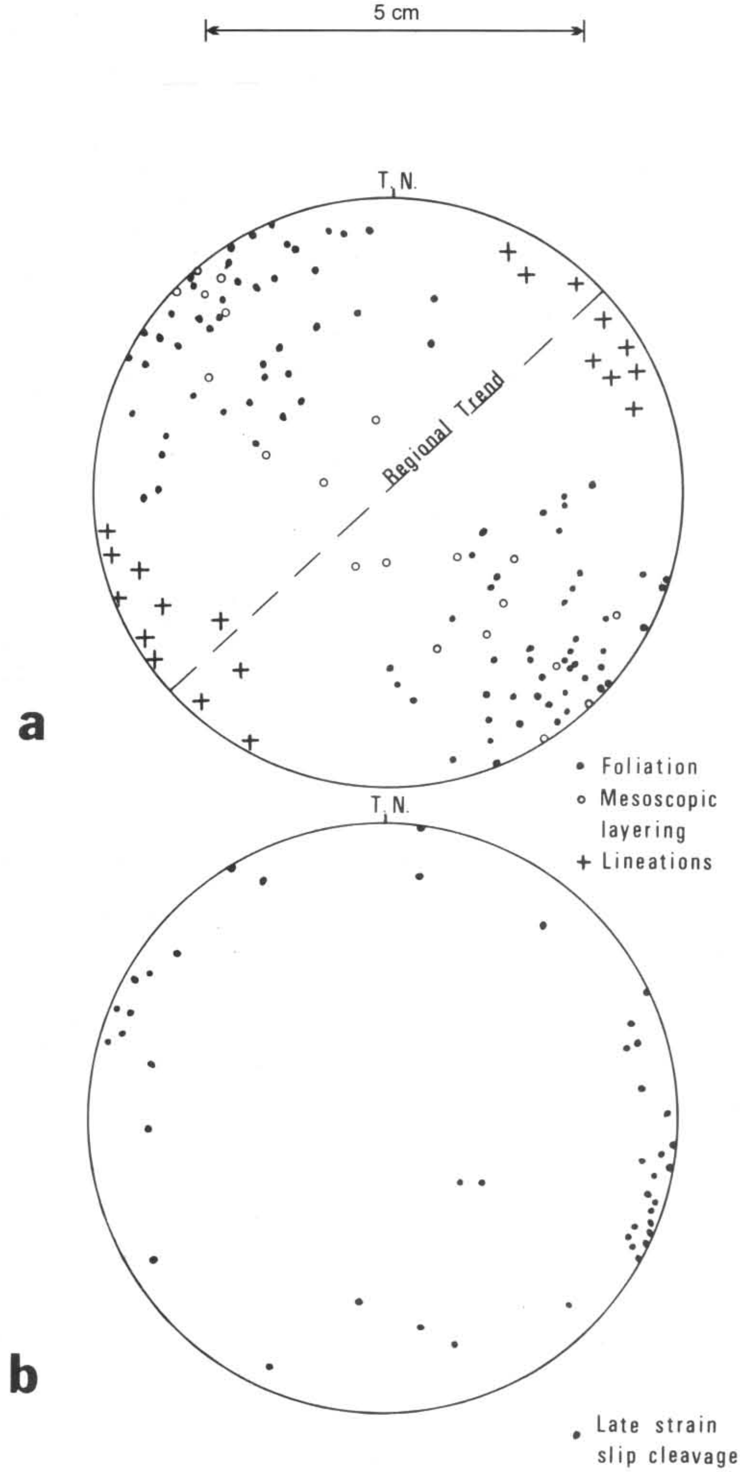


Figure 14. *Structural data, Keith Metamorphics.*

rocks, but the westernmost exposures of the Burnie Formation near Doctors Rocks [810477] are glossy phyllite facing downward to the south-east. Thus the Keith Metamorphics appear to stratigraphically underlie the Burnie Formation, but overlie it in a tectonic sense.

The simple asymmetrical arrangement involving overfolding and high angle thrusting to the south-east rules out the possibility of the Keith Metamorphics being slices of an older basement, brought up from depth during crustal deformation. The Keith Metamorphics probably form a belt of metamorphism in a dispersed zone of shearing which formed as a stable shelf facies to the west and was folded out and transported to the south-east, squashing the flysch-type sediments against the older Precambrian metamorphic basement that lies at least 65 km to the east. The metamorphic belt marks a line of deep crustal weakness, that also acted as a hinge-line for Proterozoic sedimentation. It thus represents one of the important tectonic elements of Tasmania.

COOEE DOLERITE

Dolerite sills and dykes occur on the coastline between Burnie and Cooee, and also west of Blythe Heads [980414]. These dykes were described in detail by Spry (1957) who termed them the Cooee Dolerite; he considered the dykes to be Precambrian on structural and chemical grounds and a single K/Ar radiometric date of 700 m.y. (Spry, 1962) supports this. These rocks belong to the same suite that occurs in the Rocky Cape Group (Gee, 1971) and the Proterozoic of the lower Pieman River area (Spry, 1964, p. 48).

PETROLOGY

The intrusions of sodic dolerite show varying degrees of deuteric alteration and shearing. The rocks are generally hard, massive, dark green and medium-grained.

In thin section relatively fresh crystals of pyroxene up to 2 mm (probably a titan-augite variety) show marginal alteration to pale amphibole and chlorite (Spry, 1957) and are surrounded by subhedral prisms of hornblende up to 1.5 mm, terminating against the euhedral faces of the pyroxene. The hornblende is strongly pleochroic with γ-pale green, β-reddish green and α-greenish brown. Most of the plagioclase is secondary albite after labradorite with some leucocratic dolerites containing zoned subhedral crystals ranging from An_{44} to An_{63}. Minor flakes of yellow-brown biotite up to one millimetre long and rare patches of serpentine having a euhedral form after olivine occur. Accessory minerals are abundant and include ilmenite, quartz, sphene, magnetite, leucoxene and apatite.

Secondary mineralisation is the product of albitisation and uralitisation. Albite is abundant, occurring as irregular grains up to 2 mm across, with abundant inclusions of zoisite, chlorite, sericite and sphene. Small amounts of prehnite and calcite are intersertal with albite. Pale green actinolite occurs around pyroxene and hornblende and complete replacement is common. Amphibole is commonly altered to penninite.

Most of the dolerites are medium-grained with the original dolerite textures preserved. A mosaic of equant irregular albite and scattered pseudomorphs of altered pyroxene form with alteration. This mosaic texture resembles the texture of the basic schists in the Keith Metamorphics, some of which display a remnant dolerite texture.

Micro-dolerite occurs in chilled margins of some of the smaller apophyses and dykes at Cooee, while pegmatitic phases occur in irregular patches in the larger bodies. These contain titanaugite (up to 3 mm) with ophitic albite laths surrounded by fresh subhedral hornblende. Minor intersertal quartz and included needles of apatite are present. Leucocratic dolerite consisting of zoned subhedral labradorite and ahedral apatite with minor amounts of tremolite, quartz, chlorite, calcite, apatite, ilmenite and sphene is also present.

STRUCTURAL RELATIONS

The majority of dolerite intrusions occur between Burnie and Cooee, in the Parklands Flat Structural Belt. The dolerite occurs as sills and slightly transgressive sheets (fig. 15), the largest body being approximately 300 m thick. The lower, western contact is irregular, with numerous offshoots in the form of sills, dykes and sinuous apophyses.

The arenite in the contact zone has a dull white cherty appearance. In thin section minor recrystallisation of the matrix is visible although individual quartz grains are unmodified.

A raft of sediment 30 m long and 10 m thick occurs about 20 m above the base of the major body. In a 1.5 m wide zone inside the contact, the bedding laminae are strongly contorted in a "soft sediment" style, but the contact rocks show virtually no recrystallisation. This feature, together with the sinuous apophyses at the basal contact, suggests intrusion into relatively uncompacted sediments.

The Parklands Flat Structural Belt contains abundant third generation folds and some rare first generation folds, but slaty cleavage is absent. Two slightly transgressive sheets are folded by third generation folds, and contact structural effects suggest that the dolerite was intruded as sills earlier than the third generation folding and possibly related to the movement resulting in the first phase of folding. (The P_1 and P_2 phases of folding are not developed in the Parklands Flat Belt and the P_3 phase is actually the first one to develop at that particular locality). The contacts are generally "welded" to the dolerite, with no P_3 folds developed in the contact zone. However, at one locality where mesoscopic P_3 folds abutt directly against the dolerite, the contact is dislocated (fig. 15) and there are no contact effects.

The dolerite body on the foreshore adjacent to West Park Oval [905447] has an S-shaped outcrop with irregular contacts and rupture across the bedding. When the outcrop pattern is projected back onto the plane of the cross-section using the axis of the P_1 fold (inset, fig. 15) the intrusion is seen to be concordant with the folded bedding. A P_3 fold (opposite vergence to P_1, concentric style and without cleavage) occurs beneath the P_1 fold, and tapers toward the dolerite and vanishes at the contact.

These structural features indicate that on the minor scale, the dolerite bodies have acted as rigid 'massifs' for the P_3 foldings, although they have been affected by the broad P_3 folding. The precise relationship between intrusion and P_1 folding is not clear. Regionally it is probably significant that the dolerites are more abundant in both the Parklands Flat Belt which was virtually unaffected by the P_1 folding, and in the break thrusts of major folds in the Rocky Cape Group. In this latter situation, (Gee, 1971, p. 35) it has been shown that intrusion occurred during the main period of folding. It thus appears that dolerite intrusion in the Rocky Cape Geanticline was related to the first and major period of folding of the Penguin Orogeny.

THE ROCKY CAPE GEANTICLINE

The fold belts of the Rocky Cape Group and the Burnie Formation constitute the Rocky Cape Geanticline, with the Keith Metamorphics representing the axis. The Rocky Cape Group is a stable shelf facies and was deposited in a basin to the west of the present axis. During the evolution of the geosynclinal stage, the flysch-type Burnie Formation accumulated in a trough to the east of a hinge line that was the precursor of the geanticlinal axis.

During the deformation phase of the orogeny, the Rocky Cape Group was folded into a series of near concentric folds characterised by high angle thrusts. The folds become slightly asymmetric further to the east near the contacts with the Keith Metamorphics. The Burnie Formation was more strongly deformed into overturned, nearly recumbent folds. The belt now occupied by the Keith Metamorphics became a zone of intense shearing and metamorphism when the Rocky Cape Group moved against, and partly over-rode, the Burnie Formation. These movements constitute the Penguin Orogeny (Spry, 1962, p. 124), of Upper Proterozoic age.

Cambrian

RADFORDS CREEK GROUP

A small area of metamorphosed greywacke conglomerate and minor volcanic rocks occurs in the south-east corner of the Quadrangle. The rocks lie within the contact aureole of the Devonian granite, and are overlain by Ordovician conglomerate.

The greywacke conglomerate contains up to 50% of angular quartzite fragments (averaging 8 mm in diameter) in a green mafic matrix that has been recrystallised by contact metamorphism. Scattered floats of mudstone and sodic plagioclase and quartz porphyritic volcanics are present within the rock.

This association represents the western-most occurrence of the complex Cambrian sedimentary-volcanic pile of the Dial Range Trough, of the adjacent Devonport Quadrangle. The conglomeratic greywacke and porphyry form the physical continuation of the Radford Creek Group as defined by Burns (1965, p. 46).

SILICEOUS SILTSTONE AT CUPRONA

A siliceous and ferruginous siltstone formation, 100 m thick, occurs in the Cuprona-Natone area. It overlies the Burnie Formation and underlies the Ordovician conglomerate. The rock is generally a well-bedded, finely laminated siliceous siltstone with abundant fine muscovite flakes in the laminae. Some laminae are completely replaced by fine hematite. There is no clear evidence of its age, but is considered to be Cambrian. The underlying Proterozoic quartzite and slate strikes 070° and dips 50-90°E, while the siliceous siltstone strikes 035° and dips 40°E, indicating an angular discordance.

This horizon is the host rock to the iron ore bodies described by Blake (1958*a-d*). Blake considered the hematite ore bodies to be genetically related to the nearby intrusive Devonian granite, but the presence of abundant limonite-hematite clasts in the Ordovician conglomerate immediately above the iron-bearing siltstone shows this interpretation is incorrect.

Lenses of limonitised hematite up to 8 m thick occur within the siltstone. A chert and siltstone breccia with limonite matrix commonly occurs in the margins of these lenses while veins of specular hematite are present in joints, away from the iron bodies. A faint lamination is visible in the more massive hematite and some partly brecciated layers of cherty siltstone are recognisable.

The hematite veins are probably replacement bodies in tectonic breccia zones within the Cambrian siltstone. Some of these bodies (*e.g.* Purple Crag) lie very close to the top of the siliceous siltstone and pass upward into a sedimentary breccia and conglomerate containing abundant clasts of hematite-limonite and Burnie Formation quartzite. This ferruginous rudite is the base of the Ordovician Conglomerate. The iron ore bodies were thus exposed prior to deposition of the Ordovician rocks, and the mixture of limonite and hematite, both *in situ* and as clasts, suggests a period of fossil gossanisation.

Ordovician

Ordovician siliceous conglomerate and conglomeratic sandstone crop out in the Quadrangle while limestone is thought to underlie Tertiary basalt in the trough of the Camena Syncline. The conglomeratic rocks are equivalent to the Duncan Conglomerate of the Dial Trough (Burns, 1965, p. 61), and are approximate temporal equivalents of the Owen Conglomerate found elsewhere in Tasmania.

The Ordovician rocks lie south-east of a line trending SW from Sulphur Creek (Devonport Quadrangle, 49/011396) through Cuprona [957334] to Natone [928302] and form the western limb of the Camena Syncline. A small strike ridge of conglomerate occurs at Riana [998256] on the eastern limb of the syncline.

Burns noted that the conglomerate overlies different stratigraphic units of the Cambrian Succession in the Devonport Quadrangle, and overlies the Proterozoic at Sulphur Creek. In the Burnie Quadrangle the conglomerate overlies Cambrian(?) siliceous siltstone in the Cuprona-Natone area but overlies the Radford Creek Group at Riana.

In the Blythe River gorge at Cuprona, the base of the conglomerate is a poorly sorted breccia about 20 m thick, consisting of angular fragments of Proterozoic quartzite, siliceous siltstone, limonite and hematite, and rounded fragments of rare chert. Pebble size averages 3 cm, but ranges up to 15 cm. The matrix is a siliceous grit, and is replaced in part by limonite. Veins of specular hematite are present.

The contact between the Cambrian(?) siliceous siltstone and the ferruginous breccia is steep and not concordant with the bedding in the overlying conglomerate. If the bedding in the conglomerate is rotated back to horizontal, the siliceous conglomerate still dips at about 30°SE. The unconformity surface thus appears to have a steep pre-existing dip.

The main conglomerate unit is about 1100 m thick. The lower portion consists of thickly bedded conglomerate composed predominantly of subangular Proterozoic quartzite clasts averaging 3 cm, although some large slabs up to 7 m in diameter occur. Small amounts of rounded chert, hematite and mafic volcanic rocks are present.

The upper conglomerate portion consists of a medium-bedded sandstone interlayered with well sorted quartzite conglomerate. The sandstone is commonly cross-bedded and has frequent gritty laminae. The conglomerate has an average pebble size of 20 mm with rare fragments of mafic volcanic rocks and chert. The sandstone beds, and the sandstone matrix of the conglomerate have a ferruginous cement.

At Riana, the exposed thickness of conglomerate is only 200 m, suggesting a rapid thinning toward the centre of the Dial Trough. The conglomerate is well bedded, consisting of beds of subangular chert fragments between 3 and 20 mm in diameter (60%), and beds of granule sandstone.

Blake (1958*d*) recorded an outcrop of limestone overlying the conglomerate in the acute bend in the Blythe River, one kilometre north-east of the Camena bridge, but this outcrop was not found.

Devonian

TABBERABBERAN FOLD STRUCTURES

The Middle Devonian Tabberabberan Orogeny was a polyphase movement involving granitic intrusion which marked the termination of Lower Palaeozoic tectonic activity in Tasmania. Tabberabberan fold structures have a minor effect in the Burnie Quadrangle and are generally confined to the marginal zone of the Dial Trough which was subject to strong Tabberabberan deformation (Burns, 1965, p. 161).

The only regional Tabberabberan structure in the Burnie Quadrangle is the Camena Syncline (fig. 2), which marks the boundary between the Rocky Cape Geanticline and the Dial Trough. This syncline is a broad, open, non-plunging structure that trends approximately 040°.

HOUSETOP GRANITE

The northern extension of the Housetop Granite Batholith occurs in the south-east corner of the Quadrangle. It is generally a uniformly medium-grained adamellite, but is a coarse porphyritic potash granite with orthoclase phenocrysts up to 4 cm long, along its eastern contact with the Cambrian rocks. Exposed contacts with the country rocks are scarce due to the extensive cover of Tertiary basalt but a contact against Proterozoic arenite is observed in the Emu River [882286], where a narrow glassy aureole 10 m in width occurs.

The mapped portion of the batholith has a rectangular shape (fig. 2), bluntly cutting the Camena Syncline and displacing the Proterozoic-Lower Palaeozoic boundary on the western margin. Age determinations on the granite have indicated an age between 375 and 363 m.y. (McDougall and Leggo, 1965).

Permo-Carboniferous

ARTHUR RIVER - OONAH AREA

A.B. Gulline

The region described is the south-west section of a trough of Permo-Carboniferous sedimentary rocks which extends from Bass Strait to beyond the southern edge of the Quadrangle. This area has a high relief due to the deep incision of the Arthur, Hellyer and Cam Rivers. It has a high annual rainfall and is heavily timbered with rain forest vegetation.

The most detailed work was done in the vicinity of the confluence of the Arthur and Hellyer Rivers [555240], from Blackwell Road, and in the West Takone [570280] and Oonah [643227] areas.

Two formations of Carboniferous to Permian age are recognised in these areas: the Wynyard Tillite and the Inglis Siltstone. Thin patches of gravel,

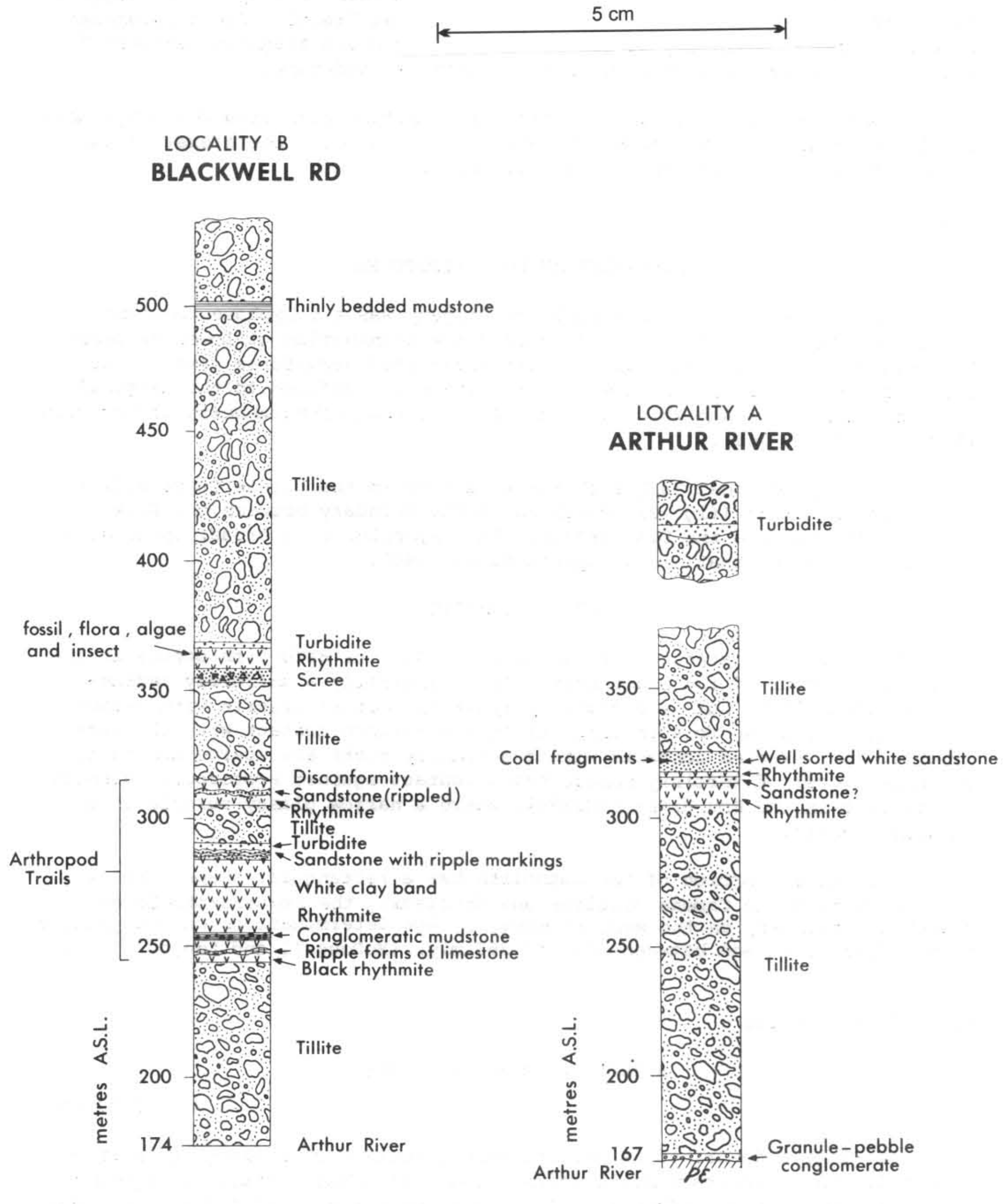


Figure 16. *Wynyard Tillite sections, Arthur River-Oonah area.*

usually partly obscured by overlying Tertiary basalt remnants, overlie these on some hilltops. Just north of Oonah, the Inglis Siltstone and Wynyard Tillite have been intruded discordantly by a large body of Jurassic dolerite. Much of this dolerite area is overlain by basalt.

WYNYARD TILLITE

The Wynyard Tillite was first recognised and described in part by Etheridge (1883) who referred to it as the Table Cape Conglomerate. Other geologists have subsequently used different names but it is now defined as "that formation of tillite with subordinate sandstones and varved mudstones, resting unconformably on Devonian or older rocks and overlain conformably by sandstones and siltstones as exposed in the creek bed east of Oonah Post Office". (Banks *et al.*, 1955). This creek is one of the headwater tributaries of the Cam River.

The Wynyard Tillite is generally well exposed in areas of high relief where all units form cliffs, but creeks and road cuttings give the best exposures in less dissected country. The lowest unit observed is at an unconformity in the Arthur River [544246, Locality A] where irregular lenses of granule conglomerate up to one metre thick overlie Precambrian quartzite and slate. The granules are angular to sub-rounded rock fragments and quartz grains in a closely set matrix of medium sand grade. Where this conglomerate has not been deposited, tillite or diamictite, the second unit, rests unconformably on the Precambrian rocks. The base of the formation is not exposed in the Blackwell Road section [571223, Locality B].

Tillite forms the major thickness of the formation and is generally massive and without visible bedding (plate 9). Its colour ranges from dark grey to khaki depending on the degree of weathering of the matrix. It frequently forms cliffs, the highest seen being about 10 m. No exposures were good enough to determine the maximum thickness of any one bed of tillite, but 150 to 180 m of tillite occur above the unconformity at the Arthur River.

Partings sub-parallel to the bedding occur in the tillite and are probably joint planes. The bounding surfaces of tillite units are usually non-planar but are sharp where they have been seen above or below lithologically different units.

In the unweathered state tillite is dark grey to almost black, very dense and extremely tough. It consists of unsorted sub-angular to rounded, sometimes faceted and striated phenoclasts of a variety of rock types set in a matrix of angular rock fragments and rock flour with a carbonate cement. Phenoclastic boulders range in size up to 3 m but the majority at Locality A range from 10 to 30 cm.

The third unit deposited in the Wynyard Tillite is a laminated mudstone or rhythmite (plate 10). This was first found to crop out about 180 m above the base of the formation at Locality A (fig. 16). The rhythmite and tillite have a sharp contact, indicating a rapid change in conditions of deposition. The basal part of the rhythmite sequence has a generally higher proportion of larger dropstones (plate 11) than the rhythmites higher in the succession. At Locality A, the rhythmites are light brown to green, of clay grade and quite talcose to touch and contain dropstones. Toward the top of the unit sandstone is interbedded with the rhythmites.

At Locality B, the rhythmites are exposed at approximately the same height above the Arthur River as at Locality A, but the unconformity between the tillite and Precambrian rocks was not observed. The rhythmites differ from those at Locality A, both in lithology and in that they are much thicker

Plate 9. *Massive tillite, Hellyer River.*

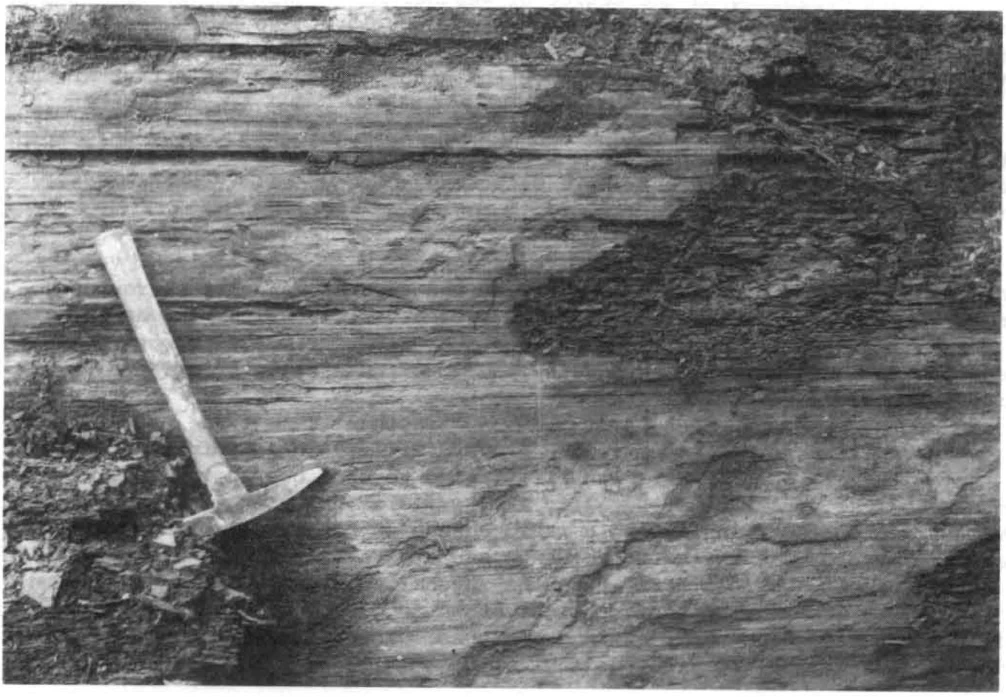


Plate 10. *Finely laminated rhythmite, Blackwell Road.*

as a unit. At the base they are black, have a carbonate cement and contain dropstones, and have a ripple marked form due to current action. The troughs of the ripples are filled at several levels with ripple mark forms of calcareous mudstone which shows current-bedding in thin section.

Colour changes up the succession from black to brown, dark green, khaki to lustrous grey at the top. Particle size does not change but grading can be seen in thin section. Grain size grades from 20 to 4 µm from the bottom to the top of one lamination.

This section of rhythmites has a thickness of about 43 m. The next exposure measures only 3 m but the rhythmites have been eroded and are disconformably overlain by tillite without suffering distortion.

The highest rhythmite section is olive-green in colour and is exposed over about 9 m. Very fine ripples of coarse sand and a lens of turbidite sandstone are seen on some bedding surfaces. This sandstone has formed lode casts on the underlying rhythmites.

Overlying the rhythmites at Locality B is a sequence of turbidite sandstone. This is not as continuous as the tillite or rhythmites but makes up a considerable portion of the surface outcrop. The thicker beds have been recorded as lensing out and thinner beds have not been traceable over any distance. Turbidites are best developed at the top of rhythmite sections. Thin and not very extensive turbidite sandstone has been noted in tillite sections and within rhythmite sections.

The onset of turbidite deposition is first indicated in rhythmite sections by thin, graded sandstone interbedded with rhythmites. The number and thickness of turbidite units increases and within 6 m thickens from 1 mm to 1.5 m. The lower beds, which are about 2 to 20 cm in thickness, usually show strong development of ripple marks. Thin rhythmites occur between sandstones in this section. Some of the thin (2-9 cm) lower sandstone beds have a carbonate cement.

Graded bedding can be detected in sandstone beds of all thicknesses, the overall grain size range being from pebble to clay. Current-bedding is sometimes present in finer beds, while mud pellets occasionally occur near the top of thicker beds. Composition varies from lithic to quartz sandstone. The base of the turbidite beds vary from ripple marked, to disrupted, to planar, depending on the surface on which they were deposited and the grain size at the base of the deposit.

At Locality A, the sandstone at the top of the rhythmite sequence is a clean white-weathering well sorted even-grained sandstone with beds up to 1.8 m thick (fig. 16). Above the thickest beds the grain size decreases and a laminated sandy siltstone is present below the tillite. Carbonaceous fragments were abundant on one bedding plane. Although this sandstone unit appears to have had an identical development to the turbidites at Locality B, and occurs on a similar horizon, the reason for it not being a turbidite may possibly be explained in terms of its position in the depositional basin and the environment at this position. Further mapping would be necessary to reach a definite conclusion.

From the exposures examined, the cycle of deposition appears to be tillite-rhythmite-turbidite-tillite, which can be explained by postulating deposition from a wet-base glacier. Interrupted cycles and evidence of erosion of units are visible in some sections.

A composite section from the succession mapped at Locality B gives an

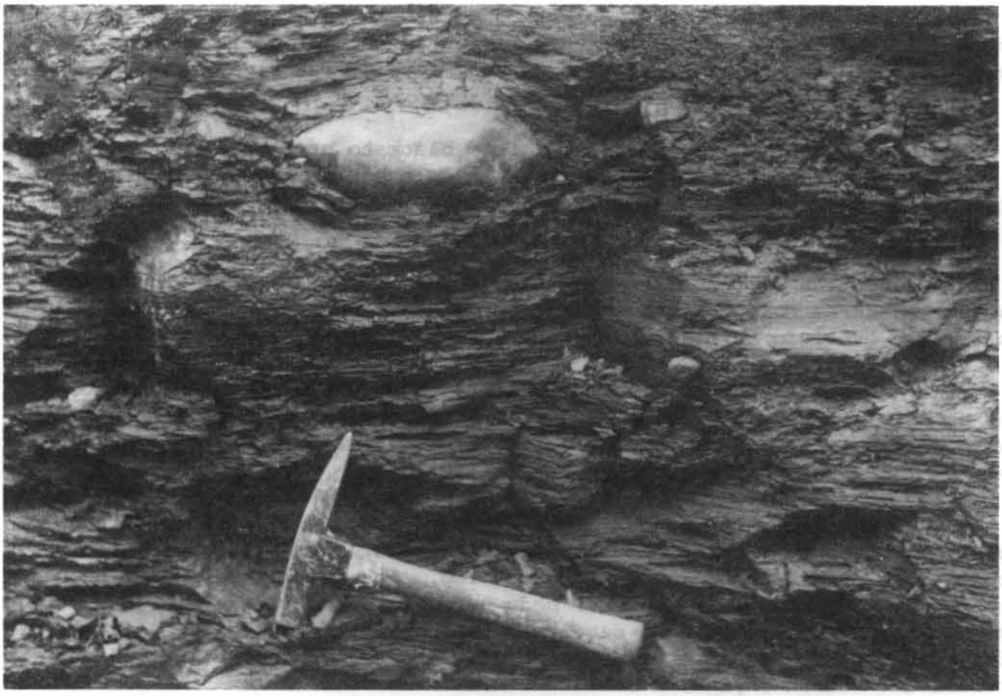


Plate 11. *Dropstones in rhythmite, Blackwell Road.*

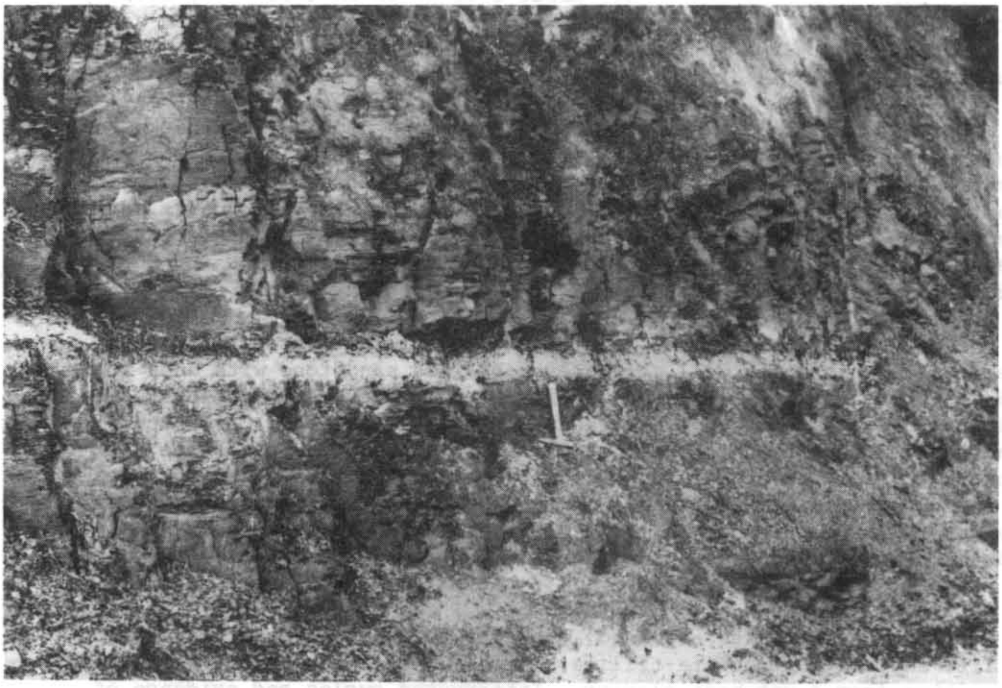


Plate 12. *Horizontally bedded rhythmites containing a thin pale coloured rhythmite band; Blackwell Road.*

approximate thickness of 370 m made up of 280 m of tillite, 55 m of rhythmites and 35 m of sandstone (fig. 16).

A disconformity occurs in this section, where tillite overlies rhythmite unevenly. The latter has been eroded, presumably by the movement of tillite over it. The rhythmite shows slight evidence of compressional characteristics and is polished at the contact with the tillite. Movement of the tillite appears to have been from a westerly direction.

A second disconformity on Blackwell Road, north of the Hellyer River bridge, shows assimilation of turbidite sandstone above rhythmite. Here sandstone beds have been lifted up by mobile till, disrupted and corroded and elongate oval boulders of turbidite are now incorporated in the tillite. All boulders examined still retained their depositional orientation as to top and bottom.

Phenoclasts in the tillite have no preferred orientation with the exception of elongate and discoidal boulders which frequently have their long axis sub-parallel to the bedding.

The rhythmite and turbidite units are almost horizontally bedded (plate 12) and all dips recorded were small and random in direction. This would be expected with deposits of lenticular form and those subjected to heavy loading by thick tillite deposits while still in a state of plasticity.

The direction of the source of sediments forming the deposit was arrived at primarily from measurements taken from current ripple marks with several substantiating directions gleaned from striae and tillite movement over rhythmite and turbidite.

The palaeocurrent and associated sediments have come from directions ranging from west to a few degrees east of south. Further current directions could be obtained from rhythmites deposited over a dropped pebble. These range in size from sand grade up to 18 cm. Compaction is marked where a pebble has fallen into rhythmite (fig. 17). From the impact marks there appears to have been little if any lateral velocity on the dropped pebbles although it may be possible to determine current directions from laminations around the pebble after it was dropped.

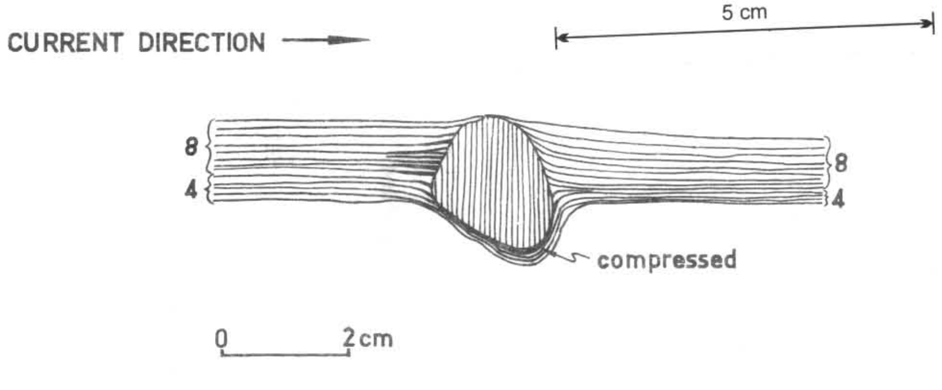


Figure 17. *Deposition and compression around a dropped pebble.*

In several cases, pebbles of about 2 cm diameter were found to have rhythmites deposited over them as depicted in Figure 17. No readings were obtained from these as the feature was noted in unoriented collected

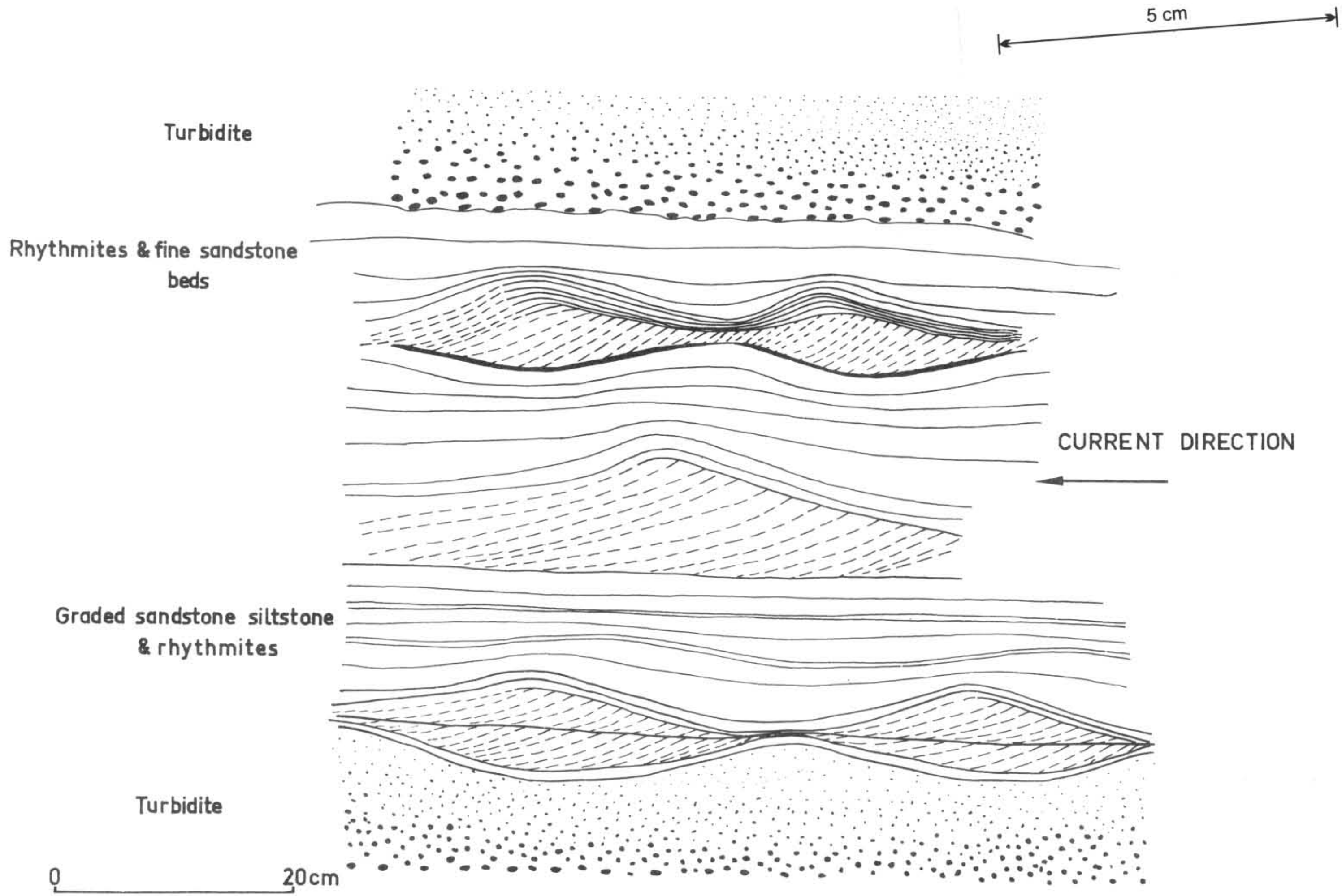


Figure 18. *Sedimentary features associated with turbidity currents, Wynyard Tillite.*

specimens. Ripple marks are of the current type (fig. 18) and sections show current bedding in all ripples.

INGLIS SILTSTONE

The transition from Wynyard Tillite to Inglis Siltstone is rapid, with the diamictite of tillitic appearance grading to stratified sandstone, mudstone and siltstone in a marked change of environment over about 5 m. A few boulders and pebbles, often glacially striated, occur scattered through the predominantly dark grey mudstone which overlies the tillite. Lenticular beds of Tasmanite Oil Shale up to 0.6 m thick occur in silty mudstone from 6 to 20 m above the base of the siltstone. *Tasmanites* is dispersed through adjacent beds over approximately one metre.

Above this horizon bedding is difficult to define. Grey mudstone is the most common rock type, although occasional tough and sandy horizons occur which frequently form waterfalls in creeks. Black pyritic micaceous mudstone which weathers to a dark, puggy clay also occurs and contains occasional pyrite nodules.

Towards the top of the formation, grey siltstone which weathers to a creamy-brown colour contains discoidal arenaceous foraminifera distinguishable under hand lens inspection. One species is characterised by its large smooth arenaceous test, circular in outline, with a long planispirally coiled tubular chamber while the other form has a circular to broadly rounded smooth test. Some of this type were slightly compressed with pit like structures on some weathering surfaces.

Crespin (1958, p. 27) described an assemblage of arenaceous specimens unique to Tasmania from the Inglis Siltstone at Oonah. Descriptions and figures suggest that the two species referred to above are *Ammodiscus oonahensis* Crespin and *Thuramminoides sphaeroidales* Plummer respectively. Arenaceous foraminifera are known to have thrived in cold water where temperature is probably more ecologically important than depth (Crespin, 1958, p. 28). Thus it is apparent that the cold of the preceeding glaciation relating to the deposition of Wynyard Tillite still influenced marine faunas during deposition of the Inglis Siltstone.

Nearer the top of the formation fossils become more abundant and crinoid fragments are plentiful, possibly indicative of shallowing water. Further fossiliferous pyritic siltstone beds occur at the top of the formation and contain a variety of molluscs, brachiopods and bryozoans, together with crinoid debris, a little carbonaceous material and numerous pebbles. This is the highest Permian found in the Oonah-Hellyer River area and is included in the Inglis Siltstone giving this formation a total thickness of about 130 m.

A lithologically identical section of Inglis Siltstone containing foraminifera occurs in the Preolenna area (Bravo, this volume) but the Tasmanite Oil Shale was not seen.

PREOLENNA - WEST TAKONE AREA

A.P. Bravo

The first detailed study of the geology of this area was made by Loftus Hills in 1913, when he examined the area around the Preolenna Coalfield. Hills outlined six sub-divisions for the rocks then considered Permo-Carboniferous in age.

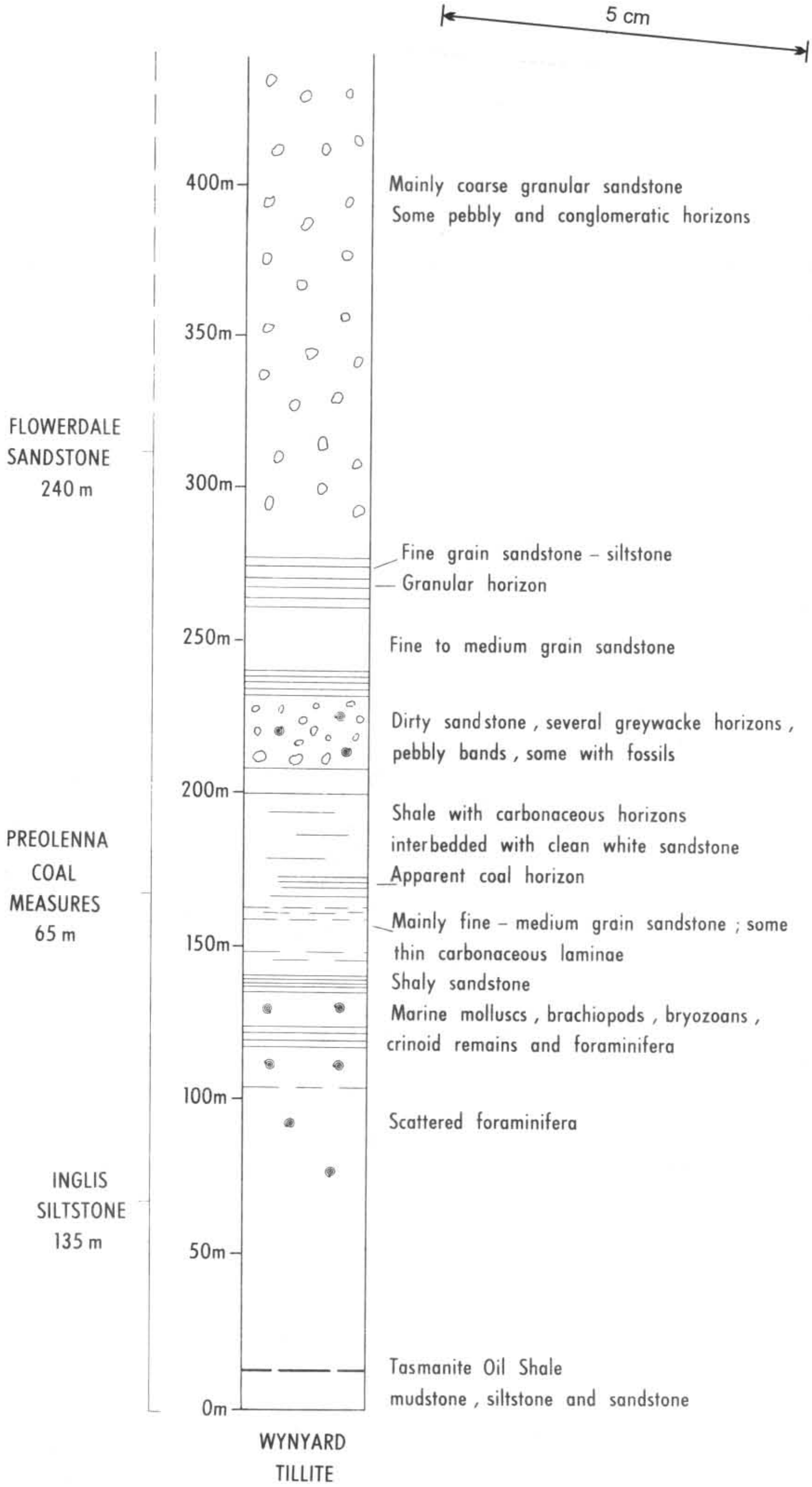


Figure 19. *Permian section, Preolenna-Flowerdale area.*

Voisey (1938), utilising the geological evidence of Hills, re-arranged the sub-divisions into a sequence of four stages. The overall grouping and formation nomenclature adopted for the Permian of the Burnie Quadrangle is in accord with that used by Voisey with the exception of the Inglis Siltstone, which replaces mudstone. McNeil (1961) described Permian formations in the Arthur River area, which are similar to those rocks occurring in the Preolenna-West Takone area.

The area south of Wynyard consists of deep gorges and numerous tributaries of the Jessie, Flowerdale and Inglis Rivers cut into the mudstone and diamictite of the Wynyard Tillite. The base of the Wynyard Tillite is not exposed in the area and an unknown thickness of tillitic material is overlain by about 135 m of Inglis Siltstone. This is overlain in turn by sandstones of the Preolenna Coal Measures, which crop out on the steep NW slopes of the Jessie River valley. This area appears to be the only locality where the upper formation, the Flowerdale Sandstone, is exposed.

The Permian sequence (fig. 19) has been intruded by dolerite, which is exposed on Diabase Hill, a watershed between the Jessie and Flowerdale Rivers. An extensive cover of basalt exists SE of the Jessie River, and large tracts of arable land occur on the deep soils developed from the weathering and decomposition of this rock. Deposits of sand and gravel underlie the basalt.

Weathering of the Flowerdale Sandstone produces a lag deposit of coarse quartz sand and boulders and it is reasonable to assume that the Flowerdale Sandstone was the immediate source of the well-washed coarse granular sands, pebbles and cobbles, that have collected in the lower reaches of the Flowerdale and Inglis Rivers (fig. 21). The southernmost deposit of gravel occurs in a quarry on the Preolenna road, near the Inglis River bridge. Further to the south, a thin veneer of isolated pebbles in sand can be found only where the basalt has been stripped or eroded.

WYNYARD TILLITE

At least 210 to 250 m of tillite, presumably Carboniferous in age, is exposed in the Inglis River valley. The predominant lithology is a conglomeratic, bouldery mudstone or diamictite which, because of its assumed origin, is referred to as tillite.

The tillite consists of a disrupted framework of isolated clasts, some with striations and an occasional facetted edge, in a silty clay matrix. The clasts are mainly well rounded and consist of quartzite, banded hornfels, white quartz, chlorite and muscovite schist, mudstone and slate fragments as well as the occasional granite pebble. The lithological diversity of clast boulders is a feature of most outcrops. The clasts are polymodal with respect to size range which may vary from boulders of about 30 cms across (but generally less), down to pebbles and granules. Generally, the tillite contains about 20-30% boulders in a profusion of matrix with a complete absence of sorting. The matrix is structureless with very little stratification or evidence of bedding. The long axis of the majority of clasts have no preferred orientation. The tillite cropping out near the junction of the Inglis and Calder Rivers [641418] is predominantly a grey mudstone with less than 10% of clasts, usually only in the pebble range (less than 3 cm) although rounded boulder erratics up to 13 cms are scattered throughout.

Rhythmite deposits have been found at several horizons within the tillite but it is not known whether they occur at a consistent stratigraphic horizon. Because of the limited exposure in some areas, it is possible that a complete distribution of rhythmites is not shown on the map.

There appear to be two types of rhythmite deposits. The more characteristic of these consists of highly coloured laminations that appear to be alternations of very fine sandstone or siltstone with claystone. The laminae break apart to reveal many granules and fine pebbles embedded within mudstone. In some instances, weathering of pebbles has produced iron staining. The second type consists of thicker strata, up to one centimetre thick, of dull grey, fine sandstone with interleaves of light grey to white siltstone and clay. Both types of alternations are considered to be rhythmites of glaciolacustrine origin, because of the presence of dropped pebbles that have penetrated and distorted the laminae. Other characteristics of the rhythmites are in accordance with the descriptions of Banks *et al.*, (1955).

Medium-grained sandstone beds, in places cross-bedded and with some evidence of ripple marks, have spatial association with the rhythmites.

INGLIS SILTSTONE

The Inglis Siltstone conformably overlies the Wynyard Tillite in this area. The rock is similar to that described by Gulline (this volume) and will not be discussed further.

PREOLENNA COAL MEASURES

At the top of the Inglis Siltstone, the sequence passes from grey to brown siltstone, through coarse white sandstone into shaly beds of carbonaceous sandstone. Lithologically, the Preolenna Coal Measures consist of interbedded white, clean, quartzose sandstone and carbonaceous, micaceous sandstone, the latter including some thin sandstone beds, shales and thin laminations of carbonaceous material. The clean sandstone is usually fairly tough and massive, well sorted and fine-to medium-grained. Some of the medium-grained sandstone contains finely disseminated clastic carbonaceous material and a small amount of micaceous material. Other sandstones split readily to reveal planar surfaces (akin to bedding) which contain abundant white mica and black carbonaceous fragments that appear to be carbonised plant remains. Several well-preserved impressions of *Glossopteris* leaves have been found in sandstone in the Flowerdale River. The shales consist of medium-grained sandstone, sometimes containing carbonaceous laminae and discontinuous black stringers that contain abundant carbonaceous and micaceous material. The carbonaceous material is generally unidentifiable, although some linear fragments are apparently fibrous. The sulphurous content of the coal measures is evident from a yellow seepage discolouration noted in places.

The coal measures occur on the NW side of the Jessie River gorge, and in the Flowerdale River south of Preolenna. Both areas have been the site of some coal mining activity, although of apparently negligible economic importance. Hills (1913) suggested that four coal seams occurred in the area. The overgrowth of vegetation has made the relocation of any seams almost impossible, with the exception of one seam in Preolenna Creek below an old mine tunnel. From Hills' description of the tunnel workings, it appears that the seams had a variable dip, ranging from 14° to 20° to the west. Toward the end of the coal mine track a seam of coal 45 cm thick has a dip of 40° to the west. Here, a fairly well-sorted fine-grained sandstone, containing some mica and carbonaceous material, is overlain by black, carbonaceous and micaceous shale which underlies the coal horizon. In the first 30 cm above the coal, thin bands and laminae of clastic carbonaceous material are contained within a well-sorted, medium-grained, micaceous sandstone. McNeil (1961) reported similar lithologies containing a thin coal seam in Relapse Creek (Trowutta Quadrangle). Hughes (1962) described an occurrence of coal west of the quadrangle boundary near West Takone, where 30 cm of good quality coal overlying coarse sandstone was in turn overlain by over a metre of carbonaceous shale and fine-grained sandstone.

FLOWERDALE SANDSTONE

The Flowerdale Sandstone includes units E and F of Hills (1913). It appears to be exposed only in the Flowerdale River area where an almost complete section occurs (fig. 19). The Flowerdale Sandstone is about 215 m thick and consists of several different lithologies. Generally the sequence passes upward from pebbly sandstone containing a fossiliferous horizon, through dirty to almost greywacke sandstone, to a sequence of fine sandstone and siltstone which in turn is overlain by white, argillaceous, coarse quartz sandstone.

The lower pebbly sandstone, equivalent to unit E of Hills, has been included in the Flowerdale Sandstone mainly for ease of mapping. Above the Meunna Road bridge [562354], the pebbly sandstone consists of isolated granules and mainly rounded small pebbles in a fine-sandy matrix. Boulders of rounded to sub-rounded chloritic schist, slate and quartzite up to 20 cm are scattered throughout. Bands of poorly sorted, pebbly sandstone, 15 to 30 cms thick, with an intermixed matrix ranging from a coarse sand to a grey silt, are interbedded with grey, dirty sandstone. Tough resistant greywacke-type sandstone is also present and forms small waterfalls in the Flowerdale River at several localities. Mudstone fragments weathering to argillaceous material give an interbedded medium-to coarse-grained sandstone a distinctive brown and white speckled appearance. Fossils occur at some horizons. A brownish siltstone contains fenestellids while a shelly fauna of brachiopods and pectinids occurs in a pebbly band.

Above the lower pebbly unit the sandstone becomes finer grained but still contains isolated pebbles and an occasional boulder up to one metre across. Most of the pebbles are less than 4 cm across and consist of slate, mudstone, quartzite and quartz. Several flakes of biotite up to 7 mm across were also noted. The pebbles have various shapes, some being rounded, and others half rounded, while the slate fragments are highly angular. The bulk of the rock when unweathered is a mottled dark grey colour. It appears to be a fairly even-grained, medium sandstone which is micaceous and contains finely disseminated specks of clastic carbonaceous material. As the sorting gets poorer the rock grades to a dirty sandstone with a variety of pebbles and small boulders.

Overlying this is a sequence of about 40 m of well sorted fine-grained sandstone and siltstone which appears to be unfossiliferous. The unweathered rock is typically a grey, micaceous sandstone, which becomes golden yellow on weathering with a characteristic development of Liesegang rings. Fine black specks scattered throughout the sandstone are probably carbonaceous material. The sandstone passes upward into siltstone with similar features to those just described. The siltstone is also well sorted apart from the occasional coarse to granular quartz grains and occasional rounded pebble. This is overlain by a gritty band of coarse to granular sandstone containing an occasional flat rounded pebble. At the top of this unit the siltstone passes into light grey to white medium-grained sandstone.

Above this, the sequence consists of friable and porous coarse-grained sandstone. The rock is mainly quartzose but white bleached mudstone fragments are also evident, which on weathering would apparently contribute to the friability and porosity. The upper 100 m of the Flowerdale Sandstone consists of coarse to granular sandstone with pebbly to conglomeratic bands. Some micaceous material and flakes of molybdenite occasionally occur in the sandstone. Where the sandstone becomes conglomeratic the pebbles and boulders are mainly quartz (some pink quartz is usually present), bleached quartzite, chert and schist.

The true thickness of the Flowerdale Sandstone (fig. 19) is not known, as erosion has probably removed the top of the formation.

GEOLOGICAL HISTORY

Following erosion during the late Devonian and probably early Carboniferous, the area became submerged and subjected to deposition of sediments of mainly glacial origin. Glacial erosion of the land and shallowly submerged regions was contemporaneous with deposition.

Initially, a thin discontinuous fine conglomerate was deposited on the basement. This conglomerate shows some sorting and is possibly a turbidite from the forset slope of the advancing till which was subsequently deposited on top of it. A thick deposit of tillite was apparently followed by a rise in water level with consequent recession of the glaciers. The type of rocks deposited indicate wet base glaciers as the source of sediments (Carey and Ahmad, 1961). With the recession of the grounded shelf zone of the wet base glaciers, the tillite surface became sub-aqueous below the floating shelf zone of the glaciers.

Melt water deposited fine silt and mud as thin graded laminae in thick rhythmite deposits conformably overlying tillite (fig. 16). Numerous erratics and pebbles were dropped into the rhythmite from the floating shelf ice, together with an abundance of particles of coarse to medium sand grade. Some of the sand grade particles may have come from turbidites which were later deposited within and over the laminated sediments. At this stage the only faunal life recorded reached a maximum. The lower rhythmites and the calcareous sandstone units are black, due to fine carbonaceous particles which probably indicate the presence of some faunal and floral life.

Turbidity current action initially proceeded quietly with thin turbidite deposits, but increased in energy resulting in complex ripple marking and thick turbidite sandstone and granule conglomerate development. It then gradually diminished, depositing thin ripple marked turbidites followed by another rhythmite sequence. These turbidites probably came from the forset slope of the next tillite, which would have been advancing during deposition of the stratified sediments regardless of warmer climate (Carey and Ahmad, 1961, p. 884-885).

Six metres of tillite overlying the thin rhythmite horizon could also originate from the forset of the main tillite, as a further 3 m of rhythmites again overlie this tillite. The 3 m thick rhythmite section is eroded at the top and disconformably overlain by a further 33 m of tillite, which represents the second major ice advance. This advance started from the grounded shelf zone at the same time as the lower rhythmites were forming. A further rise in water level followed this deposition and rhythmites were again deposited conformably overlying the tillite. Plants occur in this rhythmite section and it is considered that the climate had been gradually ameliorating since the first tillite stage.

A further deposition of 150 m of unstratified tillite suggests a re-intensification of glaciation, with these sediments persisting until marine Permo-Carboniferous siltstone occurs. Due to melting and subsidence, the continental deposition basin had probably joined a saline or marine basin, the wet base glaciers had disappeared or were completely floating and only a few remaining highland areas supported dry base glaciers. These sloughed off icebergs where they reached the sea and the material carried by these icebergs is considered to be the source of the dispersed and occasional concentrations of boulders throughout the Permian System (Carey and Ahmad, 1961).

After a considerable period of marine deposition, freshwater deltaic deposits with coal seams and carbonaceous remains were laid down suggesting a pluvial stage. This decreased temporarily, allowing a short marine incursion. A vigorous pluvial and fluvial era followed, resulting in the deposition of the thick, fine-to coarse-grained Flowerdale Sandstone. This unit was probably derived from terrestrial glacial deposits.

PALAEONTOLOGY

M.J. Clarke

WYNYARD TILLITE

Identifiable fossils are restricted to the rhythmite horizons within the Wynyard Tillite, although carbonaceous fragments occur in sandstone at Locality A. Trace fossils occur in the lowest rhythmites at Locality B, and increase in abundance up to the first turbidite unit. Some also occur in the second rhythmite sequence, but none was observed in the third and highest rhythmite unit. These trace fossils were first described as *Tasmanadia twelvetreesi* by Chapman (1929), who assigned a Cambrian age and interpreted them as annelid remains. Glaessner (1957) re-examined the type material (from Kirkup's Quarry on the Arthur River - 555160) and considered *Tasmanadia* to be an arthropod track. Both Glaessner and Häntzschel (1962) adopted Chapman's Cambrian age assignment without comment. Gulline (1967) corrected the age assignment to Late Carboniferous, and noted that the original erroneous Cambrian age assessment probably stemmed from Chapman's misidentification of the host rock as slate. *Tasmanadia* closely resembles certain of the tracks described as *Diplichnites* from the Permo-Carboniferous glacial Dwyka Series in South Africa (Savage, 1971). Riek (1973) stated *Tasmanadia* to be the tracks of euthycarinoid crustaceans.

During mapping, the highest rhythmite horizon yielded a fragmentary specimen of the fossil plant *Rhacopteris ovata* (M'Coy) (Banks, *in* Gulline, 1967). More recent and intensive collecting has yielded anostracans, an almost complete specimen of the megasecopteran insect *Psychroptilus burrettae* (Riek, 1976), and a considerable volume of additional and more complete plant material. Gould (1975) records *Botrychiopsis plantiana* (Carruthers) [=*Rhacopteris ovata* (M'Coy) of Banks (*in* Gulline, 1967)] and *Aphlebia* sp. Large numbers of arcuate hair-like structures of probable plant origin (E. Plumstead pers. comm.) are also present. Samples processed palynologically have yielded assemblages referable to the Stage 1 *Potonieisporites* (Late Carboniferous) Microflora (P.R. Evans pers. comm.). Samples of rhythmite from near the base of the Wynyard Tillite at Pine Point near Wynyard (Table Cape Quadrangle) and from basal tillite on the Queenstown-Strahan road (Strahan Quadrangle) have also yielded assemblages definitive of the Stage 1 *Potonieisporites* Microflora, together with rare specimens of the spinose acritarch *Veryhachium* (E.M. Kemp pers. comm.). The latter adds support to the hypothesis of wet-base glaciers discharging their debris at or below sea level as a mechanism for the deposition of large thicknesses of tillite (Carey and Ahmad, 1961).

INGLIS SILTSTONE

The uppermost richly fossiliferous parts of the Inglis Siltstone are exposed in cuttings alongside a logging track at Scolyers Hill [641235] immediately west of the Waratah Highway near Oonah.

Fossils collected at this locality include:

Deltopecten illawarensis (Morris)

Eurydesma cordatum Morris

Eurydesma hobartensis (Johnston)

Merismopteria carrandibbiensis (Dickins)

Myonia morrisi (Etheridge)

Neoschizodus australis Runnegar

Keeneia sp.

Trigonotreta stokesi Koenig

Martiniopsis konincki Etheridge

Martiniopsis sp. nov., cf. M. *elongata* McClung and Armstrong.

Pseudosyrinx allandalensis Armstrong

Strophalosia sp. nov.

Stenopora sp.

Fenestellids

abundant Crinoid debris.

The occurrence of *Eurydesma cordatum, Deltopecten illawarensis, Myonia morrisi, Neoschizodus australis, Trigonotreta stokesi* and *Martiniopsis konincki* indicates a firm correlation with the Allandale Fauna of New South Wales (Runnegar, 1967; 1969), and with various pre-Mersey, pre-Liffey and pre-Faulkner Group successions elsewhere in Tasmania. However, the occurrence of *Strophalosia* sp. nov. may be important. This species also occurs in the lower parts of the Permian sequence at Point Hibbs (Banks and Ahmad, 1962), in the Kansas Creek Beds on Western Bluff (Jennings, 1963), and in the Spreyton Beds near Latrobe (Burns, 1965). In contrast *Strophalosia subcircularis* Clarke characterises the immediate pre-Mersey Group faunas at Golden Valley near Deloraine (Clarke, 1968), and at Beaconsfield (Clarke, 1969). If these two species are not geographic variants and have temporal significance, it may prove possible to subdivide the Allandale Fauna in Tasmania. A corollary is that the incoming of richly fossiliferous "Golden Valley Group" facies may have occurred earlier in north-western Tasmania than elsewhere. Allowing a conformable passage between the Mersey Group correlates and the beds immediately below, it would also follow that the spread of non-marine Mersey Group conditions was similarly diachronous, with the onset occurring first in the west, and only later spreading eastwards. A complete discussion of recent biostratigraphic data for other Tasmanian Permian sequences is given by Clarke and Banks (1975).

Jurassic dolerite

Dolerite occurs to a limited extent in the south-western section of the quadrangle. A small remnant sill occurs at Diabase Hill south of Preolenna, where the dolerite overlies Permian Flowerdale Sandstone. Irregular and slightly transgressive intrusions occur at Takone and between Henrietta and Oonah.

The dolerite has a medium- to coarse-grained texture, but is fine-grained with platey jointing at chilled contact margins.

Tertiary

The Tertiary system comprises a lower and upper group of basalt flows, separated by terrestrial and marine sediments. Overlying the upper basalt is a discontinuous sheet of normally unconsolidated siliceous sand, gravel and marine calcarenite. The sand and gravel is commonly silicified near the contact with the basalt.

SEDIMENTARY ROCKS

A deposit of well sorted and well rounded granule conglomerate, coarse sand, fine sand and clay occurs along the hills behind the coastal plain from Howth to Somerset. This deposit forms a 14 m thick bed which can be traced around the hill behind Burnie from Romaines Creek to West Park. It is the locus for landslides in the Burnie area (Hughes, 1959*a*). Thinner isolated lenses of conglomerate also occur within the upper basalt on the plateau south of Burnie.

A well-sorted, silicified, medium-grained sandstone and siltstone, with occasional flat and rounded quartzite pebbles occurs at the eastern head of the Emu River [931421]. The rock is intensely contorted into many small recumbent folds, and the sandstone layers show boudinage. Some sandy layers have been silicified to black chert. It is suggested that this represents a strand line deposit, which was over-ridden by basalt lava while it was still unconsolidated. The nearby deposit of fine silica at Wivenhoe (934416, Hughes, 1959*b*) is also a sub-basaltic sand.

A fossiliferous fine-grained calcarenite containing fossils indicating Late Oligocene age crops out one kilometre south of Doctors Rocks. This is a correlate of the Table Cape Group that crops out at Fossil Bluff near Table Cape (Gee, 1971). Terrestrial sandy sediments occur in the same stratigraphic position approximately 5 km south-east of Doctors Rocks but the relationship between the two rock types is not known.

VOLCANIC ROCKS

Tertiary volcanic rocks occur over approximately one-third of the quadrangle. The flows frequently extend from near sea level to the higher plateaux up to 35 km inland and overlie all older rocks. Basalt overlies Tertiary non-marine sediments at several locations, forming deep lead deposits. The easternmost basalt flows on the Burnie sheet cover the Howth and Riana deep leads, which are described in the Devonport Explanatory Report (Burns, 1965).

No eruptive centres have been located with certainty but a probable centre occurs at Mt Hicks [761445]. The flows were probably erupted from numerous centres. Columnar jointing is typical of massive basalt flows and is well developed in a quarry near the Burnie wharves [915441].

The Tertiary volcanic rocks are olivine basalts and display a variety of textures. Two distinct basalt flows occur in the quadrangle. The lower basalt is a valley filling phase of limited extent and is represented by columnar basalts at Burnie wharves and Doctors Rocks. The upper basalt forms an extensive sheet which covered most of the area during the period of Tertiary volcanic activity, Round Hill probably being the only topographic feature protruding through the basalt. The sheet has been heavily dissected and partly removed by the present drainage system. Where underlain by Proterozoic rocks, the pre-basalt topography appears to be quite flat, but the relief is more marked where Lower Palaeozoic rocks underlie the basalt. The trough of the Camena Syncline was the locus of a substantial pre-basalt river; other rivers entered the sea at Howth, Burnie and Doctors Rocks.

A 200 m thick unit of volcanic breccia overlying Proterozoic rocks and a thin flow of columnar basalt occurs at St Georges Falls [774317] and Sandersons Falls [784322] west of West Ridgley. The unit thins to the north-east and grades laterally into a scoriaceous lava and then into normal massive basalt. On the western side of the Cam River, 500 m from Sandersons Falls, the breccia is only 7 m thick and passes upward into a layer of amygdaloidal basalt, with thin tuff bands, and then into normal basalt.

The volcanic breccia is a hard, poorly sorted rock containing mainly angular fragments of Proterozoic arenite, amygdaloidal basalt up to 60 cm across, and small fragments of black glass about one centimetre across. Rare fragments of Permian mudstone are present. The matrix is of a fine granular glass, ash and lava fragments. The bedding is indistinct. Locally, dips of up to 20° have been recorded.

Quaternary

OLDER DEPOSITS ON COASTAL PLATFORMS

Semi-consolidated sand and gravel occur as superficial deposits on the coastal platforms at Blythe Heads, Burnie and Somerset. These deposits are exposed in the estuarine reaches of the Blythe (Gee, 1964) and Cam Rivers, and consist of bedded sand containing irregular gritty bands and roundstone gravel in a sandy matrix. The sands have a red ferruginous or a black carbonaceous cement. A talus wedge is commonly developed at the foot of the scarps to the rear of these platforms.

These sediments are probably of Pleistocene age.

RIVER ALLUVIUM

Recent alluvial sands and silts occur in sections of the major rivers and also as thin veneers on the older deposits on the coastal platforms. Some recent reworking of these sediments has produced minor dune and beach deposits on the coastline.

ECONOMIC GEOLOGY

Metallic minerals

G.R. Green

Deposits of iron and copper are located within the quadrangle, but no mining of these or other metallic minerals is currently being undertaken. A small quantity of alluvial gold was extracted towards the end of the last century.

GOLD

Montgomery (1896) reported that sub-basalt gravel in the area was often auriferous. The gravel consisted of a layer of well rounded quartz pebbles immediately below the basalt at an elevation of 90 to 150 m. The richest deposits occurred near outcrops of "mudstone conglomerate" (Wynyard Tillite) in the Inglis and other rivers. Montgomery postulated that much of the gold could have been derived from boulders (erratics) in the conglomerate or possibly from the mudstone matrix. Auriferous gravel was observed in the Inglis, Calder and Cam Rivers and in Big, Camp and Seabrook Creeks. No production figures are available although Montgomery recorded: "A good deal of gold has been at one time and another obtained from this district, and a few men constantly make a living by sluicing even yet".

IRON

Iron deposits occur in the Blythe River - Cuprona, Natone and Highclere areas.

BLYTHE RIVER - CUPRONA AND NATONE

The Blythe River - Cuprona and Natone deposits appear to be segments of a zone of hematite mineralisation separated by basalt cover. The deposits occur in a Cambrian(?) siliceous siltstone between the Proterozoic Burnie Formation and Ordovician chert and quartzite conglomerate (Gee *et al.*, 1968; Gee, this volume).

History

Early work was concentrated on the Blythe River and Cuprona deposits; the first mining lease was held by R. Quiggin and W. Jones in 1891. This lease was transferred to Blythe River Iron Mines Limited about 1900.

J.H. Darby in 1900 was optimistic about the possibility of using Blythe River ore together with New South Wales ore as the basis of an iron smelting industry and consequently 1000 tonnes of ore were quarried from the northern outcrop (fig. 20) for testing. A tramway was constructed from the deposit to Blythe Heads and a survey for a railway was undertaken.

The company offered the rights of purchase of the property to the Commonwealth Government in 1919, but the report of Boyd, Gibson and Young (1919) downgraded previous estimates of reserves and the lease was relinquished in 1926. Nye (1937) confirmed the findings of Boyd, Gibson and Young.

Early estimates of reserves were:

Montgomery (1894)	30 million tons
Darby (1900)	24.5 million tons
Twelvetrees (1901)	17-23 million tons
Boyd, Gibson and Young (1919)	9 million tons

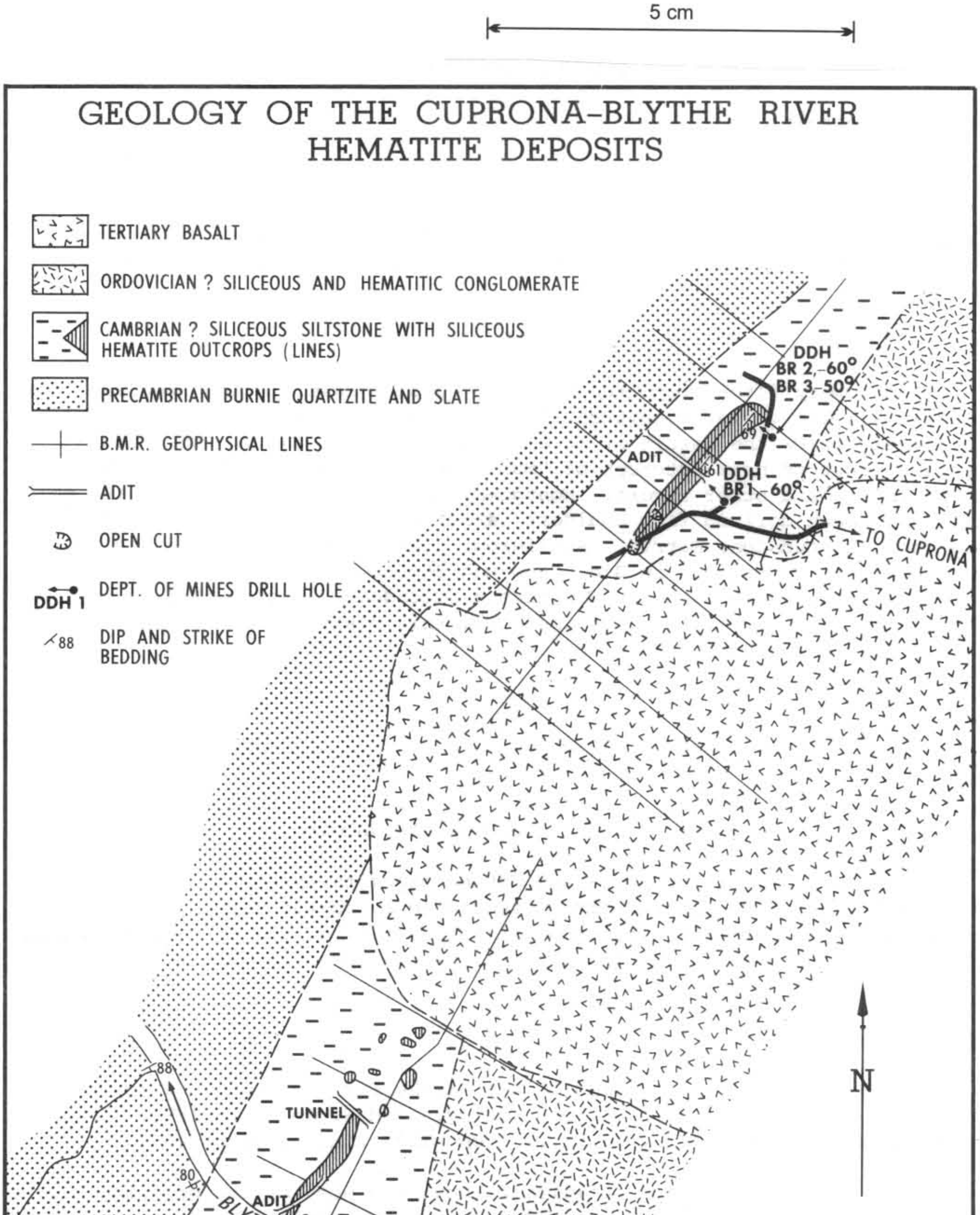

5 cm
GEOLOGY OF THE CUPRONA-BLYTHE RIVER HEMATITE DEPOSITS
TERTIARY BASALT
ORDOVICIAN ? SILICEOUS AND HEMATITIC CONGLOMERATE
CAMBRIAN ? SILICEOUS SILTSTONE WITH SILICEOUS HEMATITE OUTCROPS (LINES)
PRECAMBRIAN BURNIE QUARTZITE AND SLATE
B.M.R. GEOPHYSICAL LINES
ADIT
OPEN CUT
DDH 1
DEPT. OF MINES DRILL HOLE
88
DIP AND STRIKE OF BEDDING
DDH
BR 2, 60°
BR 3, 50°
ADIT
DDH
BR 1, 60°
TO CUPRONA
TUNNEL
ADIT
BLYTHE RIVER
ADIT
ADIT
PURPLE CRAG
EASTERN CRAG
88
80
70
57
50
62
N
GEOLOGIST: G.R.GREEN 1977
Compiled from Blake (1958*d*)
Noldart (1966)
Gee *et al.* (1968)
0 100 200 300
METRES
TASMANIA DEPARTMENT OF MINES, JANUARY 1977

Figure 20.

The only subsequent activity has been the quarrying of 2555 tonnes of ore at Cuprona in 1940-41, by the Australian Commonwealth Carbide Company for ferro-silicon manufacture at Electrona (Thomas and Henderson, 1943*a*, Blake, 1958*d*).

Following aeromagnetic surveys over the iron deposits of north-western Tasmania by the Bureau of Mineral Resources (Goodeve, 1955; Parkinson, 1956), ground magnetic surveys were undertaken on the Blythe River, Natone and Highclere deposits (Keunecke, 1959), with follow-up geological investigations by the Department of Mines (Blake, 1958 *a,b,d,*). Subsequently three diamond drill holes were completed at Cuprona (Noldart, 1966) the results confirming the pessimistic views of earlier writers. Present exploration in the Blythe River - Cuprona and Natone districts is being undertaken by Tasminex N.L.

The Natone deposit was initially examined by J.S. Rutherford, about 1900, who sank a 15 m deep shaft. J. Linell Cook (Holdings Pty Ltd) further worked the deposit in 1938 by shaft sinking and trenching. Following a private geophysical survey, two vertical holes about 22 m long were drilled by the Department of Mines, but these failed to intersect any large scale mineralisation.

Woolnough (1939), the Commonwealth Geological Advisor, stated that a major deposit did not exist at Natone but Ferrico Pty Ltd continued exploration in 1940-41.

Subsequent departmental reports by Thomas and Henderson (1943*a*) and Blake (1958*b*) showed that the deposits at Natone were limited in extent. Keunecke (1959) carried out a magnetic survey and found significant anomalies along the strike south-west of the shafts sunk by Rutherford. Keunecke recommended six drill holes to explore the anomalies, but no further work was undertaken. Another magnetic survey was carried out at Natone by Eadie (1964), with similar results.

Geology

The Natone and Blythe River - Cuprona deposit is a NNE-trending hematite-jasper-quartz body, in part overlain by Tertiary basalt. The mineralisation is localised in Cambrian(?) siltstone between the Burnie Formation and Ordovician conglomerate. At Cuprona, the conglomerate contains pebbles of hematite and jasper immediately above the iron deposit. Veins of specular hematite also occur in the conglomerate.

Montgomery (1894) considered the deposits to be of syngenetic origin due to the conformity of the deposit with the host rock. Later authors (Twelvetrees, 1901; Twelvetrees and Reid, 1919; Boyd, Gibson and Young, 1919; Nye, 1937; Blake, 1958*b*, 1958*d*) have regarded them as replacement deposits associated with Devonian granite.

Gee (*in* Noldart, 1966) postulated a syngenetic model of hematite genesis based on the stratiform nature of the mineralisation and the hematite clasts in the overlying conglomerate. More recently Gee (this volume) considered that the deposits were formed by replacement of the Cambrian(?) siltstone prior to the deposition of Ordovician conglomerate.

In polished section the hematite consists of fine, subparallel lamellae which are occasionally folded and associated with intermittent coarser recrystallised plates, supporting the belief that the hematite was deposited before the Tabberabberan Orogeny.

Gee's evidence for a replacement origin of a fine lamination in the massive hematite, as also recorded by Montgomery (1894), and the occurrence of fine hematite in laminae of the siltstone are considered to be equally indicative of surface precipitation originating from ascending solutions of unknown origin. Bands of coarse specular hematite both in the iron formation and Ordovician conglomerate are probably a result of tectonic remobilisation and recrystallisation.

HIGHCLERE

A small iron deposit occurs within the Burnie Formation, 1.6 km east of Highclere, immediately to the west of the Housetop Granite contact. Previous geological reports on the deposit include those by Thomas and Henderson (1943*a*), Blake (1958*a*) and Jack (1965*a*). A ground magnetic survey was performed by the Bureau of Mineral Resources (Keunecke, 1959) in which four major magnetic anomalies were detected, three of which were investigated by diamond drill holes drilled by the Department of Mines (Jack, 1965*a*). The drilling results showed small high grade patches of ore totalling some 27 000 tonnes of 55-60% Fe occurring within a larger, lower grade area of mineralisation containing possibly 250 000 tonnes of 30% Fe (Jack, 1965*a*). Minor tungsten mineralisation occurs with the iron oxides.

Geology and genesis

Deep weathering has obscured most of the critical features of the geology with only scattered boulders of massive hematite, occasionally containing minor quartz, remaining on the surface. The host rock recovered in the diamond drill core is a brown, highly weathered limonitic clay (Jack, 1965*a*) with small patches of a bright green material which may be weathered epidote. In polished section the iron oxide forms a mosaic of interlocking, idiomorphic grains, consisting of an internal array of intersecting hematite 'needles' suggesting a replacement of magnetite along the (111) crystallographic plane. The occurrence of minor tungsten in the deposit and the textural contrast with the Blythe River and Natone hematite, suggests that the Highclere deposit is of contact metasomatic origin as previously believed.

The deep weathering of the host rock precludes identification of its nature, but a thinly bedded, pure limestone occurs within the Burnie Formation in the Guide River, 1.6 km south of the Guide Falls; such carbonate-bearing horizons are favourable hosts for the Highclere type of mineralisation.

MANGANESE

Minor manganiferous oxides occur at the northern end of the Natone hematite mineralisation and Jack (1965*b*) records 16% Mn and 36% Fe from a grab sample of scree. A chip sample taken along a 5.5 m section in a road cutting assayed at 24% Mn and 38% Fe. The mineralisation is in the surface weathered zone and is unlikely to be of economic importance due to its patchy oocurrence.

COPPER

Small copper deposits occur sporadically within the Burnie Formation at Natone (Rutherford's prospect, Woodstock) and Cuprona (Copper King Mine). The deposits are restricted to a zone approximately 500 m west of the iron formation.

COPPER KING MINE

History

The mine is situated about 2 km west of Cuprona where lease 915M of 25 ha was taken out in 1904 by L.J. Clark and C. Sice. In 1905 the lease was transferred to an Adelaide company and by 1907 the main shaft had been sunk to a depth of 45 m. The mine closed in September, 1908, but was later taken over by a small Burnie syndicate. They extended the shaft to a depth of 78 m and worked a shoot or ore to the south. The ore was reported as pinching out at depth and the mine finally closed in 1909. A total of 1314 tonnes of concentrate, with an average grade of 16.7%, were shipped during the period 1904-1909. Intermittent prospecting has occurred since closure.

Geology

In the mine area (anon., 1968) the Burnie Formation strikes north-east and dips east at between 45° and 80°. The pyrite-chalcopyrite ore occurs mainly in vertical E-trending quartz veins within massive quartzite in a NE-trending zone 9 m in width. Elsewhere chalcopyrite and pyrite occur in veins and patches of quartz-siderite gangue within slate. Smaller copper prospects occur intermittently north-east and south-east of the Copper King Mine and as far north as Heybridge (Twelvetrees, 1906).

In polished section the ore consists of euhedral pyrite embedded in a matrix of chalcopyrite and gangue. Evidence of deformation is provided by the common cataclastic brecciation with the fractures healed by remobilised (?) chalcopyrite.

Twelvetrees (1903) attributed the mineralisation to the Devonian granite and later Twelvetrees and Reid (1919) remarked that: "...there appears to have been a deposition of copper along parallel lines, and wherever the iron development is strong the parallel copper deposition is also pronounced. At the northern end of the iron lode the hard siliceous contact-rock is sparsely impregnated with specularite, iron, and copper pyrites. This strengthens a supposition that the deposition of both iron and copper ores formed part of one and the same physical process".

In view of this a Cambrian age for the copper and also the iron mineralisation must be considered.

Four holes drilled by the Department of Mines in 1969 failed to intersect any significant mineralisation, with the exception of a section of 0.75 m of 0.48% Cu in Hole No. 1 and 0.3 m of 2.63% in Hole No. 2.

RUTHERFORD'S MINE AND WOODSTOCK PROSPECT

The deposits are situated approximately 200 m north-west of Natone in the headwaters of Chasm Creek. Rutherford's Mine was discovered in 1900 and Twelvetrees (1906) reported that the lodes were being worked from a drive and a shaft, and that 69 tonnes of ore had been recovered. Three years later, funds had been exhausted and a total of 100 tonnes of ore averaging 10% Cu had been produced.

Further prospecting at the Woodstock prospects occurred in the early 1940s consisting of two adits and a small shaft some 100 m north of Rutherford's original shaft (Henderson, 1941; Nye, 1941; Thomas and Henderson, 1943*b*), but little or no ore was recovered.

5 cm

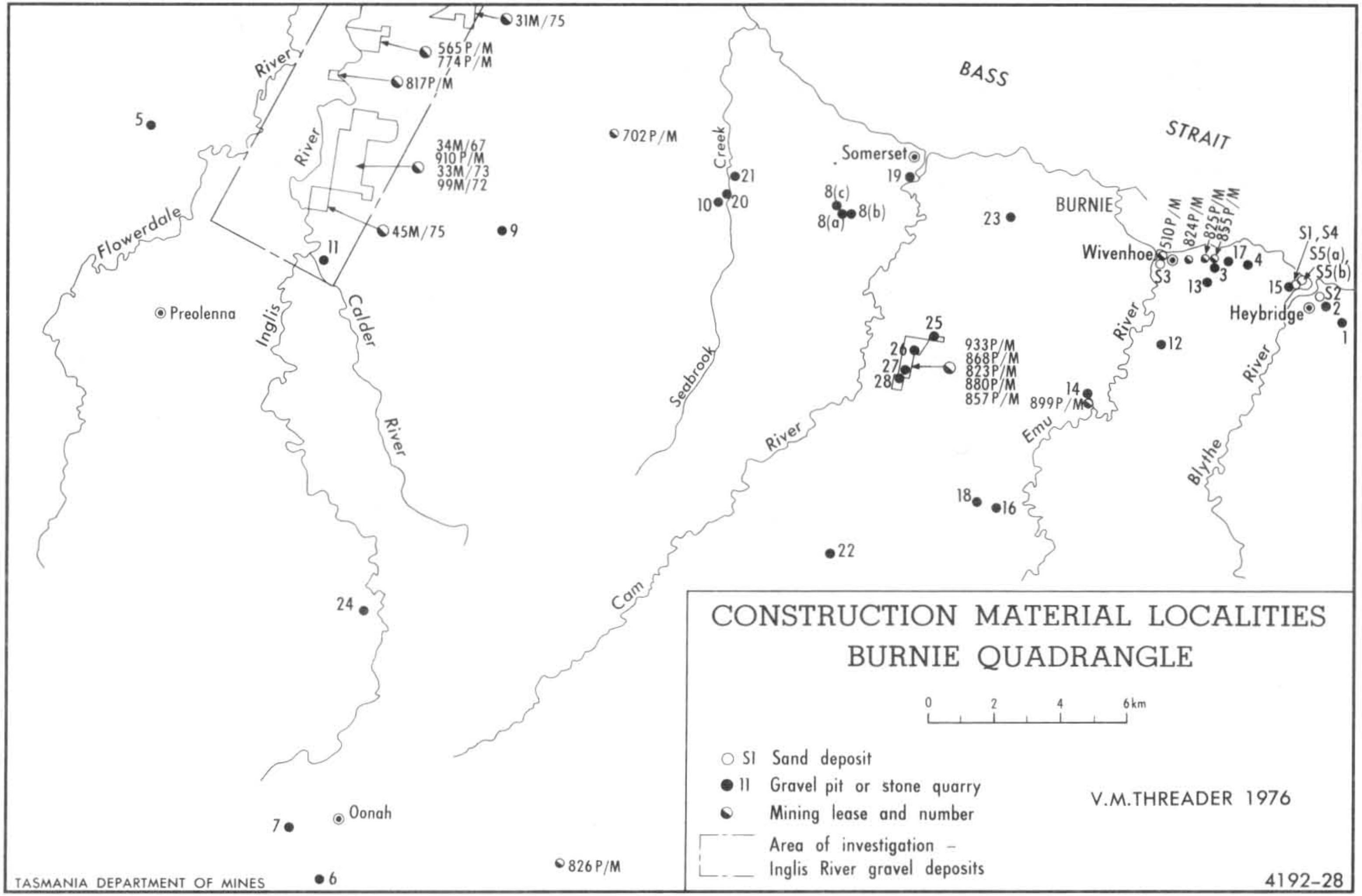


Figure 21.

Geology

The deposits are similar to those of the Copper King Mine, and consist of isolated veins of quartz containing pyrite and chalcopyrite. The veins penetrate quartzite and slate of the Burnie Formation within a 100 m wide NE-trending zone.

The lodes near the surface are capped with limonitic gossan and in the shallow adits Nye (1941) recorded supergene alteration with bleaching of the slate adjacent to the lodes and development of secondary covellite and sulphate.

The lodes are generally narrow and discontinuous, ranging in strike from 40° to 320° and dipping steeply west. Thomas and Henderson (1943*b*) reported a 4.6 m wide section in the underground workings. The lodes are cut by faults and are reported to cross-cut folds in the Burnie Formation (Thomas and Henderson, 1943*b*) and thus post-date the Penguin Orogeny.

Chip samples of lode material collected by Nye, Thomas and Henderson showed a range in copper content from 1.5 to 3.1%.

The small size and irregularity of the vein systems indicate that further prospecting is not warranted under present conditions.

Non-Metallic Minerals

V.M. Threader

COAL

Production of coal in the Burnie Quadrangle was centred on the Preolenna coal fields, about 20 km south-west of Wynyard. At Preolenna, four thin seams of coal may be correlated with the Mersey Coal Measures of Latrobe and Illamatha. These seams have previously been correlated with the Greta Coal Series of New South Wales but are now thought to be Sakmarian/Artinskian in age and so predate the Greta Coal Series which is Artinskian in age (Clarke and Banks, 1975). Hills *et al.* (1922) considered that the Cygnet Coal Measures were also present in the area, and that these could be correlated with the Tomago Coal Measures of New South Wales (Tatarian), but their presence has not been confirmed.

The four seams crop out in the Flowerdale River valley over a distance of about 3 km and range in thickness from 0.2-0.6 metres. Hills *et al.* (1922) estimated reserves at 5 million tonnes. The coal has a lower ash content than the Triassic coals of Tasmania, but a higher sulphur content, volatile content and calorific value. A typical analysis (Hills *et al.*, 1922) of Preolenna coal is:

			%
Volatiles	32.46%	S	5.87
Fixed carbon	52.30%	H	5.30
Ash	13.72%	C	65.34
Moisture	1.52%	O	8.16
SG	1.25	N	1.61
Calorific value	28.3 MJ/kg		

The presence of coal was noted by Montgomery in 1896 from fragments in the river gravels. This discovery led to the eventual opening up of the field, but progress was hampered by poor access. A railway was constructed from Flowerdale to Preolenna in 1917 and was extended a further 7 km to Maweena in 1924. Coal was actively mined in the period 1918-1928 with a

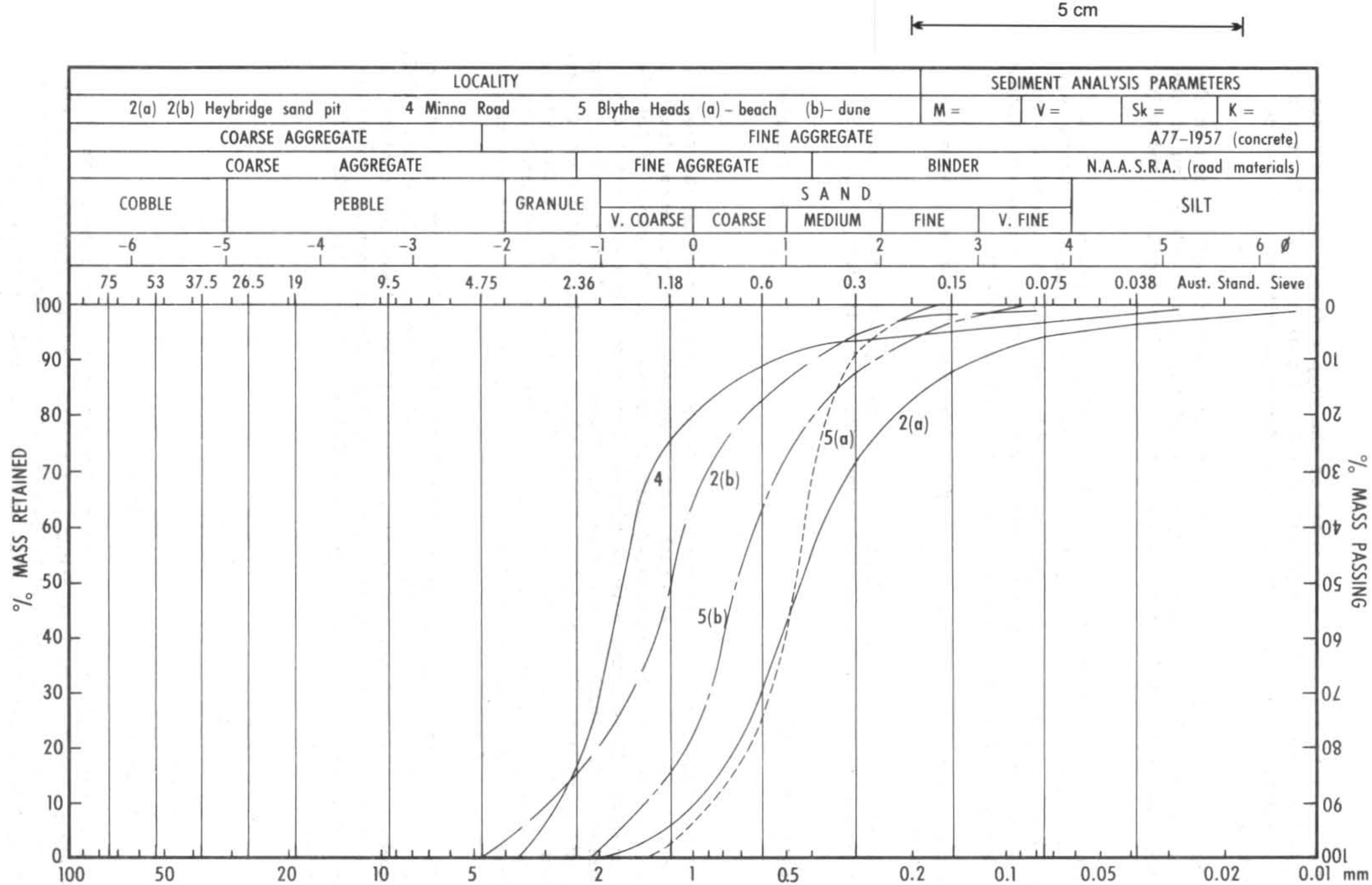


Figure 22. *Grading curves, Blythe River sand deposits.*

recorded production of 1370 tonnes. Most of the coal production was used by the cement works at Railton but the thin seams were uneconomic to work. Brief interest was shown in the coal as a source of oil during the 1939-1945 war but this venture was also uneconomic. The coal fields are at present held under exploration licence.

OIL SHALE

Small deposits of Tasmanites oil shale occur near Oonah [643227]. Henderson (1944) described the occurrence as being too small and of too low a yield to be of economic importance.

FINE AGGREGATE

Sand is currently being mined at several places within the quadrangle (table 3). The localities of old and currently operating quarries are shown in Figure 21.

Inglis River

White quartz gravel of pre-basaltic age occurs in the valleys of the Flowerdale, Inglis and Cam Rivers and Seabrook Creek. The largest deposit occurs in the Inglis River area and is the principal source of concrete aggregate for the Burnie area and a major source of road-making materials. This deposit is currently being investigated by the Department of Mines and a preliminary report is given in Appendix 1.

Determination of the gravel:sand:mud ratio of each sample, the textural classification of the whole sample and the mean diameter of the sand fraction has been made. These results are listed in Table 4 and show that sand with a medium-coarse mean grain size is a major constituent of these gravels.

Total sand reserves from this deposit are not known, but will be estimated on completion of the study.

Blythe Heads

An extensive sand deposit borders the Blythe River at Heybridge (fig. 21-S2). The Public Works Department works a pit which supplies sand for hot mix sealants for roads. A smaller worked out pit lies on the west bank of the river near Minna Road. The deposits are remnants of former terraces and extend up to 15 m above river level.

On the west bank of the river at Blythe Heads, approximately 100 m of dune sand and an equal width of coarse beach berm sand (S5b and S5a) have been worked in the past. It would be preferable if future operations outside the main Heybridge working area were confined to the old Public Works Department pit at Minna Road (S1) and the partly worked out dune area. Such operations, under supervision, should result in rehabilitation of these two areas. Limited amounts of sand could be won from the beach above high water mark, as this area is probably replenished naturally, but it would be better to prohibit mining in this area due to difficulties in controlling the operations. Grading curves for sand at Blythe Heads are given in Figure 22.

Wivenhoe

A small deposit of fine silica sand occurs near the Emu River at Wivenhoe (S3). This sand was formerly marketed as an abrasive but the deposit has been built over and is no longer available for mining. The sand was formed by mechanical breakdown of Precambrian siltstone and similar material may occur in the river banks further upstream.

Table 2. SIZING ANALYSIS AND PHYSICAL PROPERTIES OF CONSTRUCTION MATERIALS, BURNIE QUADRANGLE

No.*	AMG† Reference	Locality	Sizing Analysis Cumulative % passing (*mm*)												
			37.5	26.5	19	9.5	4.75	2.36	1.18	0.6	0.425	0.3	0.15	0.075	0.038
1a	DQ156510	Heybridge		100	98	88	71	62			48			31	
1b	DQ156510	Heybridge		100	99	85	62	48			30			15	
1c	DQ156510	Heybridge		100	96	73	48	35			22			9	
1d	DQ156510	Heybridge		100	98	77	53	40			24			11	
2	DQ150516	Heybridge	100	99	95	81	54	48			35			22	
3a	DQ115527	Round Hill													
3b	DQ115527	Round Hill	100	97	94	74	56	48			28			17	
4	DQ125528	Round Hill	100	98	94	80	65	56			45			36	
5	CQ782565	Lapoinya													
6	CQ838331	Oonah													
7	CQ828347	Oonah													
8a	CQ998541	Murchison Highway													
8b	DQ000541	Murchison Highway													
8c	CQ996543	Murchison Highway													
9	CQ893535	Oldina													
10	CQ960544	Lower Mt Hicks													
11	CQ835524	Calder	100	98	86	59	21	7			2			1	

*Pit locations on Burnie Construction Materials map (fig. 21)
†For ANG reference see opposite page.

Table 2. (continued)

No.*	ANG‡ Reference	Locality	Dust Ratio	Liquid Limit	Plasticity Index	Linear Shrinkage	Pit State	Remarks
1a	39/996397	Heybridge	0.66	18	0.2	1	D	
1b	39/996397	Heybridge	0.48	17	0	-	D	
1c	39/996397	Heybridge	0.40	NP	NP	NP	D	
1d	39/996397	Heybridge	0.46	14	0	-	W	
2	39/990403	Heybridge	0.64	26	9	4.5	D	
3a	39/952416	Round Hill	0.77	39	21	9.5	W	Burnie slate and quartzite.
3b	39/952416	Round Hill	0.62	27	9	4	?	
4	39/962417	Round Hill	0.79	23	7	3	W	
5	39/588462	Lapoinya					W	
6	39/646205	Oonah					D	
7	39/635222	Oonah					W	
8a	39/824433	Murchison Highway					D	
8b	39/826433	Murchison Highway					D	Quartz gravel.
8c	39/822435	Murchison Highway					D	
9	39/709427	Oldina					W	
10	39/782436	Lower Mt Hicks					W	Burnie slate and quartzite.
11	39/645416	Calder	0.7	29	12	7	D	

*Pit locations on Burnie Construction Materials map (fig. 21)
‡For AMG reference see opposite page.
xD = Disused, W = Working, N = New site.

Table 2. (continued)

No.*	AMG† Reference	Locality	Sizing Analysis Cumulative % passing *(mm)*												
			37.5	26.5	19	9.5	4.75	2.36	1.18	0.6	0.425	0.3	0.15	0.075	0.038
12	DQ098502	Fernglade Rd	79	67	59	44	33	26			17			11	
13	DQ112522	Round Hill Lookout	63	49	36	26	21	18			14			10	
14	DQ076484	Cascades Rd	67	56	42	34	25	24			18			10	
15	DQ141521	Heybridge	72	64	57	44	31	26			17			10	
16	DQ048451	Darling Falls	83	72	60	48	38	33			22			17	
17	DQ119529	Round Hill	70	64	58	48	41	35			25			17	
18	DQ042452	Ridgley													
19	DQ018552	Somerset	68	54	47	35	29	24			17			10	
20	CQ963546	Lower Mt Hicks			100	98	92	69			27			22	
21	CQ963550	Lower Mt Hicks	91	80	71	65	54	47			29			18	
22	CQ996436	West Ridgley Rd	100	86	77	64	49	39			26			20	
23	DQ051541	Parkgrove													
24	CQ851415	Takone													
25	DQ024501	West Mooreville Rd													
26	DQ019498	West Mooreville Rd													
27	DQ014491	West Mooreville Rd													
28	DQ014490	West Mooreville Rd													

*Pit locations on Burnie Construction Materials map (fig. 21)
†For ANG reference see opposite page.

Table 2. (continued)

No.*	ANG‡ Reference	Locality	Dust Ratio	Liquid Limit	Plasticity Index	Linear Shrinkage	Pit State x	Remarks
12	39/933389	Fernglade Rd	0.62	26	17(?)	4	W	
13	39/948410	Round Hill Lookout	0.71	29	10	4	D	
14	39/908369	Cascades Rd	0.56	-	-	-	D	Burnie slate and quartzite.
15	39/980409	Heybridge	0.58	29	8	6	N	
16	39/877333	Darling Falls	0.78	44	19	9	W	
17	39/956418	Round Hill	0.69	23	7	5	W	
18	39/871335	Ridgley					D	Crushed basalt.
19	39/846444	Somerset	0.57	29	10	5	W	Burnie slate and quartzite.
20	39/785438	Lower Mt Hicks	0.79	-	-	-	D	Quartz gravel.
21	39/786443	Lower Mt Hicks					W	
22	39/820318	West Ridgley Rd	0.75	35	15	8	W	Burnie slate and quartzite.
23	39/882432	Parkgrove					D	
24	39/661297	Takone					D	
25	39/852388	West Mooreville Rd					W	
26	39/846385	West Mooreville Rd					W	Crushed basalt.
27	39/841378	West Mooreville Rd					W	
28	39/841377	West Mooreville Rd					W	

*Pit locations on Burnie Construction Materials map (fig. 21)
‡For AMG reference see opposite page.
xD.= Disused, W = Working, N = New site.

Table 3. KEY TO MINING LEASES, BURNIE QUADRANGLE

Lease No.*	Locality	Material	Operator
31M/75	Calder	Gravel	J.H. Bugg
33M/73	Calder	Sand, gravel	B.K. Fielding
34M/67	Upper Calder	Stone	Brambles Holdings Ltd
45M/75	Calder	Gravel	L.W. Morris
99M/72	Calder	Gravel	P.M. Voss
510P/M	Wivenhoe	Sand	R.T. Williams
565P/M	Calder	Stone	Brambles Holdings Ltd
702P/M	Mt Hicks	Stone	Brambles Holdings Ltd
774P/M	Calder	Stone	A.J. Stone
817P/M	Calder	Gravel	S. Dyson
823P/M	West Mooreville Rd	Stone	F.W. Grainger
824P/M	Wivenhoe	Sand, gravel freestone	L.G. Holloway
825P/M	Round Hill	Sand, gravel freestone	L.G. Holloway
826P/M	Oonah	Basalt	L.G. Holloway
855P/M	Round Hill	Freestone, gravel	L.G. Holloway
857P/M	Ridgley	Stone	J.L. and E.M. Jones
868P/M	Mooreville Rd	Stone	I.A. and P.P. Young
880P/M	West Mooreville Rd	Basalt	Brambles Holdings Ltd
899P/M	Burnie	Stone	Singline Constructions Pty Ltd
910P/M	Calder	Stone	C.E. and D.E. Beveridge
933P/M	West Mooreville Rd	Stone	Brambles Holdings Ltd

*Lease locations on Burnie Construction Materials map (fig. 21)

COARSE AGGREGATE

Inglis River gravel deposits

The quartz gravel deposit in the Inglis River area is quarried by several operators (fig. 21, table 3). The material is separated into gravel and sand fractions and the gravel is crushed to meet standard specifications for concrete aggregate and blended, again according to specification, with sand for ready-mixed concrete. Some gravel is used, as mined, as an 'all-in' aggregate for domestic purposes. The gravel is also used as road-making aggregate, but is lacking in fine aggregate and binder for good compaction and should be blended to overcome these deficiencies. A detailed discussion of the Inglis River gravel deposits is given in Appendix 1.

Burnie slate and quartzite

These Precambrian rocks form the bedrock in the Burnie area. They were almost completely covered by basalt during the Tertiary except for a few isolated higher hills (*e.g.* Round Hill). Most of the rivers in the area have cut down through the basalt and re-exposed bedrock, as can be seen in the valleys of the Flowerdale, Inglis, Cam, Emu and Blythe Rivers and Seabrook Creek.

The slate and quartzite has been extensively used throughout the Quadrangle as a road-making aggregate. There are about twenty existing quarries (fig. 21, table 2).

These rocks generally make a low to medium quality aggregate which tends to have an excessive fines content and a high plasticity (table 2).

The material is fairly uniform but differs between quarries in the degree of weathering and also in the slate:quartzite ratio.

The quarrying of this material in the Burnie area was discussed by Threader (1975) for the purpose of assessing the importance of the Round Hill quarries, the existence of which is objected to on environmental grounds. It should not be difficult to find alternative sites in similar rock if the Round Hill quarries are to be closed down and an investigation of possible sites should be undertaken.

Tertiary basalt

Basalt is widespread throughout the Burnie Quadrangle and several quarries on West Mooreville Road are in continuous operation (fig. 21). These quarries yield fresh rock which is crushed and used for road sealing aggregate and concrete making. None of the quarries exceeds 15 m in depth and none has as yet penetrated the full basalt thickness. There is an overburden of 1-2 m of decomposed material which has some application as a road-making material but it tends to have a high plasticity.

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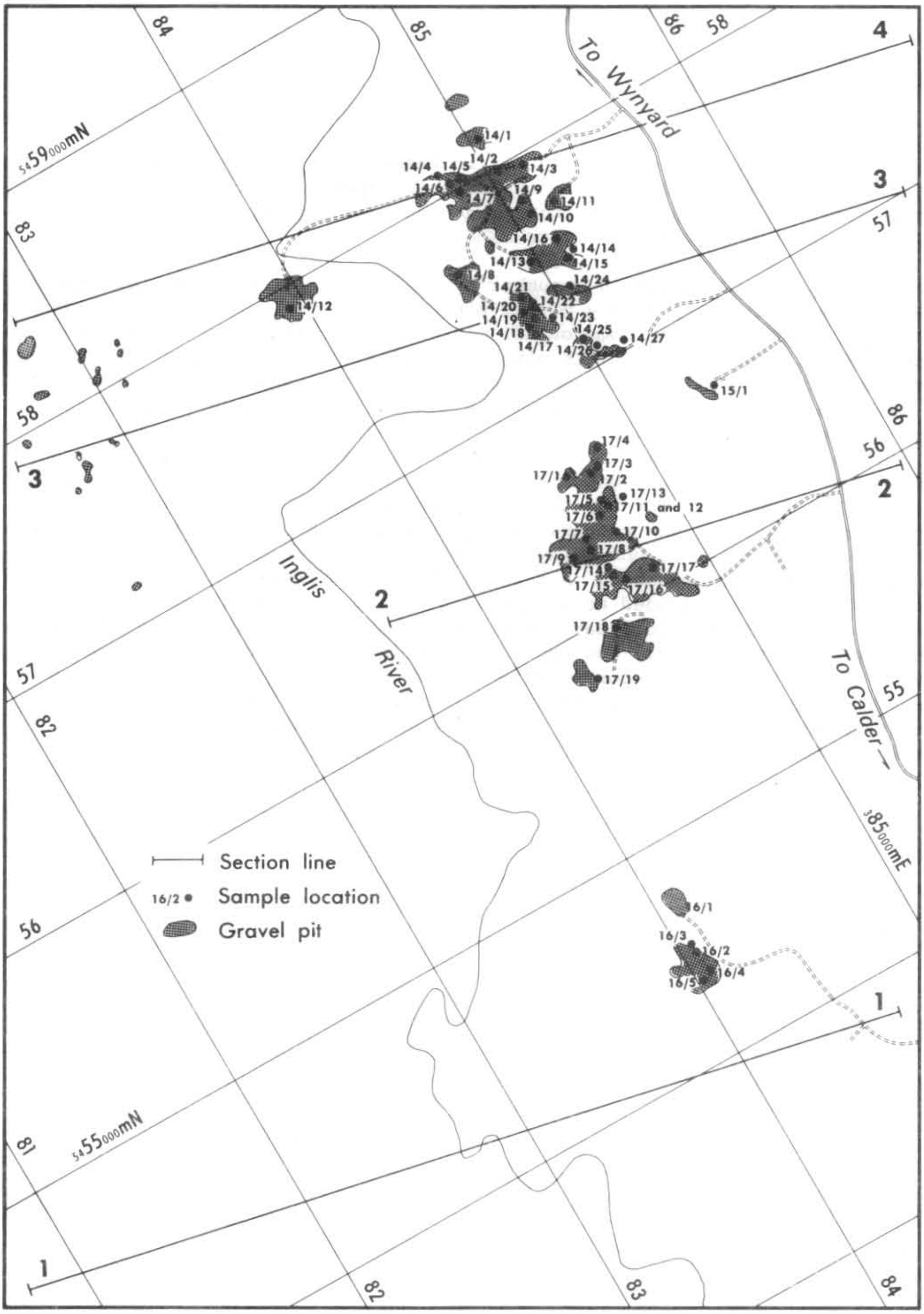
APPENDIX 1

Inglis River gravel deposits, Flowerdale

V.M. Threader

The largest quartz gravel deposit in Tasmania occurs in the Inglis River valley. This deposit is of considerable importance to industry in the Burnie district, as it supplies concreting and road aggregates, hot mix sealants for roads and sand for concrete blocks.

The deposit is worked in a number of mining leases and Lands Department licences. A preliminary survey of the mining tenements has been made (figs 23-26) and a sampling programme of all workings was carried out in the summer of 1974-75. The sample points were numbered according to quarry, with a second number designating the sample point within the quarry and a letter for the individual sample in each channel. Sizing analyses (table 4, on microfiche in pocket) were carried out by the Department of Mines Laboratories. The gravel: sand: mud ratio for each sample is given, together with the mean diameter of the gravel and sand fractions and the appropriate term in common usage. A weighted mean for the total samples in each channel of samples is also given to indicate the probable distribution in the total section. Where a portion of the total is obviously unusable it has been excluded from the calculation where practicable. A ternary diagram indicating the types of sediment present is included as a general guide to the overall composition (fig. 27). Individual plots have also been prepared for each quarry so that each sample can be plotted, and these will be included in a further report. Further investigation will concentrate on some promising areas not yet examined, probably by resistivity survey and test drilling of any areas with positive results. An estimate of reserves and a recommended plan for the control of future mining operations will complete the survey.



INGLIS RIVER GRAVEL DEPOSITS
Southern area

Figure 23.

5 cm

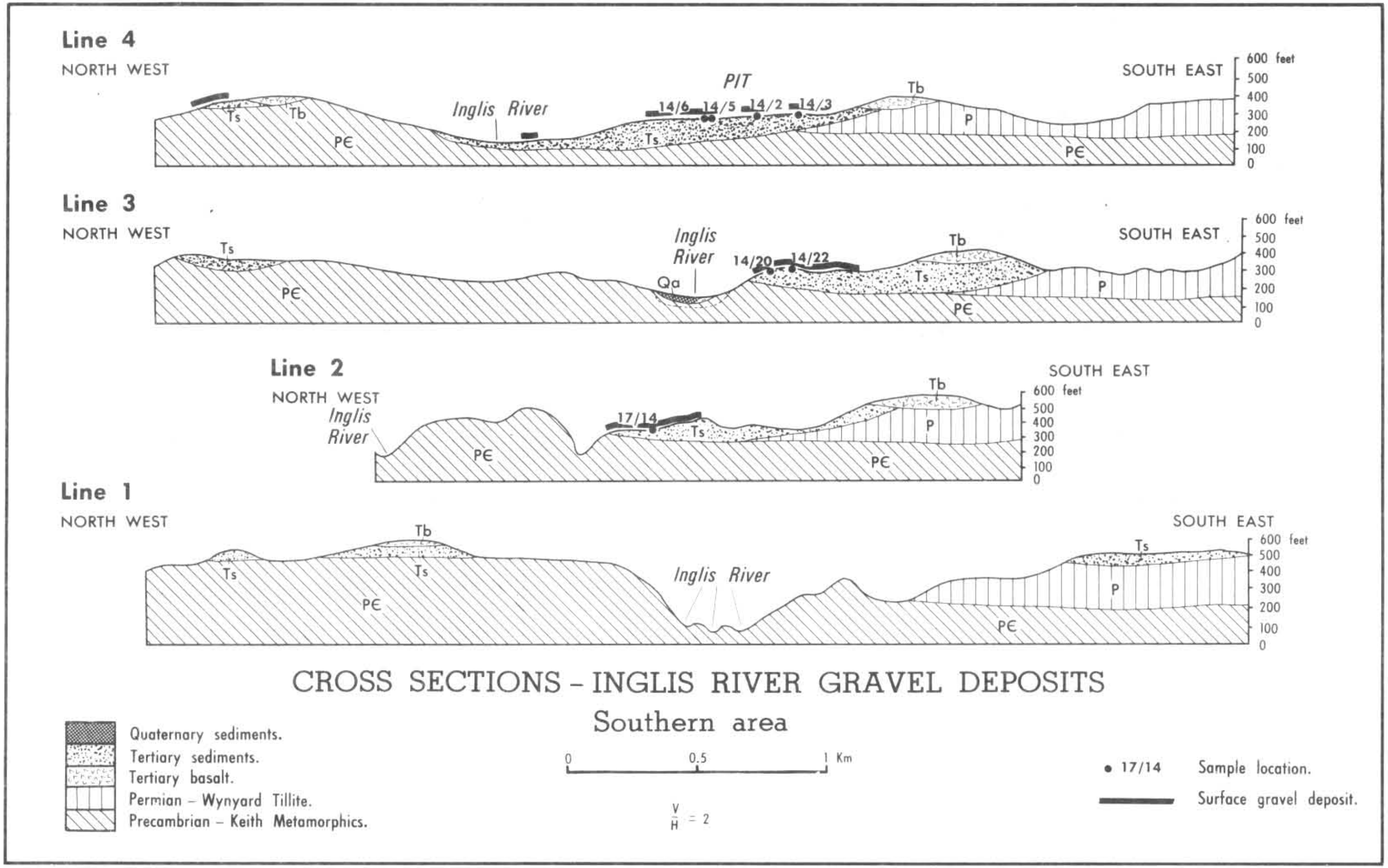
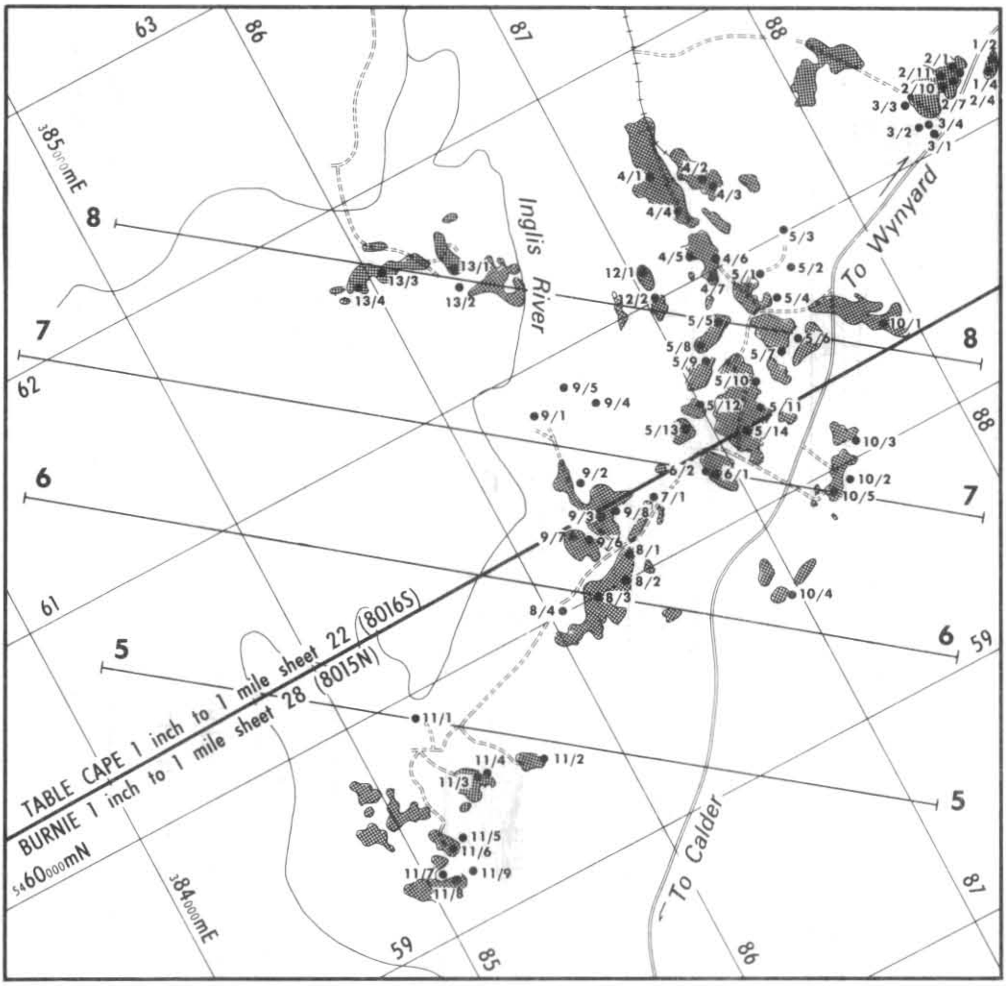


Figure 24.



INGLIS RIVER GRAVEL DEPOSITS

Northern area

0 — 1000 metres

Section line
10/2 • Sample location
Gravel pit

Figure 25.

5 cm

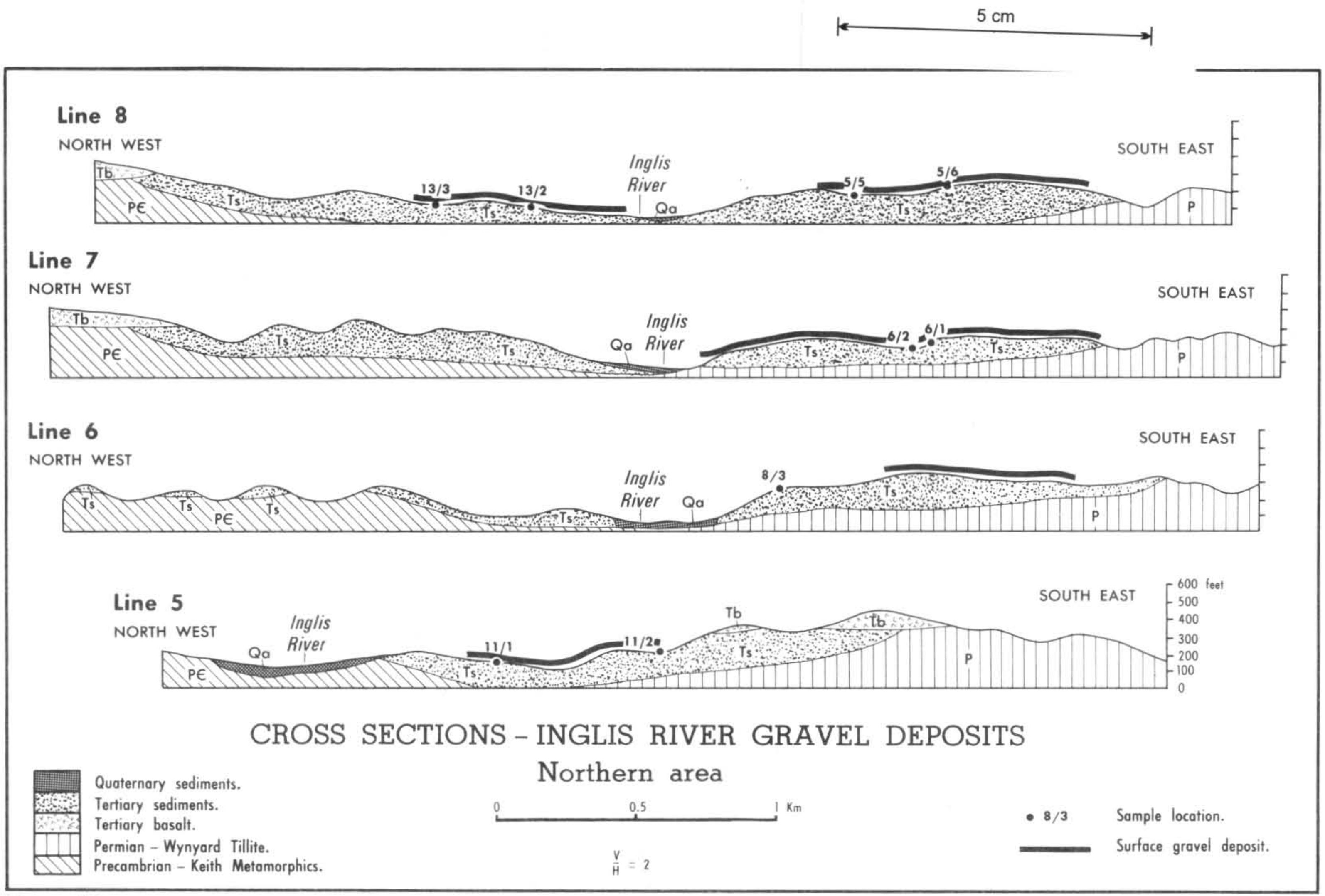
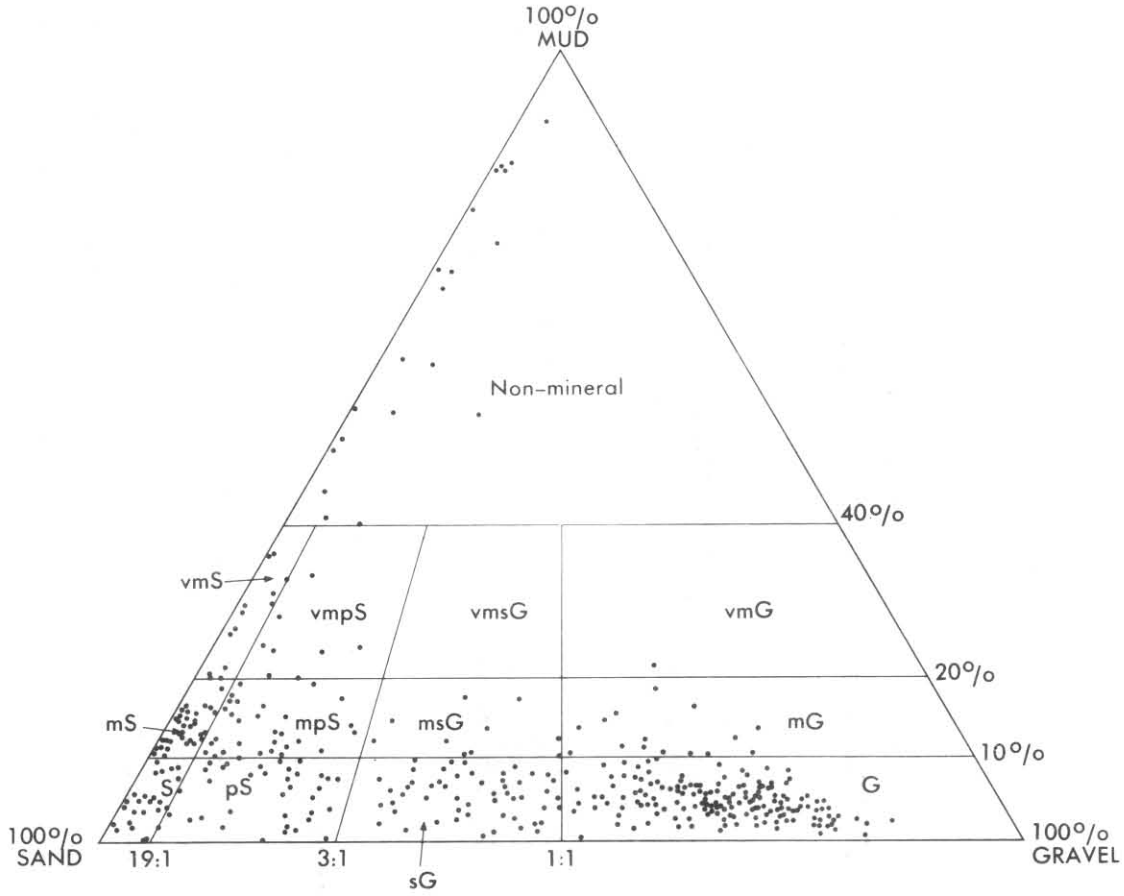

5 cm
Line 8
NORTH WEST
SOUTH EAST
Inglis River
Tb
PЄ
Ts
Qa
P
13/3
13/2
5/5
5/6
Line 7
NORTH WEST
SOUTH EAST
Inglis River
6/2
6/1
Line 6
NORTH WEST
SOUTH EAST
Inglis River
8/3
Line 5
NORTH WEST
SOUTH EAST
Inglis River
11/1
11/2
600 feet
500
400
300
200
100
0
CROSS SECTIONS - INGLIS RIVER GRAVEL DEPOSITS
Northern area
Quaternary sediments.
Tertiary sediments.
Tertiary basalt.
Permian - Wynyard Tillite.
Precambrian - Keith Metamorphics.
0
0.5
1 Km
V/H = 2
8/3 Sample location.
Surface gravel deposit.

Figure 26.



vmS	very muddy sand	msG	muddy sandy gravel
vmpS	very muddy pebbly sand	mG	muddy gravel
vmsG	very muddy sandy gravel	S	sand
vmG	very muddy gravel	pS	pebbly sand
mS	muddy sand	sG	sandy gravel
mpS	muddy pebbly sand	G	gravel
Non-mineral	unsuitable for use as aggregate		

Figure 27. *Classification of samples, Inglis River gravel deposits.*

5 cm

APPENDIX 2

Transformation of grid references

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

ANG 100-yard reference	*AMG 100-metre reference*	*ANG 100-yard reference*	*AMG 100-metre reference*
39/483476	CQ686577	39/848457	DQ020564
39/544246	CQ744368	39/882286	DQ053408
39/555160	CQ754289	39/890450	DQ058558
39/555240	CQ754362	39/905447	DQ072555
39/557413	CQ755521	39/909445	DQ076553
39/562354	CQ760466	39/915441	DQ081550
39/570280	CQ768399	39/928302	DQ095423
39/571223	CQ769347	39/931421	DQ096532
39/636492	CQ826593	39/934416	DQ099527
39/641235	CQ831358	39/945420	DQ109531
39/641418	CQ831526	39/955417	DQ118528
39/641428	CQ831535	39/957334	DQ121452
39/643227	CQ835351	39/965422	DQ127533
39/761445	CQ941552	39/980414	DQ141526
39/774317	CQ954435	39/986412	DQ147524
39/784322	CQ963440	39/998256	DQ159381
39/802487	CQ978591	49/011396	DQ170510
39/806483	CQ981587	49/026386	DQ183501
39/810477	CQ985581		

Table 4, SIZING ANALYSIS, INGLIS RIVER GRAVEL DEPOSITS.

Sample	Reg. No.	AMG Reference *ANG Reference*	Thickness *(m)*	% Gravel	% Sand	% Mud	Texture*	Mean diameter: Gravel fraction *(mm)*	†	Mean diameter: Sand fraction *(mm)*	†
1- 2a	740060	88796123	0.81	67.7	27.3	5.0	G	13	P	0.57	C
2b	740061	*70425119*	0.69	71.2	23.0	5.8	G	18.4	P	0.47	M
2c	740062		0.58	37.3	54.9	7.8	sG	10	P	0.47	M
2d	740063		1.27	1.2	92.5	6.3	S	3.2	G	0.11	M
		Total	3.35								
		Weighted mean:		37.95	55.91	6.1	sG	8	P	0.41	M
1- 4a	740064	88776120	0.76	57.0	41.3	1.7	G	12.1	P	0.76	C
4b	740065	*70395116*	0.91	60.8	31.7	7.5	G	14.9	P	0.52	M
4c	740066		2.13	3.3	91.2	5.5	S	14.9	P	0.33	M
		Total	3.80								
		Weighted mean:		27.8	67.0	5.2	sG	13.9	P	0.47	M
2- 1a	740067	88666127	1.72	57.9	37.2	4.9	G	6	P	0.5	M
1b	740068	*70275124*	0.99	43.5	53.5	3.0	sG	13	P	0.66	C
1c	740069		0.23	1.4	95.8	2.8	S	3.2	G	0.57	M
1d	740070		0.76	45.8	51.7	2.5	sG	7.5	P	0.71	C
		Total	3.70								
		Weighted mean:		48.0	48.2	3.8	sG	7.5	P	0.57	M
2- 4a	740071	88666124	1.91	55.7	33.1	11.2	mG	10	P	0.47	M
4b	740072	*70275120*	0.59	14.2	31.7	54.1	NM	3.2	G	0.38	F
4c	740073		1.22	30.0	66.0	4.0	sG	10	P	0.76	C
4d	740074		0.96	4.0	91.4	4.6	S	3.2	G	0.66	C
		Total	4.68								
		Weighted mean:		33.2	53.5	13.3	msG	7	P	0.44	M

*See Figure 25.

†Descriptive terms: P = pebble, G = granule, C = coarse, M = medium, F = fine, VF = very fine.

Table 4. (continued)

Sample	Reg. No.	AMG Reference *ANG Reference*	Thickness (m)	% Gravel	% Sand	% Mud	Texture*	Mean diameter: Gravel fraction (mm)	†	Mean diameter: Sand fraction (mm)	†
2- 7a	740075	88636123	2.01	52.8	34.4	12.8	mG	9.2	P	0.5	M
7b	740076	*70245119*	3.25	22.5	72.6	4.9	pS	5.7	P	0.62	C
7c	740077		0.6	53.1	34.8	12.1	mG	13.9	P	0.47	M
		Total	5.87								
			Weighted mean:	36.1	55.6	8.3	sG	7.5	P	0.5	M-C
2-10a	740078	88586125	0.79	29.0	65.7	5.3	sG	8.6	P	0.66	C
10b	740080	*70195122*	0.74	48.2	44.8	7.0	G	6	P	0.71	C
10c	740081		1.88	27.8	65.1	7.1	sG	4.3	P	0.87	C
10d	740082		0.71	44.8	44.0	11.2	mG	7	P	0.71	C
10e	740083		1.04	0.7	88.6	10.7	mS	3.2	G	0.41	M
		Total	5.16								
			Weighted mean:	24.4	56.5	7.3	msG	4	P-G	0.66	C
2-11a	740084	88586127 *70195124*	1.93	80.7	16.3	3.0	G	12.1	P	0.57	C
3- 1a	740085	88446107	0.91	44.6	53.4	2.0	sG	8.6	P	0.87	C
1b	740086	*70035102*	1.04	63.2	34.6	2.2	G	8	P	0.87	C
1c	740087		0.91	41.7	52.4	5.9	sG	6	P	0.87	C
1d	740088		0.84	1.9	88.6	9.5	S	3.2	G	0.44	M
1e	740089		0.86	23.9	60.7	15.4	msG	8.6	P	0.33	M
		Total	4.56								
			Weighted mean:	36.5	49.7	6.7	msG	4	P-G	0.66	C

*See Figure 25.

†Descriptive terms: P = pebble, G = granule, C = coarse, M = medium, F = fine, VF = very fine.

Table 4. (continued)

Sample	Reg. No.	AMG Reference *ANG Reference*	Thickness *(m)*	% Gravel	% Sand	% Mud	Texture*	Mean diameter: Gravel *(mm)*	Gravel fraction †	Sand *(mm)*	Sand fraction †
3- 2a	740090	88406112	1.75	49.6	46.5	3.9	G	8	P	0.76	C
2b	740091	*69995108*	0.94	55.4	37.9	6.7	G	13.9	P	0.38	M
		Total	2.69								
			Weighted mean:	51.6	43.5	4.9	G	10	P	0.54	C
3- 3a	740092	88406123	1.19	29.3	63.4	7.3	sG	5.3	P	0.81	C
3b	740093	*69995120*	0.48	32.3	58.1	9.6	sG	4.9	P	0.71	C
3c	740094		0.41	30.9	50.7	18.4	msG	5.7	P	0.66	C
3d	740095		0.51	34.5	50.8	14.7	msG	6.5	P	0.44	M
		Total	2.59								
			Weighted mean:	31.1	57.9	10.9	msG	5.3	P	0.57	C
3- 4a	740096	88466113 *70055109*	2.54	54.6	41.9	3.5	G	8	G	0.87	C
4- 1a	740524	87276148	3.52	70.8	25.1	4.1	G	10	G	0.5	M-C
1b	740525	*68765148*	1.98	5.0	89.0	6.0	pS	18.4	G	0.27	M
1c	740526		5.12	59.1	33.6	7.3	G	8.6	G	0.54	C
1d	740527		1.62	76.3	21.3	2.4	G	16	G	0.47	M
1e	740528		0.48	41.8	54.6	3.6	sG	4.6	P	0.35	M
1f	740529		1.67	11.9	83.9	4.2	pS	3.2	G	0.35	M
1g	740530		0.96	29.6	62.6	7.8	sG	6.5	P	0.38	M
1h	740531		1.14	3.3	86.8	9.9	S	3.2	G	0.5	M-C
1i	740532		1.04	64.7	25.9	9.4	G	13.9	P	0.47	M
1j	740533		0.61	5.1	69.8	25.1	vmpS	3.2	G	0.33	M
		Total	18.14								
			Weighted mean:	47.0	47.0	6.0	sG	8	P	0.44	M

*See Figure 25.

†Descriptive terms: P = pebble, G = granule, C = coarse, M = medium, F = fine, VF = very fine.

Table 4. (continued)

Sample	Reg. No.	AMG Reference / *ANG Reference*	Thickness (*m*)	% Gravel	% Sand	% Mud	Texture*	Mean diameter: Gravel fraction (*mm*)	†	Mean diameter: Sand fraction (*mm*)	†
4- 2a	740534	87476138	1.45	67.8	29.7	2.5	G	11.3	P	0.62	C
2b	740535	*68975137*	0.20	20.1	72.6	7.3	pS	7.5	P	0.35	M
2c	740536		5.12	55.0	36.8	8.2	G	6.5	P	0.5	M
2d	740537		2.33	61.5	32.0	6.5	G	10	P	0.54	C
2c	740538		1.52	12.1	77.6	10.3	mpS	3.2	G	0.71	C
2f	740539		1.19	37.5	54.4	8.1	sG	6	P	0.71	C
		Total	11.81								
			Weighted mean:	50.0	42.6	7.4	G	7	P	0.54	C
4- 3a	740540	87506131	1.12	70.3	27.5	2.2	G	13	P	0.44	M
3b	740541	*69005130*	2.16	2.4	82.3	15.3	mS	3.2	G	0.27	M
3c	740542		1.77	59.7	33.3	7.0	G	13	P	0.44	M
		Total	5.05								
			Weighted mean:	37.5	53.0	9.5	sG	7.5	P	0.31	M
4- 4a	740543	87316129	2.54	82.5	16.5	1.0	G	16	P	0.5	M
4b	740544	*68805128*	1.62	35.1	62.1	2.8	sG	5.7	P	0.38	M
4c	740545		0.66	4.1	87.5	8.4	S	3.2	G	0.44	M
4d	740546		2.33	71.7	22.6	5.7	G	13	P	0.47	M
		Total	7.15								
			Weighted mean:	61.0	35.4	3.6	G	10.6	P	0.44	M
4- 5a	740547	87266108	1.52	2.1	92.4	5.5	S	3.2	G	0.44	M
5b	740548	*68745105*	3.05	54.1	40.0	5.9	G	6	P	0.5	M
		Total	4.57								
			Weighted mean:	36.8	57.4	5.8	sG	4.9	P	0.22	F

*See Figure 25.
†Descriptive team: P = pebble, G = granule, C = coarse, M = medium, F = fine, VF = very fine.

Table 4. *(continued)*

Sample	Reg. No.	AMG Reference *ANG Reference*	Thickness *(m)*	% Gravel	% Sand	% Mud	Texture*	Mean diameter: Gravel fraction *(mm)*	†	Mean diameter: Sand fraction *(mm)*	†
4- 6	740549	87366104	4.50	77.6	19.2	3.2	G	14.9	P	0.5	M-C
4- 7a	740550	87326096	0.43	1.5	95.5	3.0	S	3.2	G	0.29	M
7b	740551	*68805092*	1.83	60.8	36.0	3.2	G	11.3	P	0.44	M
7c	740552		1.0	1.0	93.3	5.7	S	3.2	G	0.27	M
7d	740553		1.78	69.1	26.4	4.5	G	13.9	P	0.44	M
		Total	4.55								
		Weighted mean:		51.7	44.3	4.0	G	10	P	0.38	M
5- 1a	740554	87526087	1.40	0	97.4	2.6	S	13.9	P	0.47	M
1b	740555	*69025081*	0.42	1.0	13.7	85.3	NM	3.2	G	0.14	VF
1c	740556		0.71	77.8	19.0	3.2	G	21.1	P	0.47	M
1d	740557		0.91	14.1	73.6	12.3	mpS	3.2	G	0.33	M
1e	740558		1.14	59.2	33.1	7.7	G	7.5	P	0.66	C
		Total	4.58								
		Weighted mean:		29.7	56.8	13.5	msG	8.6	P	0.38	M
5- 2a	740559	87656085	3.05	78.7	19.6	1.7	G	16	P	0.71	C
2b	740560	*69165079*	2.49	49.6	46.5	3.9	G	6	P	0.71	C
2c	740561		0.74	1.2	89.7	9.1	S	3.2	G	0.29	M
		Total	6.28								
		Weighted mean:		58.0	38.5	3.4	G	9.2	P	0.62	C
5- 3a	740562	87686101	2.34	50.7	43.7	5.6	G	6	P	0.87	C
3b	740563	*69205097*	1.17	0.7	88.7	10.6	mS	3.2	G	0.29	M
		Total	3.51								
		Weighted mean:		34.0	58.7	7.3	sG	4.9	P	0.57	C

*See Figure 25.
†Descriptive terms: P = pebble, G = granule, C = coarse, M = medium, F = fine, VF = very fine.

Table 4. (continued)

Sample	Reg. No.	AMG Reference *ANG Reference*	Thickness *(m)*	% Gravel	% Sand	% Mud	Texture*	Mean diameter: Gravel fraction *(mm)*	†	Mean diameter: Sand fraction *(mm)*	†
5- 4a	740564	87516076	0.96	67.0	29.7	3.3	G	12.1	P	0.47	M
4b	740565	*69015069*	0.56	21.8	69.9	8.3	pS	13.9	P	0.35	M
4c	740566		2.16	76.1	21.0	2.9	G	12.1	P	0.66	C
4d	740567		4.17	37.7	58.7	3.6	sG	4.9	P	0.76	C
4e	740568		0.30	6.6	82.9	10.5	mpS	3.2	G	0.25	M
		Total	8.15								
		Weighted mean:		49.1	47.0	4.0	G	7.5	P	0.62	C
5- 5a	740560	87256079	2.82	0.8	86.3	12.9	mS	3.2	G	0.22	F
5b	740561	*68735073*	2.74	64.2	32.1	3.7	G	13.9	P	0.54	C
5c	740562		0.91	3.3	79.4	17.3	mS	3.2	G	0.27	M
5d	740563		2.64	68.1	28.0	3.9	G	10	P	0.71	C
5e	740564		1.83	3.4	76.9	19.7	mS	3.2	G	0.19	F
		Total	10.94								
		Weighted mean:		33.6	56.5	9.9	sG	6	P	0.29	M
5- 6a	740565	87506057	1.78	70.8	26.6	2.6	G	10	P	0.66	C
6b	740566	*69005049*	2.46	46.2	51.2	2.6	sG	6.5	P	0.66	C
6c	740567		1.60	4.6	90.5	4.9	S	3.2	G	0.31	M
6d‡	740568		(0.91)	0.6	62.7	36.7	vmS	3.2	G	0.16	F
		Total	5.84								
		Weighted mean:		42.3	54.5	3.23	sG	6	P	0.54	C

‡Excluded from weighted mean.
*See Figure 25.
†Descriptive terms: P = pebble, G = granule, C = coarse, M = medium, F = fine, VF = very fine.

Table 4. (continued)

Sample	Reg. No.	AMG Reference *ANG Reference*	Thickness *(m)*	% Gravel	% Sand	% Mud	Texture*	Mean diameter: Gravel fraction *(mm)*	†	Mean diameter: Sand fraction *(mm)*	†
5- 7a	740569	87436055	1.52	66.8	31.0	2.2	G	10.6	P	0.81	C
7b	740570	*68925047*	0.58	21.1	74.9	4.0	pS	11.3	P	0.54	C
7c	740571		2.49	16.3	75.4	8.3	pS	13	P	0.38	M
7d‡	740572		(0.91)	0.3	70.4	29.3	vmS	3.2	G	0.18	F
		Total	4.59								
		Weighted mean:		33.6	60.6	5.7	sG	12.1	P	0.5	M-C
5- 8a	740873	87116073	5.00	66.3	30.8	2.9	G	13	P	0.81	C
8b‡	740874	*68575067*	(3.35)	0.8	71.8	27.4	vmS	3.2	G	0.19	F
8c‡	740875		(0.46)	0.2	50.2	49.6	NM	3.2	G	0.13	F
8d‡	740876		(1.22)	0.5	56.7	42.8	NM	3.2	G	0.15	F
		Total	10.03								
5- 9a	740877	87126066	1.12	58.3	39.2	2.5	G	7	P	0.71	G
9b	740878	*68585059*	1.93	72.5	25.5	2.0	G	14.9	D	0.54	C
9c	740879		0.51	5.9	33.7	60.4	NM	3.2	G	0.16	F
9d	740880		2.97	71.6	24.3	4.1	G	9.2	P	0.66	C
9e	740881		1.07	47.5	47.7	4.8	sG	7	P	0.76	C
9f	740882		2.29	5.9	77.4	16.7	mpS	3.2	G	0.29	M
9g	740883		0.91	0.1	45.1	54.8	NM	3.2	G	0.13	F
9h	740884		0.36	50.7	29.9	19.4	mG	6	P	0.47	M
		Total	11.16								
		Weighted mean:		45.1	41.4	13.4	mG	6.5	P	0.41	M

‡Excluded from weighted mean.
*See Figure 25.
†Descriptive terms: P = pebble, G = granule, C = coarse, M = medium, F = fine, VF = very fine.

Table 4. (continued)

Sample	Reg. No.	AMG Reference *ANG Reference*	Thickness (m)	% Gravel	Sand	Mud	Texture*	Mean diameter Gravel fraction (mm)	†	Sand fraction (mm)	†
5-10a	740885	87276049	2.64	72.3	25.2	2.5	G	10	P	0.76	C
10b	740886	*68745040*	1.60	16.9	74.3	8.8	pS	3.2	G	0.5	M-C
10c	740887		0.46	30.9	56.0	13.1	msG	22.6	P	0.23	F
10d	740888		1.22	8.9	73.6	17.5	mpS	3.2	G	0.23	F
		Total	5.92								
		Weighted mean:		41.0	50.8	8.1	sG	6	P	0.47	M
5-11a	740889	87236038	1.83	66.6	29.9	3.5	G	13	P	0.47	M
11b	740890	*68705028*	2.06	44.1	47.2	8.7	sG	5.3	P	0.57	C
11c	740891		3.15	3.6	63.1	34.3	vmpS	3.2	G	0.19	F
11d	740892		1.32	61.4	31.4	7.2	G	5.7	P	0.62	C
		Total	8.36								
		Weighted mean:		36.5	46.9	17.0	msG	5.3	P	0.33	M
5-12a	740893	87006051	0.56	20.0	78.2	1.8	pS	13.9	P	0.62	C
12b	740894	*68455043*	0.61	63.9	31.5	4.6	G	8	P	0.54	C
12c	740895		4.32	40.1	54.3	5.6	sG	5.3	P	0.66	C
12d	740896		1.47	13.5	77.7	8.8	pS	3.2	G	0.62	C
12e	740897		0.66	40.8	52.6	6.6	sG	5.7	P	0.57	C
12f	740898		1.73	5.4	90.7	3.9	pS	3.2	G	0.5	M-C
		Total	9.35								
		Weighted mean:		29.9	64.5	5.6	sG	4.9	P	0.54	C

*See Figure 25.
†Descriptive terms: P = pebble, G = granule, C = coarse, M = medium, F = fine, VF = very fine.

Table 4. (continued)

Sample	Reg. No.	AMG Reference *ANG Reference*	Thickness *(m)*	% Gravel	Sand	Mud	Texture*	Mean diameter Gravel fraction *(mm)*	†	Sand fraction *(mm)*	†
5-13a	740899	86916045	3.96	57.1	37.8	5.1	G	7	P	0.76	C
13b	740900	*68355036*	2.31	7.7	84.1	8.2	pS	3.2	G	0.41	M
13c	740901		1.09	5.5	81.7	12.8	mpS	3.2	G	0.25	M-F
13d	740902		0.71	37.3	57.5	5.2	sG	4.6	P	0.62	C
		Total	8.07								
		Weighted mean:		34.2	58.7	7.0	sG	4.9	P	0.5	M-C
5-14a	740903	87126032	0.5	84.4	13.1	2.6	G	24.2	P	0.5	M-C
14b	740904	*68585022*	1.02	64.4	31.3	4.3	G	8	P	0.81	C
14c	740905		2.19	75.0	19.8	5.2	G	13.9	P	0.44	M
		Total	3.72								
		Weighted mean:		73.4	22.0	4.6	G	12.1	P	0.5	M-C
14d‡	740906		1.52	0.5	48.3	51.2	NM	3.2	G	0.15	F
15e‡	740907		1.22	1.5	12.8	85.7	NM	3.2	G	0.19	F
16f	740908		0.36	0	95.2	4.8	S	-		0.20	F
17g	740909		0.71	1.3	83.7	15.0	mS	3.2	G	0.16	F
18h	740910		0.36	53.5	36.6	9.9	G	6	P	0.81	C
		Total	1.43								
		Weighted mean:		14.1	74.7	11.1	mpS	2.8	G	0.25	M-F
6- 1a	741341	86926022	4.82	36.6	59.3	4.1	sG	5.3	P	0.76	C
1b	741342	*68365011*	1.47	55.9	38.9	5.2	G	5.3	P	0.54	C
		Total	6.29								
		Weighted mean:		41.1	54.5	4.4	sG	5.3	P	0.66	C

‡Excluded from weighted mean.
*See Figure 25.
†Descriptive terms: P = pebble, G = granule, C = coarse, M = medium, F = fine, VF = very fine.

Table 4. (continued)

Sample	Reg. No.	AMG Reference *ANG Reference*	Thickness *(m)*	% Gravel	% Sand	% Mud	Texture*	Mean diameter Gravel fraction *(mm)*	†	Mean diameter Sand fraction *(mm)*	†
6- 2a	741343	86896025	2.13	9.5	79.6	10.9	mpS	3.2	G	0.57	C
2b	741344	*68325014*	0.61	63.0	31.3	5.7	G	11.3	P	0.38	M
2c	741345		0.71	3.5	66.1	30.4	vmpS	3.2	G	0.18	F
2d	741346		3.48	20.0	74.1	5.9	pS	5.3	P	0.44	M
		Total	6.93								
		Weighted mean:		18.9	71.2	9.9	pS	4.6	P	0.41	M
7- 1a	741347	86646025	1.50	47.9	47.3	4.8	G	4.9	P	0.81	C
1b	741348	*68055015*	5.08	17.0	75.8	7.2	pS	3.2	G	0.54	C
1c	741349		1.12	65.8	27.3	6.9	G	8	P	0.38	M
		Total	8.00								
		Weighted mean:		30.8	62.6	6.6	sG	4	P-G	0.54	C
8- 1a	741350	86446008 *67834996*	4.42	2.8	91.3	5.9	S	3.2	G	0.5	M-C
8- 2a	741351	86375999 *67554987*	7.44	1.3	94.7	4.0	S	3.2	G	0.44	M
8- 3a	741352	86225998 *67594986*	6.15	0.8	97.4	1.8	S	3.2	G	0.47	M
8- 4a	741353	86066000	1.83	77.6	19.2	3.2	G	16	P	0.44	M
4b‡	741354	*67414988*	2.59	2.1	27.8	70.1	NM	3.2	G	0.29	M

‡Excluded from weighted mean.
*See Figure 25.
†Descriptive terms: P = pebble, G = granule, C = coarse, M = medium, F = fine, VF = very fine.

Table 4. (continued)

Sample	Reg. No.	AMG Reference *ANG Reference*	Thickness (m)	% Gravel	% Sand	% Mud	Texture*	Mean diameter Gravel fraction (mm)	†	Mean diameter Sand fraction (mm)	†
9- 1a	741355	86356080	0.61	63.8	29.7	6.3	G	12.1	P	0.41	M
1b	741356	*67745075*	0.15	4.8	87.9	7.3	pS	3.2	G	0.47	M
1c	741357		1.65	51.9	40.7	7.4	G	6.5	P	0.54	C
1d	741358		1.56	63.1	30.7	6.2	G	12.1	P	0.44	M
1e	741359		0.84	13.2	70.5	16.3	mpS	3.2	G	0.33	M
		Total	4.81								
		Weighted mean:		48.8	42.7	8.4	G	7.5	P	0.44	M
9- 2a	741360	86386046 *67775038*	4.7	39.3	54.4	8.4	sG	7.5	P	0.44	M
9- 3a	741361	86406027	2.06	65.7	29.1	5.2	G	12.1	P	0.54	C
3b	741362	*67795017*	0.76	51.5	44.1	5.4	G	6.5	P	0.87	C
3c	741363		0.41	12.1	73.9	14.0	mpS	3.2	G	0.35	M
3d	741364		0.51	2.1	25.7	72.2	NM	3.2	G	0.20	F
3e	741365		1.80	7.3	81.0	11.7	mpS	3.2	G	0.25	M-F
3f	741366		0.76	0.4	82.4	17.2	mS	3.2	G	0.22	F
3g	741367		0.76	0.3	19.9	79.8	NM	3.2	G	0.19	F
		Total	6.30								
		Weighted mean:		30.7	54.8	14.5	msG	4.9	P	0.38	M
9- 4a	741368	86616073	1.52	35.8	58.5	5.7	sG	5.3	P	0.57	C
4b	741369	*68025067*	8.41	21.1	75.9	3.0	pS	4.9	P	0.5	M-C
		Total	9.93								
		Weighted mean:		23.3	73.2	3.4	pS	4.9	P	0.47	M

*See Figure 25.
†Descriptive terms: P = pebble, G = granule, C = coarse, M = medium, F = fine, VF = very fine.

Table 4. (continued)

Sample	Reg. No.	AMG Reference *AMG Reference*	Thickness *(m)*	% Gravel	% Sand	% Mud	Texture*	Mean diameter Gravel fraction *(mm)*	†	Mean diameter Sand fraction *(mm)*	†
9- 5a	741370	86526084	2.44	72.5	23.2	4.3	G	13	P	0.54	C
5b	741371	*67935079*	2.90	70.2	20.9	8.9	G	13	P	0.47	M
		Total	5.34								
		Weighted mean:		71.2	21.9	6.8	G	13	P	0.5	M-C
9- 6	741372	86316021 *67695011*	3.05	34.3	57.3	8.4	sG	6.5	P	0.66	C
9- 7a	741373	86276026	1.88	70.3	24.3	5.4	G	12.1	P	0.44	M
7b	741374	*67655016*	1.12	54.7	37.1	8.2	G	7	P	0.44	M
7c	741375		0.96	10.7	68.4	20.9	vmpS	3.2	G	0.22	F
7d	741376		0.66	0.6	26.9	72.5	NM	3.2	G	0.125	VF
		Total	4.62								
		Weighted mean:		51.4	38.6	9.9	G	7.5	P	0.31	M
9- 8a	741377	86486027	1.62	62.9	32.1	5.0	G	3.2	G	0.62	C
8b	741378	*67885017*	2.82	16.3	73.0	10.7	mpS	3.2	G	0.71	C
		Total	4.44								
		Weighted mean:		33.3	53.1	8.6	msG	3.2	G	0.66	C
10- 1a	741379	87886045	0.76	12.7	75.4	11.9	mpS	3.2	G	0.62	C
1b	741380	*69415035*	1.14	68.7	27.0	1.3	G	13.9	P	0.57	C
1c	741381		1.37	29.1	65.9	5.0	sG	4.9	P	0.76	C
1d	741382		0.66	42.7	51.4	5.9	sG	8	P	0.54	C

Table 4. (continued)

Sample	Reg. No.	AMG Reference / *ANG Reference*	Thickness (m)	% Gravel	% Sand	% Mud	Texture*	Mean diameter: Gravel (mm)	Gravel fraction †	Mean diameter: Sand (mm)	Sand fraction †
10- 1e	741383	87886045	2.64	2.4	79.7	17.9	mS	3.2	G	0.2	F
1f	741384	*69415035*	1.07	8.5	81.5	10.0	pS	3.2	G	0.29	M
		Total	7.64								
		Weighted mean:		22.4	66.7	10.8	msG	4.9	P	0.35	M
10- 2a	741385	87415993	2.03	75.7	20.3	4.0	G	14.9	P	0.44	M
2b	741386	*68894979*	1.56	11.7	79.5	8.8	pS	3.2	G	0.54	C
2c	741387		1.29	60.0	33.6	6.3	G	5.3	P	0.62	C
2d	741388		3.07	29.5	62.5	8.0	sG	5.3	P	0.62	C
2e	741389		1.17	51.7	47.5	0.8	G	-	-	0.93	C
		Total	9.12								
		Weighted mean:		43.9	50.0	6.1	sG	5.3	P	0.57	C
10- 3a	741390	87526006	3.16	28.1	67.1	4.8	sG	5.3	P	0.66	C
3b	741391	*69014993*	4.42	0.4	86.6	13.0	mS	3.2	G	0.29	M
3c	741392		0.91	42.9	43.9	13.2	msG	8	P	0.35	M
		Total	8.49								
		Weighted mean:		16.1	74.3	9.6	pS	4.3	P	0.41	M
10- 4a	741393	86965962	2.16	6.5	84.0	9.5	pS	3.2	G	0.62	C
4b	741394	*68394945*	6.27	0.1	84.0	15.9	mS	3.2	G	0.33	M
		Total	8.43								
		Weighted mean:		1.7	84.0	14.2	mS	3.2	G	0.38	M

*See Figure 25.
†Descriptive terms: P = pebble, G = granule, C = coarse, M = medium, F = fine, VF = very fine.

Table 4. (continued)

Sample	Reg. No.	AMG Reference *ANG Reference*	Thickness *(m)*	% Gravel	% Sand	% Mud	Texture*	Mean diameter Gravel fraction *(mm)*	†	Mean diameter Sand fraction *(mm)*	†
10- 5a	741395	87345992	0.99	41.2	58.0	0.8	sG	4.6	P	0.87	C
5b	741396	*68814978*	0.71		Material cemented		-	excluded from calculations			
5c	741397		0.91	32.6	61.6	5.8	sG	4.6	P	0.71	C
5d	741398		0.86	1.5	86.3	12.2	mG	3.2	G	0.16	M
		Total	2.76								
		Weighted mean:		26.0	68.0	6.0	sG	4.3	P	0.47	M
11- 1a	741399	85295992	5.66	69.6	27.4	3.0	G	9.2	P	0.57	C
1b	741400	*66574980*	1.07	72.0	24.7	3.3	G	12.1	P	0.41	M
1c	741401		2.08	0.6	14.5	84.9	NM	3.2	G	0.11	VF
1d	741402		0.76	2.3	36.6	61.1	NM	3.2	G	0.15	F
1e	741403		0.46	53.3	36.1	10.1	mG	6.5	P	0.47	M
		Total	10.03								
		Weighted mean:		70.0	27.0	3.0	G	10	P	0.54	C
11- 2a	741404	85695949	4.42	77.8	19.4	2.8	G	14.9	P	0.5	M-C
2b	741405	*67004933*	0.46	18.2	78.3	3.5	pS	5.7	P	0.71	C
2c	741406		1.56	66.3	31.8	1.9	G	7.5	P	0.81	C
2d	741407		2.57	73.3	24.0	2.7	G	13.9	P	0.66	C
2e	741408		0.81	60.7	28.4	10.9	mG	8	P	0.33	M
2f	741409		0.61	6.2	60.1	33.7	vmpS	3.2	G	0.18	F
2g	741410		1.93	69.0	26.5	4.5	G	7	P	0.5	M-C
2h	741411		0.41	4.9	77.3	17.8	mpS	3.2	G	0.22	F
		Total	12.77								
		Weighted mean:		65.2	29.4	5.4	G	10	P	0.47	M

*See Figure 25.
†Descriptive terms; P = pebble, G = granule, C = coarse, M = medium, F = fine, VF = very fine.

Table 4. (continued)

Sample	Reg. No.	AMG Reference *ANG Reference*	Thickness (m)	% Gravel	% Sand	% Mud	Texture*	Mean diameter: Gravel fraction (mm)	†	Mean diameter: Sand fraction (mm)	†
11- 3a	741412	85415955 *66704940*	6.55	54.7	41.0	4.3	G	6	P	0.81	C
11- 4a	741413	85455955	3.76	70.3	23.8	5.9	G	10	P	0.57	C
4b	741414	*66744940*	1.88	44.9	48.3	6.8	sG	6	P	0.76	C
		Total	5.64								
		Weighted mean:		61.8	32.0	6.2	G	8.6	P	0.62	C
11- 5a	741415	85225935	2.69	61.8	36.2	2.0	G	8.6	P	0.71	C
5b	741416	*66494918*	1.22	0.7	72.6	26.7	vmS	3.2	G	0.18	F
5c	741417		0.41	20.6	65.1	14.3	mpS	4.3	P	0.41	M
		Total	4.32								
		Weighted mean:		40.6	49.2	10.1	msG	6	P	0.44	M
11- 6a	741418	85165931	1.17	68.0	29.7	2.3	G	8.6	P	0.66	C
6b	741419	*66424914*	2.44	2.7	76.5	20.8	vmS	3.2	G	0.27	M
		Total	2.61								
		Weighted mean:		23.9	61.3	14.8	msG	4.6	P	0.33	M
11- 7a	741420	85065925	3.30	70.6	25.7	3.7	G	13	P	0.5	M-C
7b	741421	*66314907*	1.32	66.1	29.7	4.2	G	7	P	0.66	C
7c	741422		1.37	3.1	83.9	13.0	mS	3.2	G	0.31	M
7d	741423		1.73	54.9	34.4	10.7	mG	10	P	0.38	M
		Total	7.72								
		Weighted mean:		54.3	38.7	7.0	G	8.6	P	0.41	M

*See Figure 25.

†Descriptive terms: P = pebble, G = granule, C = coarse, M = medium, F = fine, VF = very fine.

Table 4. (continued)

Sample	Reg. No.	AMG Reference *ANG Reference*	Thickness *(m)*	% Gravel	% Sand	% Mud	Texture*	Mean diameter Gravel fraction *(mm)*	†	Mean diameter Sand fraction *(mm)*	†
11- 8a	741424	85115920	1.02	77.9	19.9	2.2	G	7.5	P	0.54	C
8b	741425	*66364902*	1.22	73.4	22.6	4.0	G	11.3	P	0.44	M
8c	741426		1.22	59.1	34.1	6.8	G	5.3	P	0.57	C
8d	741427		0.99	67.8	25.1	7.1	G	12.1	P	0.54	C
8e	741428		0.36	44.9	47.0	8.1	sG	6	P	0.62	C
8f‡	741429		0.96	0	69.3	30.7	vmS	-	-	0.16	F
		Total	5.77								
		Weighted mean:		67.4	27.3	5.3	G	8.6	P	0.47	M
11- 9a	741430	85185920	1.22	61.3	34.3	4.4	G	6	P	0.71	C
9b	741431	*66444902*	3.05	29.3	64.2	6.5	sG	4	P	0.81	C
9c	741432		0.51	2.7	84.4	12.9	mS	3.2	G	0.47	M
		Total	4.78								
		Weighted mean:		34.6	58.7	6.6	sG	4.3	P	0.71	C
12- 1a	741974	87046112	2.43	81.8	16.0	2.2	G	18.4	P	0.31	M
1b	741975	*68505109*	2.39	1.1	77.6	21.3	vmS	3.2	G	0.19	F
1c	741976		1.35	62.5	34.6	2.9	G	9.2	P	0.47	M
1d	741977		0.38	1.2	77.3	21.5	vmS	3.2	G	0.29	M
1e	741978		1.73	65.2	29.0	5.8	G	13	P	0.54	C
1f	741979		1.62	45.4	43.1	11.5	mG	4.6	P	0.81	C
1g	741980		2.36	1.1	87.5	11.4	mS	3.2	G	0.25	F
1h	741981		0.71	19.6	65.3	15.1	mpS	6	P	0.38	M
		Total	12.88								
		Weighted mean:		37.4	52.1	10.4	sG	7	P	0.35	M

*See Figure 25.
†Descriptive terms: P = pebble, G = granule, C = coarse, M = medium, F = fine, VF = very fine.

Table 4. (continued)

Sample	Reg. No.	AMG Reference *ANG Reference*	Thickness *(m)*	% Gravel	% Sand	% Mud	Texture*	Mean diameter Gravel fraction *(mm)*	†	Mean diameter Sand fraction *(mm)*	†
12- 2a	741982	87056100	3.76	72.0	24.8	3.2	G	12.1	P	0.54	C
2b	741983	*68515096*	1.98	58.5	37.6	3.9	G	7	P	0.93	C
2c	741984		1.32	5.0	77.8	17.2	mpS	3.2	G	0.25	F
		Total	7.06								
		Weighted mean:		55.6	38.3	6.0	G	7.5	P	0.54	C
13- 1a	741985	86346152	1.32	56.1	36.5	7.4	G	7.5	P	0.62	C
1b	741986	*67745154*	2.62	46.5	47.6	5.9	sG	4.9	P	0.76	C
1c	741987		0.41	65.5	23.1	11.4	mG	16	P	0.44	M
1d	741988		1.56	54.0	35.3	10.7	mG	5.3	P	0.5	M-C
1e	741989		0.84	63.2	29.4	7.4	G	13.9	P	0.44	M
1f	741990		1.91	3.9	79.4	16.7	mS	3.2	G	0.31	M
		Total	8.66								
		Weighted mean:		42.3	47.8	0.8	sG	5.7	P	0.47	M
13- 2a	741991	86336145	2.64	66.6	28.1	5.3	G	9.2	P	0.57	C
2b	741992	*67735146*	0.61	3.1	65.3	31.6	vmS	3.2	G	0.27	M
2c	741993		0.76	49.1	28.4	22.5	vmG	14.9	P	0.44	M
2d	741994		0.38	12.1	63.7	24.2	vmpS	12.1	P	0.33	M
		Total	4.39								
		Weighted mean:		50.0	36.4	13.5	mG	10.6	P	0.41	M
13- 3a	742023	86066165	0.91	16.4	77.1	6.5	pS	4.9	P	0.5	M-C
3b	741995	*67435169*	1.12	3.7	83.4	12.9	mS	3.2	G	0.27	M
3c	741996		1.22	9.2	87.4	3.4	pS	3.2	G	0.62	C
3d	741997		0.20	44.5	53.5	2.0	sG	5.7	P	0.71	C

Table 4. *(continued)*

Sample	Reg. No.	AMG Reference *ANG Reference*	Thickness *(m)*	% Gravel	% Sand	% Mud	Texture*	Mean diameter: Gravel fraction *(mm)*	†	Mean diameter: Sand fraction *(mm)*	†
13- 3e	741998		0.43	5.1	92.7	3.2	pS	3.2	G	0.33	M
3f	741999		0.71	18.8	79.0	2.2	pS	4.9	P	0.66	C
3g	742000		1.22	46.3	52.5	1.2	sG	5.3	P	1	C
3h	742001		1.27	4.4	94.6	1.0	S	3.2	G	0.35	M
3i	742002		0.18	41.5	57.0	1.5	sG	4.9	P	0.62	C
3j	742003		0.36	17.1	82.4	0.5	pS	4.9	P	0.5	M-C
3k	742004		0.61	47.3	48.0	4.7	sG	8	P	0.27	M
3l	742005		0.46	5.4	82.9	11.7	mpS	3.2	G	0.27	M
3m	742006		0.61	15.6	59.7	24.7	vmpS	4.9	P	0.47	M
		Total	9.30								
		Weighted mean:		18.4	75.8	5.8	pS	4.3	P	0.47	M
13- 4a	742007	85956164	0.51	24.1	75.3	0.6	pS	4.9	P	0.66	C
4b	742008	*67315168*	0.51	4.7	94.2	1.1	S	3.2	G	0.47	M
4c	742009		1.52	0.5	87.3	12.2	mS	3.2	G	0.19	F
4d	742010		0.66	2.4	93.1	4.5	S	3.2	G	0.33	M
4e	742011		2.06	18.9	79.5	1.6	pS	4.6	P	0.62	C
4f	742012		0.20	7.7	89.0	3.3	pS	3.2	G	0.23	F
4g	742013		0.15	28.7	68.7	2.6	sG	4.9	P	0.71	C
4h	742014		0.23	2.1	95.7	2.2	S	3.2	G	0.25	F
4i	742015		0.43	32.2	65.7	2.1	sG	8	P	0.44	M
4j	742016		0.20	11.9	86.1	2.0	pS	8.6	P	0.27	M
4k	742017		0.66	37.0	59.9	3.1	sG	5.7	P	0.62	C
4l	742018		0.66	1.6	84.2	14.2	mS	3.2	G	0.31	M
		Total	7.79								
		Weighted mean:		13.3	81.5	5.1	pS	4.3	P	0.41	M

*See Figure 25.
†Descriptive terms: P = pebble, G = granule, C = coarse, M = medium, F = fine, VF = very fine.

Table 4. (continued)

Sample	Reg. No.	AMG Reference *ANG Reference*	Thickness (m)	% Gravel	Sand	Mud	Texture*	Mean diameter Gravel fraction (mm)	†	Sand fraction (mm)	†
14- 1a	742245	85065817	1.27	76.6	18.9	4.5	G	17.1	P	0.31	M
1b	742246	*66304789*	1.56	39.4	52.5	8.1	sG	7.5	P	0.47	M
1c	742247		1.27	64.7	31.6	3.7	G	12.1	P	0.5	M-C
1d	742248		0.91	32.8	59.4	7.8	sG	7.5	P	0.54	C
1e	742249		2.49	73.0	22.9	4.1	G	12.1	P	0.38	M
1f	742250		1.52	0.4	93.4	6.2	S	3.2	G	0.35	M
1g	742251		3.66	58.4	34.7	6.9	G	7.5	P	0.66	C
1h	742252		2.92	2.2	82.1	15.7	mS	3.2	G	0.41	M
1i	742253		3.86	39.8	54.6	5.6	sG	4.9	P	0.76	C
1j	742254		2.44	6.6	82.4	11.0	mpS	3.2	G	0.71	C
		Total	21.90								
		Weighted mean:		38.5	53.8	7.7	sG	6	P	0.54	C
14- 2a	742255	85075800	3.76	73.5	21.9	4.6	G	13	P	0.41	M
2b	742256	*66314771*	1.67	39.2	51.8	9.0	sG	5.3	P	0.71	C
2c	742257		1.12	2.8	87.6	9.6	S	3.2	G	0.41	M
		Total	6.55								
		Weighted mean:		52.7	40.8	6.6	G	8	P	0.47	M
14- 3a	742258	85195797	2.23	35.7	55.3	9.0	sG	4.9	P	0.71	C
3b	742259	*66444767*	2.44	1.3	82.9	15.8	mS	3.2	G	0.29	M
		Total	4.67								
		Weighted mean:		17.7	69.7	12.6	mpS	4	P	0.44	M

*See Figure 25.
†Descriptive terms: P = pebble, G = granule, C = coarse, M = medium, F = fine, VF = very fine.

Table 4. (continued)

Sample	Reg. No.	AMG Reference *ANG Reference*	Thickness (m)	% Gravel	% Sand	% Mud	Texture*	Mean diameter Gravel fraction (mm)	†	Mean diameter Sand fraction (mm)	†
14- 4a	742260	84825812	4.01	78.5	18.6	2.9	G	14.9	P	0.47	M
4b	742261	*66034784*	0.66	4.7	76.3	19.0	mpS	6.5	G	0.29	M
4c	742262		0.61	40.4	50.4	9.2	sG	3.2	P	0.54	C
4d	742263		1.17	71.2	24.0	4.8	G	14.9	P	0.44	M
4e	742264		1.42	12.1	71.9	16.0	mpS	3.2	G	0.47	M
4f‡	742265		(0.91)	1.0	29.6	69.4	NM	3.2	G	0.13	F
		Total	7.87								
			Weighted mean:	56.3	36.3	7.4	G	10	P	0.44	M
14- 5a	742266	84895805	3.18	76.7	20.8	2.5	G	18.4	P	0.38	M
5b	742267	*66114776*	2.44	–	95.0	5.0	S	–	–	0.29	M
5c	742268		0.76	76.8	20.6	2.6	G	14.9	P	0.35	M
		Total	6.38								
			Weighted mean:	47.4	49.1	3.5	sG	5.7	P	0.33	M
14- 6a	742269	84865805	1.67	64.9	30.8	4.3	G	10	P	0.47	M
6b	742270	*66084776*	0.76	20.4	71.2	8.4	pS	6	P	0.62	C
6c	742271		1.98	54.5	41.1	4.4	G	8	P	0.5	M-C
6d	742272		1.07	64.1	31.9	4.0	G	14.9	P	0.44	M
		Total	5.48								
			Weighted mean:	54.8	40.3	4.8	G	9.2	P	0.47	M

‡Excluded from weighted mean.
*See Figure 25.
†Descriptive terms: P = pebble, G = granule, C = coarse, M = medium, F = fine, VF = very fine.

Table 4. (continued)

Sample	Reg. No.	AMG Reference *ANG Reference*	Thickness *(m)*	% Gravel	% Sand	% Mud	Texture*	Mean diameter: Gravel fraction *(mm)*	†	Mean diameter: Sand fraction *(mm)*	†
14- 7a	742273	84875800	2.29	76.2	19.5	4.3	G	18.4	P	0.41	M
7b	742274	*66094771*	1.22	62.7	31.3	6.0	G	9.2	P	0.33	M
7c	742275		1.12	0.9	82.0	17.1	mS	3.2	G	0.23	F
		Total	4.63								
			Weighted mean:	54.4	37.7	7.8	G	10	P	0.33	M
14- 8a	742276	84675770	1.60	57.5	35.7	6.8	G	13.9	P	0.44	M
8b	742277	*65864738*	0.43	45.8	49.9	4.3	sG	9.2	P	0.44	M
8c	742278		3.50	59.0	32.5	8.5	G	5.7	P	0.5	M-C
8d	742279		1.42	70.7	21.8	7.5	G	21.1	P	0.35	M
8e	742280		0.41	7.8	71.1	21.1	vmpS	3.2	G	0.27	M
8f	742281		4.09	60.5	32.1	7.4	G	7.5	P	0.5	M-C
8g	742282		3.20	66.2	29.1	4.7	G	19.7	P	0.35	M
		Total	14.65								
			Weighted mean:	60.1	32.6	7.3	G	10	P	0.44	M
14- 9a	742283	85105782	1.27	73.4	21.4	5.2	G	14.9	P	0.47	M
9b	742284	*66344751*	2.44	66.4	26.6	7.0	G	9.2	P	0.54	M
9c	742285		1.56	12.6	74.6	12.8	mpS	8	P	0.29	M
		Total	5.26								
			Weighted mean:	52.2	39.5	8.3	G	10	P	0.44	M
14-10a	742554	85125775	1.22	32.1	60.6	7.3	sG	8	P	0.54	C
10b	742555	*66364743*	0.46	49.8	40.5	9.7	G	10	P	0.38	M
10c	742556		1.29	11.6	77.0	11.4	mpS	7	P	0.33	M
10d	742557		0.84	64.0	21.3	14.7	mG	11.3	P	0.41	M
		Total	3.81								
			Weighted mean:	34.3	55.1	10.6	msG	8.6	P	0.41	M

Table 4. (continued)

Sample	Reg. No.	AMG Reference *ANG Reference*	Thickness *(m)*	% Gravel	% Sand	% Mud	Texture*	Mean diameter: Gravel fraction *(mm)*	†	Mean diameter: Sand fraction *(mm)*	†
14-11a	742558	85225775	1.62	67.2	27.5	5.3	G	9.2	P	0.5	M-C
11b	742559	*66474743*	2.36	77.4	19.6	3.0	G	19.7	P	0.38	M
11c	742560		3.66	65.6	28.1	6.3	G	9.2	P	0.44	M
		Total	7.64								
		Weighted mean:		69.6	25.3	5.1	G	11.3	P	0.44	M
14-12a	742561	83945793	0.81	28.8	60.7	10.5	msG	5.7	P	0.54	C
12b	742562	*65074764*	0.86	70.7	21.2	8.1	G	9.2	P	0.33	M
12c	742563		1.88	62.3	28.0	9.7	G	14.9	P	0.41	M
12d	742564		1.14	4.9	74.9	20.2	vmpS	3.2	G	0.35	M
12e	742565		1.67	56.4	29.7	13.9	mG	6.5	P	0.41	M
		Total	6.36								
		Weighted mean:		47.3	40.1	12.7	mG	7.5	P	0.41	M
14-13a	742566	84995757	2.13	69.3	23.8	6.9	G	13.9	P	0.54	C
13b	742567	*66214724*	0.69	0.1	45.6	54.3	NM	3.2	G	0.16	F
13c	742568		0.61	1.0	86.7	12.3	mS	3.2	G	0.31	M
13d	742569		0.76	5.9	77.6	16.5	mpS	7	P	0.57	C
13e	742570		0.33	55.6	33.2	11.2	mG	13.9	P	0.29	M
13f	742571		0.46	14.0	74.7	11.3	mpS	6.5	P	0.25	F
13g	742572		1.32	44.8	40.8	14.4	mG	13.9	P	0.44	M
13h	742573		1.32	6.5	69.0	24.5	vmpS	3.2	G	0.5	M-C
		Total	7.62								
		Weighted mean:		32.2	50.4	17.4	msG	7.5	P	0.41	M

*See Figure 25.
†Descriptive terms: P = pebble, G = F = fine, VF = very fine.

Table 4. (continued)

Sample	Reg. No.	AMG Reference *ANG Reference*	Thickness *(m)*	% Gravel	% Sand	% Mud	Texture*	Mean diameter: Gravel fraction *(mm)*	†	Mean diameter: Sand fraction *(mm)*	†
14-14a	742574	85175752	1.27	73.6	22.4	4.0	G	16	P	0.44	M
14b	742575	*66414718*	0.38	66.4	29.2	4.4	G	9.2	P	0.5	M
14c	742576		4.42	74.7	21.1	4.2	G	13.9	P	0.47	M
14d	742577		0.61	47.1	37.2	15.7	mG	4.6	P	0.57	C
		Total	6.68								
		Weighted mean:		71.5	23.2	5.2	G	13	P	0.47	M
14-15a	742578	85155751	0.3	4.0	82.5	13.5	mS	3.2	G	0.41	M
15b	742579	*66394717*	0.81	66.3	28.9	4.8	G	13	P	0.47	M
15c	742580		0.66	62.3	33.3	4.4	G	9.2	P	0.41	M
15d	742581		0.28	5.6	80.9	13.5	mpS	3.2	G	0.22	F
15e	742582		1.18	8.3	81.9	9.8	pS	3.2	G	0.57	C
15f	742583		0.69	68.7	24.2	7.1	G	17.1	P	0.44	M
		Total	3.92								
		Weighted mean:		39.7	52.4	7.9	sG	7	P	0.47	M
14-16a	742584	85155759	0.86	9.0	74.7	16.3	mpS	3.2	G	0.38	M
16b	742585	*66394726*	0.23	54.1	37.3	8.6	G	11.3	P	0.38	M
16c	742586		1.73	1.8	84.5	13.7	mS	3.2	G	0.31	M
16d	742587		0.46	58.7	30.0	12.3	mG	12.1	P	0.38	M
16e	742588		0.69	2.2	75.2	22.6	vmS	3.2	G	0.22	F
16f	742589		0.76	68.0	24.5	7.5	G	16	P	0.35	M
		Total	4.73								
		Weighted mean:		21.9	64.1	14.1	msG	5.3	P	0.33	M

*See Figure 25.
†Descriptive terms: P = pebble, G = granule, C = coarse, M = medium, F = fine, VF = very fine.

Table 4. (continued)

Sample	Reg. No.	AMG Reference *ANG REference*	Thickness (m)	% Gravel	% Sand	% Mud	Texture*	Mean diameter: Gravel fraction (mm)	†	Mean diameter: Sand fraction (mm)	†
14-17a	742590	84855728	2.84	0.1	86.7	13.2	mS	3.2	G	0.33	M
17b	742591	*66064692*	1.47	32.6	56.9	10.5	msG	4.9	P	0.76	C
17c	742592		2.44	14.2	75.1	10.7	mpS	3.2	G	0.76	C
		Total	6.75								
		Weighted mean:		12.3	76.0	11.7	mpS	3.7	P	0.54	C
14-18a	742593	84845731	1.73	33.5	59.0	7.5	sG	8	P	0.81	C
18b	742594	*66054695*	2.59	0.6	83.8	15.6	mS	3.2	G	0.33	M
		Total	4.32								
		Weighted mean:		13.9	73.7	12.3	mpS	4.6	P	0.41	M
14-19a	750004	84875733	1.14	15.7	74.7	9.6	pS	4.6	P	0.87	C
19b	750005	*66084698*	0.15	34.4	54.1	11.5	msG	12.1	P	0.5	M
19c	750006		1.91	4.2	81.5	14.3	mS	3.2	G	0.62	C
		Total	3.20								
		Weighted mean:		9.7	77.8	12.5	mpS	4	P	0.71	C
14-20a	750007	84845738	2.80	56.3	38.6	5.1	G	7	P	0.71	C
20b	740008	*66054703*	0.86	73.7	23.2	3.1	G	17.1	P	0.47	M
20c‡	740009		(0.46)	2.9	6.1	91.0	NM	3.2	G	0.33	M
		Total	3.66								
		Weighted mean:		60.4	35.0	4.6	G	8.6	P	0.66	C

‡Excluded from weighted mean.
*See Figure 25.
†Descriptive terms: P = pebble, G = granule, C = coarse, M = medium, F = fine, VF = very fine.

Table 4. (continued)

Sample	Reg. No.	AMG Reference *ANG Reference*	Thickness *(m)*	% Gravel	% Sand	% Mud	Texture*	Mean diameter: Gravel fraction *(mm)*	†	Mean diameter: Sand fraction *(mm)*	†
14-21a	750010	84875745	1.96	66.9	26.8	6.3	G	13	P	0.41	M
21b	750011	*66084711*	0.46	3.8	55.1	41.1	NM	3.2	G	0.25	F
21c	750012		1.17	69.0	23.2	7.8	G	11.3	P	0.41	M
21d	750013		0.81	60.2	32.2	7.6	G	5.3	P	0.47	M
21e	750014		0.38	56.0	26.6	17.4	mG	12.1	P	0.38	M
		Total	4.78								
		Weighted mean:		59.3	29.6	11.1	mG	9.2	P	0.44	M
14-22a	750015	84905740	2.90	69.7	25.6	4.7	G	13.9	P	0.33	M
22b	750016	*66114705*	1.17	23.4	63.7	12.9	msG	6	P	0.25	F
22c	750017		0.96	0.7	83.3	16.0	mS	3.2	G	0.29	M
22d	750018		0.36	62.5	24.0	13.5	mG	10.6	P	0.57	C
		Total	5.39								
		Weighted mean:		46.9	44.0	9.1	G	8.6	P	0.31	M
14-23	750019	84965730 *66184694*	4.65	18.2	70.0	11.8	mpS	6	P	0.71	C
14-24a	750020	85095739	0.76	1.7	83.3	15.0	mS	3.2	G	0.29	M
24b	750021	*66324704*	1.73	55.1	36.1	8.8	G	17.1	P	0.47	M
24c	750022		1.42	12.4	73.6	14.0	mpS	4.9	P	0.47	M
24d	750023		0.36	56.6	35.8	7.6	G	10	P	0.33	M
24e	750024		1.75	1.3	84.7	14.0	mS	9.2	P	0.27	M
		Total	6.02								
		Weighted mean:		22.7	65.0	12.2	msG	8.6	P	0.38	M

*See Figure 25.

†Descriptive terms: P = pebble, G = granule, C = coarse, M = medium, F = fine, VF = very fine.

Table 4. (continued)

Sample	Reg. No.	AMG Reference *ANG Reference*	Thickness *(m)*	% Gravel	Sand	Mud	Texture*	Mean diameter Gravel fraction *(mm)*	†	Sand fraction *(mm)*	†
16- 4a	750035	84085435	2.74	65.2	30.2	4.6	G	7.5	P	0.44	M
4b	750036	*65184373*	1.78	52.5	38.9	8.6	G	4.6	P	0.66	C
		Total	4.52								
		Weighted mean:		60.2	33.6	6.2	G	6	G	0.5	M-C
16- 5a	750037	84045434 *65134372*	3.56	17.0	64.6	18.4	mpS	4	P-G	0.57	C
17- 1a	750243	84655665 *65834623*	4.52	63.6	28.2	8.2	G	6.5	P	0.71	C
17- 2a	750244	84755661 *65944619*	2.84	-	88.0	12.0	mS	-		0.22	F
17- 3a	750245	84795662	2.36	68.0	25.3	6.7	G	16	P	0.44	M
3b	750246	*65984620*	1.27	5.4	76.3	18.3	mpS	9.2	P	0.22	F
		Total	3.63								
		Weighted mean:		46.1	43.1	10.8	mG	13	P	0.33	M
17- 4a	750247	84835869	0.56	68.2	25.8	6.0	G	10	P	0.35	M
4b	750248	*66054846*	0.66	68.6	25.7	5.7	G	13	P	0.44	M
4c	750249		1.14	59.0	36.8	4.2	G	13	P	0.47	M-C
4d	750334		1.37	-	87.6	12.4	mS	-		0.25	F
		Total	3.73								
		Weighted mean:		40.4	51.8	7.7	sG	4.9	P	0.35	M

*See Figure 25.

†Descriptive terms: P = pebble, G = granule, C = coarse, M = medium, F = fine, VF - very fine.

Table 4. (continued)

Sample	Reg. No.	AMG Reference *ANG Reference*	Thickness *(m)*	Gravel	Sand	Mud	Texture*	Mean diameter			
								Gravel fraction *(mm)*	†	Sand fraction *(mm)*	†
14-25a	750025	85035716 *66254679*	6.25	77.3	21.4	1.3	G	17.1	P	0.54	C
14-26a	750026	85065709 *66284671*	6.86	77.7	19.8	2.5	G	17.1	P	0.5	M-C
14-27a	750027	85175705	1.78	71.4	24.6	4.0	G	10	P	0.47	M-C
27b	750028	*66404667*	2.49	78.0	19.5	2.5	G	14.9	P	0.5	M-C
		Total	4.27								
			Weighted mean:	75.2	21.6	3.1	G	13	P	0.5	M-C
15- 1a	750029	85435667	0.91	70.1	26.1	3.8	G	10	P	0.47	M-C
1b	750030	*66684625*	1.37	65.5	28.6	5.9	G	6	P	0.47	M-C
1c‡	750031		(2.39)	-	63.6	36.4	vmS	-	-	0.19	F
		Total	2.28								
			Weighted mean:	67.3	27.6	5.1	G	7.5	P	0.47	M-C
16- 1a	750032	84116469 *65345504*	3.66	51.1	40.2	8.7	G	8	P	0.54	C
16- 2a	750033	84095446 *65194385*	3.50	0.5	86.2	13.3	mS	3.2	G	0.33	M
16- 3a	750034	84105450 *65204389*	5.33	51.6	37.9	10.5	mG	5.7	P	0.66	C

‡Excluded from weighted mean.
*See Figure 25.
†Descriptive terms: P = pebble, G = granule, C = coarse, M = medium, F = fine, VF = very fine.

Table 4. (continued)

Sample	Reg. No.	AMG Reference *ANG Reference*	Thickness *(m)*	% Gravel	% Sand	% Mud	Texture*	Mean diameter: Gravel fraction *(mm)*	†	Mean diameter: Sand fraction *(mm)*	†
17- 5a	750250	84735647	4.52	65.0	31.0	4.0	G	8	P	0.5	M-C
5b	750251	*65914604*	3.13	29.2	61.1	9.7	sG	4.6	P	0.44	M
		Total	7.65								
		Weighted mean:		56.3	37.6	6.3	G	6.5	P	0.47	M-C
17- 6a	750252	84705641	1.83	49.1	45.4	5.5	G	6	P	0.81	C
6b	750253	*65884597*	2.44	69.7	26.3	4.0	G	13	P	0.38	M
6c	750254		0.91	2.3	53.2	44.5	NM	8.6	P	0.15	F
6d	750255		0.46	47.8	35.7	16.5	mG	13	P	0.41	M
		Total	5.64								
		Weighted mean:		60.9	34.5	4.6	G	9.2	P	0.54	C
17- 7a	750256	84585635	4.32	75.6	19.0	5.4	G	13.9	P	0.35	M
7b	750257	*65754591*	0.48	42.1	48.9	9.0	sG	7.5	P	0.5	M-C
7c	750258		0.76	72.0	22.6	5.4	G	10.6	P	0.5	M-C
		Total	5.56								
		Weighted mean:		72.2	22.1	5.7	G	12.1	P	0.38	M
17- 8a	750259	84585631 *65754586*	4.88	76.8	18.7	4.5	G	13	P	0.38	M
17- 9a	750260	84492630	1.07	65.7	25.7	8.6	G	8	P	0.31	M
9b	750261	*65654585*	0.81	4.8	66.5	28.7	vmpS	10	P	0.14	F
9c	750262		0.96	67.4	24.9	7.7	G	7.5	P	0.35	M
9d	750263		0.64	67.5	23.0	9.5	G	10.6	P	0.23	F
9e‡	750264		(1.37)	8.0	51.7	40.3	NM	13.9	P	0.13	F
		Total	3.48								
		Weighted mean:		52.3	34.5	13.2	mG	8.6	P	0.25	F

Table 4. (continued)

Sample	Reg. No.	AMG Reference *ANG Reference*	Thickness *(m)*	% Gravel	% Sand	% Mud	Texture*	Mean diameter: Gravel fraction *(mm)*	†	Mean diameter: Sand fraction *(mm)*	†
17-11a	750268	84755644 *65944600*	4.06	23.2	67.1	9.7	sG	4	P	0.66	C
17-12a	750269	84755644 *65944600*	3.96	41.5	50.7	7.8	sG	6	P	0.47	M
17-13a	750270	84835644	1.02	60.1	34.6	5.3	G	8.6	P	0.57	C
13b	750271	*66024600*	0.41	68.2	26.5	5.3	G	13.9	P	0.47	M-C
13c	750272		1.98	19.7	71.6	8.7	pS	4.6	P	0.81	C
13d	750273		0.25	0.2	83.3	16.5	mS	3.2	G	0.38	M
13e	750274		0.46	33.6	54.9	11.5	msG	6	P	0.57	C
		Total	4.12								
		Weighted mean:		34.9	56.8	8.3	sG	6	P	0.66	C
17-14a	750275	84615619	0.28	61.7	31.7	6.6	G	7.5	P	0.57	C
14b	750276	*65784573*	0.41	7.3	77.1	15.6	mpS	4	P	0.44	M
14c	750277		0.51	1.4	77.6	21.0	vmS	8	P	0.25	F
14d	750278		0.69	1.9	81.3	16.8	mS	3.5	G	0.41	M
14e	750279		1.45	75.3	19.0	5.7	G	10.6	P	0.47	M-C
		Total	3.34								
		Weighted mean:		39.4	49.0	11.6	msG	7	P	0.41	M
17-15a	750280	84625614	0.91	46.1	44.7	9.2	G	9.2	P	0.47	M-C
15b	750281	*65794568*	1.12	15.1	72.1	12.8	mpS	4.9	P	0.41	M
15c	750282		0.69	34.2	55.3	10.5	msG	5.7	P	0.38	M
15d	750283		0.76	13.3	66.6	20.1	vmpS	6.5	P	0.29	M
		Total	3.48								
		Weighted mean:		26.6	60.4	13.0	msG	6.5	P	0.38	M

*See Figure 25.
†Descriptive terms: P = pebble, G = granule, C = coarse, M = medium, F = fine, VF = very fine.

Table 4. (continued)

Sample	Reg. No.	AMG Reference *ANG Reference*	Thickness *(m)*	% Gravel	% Sand	% Mud	Texture*	Mean diameter: Gravel *(mm)*	Gravel fraction †	Mean diameter: Sand *(mm)*	Sand fraction †
17-16a	750284	84665612	3.51	51.6	42.6	5.8	G	5.7	P	0.62	C
16b	750285	*65834565*	1.78	14.4	74.9	10.7	mpS	6	P	0.5	M-C
16c	750286		2.49	54.9	38.7	6.4	G	10	P	0.47	M-C
		Total	7.78								
		Weighted mean:		44.1	48.7	7.1	sG	7	P	0.54	C
17-17a	750287	84785609	2.44	76.9	20.8	2.3	G	14.9	P	0.47	M-C
17b	750288	*65964562*	1.52	54.7	43.0	2.3	G	7.5	P	0.5	M-C
		Total	3.96								
		Weighted mean:		68.4	29.3	2.3	G	11.3	P	0.47	M-C
17-18a	750289	84515595 *65674547*	18.00	73.7	20.4	5.9	G	17.1	P	0.5	M-C
17-19a	750290	84335577	1.32	56.2	37.8	6.0	G	6	P	0.87	C
19b	750291	*65474528*	1.96	0.3	82.6	17.1	mS	3.2	G	0.35	M
19c	750292		1.45	50.6	37.1	12.3	mG	10.6	P	0.35	M
		Total	4.73								
		Weighted mean:		31.3	56.1	12.5	msG	5.7	P	0.47	M-C

*See Figure 25.

†Descriptive terms: P = pebble, G = granule, C = coarse, M = medium, F = fine, VF = very fine.

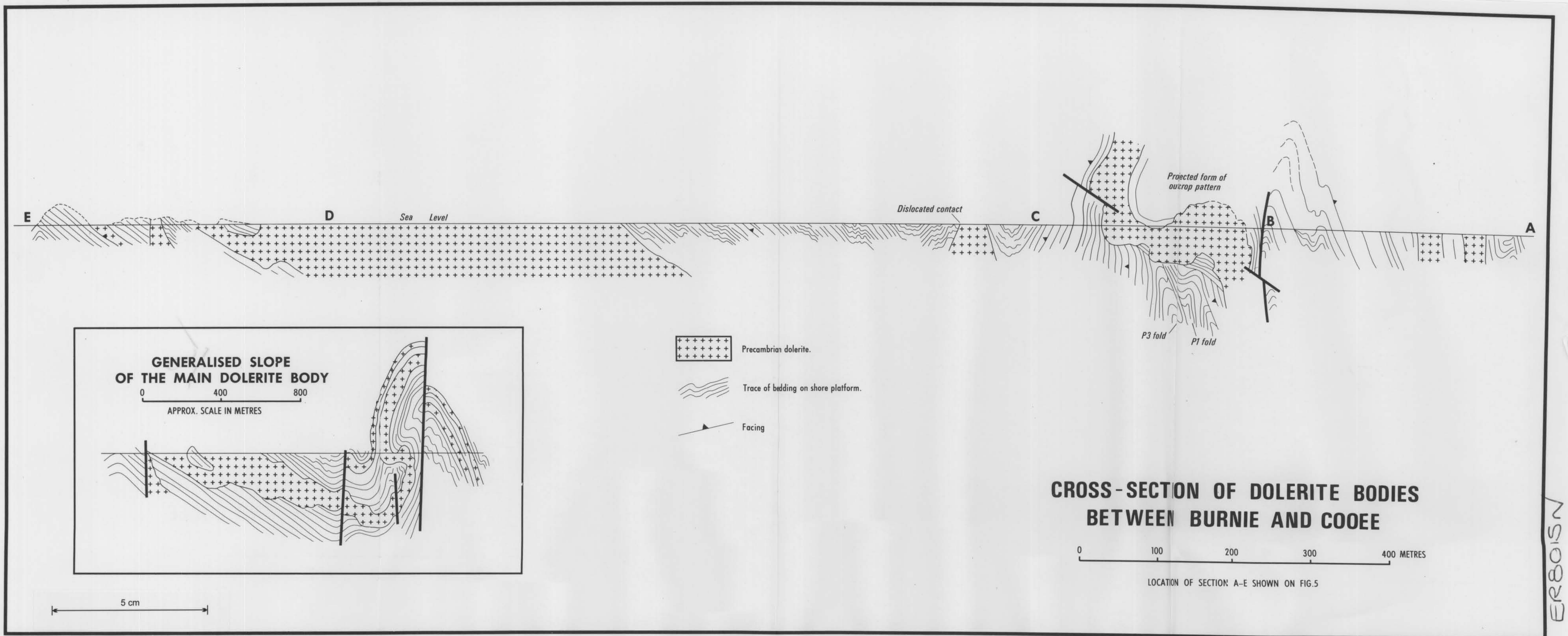

E
D
Sea Level
Dislocated contact
C
Proected form of
oucrop pattern
B
A
P3 fold
P1 fold
GENERALISED SLOPE
OF THE MAIN DOLERITE BODY
0
400
800
APPROX. SCALE IN METRES
Precambrian dolerite.
Trace of bedding on shore platform.
Facing
CROSS-SECTION OF DOLERITE BODIES
BETWEEN BURNIE AND COOEE
0
100
200
300
400 METRES
LOCATION OF SECTION A–E SHOWN ON FIG.5
5 cm

Figure 15.

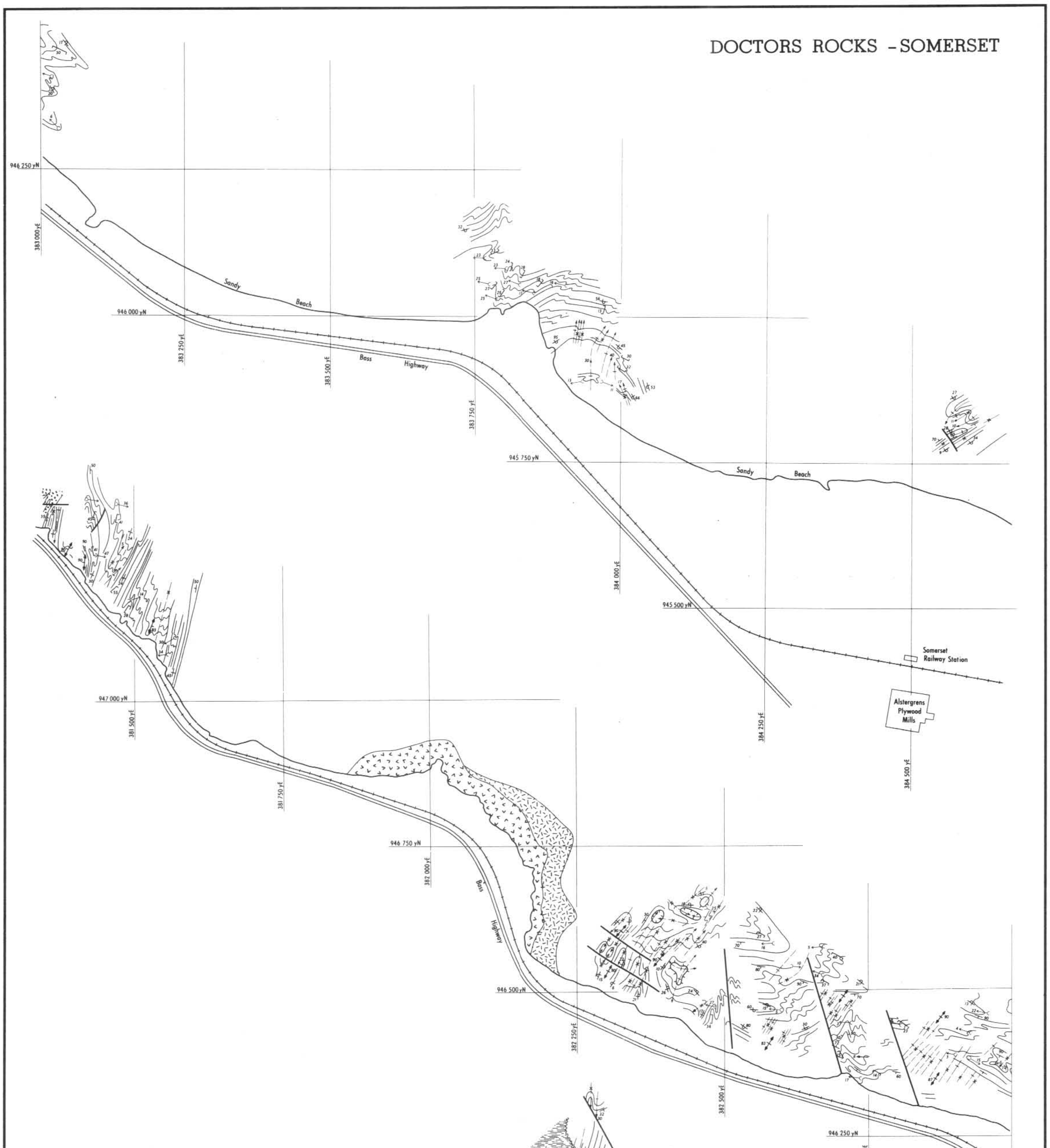


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Figure 4

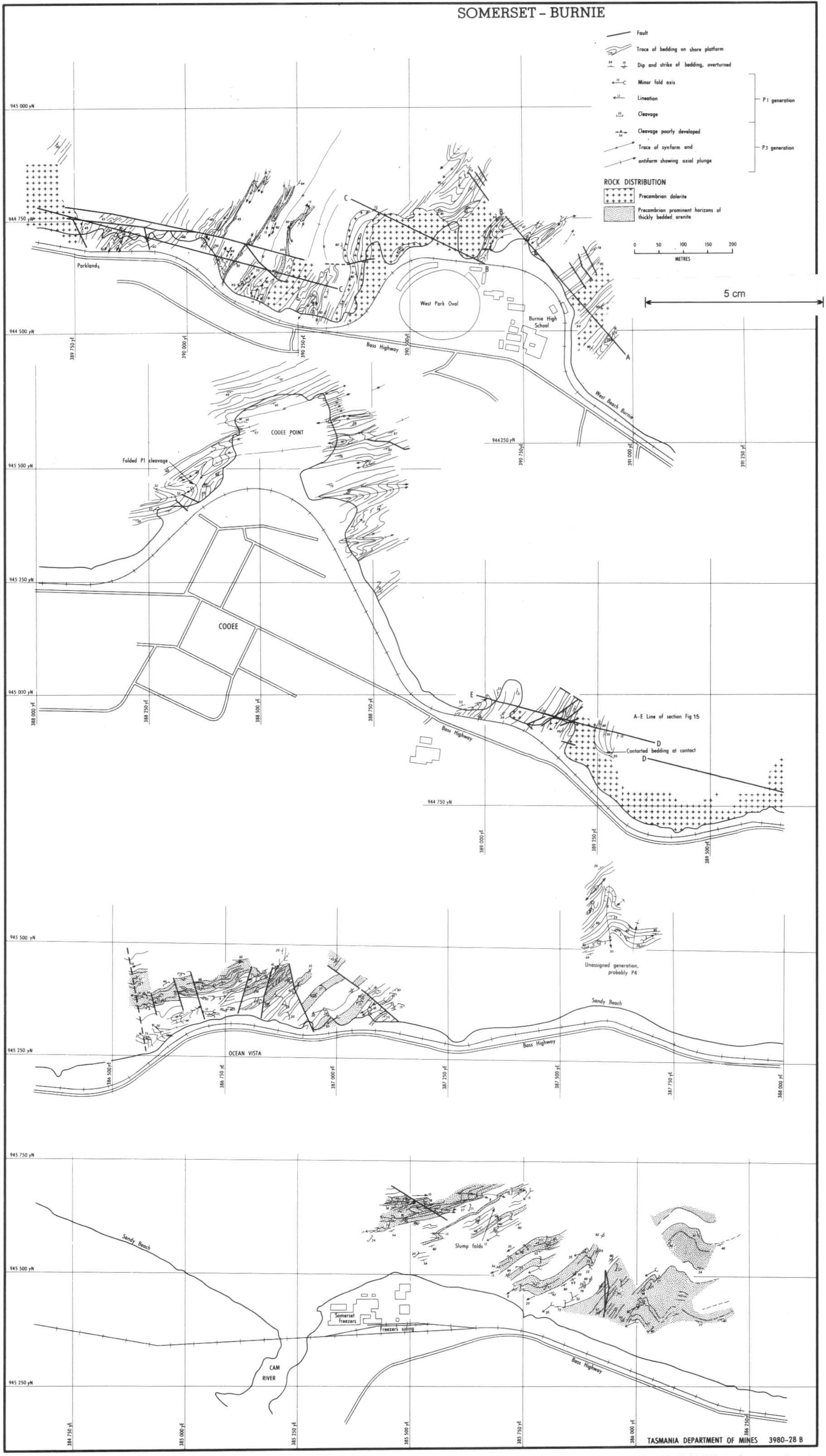
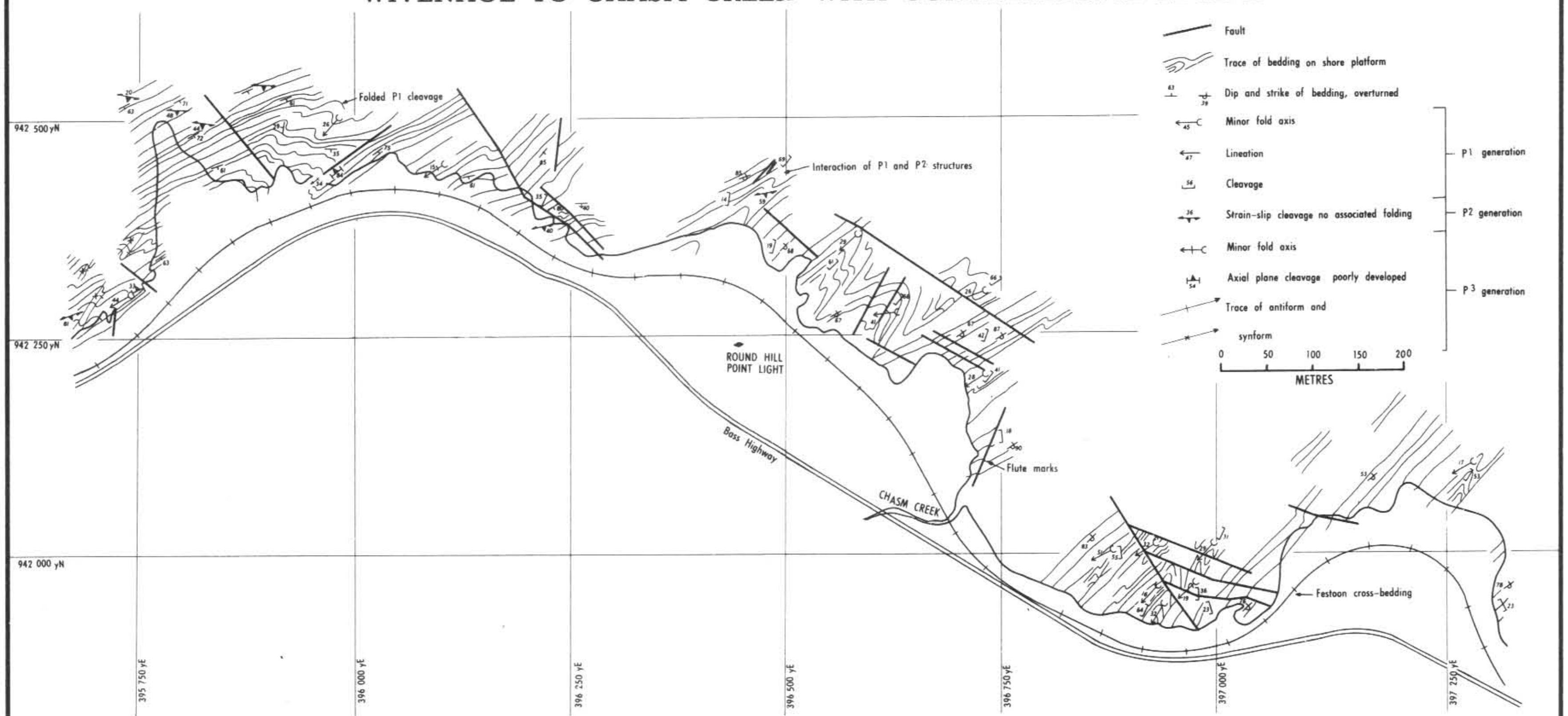
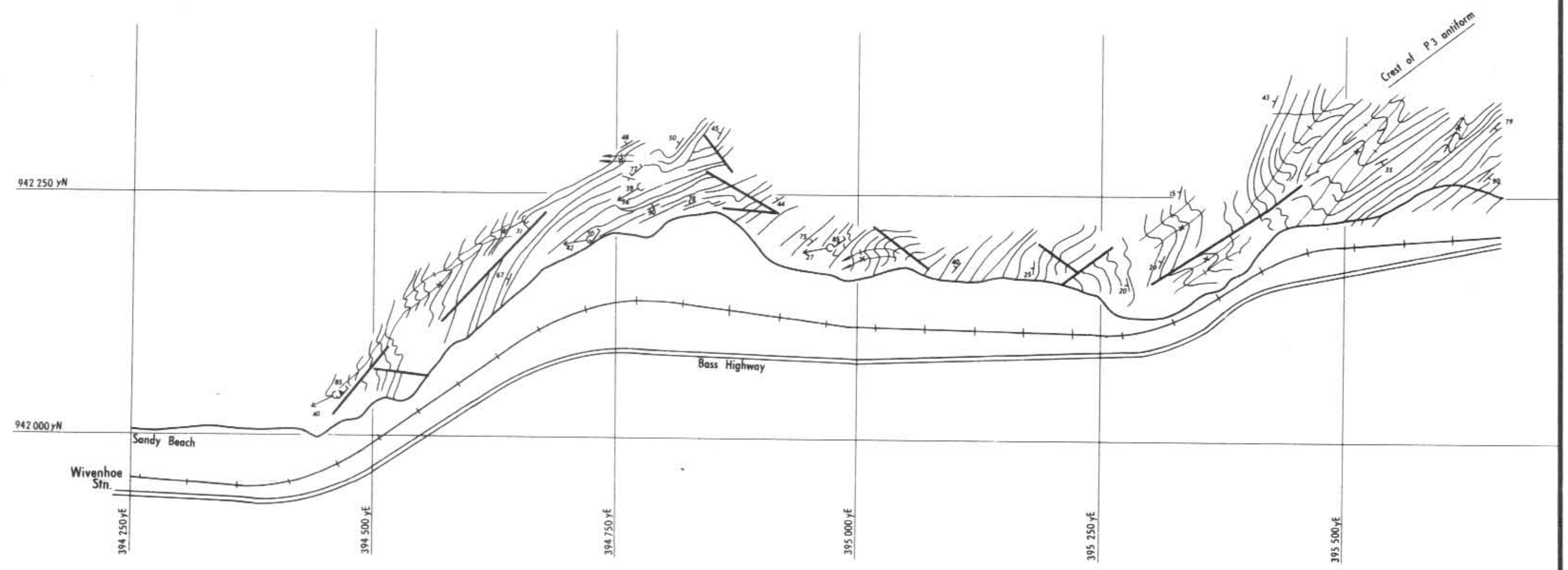

SOMERSET - BURNIE
Fault
Trace of bedding on shore platform
Dip and strike of bedding, overturned
Minor fold axis
Lineation
Cleavage
Cleavage poorly developed
Trace of synform and
antiform showing axial plunge
P1 generation
P3 generation
ROCK DISTRIBUTION
Precambrian dolerite
Precambrian prominent horizons of thickly bedded arenite
METRES
5 cm
Parklands
West Park Oval
Burnie High School
Bass Highway
West Beach Burnie
COOEE POINT
Folded P1 cleavage
COOEE
A-E Line of section Fig 15
Contorted bedding at contact
Unassigned generation, probably P4
Sandy Beach
OCEAN VISTA
Slump folds
Somerset freezers
Freezers siding
CAM RIVER
TASMANIA DEPARTMENT OF MINES 3980-28 B

Figure 5

WIVENHOE TO CHASM CREEK WITH COMPREHENSIVE LEGEND

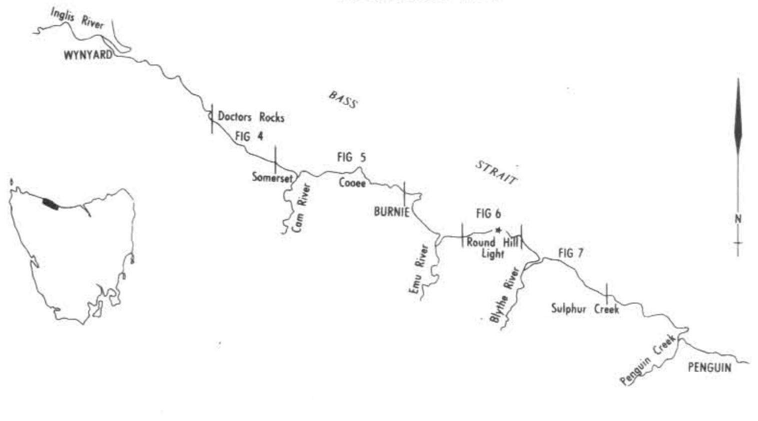




COMPREHENSIVE LEGEND

FOR DETAILED STRUCTURAL MAPS OF THE SHORE PLATFORM BETWEEN DOCTORS ROCKS AND SULPHUR CREEK

LOCATION MAP



- Tertiary basalt
- Tertiary pyroclastics
- Permian Wynyard Tillite
- Dolerite
- Dominant rock type of interbedded arenite and slate
- Prominent horizon of arenite
- Pillow lava

(Dolerite to pillow lava: Precambrian)

5 cm

- Fault
- Strike and dip of bedding in Palaeozoic rocks
- Trace of bedding on shore platform
- Bedding in Precambrian rocks, correct way up
- Bedding in Precambrian rocks, overturned on sedimentary evidence
- Bedding in Precambrian rocks, overturned on structural evidence
- Angular unconformity

P_1 generation
- Slaty or sandstone cleavage
- Minor fold axis
- Lineation (bedding and cleavage)
- Trace of larger mesoscopic antiform and synform

P_2 generation
- Strain-slip cleavage

P_3 generation
- Minor fold axis
- Axial plane cleavage
- Trace of minor antiform and synform

P_4 generation
- Strain-slip cleavage
- Trace of minor antiform and synform

P_5 generation
- Dome and basin
- Trace of minor antiform and synform

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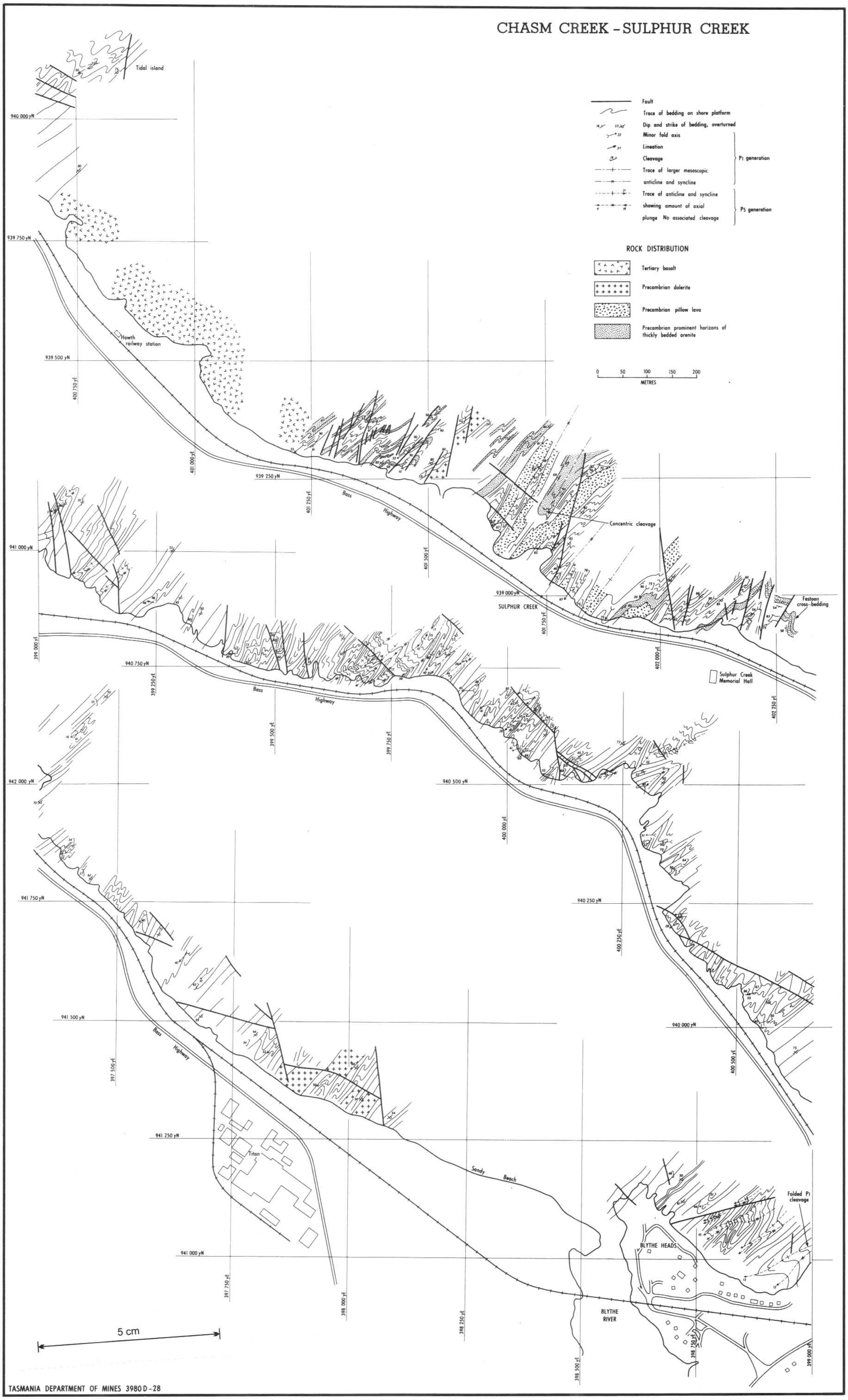

CHASM CREEK - SULPHUR CREEK
Fault
Trace of bedding on shore platform
Dip and strike of bedding, overturned
Minor fold axis
Lineation
Cleavage
Trace of larger mesoscopic anticline and syncline
P1 generation
Trace of anticline and syncline showing amount of axial plunge No associated cleavage
P5 generation
ROCK DISTRIBUTION
Tertiary basalt
Precambrian dolerite
Precambrian pillow lava
Precambrian prominent horizons of thickly bedded arenite
METRES
Tidal island
Howth railway station
Bass Highway
Concentric cleavage
SULPHUR CREEK
Festoon cross-bedding
Sulphur Creek Memorial Hall
Titan
Sandy Beach
BLYTHE HEADS
BLYTHE RIVER
Folded P1 cleavage
5 cm
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Figure 7