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TASMANIA DEPARTMENT OF MINES

GEOLOGICAL SURVEY
EXPLANATORY REPORT

GEOLOGICAL ATLAS 1:50 000 SERIES

SHEET 75(8312N)

BRIGHTON

by D.E. LEAMAN, B.Sc.(Hons.), Ph.D.

with contributions by F.L. SUTHERLAND, M.Sc., B.Sc.(Hons.),

E.A. COLHOUN, B.A., M.S., Ph.D., M.A.,

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ISSUED UNDER THE AUTHORITY OF THE HONOURABLE
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PREFACE

The Brighton geological atlas 1:50 000 map sheet was published in 1975. It covers an area lying between Kempton in the north and Bridgewater in the south, and includes Broadmarsh and Elderslie in the Jordan River valley to the west and Richmond, Colebrook in the Coal River valley to the east.

The results of detailed work on the Cainozoic volcanic rocks have been contributed by F.L. Sutherland, formerly of the Tasmanian Museum. The section on Quaternary deposits has been written by Dr E.A. Colhoun of the Geography Department, University of Tasmania.

J.G. SYMONS, Director of Mines

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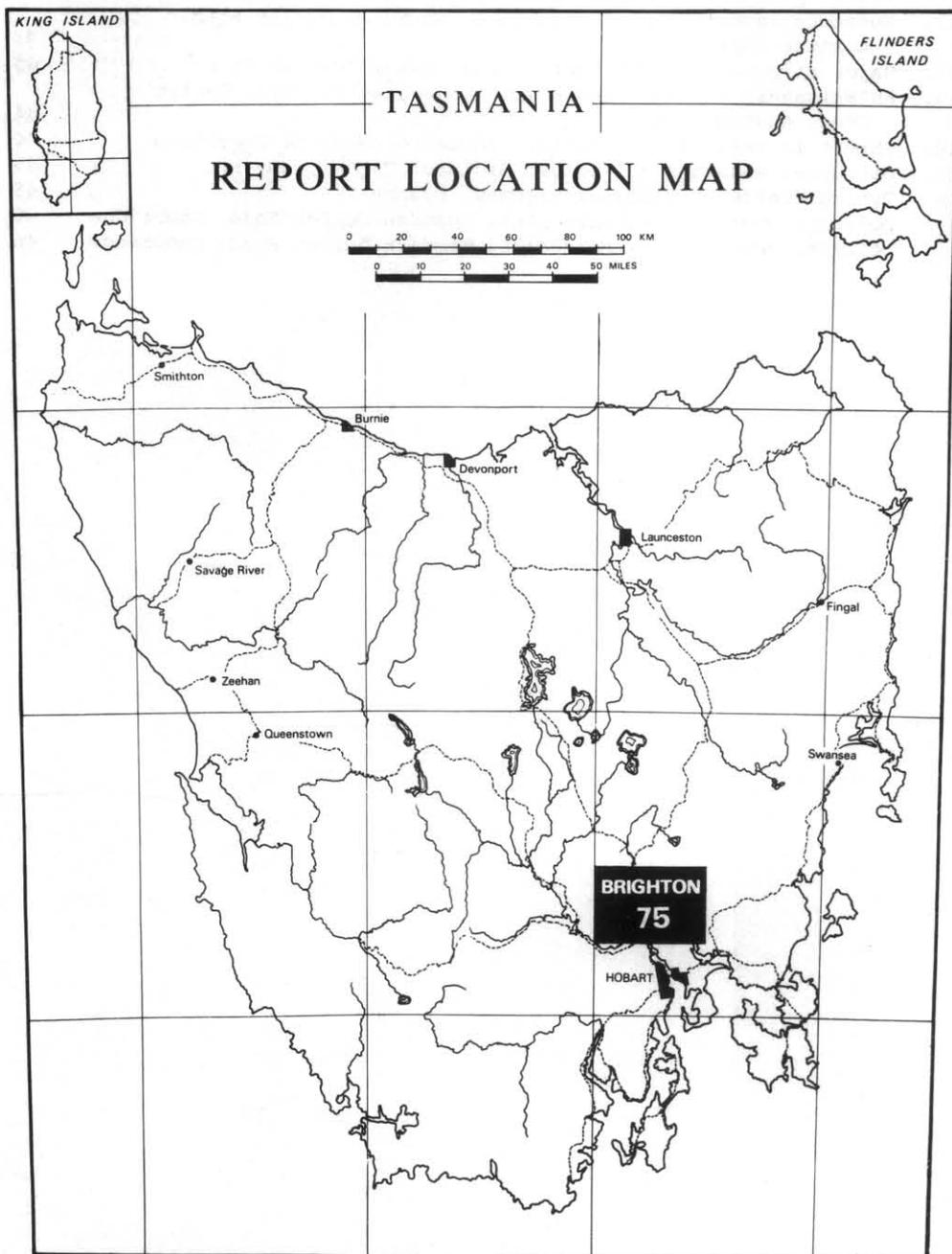


Figure 1. Location of Brighton Quadrangle.

5 cm

INTRODUCTION

The Brighton Quadrangle (fig. 1) covers an area of undulating rural land of moderate relief. The major regional occupation is stock grazing with some horticulture and minor forestry. In general, low rainfall and poorly balanced soils restrict agriculture. No metallic mineral deposits occur within the quadrangle, but coal, clay, sand, gravel and limestone deposits have been worked. Road making materials are abundant.

With the exception of the elevated Mt Dromedary plateau, access is excellent, the area being generally lightly timbered. Exposures are variable in quality and distribution, being poor in areas of low relief.

The map sheet was published in 1975 on a scale of 1:50 000. Mapping was executed on 1:15 840 dyelines supplemented by aerial photographs. Field work was undertaken intermittently between January 1966 and October 1971 concurrently with a gravity survey of the southern half of the quadrangle (Leaman, 1972).

PREVIOUS LITERATURE

The earliest detailed mapping of any part of the quadrangle was by Nye (*in Hills et al.*, 1922) which encompassed the Coal River Valley and surrounding country, with particular emphasis on coal resources. Nye (1922) extended the coverage of this map to include almost the entire eastern half of the quadrangle. These early publications were little more than sketch maps. Lewis (1946) presented a more detailed map, together with reliable observations of the south-eastern portion of the area. A soil map was produced by Dimmock (1957). The first detailed geological mapping was by Woolley (1959) in the New Norfolk-Black Hills area and McDougall (1959a) in the Pontville-Dromedary area. Sketch maps of the Dromedary-Magra area (Hughes, 1952) and the Coal River (F. Blake) were also produced, while Gatehouse (1967) mapped the Richmond-Sorell area.

Edwards (1950) and McDougall (1959b) provided petrological examinations of some basalts in the Brighton Quadrangle, while Edwards (1942) described some dolerites.

PHYSIOGRAPHY

The quadrangle is characterised by an undulating topography of generally moderate relief with isolated deeply dissected areas. Areas of low relief occur only in the valleys of the Coal, Jordan and Derwent rivers and in the Kempton and Pontville-Brighton-Tea Tree areas.

Much of the higher land is characterised by resistant dolerite masses. Triassic quartz sandstone occurs at all levels and cliff development is pronounced.

The topography is strongly influenced by faulting, as evidenced by numerous escarpments and straight, narrow valleys. The courses of the Coal and Jordan rivers and many smaller streams are also largely fault controlled and the morphology of these valleys indicates a Jurassic or possibly earlier age for this faulting.

Many streams have well developed incised meanders, particularly the Jordan River between Kempton and Elderslie, where meanders are well formed in all rock types. It is probable that the meanders formed on a wide plain and have subsequently become incised, while maintaining their form. Most

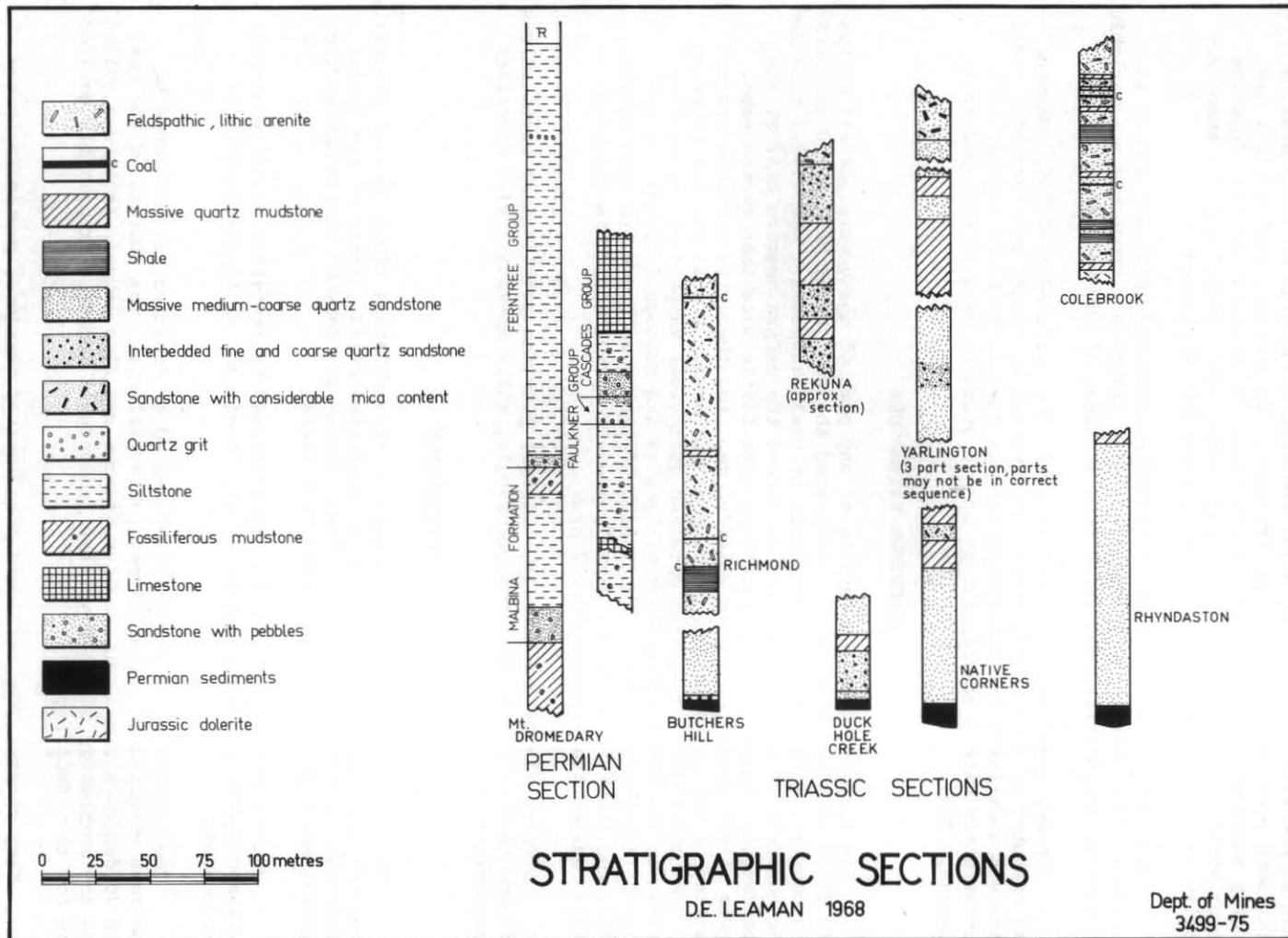


Figure 2.

streams are underfit implying larger flows in the past.

Terraces are common in many valleys, with older terraces formed up to 30 m above the present river level in the Derwent Valley. The terraces also suggest a past higher river base level and probable higher flows.

Extensive deposits of Tertiary and Quaternary materials occur in the Coal River valley. These have been dissected in the Campania-Richmond area and further gravel and alluvium deposited in the cuts. The alluvial deposits are generally highly fertile, but are subject to flooding and the development of unstable gullies.

STRATIGRAPHY

The oldest exposed rocks are of Permian age and comprise an intermittently fossiliferous siltstone-mudstone sequence with occasional limestone and sandstone units.

Triassic sandstone and mudstone, the youngest members of which contain coal, overlie the Permian rocks.

Jurassic dolerite intrudes the Permo-Triassic rocks as an integrated series of intrusions of which dyke and sheet limbs are partially exposed.

Tertiary rocks unconformably overlie the older rocks and commonly occupy eroded fault-troughs. Quaternary deposits are common in the valley floors of most streams and on many steep hillsides.

Permian

The total thickness of exposed Permian rocks is about 500 m (fig. 2). The base of the system is not exposed within the quadrangle. All the Permian formations are conformable. Faunal details are based on Clarke (1970).

BUNDELLA MUDSTONE

The Bundella Mudstone comprises about 75 m of fossiliferous, pebbly mudstone and siltstone containing calcareous mudstone and limestone units. There is no complete well-exposed section. Most occurrences are in the Dromedary-Upper Dromedary area where minor faulting disrupts the sequence. The formation was defined by Banks and Hale (1957) from exposures on the Lyell Highway [140667]* approximately 500 m south of the quadrangle boundary, where the upper pebbly fossiliferous mudstone and siltstone beds crop out, but the base is not exposed. In the Upper Dromedary region limestone, calcareous siltstone and siltstone up to 15 m thick underlie fossiliferous rocks of the more typical Bundella type. All the *Eurydesma*-rich rocks have been grouped into this formation by the author since the validity of correlations of the type attempted by Sutherland (1964) are uncertain at present.

Bundella Mudstone is characterised by *Eurydesma cordatum* Morris, *Keeneia platyschismoides* Etheridge, *Myonia morrisoni* (Etheridge), *Trigonotreta stokesi* Koenig, *Strophalosia subcircularis* Clarke and *Deltopecten illawarensis* (Morris). The formation is usually a distinctive unit and includes many rock fragments and pebbles. The upper members of the formation are olive-grey siltstone and fine sandstone which show alternating fissile and non-fissile units upon weathering. The formation shows a decreasing fossil content toward the top (Banks and Hale, 1957) and the upper beds may be devoid of fossils.

*All localities lie within the 100 km grid square EN.

FAULKNER GROUP

The Faulkner Group consists of 18-20 m of sandstone, mudstone and conglomerate of variable thickness, facies and lithology. These are the only non-marine Permian sediments, with the exception of the Cygnet Coal Measures. The group was defined by Banks and Hale (1957) and a number of members named. Although these members are mappable locally about Mt Dromedary, they are thin and have not been distinguished where rocks of this formation are exposed elsewhere. The group is predominantly unfossiliferous but occasional wood fragments occur. The Faulkner Group, as mapped, comprises the unfossiliferous strata lying between the richly fossiliferous Bundella Formation and the Cascades Group, with its distinctive fauna (Clarke, 1970).

CASCADES GROUP

The Cascades Group was defined by Banks and Hale (1957) to include the Nassau Siltstone, Berriedale Limestone and Grange Mudstone. All three units are richly fossiliferous. The Rayner Sandstone was separately defined, but the author has included this formation in the Cascades Group as it is fossiliferous and marks an abrupt change from Faulkner Group sedimentation and is a good marker horizon over the Upper Dromedary-Mt Faulkner (Hobart Quadrangle) area.

The Rayner Sandstone (Banks and Hale, 1957) comprises 3 m of pebbly, grey feldspathic sandstone with thick massive beds. It occurs beneath the fossiliferous grey-black Nassau Siltstone in the type section on Mt Faulkner and in the Dromedary range.

The Nassau Siltstone attains a maximum thickness of about 18 m. The formation is characterised by the brachiopod *Echinalosia preovalidis* (Maxwell), while spiriferids, pectinids, crinoid plates and Bryozoa are common.

The Berriedale Limestone and Grange Mudstone appear as facies variants over the Hobart and Brighton Quadrangles with a total thickness of 58-76 m. The limestone generally underlies the mudstone and is interbedded with thin siltstone units. Limestone units, or beds of calcareous mudstone occur at various levels in the Grange Mudstone. On the north face of Mt Faulkner (5 km south of the quadrangle boundary) the proportion of limestone to mudstone is 3:2, whereas on Mt Dromedary the mudstone is often absent. The limestone appears to thin rapidly to the south in the Hobart Quadrangle (Leaman, 1976).

The Berriedale Limestone consists of thickly bedded calcarenite and calcilutite. Siltstone is minor and thinly bedded, whereas coarse limestone beds occur up to 0.9 m thick, but more commonly 0.3 m in thickness. The limestone beds show pinch and swell effects which have been considered to be due to ripple-marking (Banks and Hale, 1957). Pebbles are common with the clastic content of the limestone increasing upward. Montmorillonite horizons in the limestone are thought to be due to distant volcanic activity (Brill, 1956; Hale and Brill, 1955). A chemical analysis of the limestone is given by Hughes (1957).

The Grange Mudstone is a generally fossiliferous, often pebbly association of fenestellid mudstone and siltstone. Bedding is marked and individual beds are only a few centimetres in thickness. The siltstone is lithologically similar to the siltstone of the Malbina Formation and Ferntree Group. Beds of quite pure limestone occur near the top of the unit at White Kangaroo Rivulet in the north-eastern section of the quadrangle. The Berriedale Limestone ranges in thickness from 45-76 m within the quadrangle and the Grange Mudstone from 0-30 m. Characteristic fossils include *Grantonia*

cracovens Wass, *Anidanthus springsurensis* (Booker), *Cancrinella farleyensis* (Etheridge and Dun), *Terrakea pollex* Hill, *Taeniothaerus subquadratus* (Morris), *Lyroporella*, *Thaumatoblastus*, *Wyndhamia jukesi* (Etheridge), *Euryphyllum*, *Martiniopsis profunda* (Campbell), *Grantonia hobartensis* Brown in the Berriedale Limestone and *Cancrinella farleyensis* (Etheridge and Dun), *Taeniothaerus subquadratus* (Morris), *Wyndhamia dalwoodensis* Booker, *Stenopora crinita* Lonsdale in the Grange Mudstone.

MALBINA FORMATION

The Malbina Formation consists of approximately 80 m of alternating sandstone and siltstone. Five members within the formation have been described. Basal Member A is a coarse, pebbly, fossiliferous sandstone often interbedded with calcareous siltstone and is well exposed on the eastern flank of Mt Dromedary. The thickness of this member ranges between 4-10 m. Fenestellids and stenoporids are absent and the fossil content may be low, with fossils restricted to a few beds. Members B and D are defined as pebbly siltstone and are not normally separable if Member C, a thin (1-2 m) pebbly sandstone, is not present. No sandstone clearly representing Member C has been located within the quadrangle. Member E consists of 5-10 m of fossiliferous mudstone, siltstone and intermittent sandstone and may be calcareous. The lithologies of Member E, the Grange Mudstone and the Bundella Mudstone are comparable, with all showing similar areal variations.

Member A is characterised by *Aperispirifer wairakiensis* (Waterhouse), *Martiniopsis undulosa* (Campbell) and *Terrakea concava* Waterhouse and Member E is characterised by *Megadesmus grandis* (Dana), *Terrakea brachythaera* (Morris), *Echinalosia ovalis* (Maxwell), *Astartila intrepida* (Dana), and *Vacunella curvata* (Morris).

FERNTREE GROUP

The Ferntree Group consists of the Risdon Sandstone and Ferntree Mudstone Formations.

The Risdon Sandstone at the base of the Group (Banks and Hale, 1957; Banks, 1962) is marked by beds of pebbly feldspathic sandstone 3-6 m in thickness, with an average grain size of 2-3 mm. The base of the sandstone is usually abrupt, but at the top grades into the overlying siltstone of the Ferntree Formation. The Risdon Sandstone is thickly bedded and contains rare brachiopod moulds. Angular pebbles of quartz, quartzite and granite up to 20 cm across occur within the unit.

Overlying the Risdon Sandstone is a sequence of predominantly coarse siltstone 165-180 m in thickness. The lithology is quite variable and a common association is an alternation of fissile and non-fissile bands with occasional sandstone and conglomerate. East of Craighourne a 5-6 m thick layer of quartz granules up to 5 mm set in a clay matrix occurs within 30 m of the top of the formation. Feldspar granules also occur. Fossils are rare and are generally restricted to one or two horizons, the best horizons occurring 30-40 m below the top of the formation and associated with coarsely bedded sandy siltstone containing numerous concretionary structures. The fauna is essentially similar to that of Member E of the Malbina Formation (Clarke, 1973). Worm casts and woody fragments are common throughout.

CYGNET COAL MEASURES

The Cygnet Coal Measures overlie the Ferntree Group and consist of a non-marine sequence up to 30 m thick of coal, carbonaceous mudstone and shale and, or, feldspathic sandstone containing carbonaceous fragments.

Difficulties have arisen with respect to the classification, dating and separation from the overlying non-marine rocks believed to be Lower Triassic in age (Banks and Naqvi, 1967), but spore analysis (Davidson, 1969) has shown this formation to be Permian in age. Thin carbonaceous mudstone and shale beds occur near Brandy Bottom [335927], Elderslie [062829] and Native Corners [302820]. Exposures of feldspathic sandstone (cf Barnett's Member - Leaman and Naqvi, 1967) with occasional carbonaceous fragments occur near Brandy Bottom and Craighourne Road [345898].

Triassic

Rocks of Triassic age may be divided into two associations. The first association, of Lower Triassic age (Cosgriff, 1974), consists of a sequence of quartz sandstone, mudstone and shale up to 425 m in thickness. The second association, of Upper Triassic-Rhaetic age (Hale, 1962; Townrow, 1962), contains at least 150 m of lithic-feldspathic sandstone and mudstone often with some coal. The rocks are of freshwater origin. Previously named subdivisions of the Triassic system have been found unsuitable and have not been adopted. Purely lithological associations have been indicated on the map.

QUARTZ ASSOCIATION

In order to indicate the nature and distribution of rock units, divisions have been made on a simple lithological basis; the type of sandstone and the proportion and type of shale or mudstone. Considerable care is necessary to give reliable assessments of the latter although the type of mudstone appears to be a good criterion. The following list of lithological units, which may occur within the association, are not necessarily in the order in which they occur in any given section.

Assemblage 1. Quartz grit and conglomerate. These are generally less than 0.7 m thick and consist of pebbles of quartz and quartzite up to 5 cm across. A matrix is rarely present. They occasionally form thicker but patchy occurrences at the base of the system, for example at Craighourne, but are normally scattered throughout the sandstone succession, with the grit grading into a medium- to coarse-grained sandstone.

Assemblage 2. Massively bedded, medium- to coarse-grained quartz sandstone with some mudstone and shale. This unit is dominantly sandstone, the sandstone to shale ratio normally exceeding 10:1 with the shale being very thinly bedded. This assemblage is 15-120 m in thickness and normally occurs only near the base of the system. Cliffs are a feature of this assemblage and occur frequently on the Jordan River north of Elderslie and in the hills east of the Coal River and north of Native Corners.

Assemblage 3. Similar to Assemblage 2 but with a sandstone-mudstone ratio of 3:1 or less. This assemblage may exceed 150 m in thickness.

Assemblage 4. Thinly bedded, generally fine-grained micaceous quartz sandstone containing some mudstone and shale, and often plant remains. The sandstone-mudstone ratio is often greater than 4:1. Coarser sandstone may be interbedded with the fine-grained sandstone and the feldspar content of the sandstone may exceed 10%. The thickness may exceed 90 m. Good exposures occur on Quoin Mountain and in road cuttings west of Brandy Bottom.

Assemblage 5. Occasional massive units of quartz sandstone with much massive mudstone and some shale. The sandstone ratio is often less than 1:2. The mudstone is the most stable of the Triassic system and exhibits a high degree of compaction. It shows pink blotches on unweathered faces and is grey-green when fresh. Substantial exposures occur on several elevated

areas in the Coal River valley. Occasionally thin coal seams and rare feldspathic sandstone beds occur in association with this assemblage which is invariably overlain by the lithic association. Coal has been observed in association with quartz rocks in Jerusalem Creek, 3 km west of the main Colebrook road. Red coloured mudstone beds are most common at this level, for example on Constitution Hill.

Assemblage 6. Clay pellet conglomerates only a few centimetres thick and sometimes containing vertebrate remains may occur in any of Assemblages 2, 3, 4 and 5.

The quartz rocks show a great variety of sedimentary structures. Current and festoon bedding is common and measurements of the current directions show azimuths to all points of the compass within a single group of outcrops. Insufficient data are available to suggest a preferred orientation, although a principal current direction from the north-west is inferred by Read (1960) and Hale (1962).

In general, there is a textural and compositional change through the sequence. The basal rocks are nearly always dominated by a massive medium- to coarse-grained quartz sandstone while the overlying rocks are more fine-grained, more feldspathic (c. 10-15% feldspar) and micaceous. The proportion of lutite increases upward and changes in form from thinly bedded minor shale to thick massive mudstone.

The sandstone and mudstone beds in Assemblages 2, 3, 4 and 5 may show rapid and extreme variation while maintaining the overall character of the unit, thus no attempts at correlation have been made. No complete section of the association appears to occur within the quadrangle.

LITHIC ASSOCIATION

Lithic feldspathic sandstone and mudstone have previously been called salt and pepper rocks (Hale, 1962). They are greenish grey in colour when fresh with a sandstone-mudstone ratio of usually 1:1. All variations in grain size are represented in the sandstone beds which show a characteristic fretting upon weathering. Carbonaceous lenses and thin coal seams are found in all parts of the series.

The lithic rocks also contain clay pellet beds and display cross bedding although this is much broader in style and rarely overturned.

Tertiary

SILT, SAND AND GRAVEL

Deposits of clay containing some beds of fine sand and occasional gravel occur in the valleys of the Coal River, Bagdad Rivulet, Pages Creek and Duckhole Rivulet. The major deposits occur in the eroded fault trough of the Coal River valley and are wedge-shaped in form (Leaman, 1972). The deposits have filled and overlapped the basin limits at Campania. West of Richmond the deposits contain rare bands of sand grade material in contrast with the more common sandy silt material. Lignite horizons occur near Richmond (Leaman, 1971a).

All units, but particularly the coarser sandy members, contain nodules of limonite ranging in size from 0.5-25 cm (plate 1).

The occurrence of such nodules in soft weathered units or soil profiles



Plate 1. *Limonite nodule in Tertiary clay and sand, Campania.*

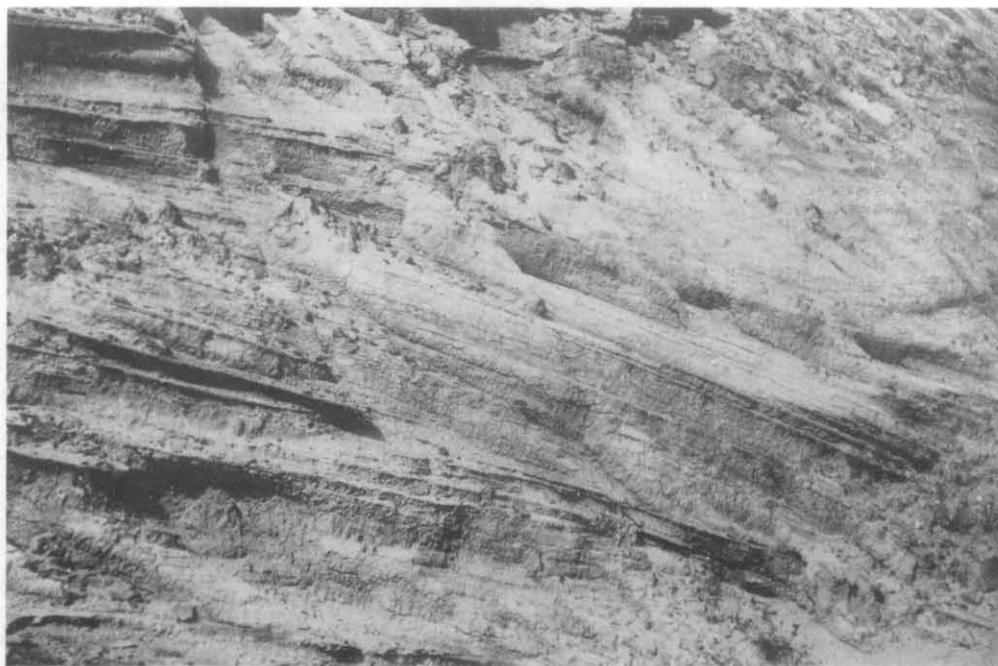


Plate 2. *Bedding in Tertiary clay and sand, Campania.*

often provides the only indication of the presence of Tertiary sediments and is normally a reliable field guide. The iron oxides may be derived from a laterising process and the nodules, as finally preserved, are presumably fragments of disrupted major deposits.

All units display a wide range of bedding features (plates 1, 2) but usually remain soft, friable and, in places, plastic. The passage of ground-water along bedding sometimes improves cementation and hardness (plate 2).

No definite marine fossils have been found in these deposits. Plant fossils consist mainly of leaf remains, wood fragments, seed cases and pollen. Organic walled microplankton have been recorded at Campania and indicate a mid-Tertiary age (Harris, 1968). These planktonic microfloras indicate marine or brackish water origins.

The age of these deposits is uncertain due to the limited evidence, but they are mainly sub-basalt deposits and therefore pre-date Tertiary volcanism. The thickness of material is generally unknown but drilling at Duckhole Rivulet and at Carrington [354717], north of Richmond, proved at least 146 m and 204 m respectively. Traces of these deposits also occur beneath the basalt at Mangalore and Pontville.

A deep, narrow channel has been proved south of Richmond and would appear to be either an outlet or a connecting passage between the basins in which the sediments were deposited (Leaman, 1971a, p.30). A complex history of erosion and deposition is implied by the form, level and deposition of many deposits.

SUB-BASALT TUFF

Sub-basalt tuffs are commonly associated with basalt flows in most parts of the quadrangle and are well exposed at Bridgewater (Sutherland, *in* Leaman, 1976). Tuffaceous and brecciated materials are less commonly seen but are associated with basalt centres east of Craighourne, and in Back Tea Tree Road (fig. 6).

SUB-BASALT GRAVEL

A cemented conglomerate including many basalt fragments occurs one kilometre east of Bridgewater. A road cutting in related material at [196683] shows a profile of weathered basalt, palaeosol, basal grit, pebbly sand and soil (plate 3). The sand content is variable. The texture throughout is very open. The source of cementation and partial silicification is uncertain in view of the demonstrable relationships to the nearest flows. The map sheet legend is in error in showing this exposure as sub-basaltic which would imply that it is older than all the basalts which are grouped together as Tertiary (Sutherland, p. 31). While younger than most lavas part of it is possibly older than the latest thin flow. The conglomerate is possibly a Pleistocene deposit but its age has not been established on present observations.

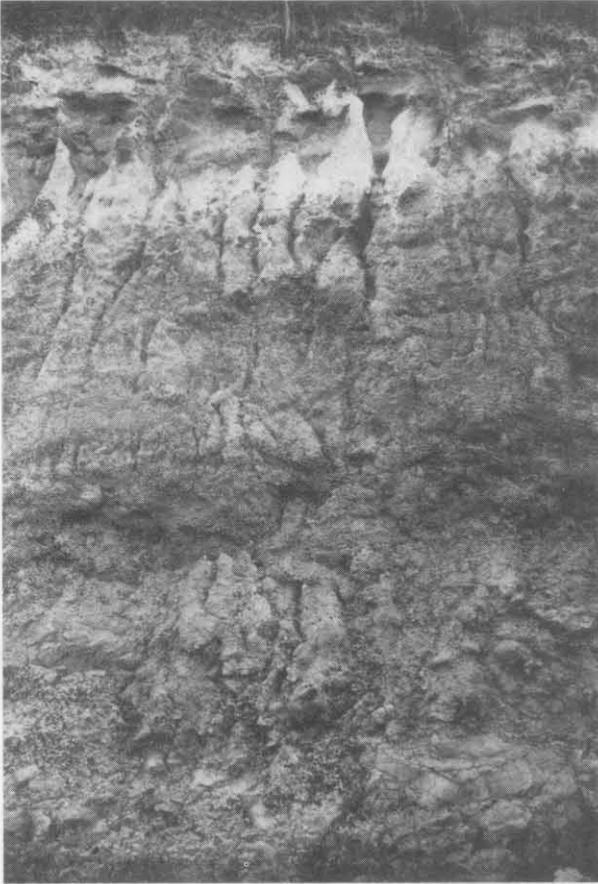


Plate 3. *Weathered basalt overlain by possible buried soil, basal grit, pebbly sand and soil. Old Beach Road, Bridgewater.*



Plate 4. *Talus overlying weathered Permian siltstone, Brandy Bottom.*

The Quaternary deposits include fluviatile gravels, sands, silts and clays, alluvial fan deposits, estuarine deposits, talus and associated slope deposits and aeolian coversands and loess. A strong palaeosol occurs at a few localities and permits a division of some of these deposits into lower and upper units.

Although the general character of the surficial deposits is known for much of the area more detail is available adjacent to the River Derwent between Dromedary and Bridgewater than elsewhere. Study in this area during and after publication of the map has permitted the determination of a provisional stratigraphic framework for the Pleistocene and Holocene deposits.

Table 1. QUATERNARY DEPOSITS OF THE BRIGHTON SHEET

Stage	Fluviatile/ Alluvial	Talus and slope deposits	Aeolian	Palaeosols
HOLOCENE	Estuarine sand, silt and swamp deposits of the Derwent	Disturbed slope deposits and landslips	Disturbed coversands (Aboriginal)	Buried soils (Aboriginal)
	Sand, silt and clay of stream valleys			
~10 000 BP				
Last Glacial	Sand, silt, clay and gravels of stream valleys	Scree, block fields and slope deposits	Upper coversands (15 740 ±700 BP) and loess	
E N E C O E S H E L P	Upper alluvial fan deposits			
Last Inter- glacial (?)				Limekiln Point palaeosol (probably >40 000 BP)
Pre- Last Glacial	Lower alluvial fan deposits		Lower coversands and loess	
	Older river gravel and sand			

PLEISTOCENE

Older river gravels and sands

Gravel and sand deposits occur up to 30 m above present river level at several localities on both sides of the Derwent Valley. These deposits, well exposed east of Windy Point [170676], represent the dissected remnants of old terraced gravels which formerly choked the Derwent and are stratigraphically the lowest Pleistocene strata known in the area.

The gravel and sand deposits are poorly to moderately consolidated and the bedding, which is distinct locally, is nearly horizontal. These deposits consist of moderately rounded and abraded cobbles up to 30 cm in diameter with a high percentage of quartzite. The gravels locally exhibit strong up-valley dipping imbrication structures which point to their deposition by the Derwent river system. The gravel and sand are weathered and iron stained and the occasional dolerite and basalt cobbles are strongly chemically decomposed.

The predominantly coarse gravel calibre of these deposits suggests that they were transported through and deposited in the Derwent Valley by a much higher energy river system than prevails at present. Such a system probably operated under colder climatic conditions than present and permitted aggradational filling of this section of the valley, possibly by a large braided river. The degree of weathering and stratigraphic position indicates that the gravel and sand are probably of pre-Last Interglacial age. The gravel and sand are locally overlain by fan, slope and aeolian deposits.

Alluvial fan gravels

On both sides of the River Derwent many of the tributary streams have deposited poorly sorted angular to poorly rounded alluvial gravels of local rock types in thick fans. South-east of Mt Dromedary, the fans associated with Dromedary Creek and Dean Brook contain abundant dolerite cobbles whereas south of the Derwent at Windy Point and Limekiln Point the fans are composed predominantly of Permian/Triassic sandstone, siltstone and mudstone fragments within a sand and silt matrix.

A section at Limekiln Point [155674] (plate 5) shows that the fan gravels are not all of the same age. The lower gravels are separated from the upper gravels by a 1-1.5 m thick aeolian sand deposit on which a palaeosol has been formed. The upper gravels are similarly capped by an aeolian deposit which is about 1 m thick.

The lower fan gravels at Limekiln Point vary from 2-10 cm in size and are partially weathered, with many of the siltstone and mudstone fragments having dark reddish-brown staining. The gravels occur as poorly stratified sheets which dip gently ($<10^\circ$) towards and pass below water level in the estuary.

The upper fan gravels range from 2-10 cm in size with occasional larger blocks up to 30 cm in size. As a whole, the deposit is poorly bedded and dips gently towards and beneath the estuary. In the Lyell Highway road sections the bedding is truncated by three deep V-shaped gullies which are filled with coarser debris from 10-30 cm in size.

The double fan sequence described for Limekiln Point appears to be a regional characteristic as a similar sequence has been recorded at Red Gum [067638] on the north-western side of the estuary (Sigleo, W.R., pers. comm.). The sedimentary characteristics of both the lower and upper fan gravels indicate that these deposits have not been transported far before being deposited. However, no significant additions are presently being made to the fan deposits through and around which the streams have cut deep valleys. The upper fan gravels were certainly mainly deposited prior to the Holocene rise of sea level in the estuary, probably during the colder climatic conditions of the Last Glacial stage. At this time strong flash flooding would have occurred in the small, steep, probably non-forested catchments as a result of snowmelt and would have permitted rapid transport and deposition of debris in the fans. The deposits were probably mainly derived from talus and associated slope deposits that were being formed by frost weathering

and moved by solifluction on the steep upper slopes of the catchments. The poor sorting and relative absence of water action has led Wasson (1977) to suggest that debris flow was an important process of transport and deposition. The lower fan gravels were probably formed by similar processes during an earlier cold stage before the development of the Limekiln Point palaeosol.

Scree and slope deposits

Thick scree and slope deposits are localised in the Brighton area and occur on and near the foot of steep slopes especially in areas of dolerite. Thin slope deposits less than one metre in thickness are common.

A primary distinction has been made on the map between scree (containing little or no matrix) and talus (containing >10% of fine fragments) and a secondary distinction based on rock type (Permian siltstone, Jurassic dolerite and Tertiary basalt). These distinctions are based on local mapping convention. Only the dolerite produces block scree accumulations with no finer constituents and these accumulations may pass vertically and downslope into finer grade dolerite slope deposits.

Accumulations of Jurassic dolerite blocks occur on and east of Mount Dromedary. The blocks are large, primarily joint determined blocks which have moved a short distance downslope and locally overlie fine-grained dolerite talus deposits.

Finer grained dolerite talus deposits occur on and adjacent to many of the higher dolerite capped hills, for example, west and south of Yarlington Tier, around Quoin Mountain, west and north of the Devils Backbone, east of Big Hill, north of Andersons Ridge, flanking Mount Dromedary on the east, south-east of One O'Clock Hill and north-east of Tanina Bluff. Basalt talus occurs south-west of Howards Hill and around Wingys Sugarloaf. Small amounts of talus derived from Permian siltstone occur on the southern slopes of Mount Dromedary, near Elderslie and at Brandy Bottom (plate 4).

The dolerite block screes and the finer grained slope deposits formed from siltstone, dolerite and basalt were probably formed on the exposed summits and steep upper slopes on more than one occasion when cold climatic conditions permitted stronger physical weathering and downslope movements to occur in a largely non-forested environment. Frost shattering and dislodging of already strongly jointed rocks to produce small angular fragments and transport of these detritals, together with previously weathered residues, by solifluction processes were probably mainly responsible for the accumulation of these slope deposits. The bulk of the extant slope deposits were produced or remobilised during the Last Glacial stage, but some may be older. Although no site in the Brighton area has unequivocally demonstrated a double sequence of slope deposits, a site at Fern Tree on Mount Wellington (Hobart Quadrangle) shows an upper grèzes litées deposit separated from a lower talus deposit by a palaeosol from which charcoal has been dated to >40 000 BP. (I-8155)¹

Aeolian deposits

Aeolian deposits consisting predominantly of massively bedded fine quartz sand occur between the lower and upper fan gravels at Limekiln Point and at Red Gum, 6 km south-west of Dromedary. These aeolian sand sheets were stabilised and experienced a prolonged period of pedogenesis prior to burial by the upper fan gravels. At Red Gum, a fossilised root channel penetrates the sandsheet.

¹Charcoal collected by E.A. Colhoun and submitted for assay by R.J. Wasson.

Aeolian coversands also occur above the upper fan gravels at Limekiln Point where they are about one metre in thickness, and as low gently undulating sheets one kilometre west of Bridgewater, on the hill spur west of the Old Beach Road bridge over the Jordan River, on the Glenfield property north-west of Cove Hill, and at Old Beach, 1.5 km south-east of the Jordan estuary. The coversands at these localities vary from less than one metre to about 4 m in thickness. At Glenfield, the basal beds of the sandsheet interdigitate with several thin wedges of sandy slope deposits that have been derived from the Triassic sandstones on the northern slope of Cove Hill (Sigleo, W.R. pers. comm.).

The primary origin of these aeolian coversands appears to have been by deflation of fine sands from the heavily aggraded bed of the River Derwent during times of lower sea level influence in the estuary. Much of the deflation may have taken place during summer low flow conditions when, except for the main channel, much of the broad river bed would have been dry. The general absence of cross-bedded structures within the sands suggests that they mainly accumulated by being trapped on a vegetated surface. The field evidence accords with the suggestion of Nicolls (1958) that the surface aeolian sands were probably formed during the later part of the Last Glacial stage. The stratigraphy indicates that an earlier phase of aeolian activity occurred after deposition of the lower fan gravels and before the development of the Limekiln Point palaeosol.

At Malcolms Hut Road, 4.5 km south-west of Richmond, an inland sand dune developed on the surface of alluvial fan gravels consists of cross-bedded quartz sands which contain charcoal fragments. These have been dated by the carbon-14 method at $15\ 740 \pm 700$ BP (SUA-376) (Colhoun, 1975).

An important section which exhibits two loess sheets occurs on the western side of the stream valley south of Limekiln Point (plate 6). An upper bed of loess 1-1.5 m thick is separated from a lower bed of loess more than 2 m thick by a reddish-brown palaeosol which is 0.3-0.5 m thick. Like the coversands the loess sheets are believed to have been deflated from the exposed bed of the Derwent during colder glacial climatic phases which were at least seasonally dry.

Dating

If the reddish-brown palaeosol is a regional marker surface, which is indicated by the charcoal from its surface at Fern Tree, Mount Wellington to be more than 40 000 radiocarbon years old, then the Pleistocene fan gravels, slope and aeolian deposits belong to an older and younger series. These series were probably formed during two colder climatic stages when conditions of surface instability prevailed because of the more vigorous effects of flooding, freeze-thaw weathering, mass movements, solifluction processes and deflation than occur presently, or occurred during the period of surface stability represented by the palaeosol. The most likely time of formation of the palaeosol was during the Last Interglacial, but its age has not yet been certainly established.

Sigleo (pers. comm.) has made an alternative interpretation of the stratigraphic sequence. He suggests a Last Glacial age for the duplicate fan slope and aeolian deposit sequence and suggests that the palaeosol was formed during the middle of the Last Glacial.

HOLOCENE

There is little information available for the deposits of Holocene age.

Alluvial deposits

Thin alluvial deposits, usually less than 5 m thick resting on a gravel base, are found in the axes and beds of most of the larger valleys and streams. The alluvial deposits vary in texture according to local lithology and relation to the present and former channel courses. The alluvial deposits of dolerite and mudstone areas are more clay-rich than those of sandstone areas. They mostly form floodplain and slightly higher terraces adjacent to the modern river courses. Some of the deposits contain charcoal. Near Campania, A. Goede (pers. comm.) has dated by the carbon-14 method the alluvial deposits in the lower part of Native Hut Rivulet to 4160 \pm 160 BP (GaK-2237) at a depth of one metre and those of the Coal River to 1730 \pm 110 BP (GaK-1678) at nearly 3 m depth. He has also obtained ^{14}C dates from the alluvial deposits in the estuary of the Coal River, south of Richmond, of 1990 \pm 100 BP and 5480 \pm 130 BP (GaK-905, GaK-2238) at 0.7 m and 1.5 m depth.

These dates support a Holocene age for much of the fine alluvial fill in the valleys, but the basal gravels and higher terrace fragments found in many of the valleys have not been dated and are probably mainly of Pleistocene age. In the lower Jordan valley a terrace at 9-11 m above the present river bed and several associated lower terrace fragments have been interpreted as being of Pleistocene age (Sigleo, pers. comm.).

Estuarine deposits

Extensive areas of estuarine silts have accumulated in the Derwent west of the Bridgewater causeway. These silts are about 25-29 m thick beneath the causeway (Leaman, 1977) having been formed in the estuary during the post Last Glacial rise of sea level. They presently border the shores with a large delta-like spread currently forming between Dromedary and Marshlands [156694]. Their accumulation has resulted from the influence of tides and flocculation of sediments from fresh and salt water mixing, together with the blocking effect of the causeway to sediment discharge.

Disturbed aeolian deposits

Several of the aeolian coversand sheets have been used by aborigines as camp sites at various times. These occupations have disturbed the surface sands which have been redeposited on top of the previously existing ground surface and soil profile, over hearth sites, and over weakly developed later soil profiles which were formed during occupation of the site.

One kilometre west of Bridgewater the surface of the coversand sheet was disturbed about 4540 \pm 105 BP (GaK-5593) and a shell midden was deposited on its surface. At Glenfield, aboriginal disturbance is recorded from hearths and burnt wood at 2055 \pm 85 BP (SUA-305), 1245 \pm 80 BP (SUA-304) and 210 \pm 80 BP (SUA-303). At Old Beach, aboriginal occupation is recorded at 5800 \pm 130 BP (SUA-306) on a charcoal sample and 5600 \pm 100 BP (SUA-307) on a *Mytilus planulatus* Lamarck shell from the same hearth, and at 1960 \pm 105 BP (SUA-308) on charcoal from another hearth site. Aboriginal impact caused disturbance and redeposition of the surface horizons of the sandsheet at these times as well as at other undated times (Sigleo and Colhoun, 1975; Sigleo, pers. comm.).

Disturbed slope deposits

Although most of the slope deposits recorded are primarily of Pleistocene age and appear to be predominantly stable under present environmental conditions, some may still be subject to slight movement. In the Dysart area roadworks have resulted in the remobilisation of landslip deposits (Sloane, 1977).

ACKNOWLEDGEMENTS

I wish to thank A. Goede, W.R. Sigleo and Dr R.J. Wasson for permitting me to include some of their research findings in this section.



Plate 5. *Section at Limekiln Point showing upper fan gravel and reddish brown palaeosol developed on aeolian sand overlying the lower fan gravel. [E.A. Colhoun]*



Plate 6. *Loess deposits south of Limekiln Point, Derwent Valley. [E.A. Colhoun]*

IGNEOUS ROCKS

Jurassic dolerite

Jurassic dolerite (McDougall, 1961) crops out over nearly half the quadrangle and forms a key structural unit. The dolerite is derived from a tholeiitic basaltic magma. Edwards (1942) sampled and petrologically examined the Gunnings Sugarloaf intrusion, but his conclusions relating to this intrusion must now be considered carefully in view of the structural evidence obtained by gravity survey. A complete description of intrusion form and structure is given by Leaman (1972, 1975).

Structural sections of the southern half of the quadrangle (fig. 3) show the intrusion forms present. Significant deviations from normal forms occur in Upper Triassic rocks in association with faults near Colebrook (fig. 4). Dolerite centres and boundary relationships are shown in Figure 5. Only in rare cases is it possible to measure the angle of discordance, most intrusions having a near-vertical or concordant boundary.

Granophyres are rare in the quadrangle, but occur east of Richmond [382688] and at Native Corners [312816]. The granophyre at Native Corners has an unusual composition which appears to be the result of assimilation. Specimens from both localities are described by Everard (*in* Leaman, 1971a). Pod-like inclusions of highly differentiated material occur in lower zone or contact dolerite in quarries on Brown Mountain and Mangalore Tier. Sill differentiation in dolerite is described by Everard (1976).

Cainozoic volcanic rocks

F.L. Sutherland

Volcanic rocks in the Brighton Quadrangle occur as flows, dykes and plugs, with some associated minor pyroclastic deposits. The rocks range from highly undersaturated (olivine nephelinite) to saturated types (olivine tholeiites). Eruptions from about twenty vents produced flows of alkali olivine basalt (40%), olivine nephelinite (25%), olivine tholeiite (20%), basanite (10%) and orthopyroxene-olivine basalt (5%). Vents are mainly located on or close to fault lines and fault intersections (50%), or near steep Jurassic dolerite intrusive contacts (40%), but a few centres lack obvious structural control (fig. 6). The vents generally lie between the major Jurassic dolerite feeders identified by Leaman (1972), though the tholeiitic centres associated with the Derwent-Jordan line lie adjacent to a major dolerite feeder axis.

The tholeiitic rocks form the largest flow areas; they lie near the terminations of the Derwent and Richmond fault troughs and have flooded old valleys draining these troughs. Near Pontville, the vents lie near some large circular features, interpreted from satellite imagery (ERTS 1) of the Derwent region, and these may represent volcanic collapse structures (K.R. Burns, CSIRO Division of Mineral Physics, pers. comm.). Similar circular features have also been interpreted in the Hobart Quadrangle, associated with some of the aligned volcanic centres postulated along the Derwent axis (Sutherland, 1976).

AGE

The age of the volcanism has not been fully established. A bore south of Campania [353721] penetrated at least two flows of transitional olivine tholeiite overlying and interbedded with Tertiary non-marine sediments of

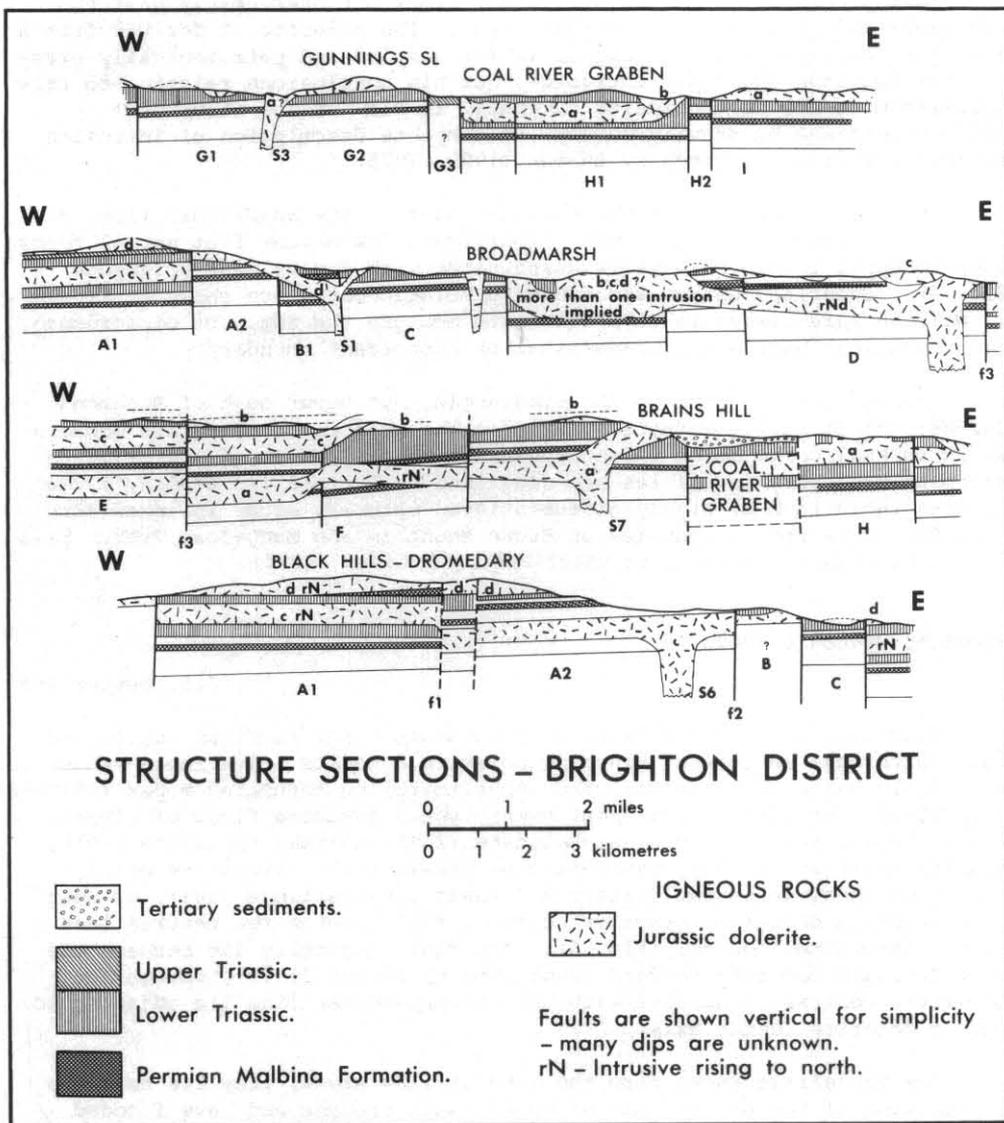


Figure 3.

← 5 cm →

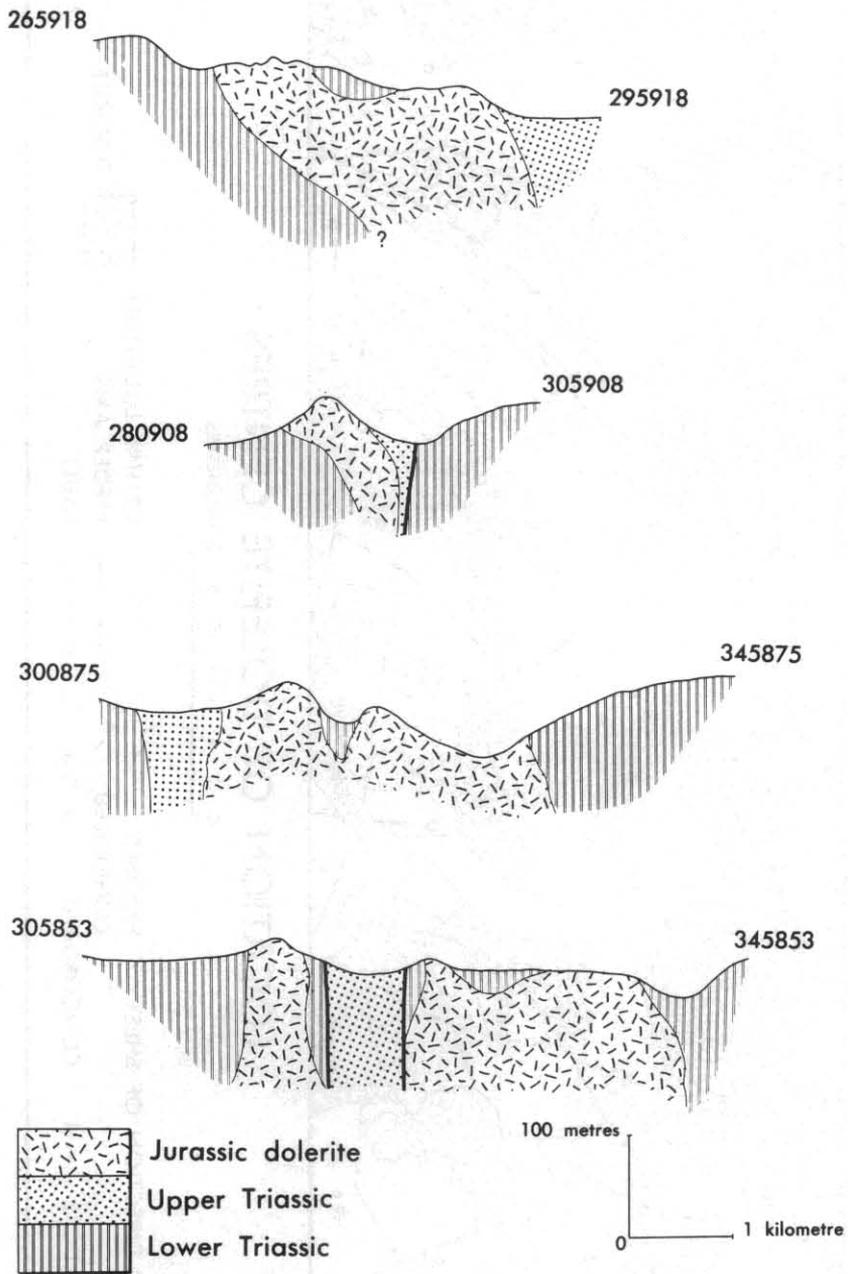


Figure 4. *Form of dolerite intrusions near Colebrook.*

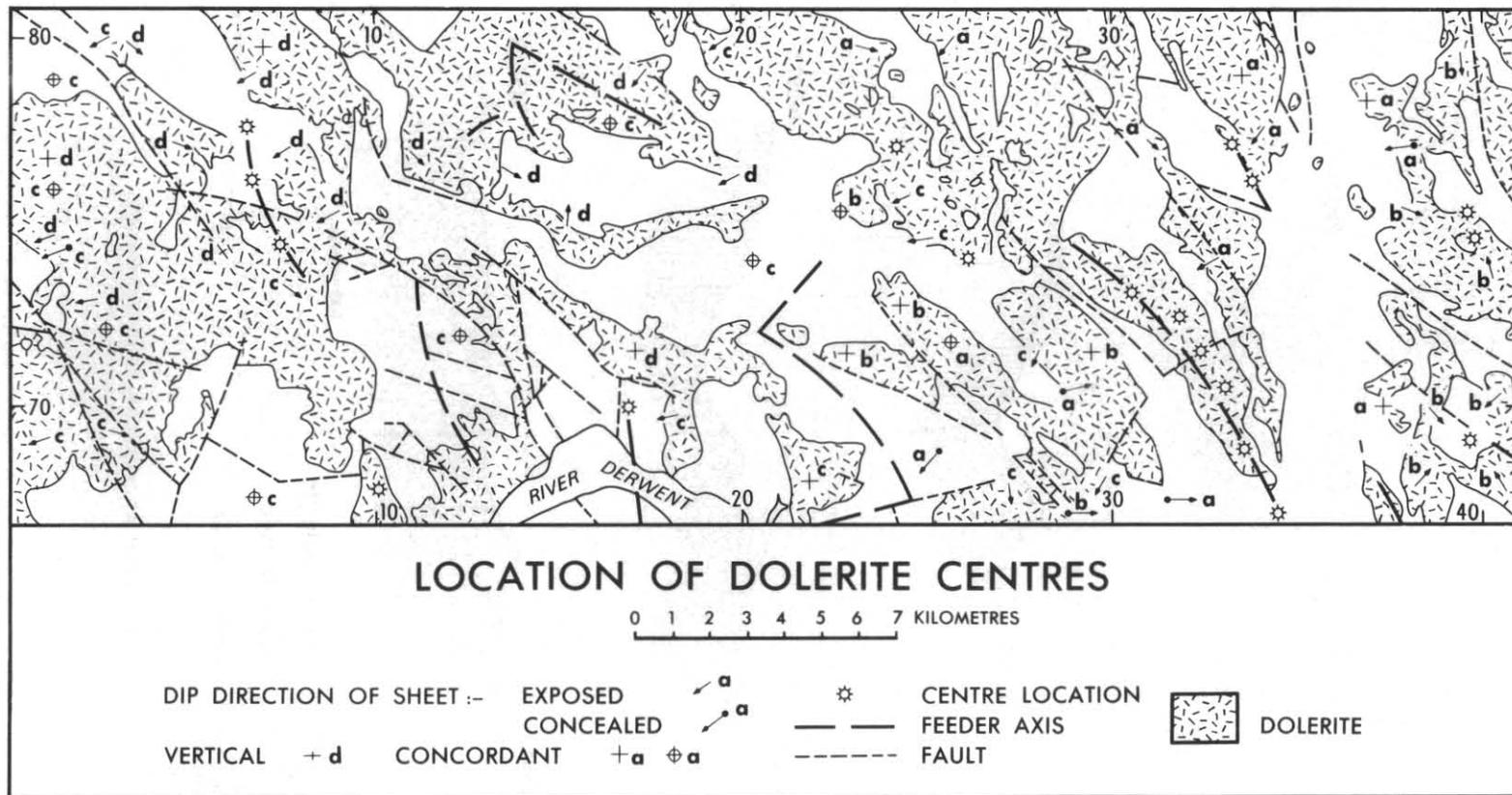


Figure 5.

↔ 5 cm ↔

the Coal River Basin (Leaman 1971a). The upper flow near Campania has been tentatively dated as mid-Tertiary on palynological grounds (Harris, 1968). Further upstream, these basalts disconformably overlie an earlier flow of alkali olivine basalt dated by K/Ar measurement as 23.6 Ma, *i.e.* Upper Oligocene age (Sutherland *et al.*, 1973). The Tertiary sediments at Campania contain planktonic microfloras of marine or brackish water origin (Harris, 1968) which may relate to periods of relatively higher sea level on Tasmanian coasts during the Miocene (Quilty, 1972). The evidence thus suggests that the bulk of the Coal River basalts were erupted in Upper Oligocene-Miocene time.

In the Brighton-Pontville area the main tholeiitic valley flow is partly dissected and is considered younger than the nearby residual plugs of alkali olivine basalt and olivine nephelinite. It is one of the 'younger' flows filling the Derwent drainage system and appears to overlie the tholeiitic flow foot breccia at Bridgewater and older tholeiitic lava and flow foot breccia around Claremont (Hobart Quadrangle). The Brighton flow compares physiographically with other Tasmanian flows dated as old as mid-Tertiary (Sutherland *et al.*, 1973). Whether the underlying flow foot breccia at Bridgewater was formed by eruption into the Derwent estuary during a higher level associated with the relative high sea level of the Miocene or was erupted into the Derwent River when dammed by earlier eruptions downstream is uncertain on present evidence.

BASALT PETROLOGY

SUMMARY

The Brighton volcanic rocks (table 2) are an extension of the basalt associations described in the Hobart area (Sutherland, 1976). The alkali basalt association is zoned geographically around the tholeiitic association, but without the outermost alkaline association. A number of the under-saturated rocks contain spinel-lherzolite xenoliths and xenocrysts (Mg-olivine, Al-enstatite, Al-diopside, Cr-spinel) suggesting a mantle origin. Some also contain high pressure megacrysts (*e.g.* Butlers Hill, table 3).

The absence of lherzolites and megacrysts from the tholeiitic rocks does not necessarily preclude mantle derivation (Sutherland, 1974). The Brighton flow, however, shows a high initial $\text{Sr}^{87}:\text{Sr}^{86}$ ratio (0.7078; Compston *et al.*, 1968), suggesting some possible crustal contamination during the evolution of the tholeiitic magma.

Accidental fragments of Permo-Triassic sediments and Jurassic dolerite are found in a number of the lavas and pyroclastics. However, 'doleritic' and 'pyroxenitic' xenoliths found in the olivine nephelinite north-east of Rekuna [320780] are not typical of the exposed country rocks. On the basis of their mineralogical composition and texture and the contrasting composition of the host olivine nephelinite, it is unlikely that these xenoliths crystallised from this magma at depth.

REKUNA XENOLITHS

Four types of 'doleritic' and 'pyroxenitic' xenoliths can be distinguished in thin sections and in mineral compositions (Sutherland; unpublished electron micro-probe analyses). A 'dolerite' of probable higher pressure origin contains labradorite ($\text{Ca}_{53}\text{Na}_{46}\text{K}_1$), Al-salitic clinopyroxene ($\text{Mg}_{41}\text{Ca}_{50}\text{Fe}_9$; Al_2O_3 8.1-8.3%), Al-bronzitic orthopyroxene ($\text{Mg}_{76}\text{Fe}_{22}\text{Ca}_2$; Al_2O_3 5.8-6.1%) and green pleonaste spinel ($\text{Mg}_{59}\text{Fe}_{41}$) and shows some strain texture. A 'dolerite' of probable lower pressure origin contains labradorite ($\text{Ca}_{49-56}\text{Na}_{42-49}\text{K}_{1-2}$), Al-ferrosalite ($\text{Mg}_{26}\text{Ca}_{50}\text{Fe}_{24}$; Al_2O_3 7.3-7.8%) and some

Table 2. CHEMICAL ANALYSES AND CIPW NORMS OF BRIGHTON CAINOZOIC VOLCANIC ROCKS.

Analysis	1	2	3	4	5
SiO ₂	51.48	46.28	44.16	43.57	41.41
TiO ₂	1.60	1.96	2.37	2.74	2.48
Al ₂ O ₃	14.18	15.64	12.56	11.88	11.81
Fe ₂ O ₃	1.56	2.19	2.95	2.85	6.04
FeO	9.61	7.66	10.57	9.55	8.03
MnO	0.15	0.17	0.21	0.19	0.21
MgO	8.18	9.33	8.42	11.68	10.39
CaO	8.95	8.23	9.64	8.61	9.97
Na ₂ O	2.61	3.96	3.54	3.74	4.25
K ₂ O	0.82	1.60	1.33	1.99	1.22
P ₂ O ₅	0.29	0.90	0.89	1.10	1.16
H ₂ O ⁺	1.00	{ 1.57	{ 2.53	{ 1.89	{ 2.42
H ₂ O ⁻	0.24				
Total	100.67	99.49	99.17	99.79	99.39

CIPW Norm

Q	0.11	-	-	-	-
Or	4.88	9.88	8.38	12.42	7.68
Ab	22.21	23.42	18.94	12.60	8.33
An	24.69	21.06	15.40	10.28	10.19
Ne	-	6.29	7.01	11.25	16.26
Di	14.75	12.39	23.83	21.71	27.80
Hy	27.34	-	-	-	-
Ol	-	18.93	16.69	21.05	19.05
Mt	2.27	1.93	2.70	2.45	2.75
Il	3.06	3.88	4.80	5.49	5.02
Ap	0.69	2.22	2.25	2.76	2.93

1. Olivine tholeiite, 400 m upstream from bridge, Bridgewater.
2. Alkali olivine basalt (transitional hawaiiite), 5km WNW of Campania.
3. Alkali olivine basalt, Butlers Hill, 9 km NNE of Pontville.
4. Basanite, Eldon, 7 km ENE of Colebrook.
5. Olivine nephelinite, 3 km NW of Campania.

Analysis 1 from Edwards (1950). Analyses 2-5, per D.H. Green (P. Beasley and E. Kiss, analysts), Research School of Earth Sciences, Australian National University.

Norms are recalculated to 100% anhydrous.

minor opaque spinel. The plagioclase tends to be allotriomorphic and the clinopyroxene shows pale olive-brown to green pleochroism and some alteration to hornblende.

A high pressure 'pyroxenite' (websterite) consists predominantly of coarser Al-bronzite (Mg₇₃₋₇₅Fe₂₅Ca₁₋₂; Al₂O₃ 4.4-4.9%) with smaller grains of Al-salite (Mg₃₉Ca₄₇Fe₁₄; Al₂O₃ 6.0%). The orthopyroxene contains regularly arranged inclusions of titan-phlogopite(?) and rare 'iddingsitised' inclusions of olivine(?) and shows strain and exsolution textures. A clinopyroxenite consists largely of a mosaic of salite (Mg₃₈Ca₄₇Fe₁₄; Al₂O₃ 0.8%).

The xenolithic occurrence lies within an area of Triassic beds which contain several plugs of closely similar alkali olivine basalt and probable sources for tholeiitic lavas (12 x 22 km, Richmond-Lowdina-Rekuna-Tea Tree; fig. 6). The xenoliths may thus represent fragments picked up from underlying crystallised basalt magma chambers as the olivine nephelinite rose up from the mantle (lherzolite inclusions). This would suggest that the Rekuna eruption post-dates the other basalts in the area. The relatively greater denudation of the other plugs is compatible with this, the only exception being the Coal River fillings where basalts were preserved under successive flows.

Alternatively, the xenoliths may represent pre-Tertiary crustal or upper mantle crystallised magmatic reservoirs. The lower pressure 'dolerite' resembles some phenocrystic phases found in Cretaceous intrusive complexes in Tasmania, which commonly do not penetrate above the Permian beds (Sutherland and Corbett, 1974). The higher pressure orthopyroxene-bearing 'dolerite' and 'pyroxenite' may come from reservoirs that fed the widespread Jurassic tholeiitic dolerite or may represent even older melting and re-crystallisation episodes associated with formation of 'granulitic' crust or mantle under Tasmania. Detailed chemical and/or age dating of the xenoliths is required to establish their precise sources.

THOLEIITIC OLIVINE BASALT

Bridgewater

Flow-foot breccia dipping east to south-east and up to 30° crops out on the eastern shore of the River Derwent between Green Point and Bridgewater. Further breccia occurs in highway cuttings and housing estate trenches east of Bridgewater, and pillow lava is exposed in cuttings on the Boyer Road west of Bridgewater railway station. The breccia is at least 35 m thick and is disconformably(?) overlain by a thin flow remnant with a vesicular base. It disappears to the east against the steep valley-fill of the Brighton basalt. Post-basaltic consolidated conglomerate overlies the breccia approximately 7 m above river level in a gully one kilometre east of Bridgewater. In addition to reworked siliceous gravel derived from a higher deposit, the conglomerate contains common pieces of basalt derived from the local capping above the breccia; the altered and leached basalt fragments probably provided the silica replacement in logs and pieces of petrified wood found in the deposit (Tasmanian Museum specimens Y994, Z1617).

The flow-foot breccia appears to pre-date the Brighton basalt, although the contact is poorly exposed, and it probably represents lava extruded from a nearby vent into a higher or dammed Derwent estuary. The pillow lava west of Bridgewater Station shows very little breccia development and may have been extruded entirely under water. Petrologically, the Bridgewater type (table 2, analysis 1) is a relatively quickly chilled olivine tholeiite (Edwards, 1950; McDougall, 1959b).

Brighton

This thick flow and its petrology has been described in detail by McDougall (1959b). Sub-basaltic contours suggest that it erupted immediately south of the Brighton Racecourse into an old valley of the Jordan River, cut to a depth well below present sea level. Lewis (1946) described scoria in railway cuttings to the south of Brighton Station, but this was not observed in the exposures seen by the writer. McDougall described nearby sub-basaltic tuff, but detailed examination suggests that the coarser lower 'tuff' represents a weathered dolerite profile.

Richmond

At least two flows of massive to locally scoriaceous basalt occupy the Coal River valley (Lewis, 1946; Gatehouse, 1967; Leaman, 1971a). The sources appear to lie in the Lowdina area, where the basalts reach their highest elevation.

In thin section, both flows appear to be transitional olivine tholeiite, mainly with an intergranular texture and amygdaloidal fillings of carbonates, iron oxides, opal and indeterminate chloritic and clay materials.

Basaltic plugs mapped near Lowdina are identical to chilled Jurassic tholeiite in thin sections and are not included with the Tertiary basalts.

ALKALI OLIVINE BASALT AND TRANSITIONAL HAWAIIITE

North-east Campania

At 'Cranston' [354791] a small plug 30 m across intrudes 3 m of poorly bedded agglomerate. The basalt tails into a small dyke dipping near vertically on its western side and shows cooling columns radially outwards. The breccia shows crude jointing parallel to the plug contact and dipping 60-90° NW. It contains angular to rounded fragments of vesicular, mostly weathered basalt, baked Triassic shale and sandstone up to 30 cm across and rare, altered Jurassic dolerite.

In thin section, the rock contains glomeroporphyritic olivine and titaniferous augite (some with corroded, more salitic cores) grading into a fine-grained base with plagioclase laths, granular iron-titanium oxide and interstitial glassy mesostasis.

The rock probably represents the feeder for the petrologically similar massive flow nearby. This forms a 33 m thick filling (dated at about 24 Ma) in an old course of the Coal River, now exposed in a gorge of the present river.

West Campania

A patch of basalt rubble several metres across occurs 2 km west of Campania. It is associated with worn chert pebbles and differs texturally from other alkali basalts in the area. It may represent a deeply eroded isolated arm of the Coal River flow or a relict flow from a plug north-west of Rekuna [293774].

In thin section, the rock is a relatively coarse-grained basalt, with olivine phenocrysts in an intergranular to sub-ophitic intergrowth of labradorite and titaniferous augite, with iron-titanium oxide grains and amygdaloidal zeolites and clays.

North-west Rekuna

This small hill [293774] of dense, massive blocky basalt contains sporadic small lherzolite xenoliths, mostly less than 3 cm across, and rare small fragments of Triassic sediments and Jurassic dolerite. In thin section, the rock contains olivine, titaniferous augite, zoned labradorite laths and granular iron-titanium oxides, in a glassy, partly feldspathoidal, and zeolitic mesostasis. Chemically (table 2, analysis 2) the basalt is relatively high in soda and approaches a transitional hawaiiite.

White Kangaroo Rivulet

This small plug of massive basalt [372861] contains olivine phenocrysts in a groundmass of prismatic titan-augite, labradorite laths, iron-titanium oxides and an interstitial glassy mesostasis.

South Richmond

A small, steep sided irregular plug is exposed in the cliffs on the east bank of the Coal River, one kilometre south-east of Richmond [367678]. In thin section, the rock contains olivine and rare clinopyroxene phenocrysts in a fluidal groundmass of zoned labradorite laths, clinopyroxene and iron-titanium oxide grains in a potassic and partly feldspathoidal mesostasis. It includes partially fused fragments of Triassic sediments, rare xenocrysts of olivine, orthopyroxene and chrome-spinel. In composition it resembles the potassic alkali olivine basalt (2% K₂O) in the plug 2 km to the south in the Hobart Quadrangle (Sutherland, 1976).

Tea Tree

Basalt forms a conical hill over 60 m high approximately 4 km south of Tea Tree [274692]. Fragments of agglomerate occur on the eastern side 10-20 m above the base of the outcrop, but whether this represents two flows is uncertain due to poor exposure. The hill probably represents an eroded neck. The lower basalt petrologically resembles the other basalts described from the Richmond-Campania-Rekuna area. The upper basalt grades into a relatively coarse-grained, more completely crystallised intergranular rock, and shows locally prominent interstitial and amygdaloidal zeolite.

Maiden Erleigh

A poor exposure of massive dense basalt probably represents a small plug one kilometre north-east of Pontville [239752]. In thin section the rock contains xenocrysts of olivine, orthopyroxene (some with reaction coronas of prismatic clinopyroxene) and chrome-spinel (with opaque reaction rims) that probably represent disaggregated lherzolite. Small megacrysts of oligoclase, clinopyroxene and pleonaste spinel up to one centimetre across also occur. The host basalt petrologically resembles the Tea Tree rock, but may be transitional to basanite.

North-east Butlers Hill

Poorly exposed, mostly dense and massive basalt with some streaky flow banding occurs north-east of Butlers Hill [260819]. The basalt grades into irregularly vesicular phases and contains common fragments of Jurassic dolerite and Triassic sediments up to 10 cm across with loose dolerite fragments up to 25 cm present amongst the basalt float. Lherzolite xenoliths up to 3 cm across are common and some basalt contains prominent megacrysts of kaersutitic amphibole (table 3, analysis 1) up to 4 cm across. Rarer megacryst species include olivine (some intergrown with amphibole), clinopyroxene and spinel. Chemically, the basalt is relatively undersaturated and approaches a basanite (table 2, analysis 3).

BASANITE

Gunns Sugarloaf

A small dyke-like plug approximately 130 m in length and 30 m in width crops out on the saddle to the west of the Gunns Sugarloaf [286700]. The dyke displays a steep platy flow structure trending NNW and contains fragments

Table 3. MEGACRYST ANALYSES, BUTLERS HILL

Analysis	1	2	3
SiO ₂	41.9	40.6	-
TiO ₂	4.1	-	17.6
Al ₂ O ₃	10.2	-	4.9
"FeO"	16.9	11.5	73.6
MgO	11.4	47.9	3.2
CaO	11.1	-	0.2
Na ₂ O	3.4	-	-
K ₂ O	1.1	-	-
Cr ₂ O ₃	-	-	0.2
MnO ₂	-	-	0.3

1. Kaersutitic amphibole (Mg₃₉Ca₂₈Fe₃₃).
2. Olivine (Mg₈₈Fe₁₂) intergrown with kaersutitic amphibole.
3. Ulvospinel.

Analyses by F.L. Sutherland, recalculated to 100% anhydrous and determined by TPD electron microprobe, Australian National University, Canberra.

of Jurassic dolerite, Triassic sediments and numerous lherzolitic xenoliths and xenocrysts up to 8 cm across.

In thin section, the basalt contains olivine and titaniferous augite phenocrysts grading into a poikilitic groundmass with late-stage labradorite (zoned from about An₆₅) and a colourless glassy mesostasis containing nepheline. No analysis is available but the rock takes a strong feldspathoidal stain test, probably sufficient to classify it as a basanite.

South Eldon

A basalt plug south of Eldon [368934] extends southward downhill as a flow remnant. The rock is dense and massive, with cooling columns mainly dipping north, and contains sporadic to common lherzolite xenoliths and xenocrysts up to 7 cm across. It also includes fragments of Permo-Triassic sediments, Jurassic dolerite and pieces of quartz schist and vein quartz, but whether the latter were derived directly from underlying folded basement rocks or were exotic fragments in the Permo-Triassic beds is uncertain.

In thin section, the basalt contains phenocrysts of olivine and titaniferous augite grading into a groundmass of plagioclase laths, irregular grains of iron-titanium oxides and analcitic, interstitial glassy mesostasis with small amygdales of zeolite.

Chemically (table 2, analysis 4), the rock contains more than 11% of normative nepheline and can be classed as a basanite, transitional towards a feldspathoidal hawaiite.

ORTHOPYROXENE-OLIVINE BASALT

A small, poorly exposed basalt outcrop occurs adjacent to the northern side of the basanite plugs at Eldon. It is a dense massive basalt and is sufficiently distinct in petrology to be regarded as a separate small plug.

In thin section, the rock contains glomeroporphyritic olivine, partly altered to serpentine, in a feldspathic groundmass of labradorite laths and plates (zoned from about An₆₅) with grains and euhedra of clinopyroxene

iron-titanium oxide and apatite needles poikilitically enclosed in the late-stage plagioclase. The olivines are rimmed by a concentration of granular titanomagnetite ($Mg_{85}Fe_{15}$) and contain granular clumps and wavy trails of exsolved iron oxide, which in some cases have almost entirely replaced the olivine. One section displayed large plates of bronzitic orthopyroxene ($Mg_{80}Fe_{17}Ca_4$; Al_2O_3 2.5-3.1%) commonly crystallised around or poikilitically enclosing the olivine and groundmass minerals. Olivines surrounded in this manner were apparently protected as no reaction rims or exsolution of iron oxide have been observed. The unusual texture of this rock and exsolution of iron oxide from olivine may be due to a roasting of the basalt by contact metamorphism (Searle, 1961) with the adjacent basanite plug presumably erupting at a later time and providing the required heat. Exsolution due to deuteric action (Wass, 1973) is less likely as the basalt shows no evidence of late-stage hydrous alteration.

OLIVINE NEPHELINITE

West Eldon

A massive plug to the west of Eldon [346937] contains fragments of baked and fused Permo-Triassic sediments and pieces of vein quartz and schist. There are sporadic lherzolite xenoliths and xenocrysts and rare clinopyroxene mosaics up to 7 cm across.

In thin section, xenocrysts are common and pyroxenes show strong resorption and well-developed reaction coronas. Olivine and titaniferous augite phenocrysts grade into the largely crystallised groundmass with nepheline uniformly distributed amongst clinopyroxene needles, granular iron-titanium oxides and some interstitial mesostasis.

North-east Rekuna

Poor outcrops of this rock cap a hill top 3 km north-west of Campania [316778] and descend north-east as flow remnants. This flow includes pieces of baked Triassic sediments, common lherzolite xenoliths and xenocrysts, and rarer banded 'doleritic' and 'pyroxenitic' xenoliths, up to 8 cm across.

In thin section, some olivine phenocrysts are 'iddingsitised' and the groundmass is generally a fine-grained felt of clinopyroxene and granular iron-titanium oxide in a scattered glassy feldspathoidal mesostasis with irregular patches of zeolite. Chemically, the rock is strongly under-saturated and is a relatively calcic olivine nephelinite (table 2, analysis 5).

Birmingham Hill

This small weathered outcrop, approximately 5 km south of Colebrook [308858], contains numerous fragments of Triassic sediments and Jurassic dolerite up to 8 cm across and some small lherzolite xenoliths. In thin section the rock has an extremely fine-grained groundmass resembling that of the olivine nephelinite north-east of Rekuna.

Goat Hill

This small plug (McDougall, 1959a) crops out approximately 7 km west of Pontville on Black Brush Road [143759] and contains numerous fragments of fused and altered sediment. In thin section, carbonated olivine phenocrysts are set in an extremely fine-grained groundmass. A strong feldspathoidal stain test and the presence of rare late-stage patches of relatively coarse nephelinite suggests an olivine-nephelinite.

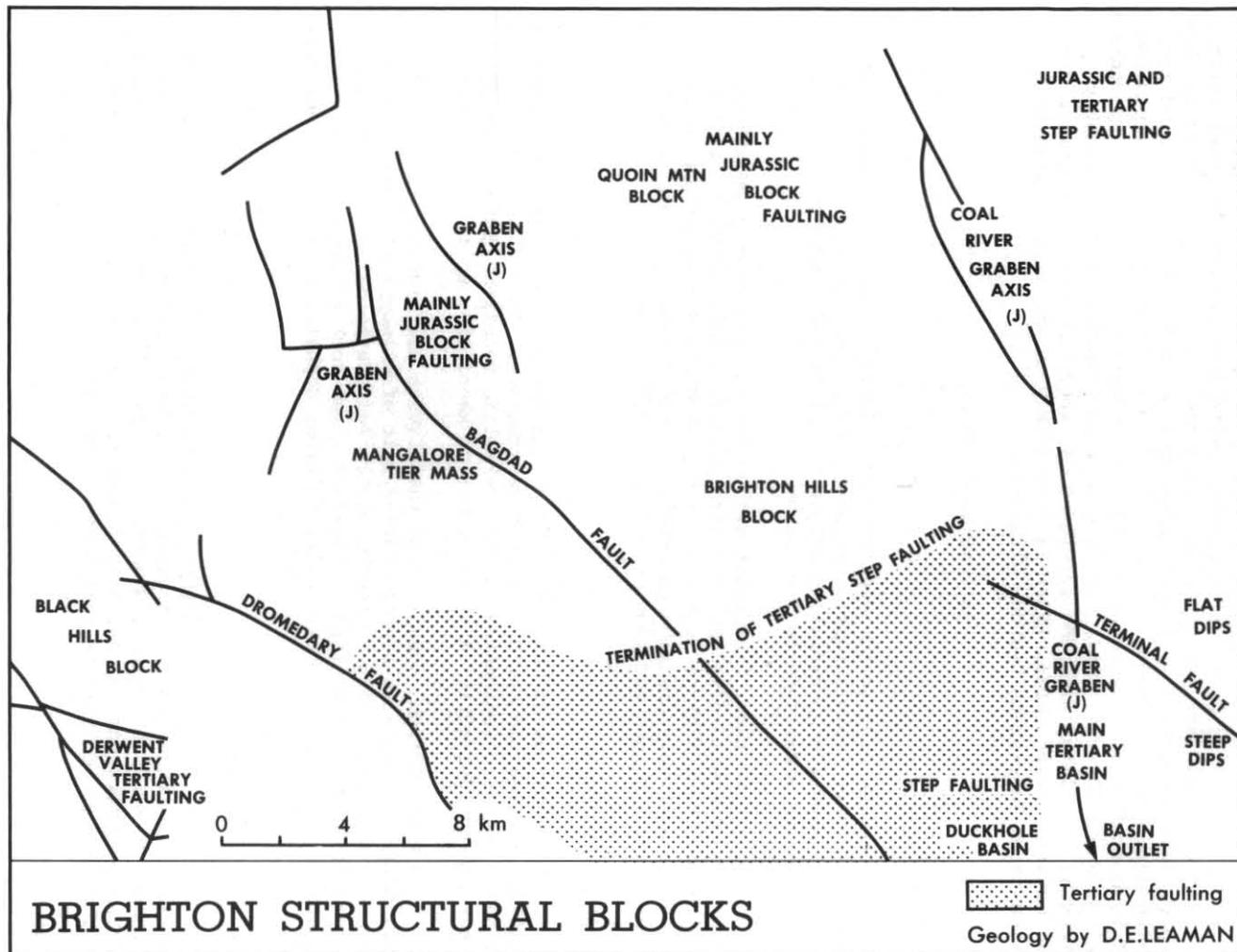


Figure 7.

5 cm

Pritchards Creek

This plug, 7 km west of Brighton [138728] (McDougall, 1959a), includes massive and vesicular phases. Fragments of Jurassic dolerite and Triassic sediments are particularly common in the marginal phases.

In thin section the olivine is 'iddingsitised' in some phases, and in the more massive rock the groundmass is crystallised and rich in nepheline.

METAMORPHIC ROCKS

Intrusions of dolerite, and to a lesser extent basalt, have produced some thermal metamorphism of rocks within the quadrangle. The effects have generally been minimal as both magmas were deficient in volatiles and aqueous solutions. The major observed effect common in the Permian quartz mudstone-siltstone and Triassic rocks is a hardening and development of flintiness, usually within about 3 m of the igneous contact. The calcareous Permian rocks of the Bundella Mudstone and Cascades Group show greater metamorphic effects, with zones up to 12 m thick altered to a more chertose texture and with mineralogical change, particularly to wollastonite. Metamorphic effects are always greater for blocks either included in an igneous body or immediately above the roof, as at Brains Hill [320730], where metamorphosed Triassic sediments occur directly above the lower sill.

STRUCTURAL GEOLOGY

The location and general relationships of the major structural features are shown in Figure 7.

Attitude of sedimentary rocks

Little information has been obtained about the dips of the sedimentary rocks within the quadrangle, as a large part of the area is covered by Triassic rocks which generally display dips poorly. In general, observed dips are usually less than 10°W. South and east of Campania, steeper dips occur which are related to hinged fault blocks associated with Tertiary faulting.

Warped upper Cascades group rocks are exposed in a road cutting [161696] on the Boyer Road west of Bridgewater (plate 7). The nearest major fault is several hundred metres to the east and its displacement is in the wrong sense to be related to this folding. The amplitude and wavelength of the fold are small, indicating that there is no deep influence. The regional dip is less than 10°SW. Small faults are present in the section but have no simple relationship to the fold. The influence of forcibly intruded dolerite at shallow depth could produce such an effect provided the non-dilatancy is sufficiently abrupt. Small scale examples at Mt Nelson (Hobart Quadrangle) indicate that bedding contortions of this type can be produced in this way. A gravity survey (Leaman, 1972) suggests that no major sheet is present in block C (fig. 3, Black Hills-Dromedary section), although a dyke finger from the feeder to the immediate south could be involved.

Faulting

Major Jurassic and Tertiary faulting has occurred within the quadrangle.

Jurassic faulting appears to have been directly associated with or immediately preceded by dolerite intrusions, such faults being indicated by

sharp intrusive boundaries or by dykes or plugs in the slip surface. Younger faults are indicated by the disruption of such intrusions. It may be impossible to determine the age of these later movements if there has been more than one pulse of intrusion, as each pulse may activate or re-activate faults.

The Dromedary Fault zone shows both metamorphic and fault properties but it is unknown whether all properties were concomitant or whether the faulting was pre-or post-intrusion. This situation is typical of the problems faced in classifying such structures. Further examples occur associated with the many minor intrusions on the faults east of Craighourne, where there is commonly insufficient evidence to show whether a fault disrupts several intrusions.

Jurassic faulting has produced N-S trending horst and graben structures, such a graben being occupied by the Coal River for part of its course. The width of the central trough is often less than one kilometre, as near Richmond and Colebrook (fig. 7).

Tertiary step faulting is superimposed on the Jurassic structures. These faults commonly downthrow to the east and trend slightly west of north. The dating of this faulting is based on its relationship with the basalt and sediments of known Tertiary age. Although there have been rejuvenations throughout the Cainozoic, the major post-dolerite movements appear to have been Cretaceous-Eocene in age, (cf Solomon, 1962). In many cases Tertiary movements have been deflected about major Jurassic structures (e.g. Mangalore Tier). The fault-dip relationship in the Richmond area indicates a shallow rotational origin.

In most parts of the quadrangle the evidence of faulting is normally excellent but becomes less clear wherever a repetition of lithologies occurs. Many of the faults indicated on the map sheet to which this is applicable should be considered to be only approximately located. No fault is shown unless at least one or two outcrops demonstrate its presence, either by way of shatter zones or by drag-dips. The alignment of basalt centres and topographic lineaments have also been utilised in determining fault locations.

Considerable faulting must be concealed beneath Tertiary sediments in the Campania area, but only two small faults have been observed within these sediments. The major faulting which produced the basin may be demonstrated at Richmond but there is no trace of the continuation of these faults toward Campania as the entire basin has been filled with sediments.

Faulting within the sediments may be quite contradictory. In Plate 8 the axis of the basin is to the right and the margin is about 100 m to the left. However, the faults are downthrown toward the margin, which also opposes the movement on the major N-S faults in the region. Compaction cannot account for the condition since it might be expected to be in the opposite sense. Although the units dip steeply south-west (plate 6, Leaman, 1971a), the sense of displacement and the confinement of the fault blocks does not allow simple resolution.

Disruption within the Triassic rocks is common and must be discussed in relation to faulting. In Plate 9, a series of arcuate low angle fractures is visible and in the centre of the photograph a massive sandstone unit has been shattered. The predominant lithology is mudstone and carbonaceous shale with interbedded quartz and feldspathic sandstone. The latter units have proved competent and shattered under distortion (plates 9, 10) while the softer units have filled voids and become homogenised. The visible fractures appear to be low angle thrusts and as such could be related to slumping

while still in a semi-compacted and fairly fluid state or to compression during intrusion.

Disruption on the scale depicted is rarely observed since rapid weathering quickly obscures the features. The current examples are exposed in major recent road cuts. There is no conclusive evidence available by which to differentiate the possible origins. Only at Mt Direction is it possible to relate similar features to a dolerite margin. However, as implied by Leaman (1975, p. 184), certain dolerite forms generate a room problem at high stratigraphic levels and massive displacement horizontally and vertically must occur. This type of structure may be extremely common.

Less competent units may be severely contorted (plate 10). Thin sandstone beds delineate the form of the fold, though shattered and fragmented, while the included and surrounding mudstones show little sign of lamination or bedding.

The presence of dolerite talus and shattered dolerite make the evaluation of the origin of these features difficult in the three sections where contorted Triassic rocks are exposed:

SECTION 1. Northern Outlet Road, Granton (Hobart Quadrangle). Plates 9 and 10 are at the northern end of the section near Black Snake Road. Within one kilometre to the south there are several major exposures of dolerite talus and much of the region is coated by at least one metre of this material. At the cutting near the end of Hilton Road (Austins Ferry), slip zones are visible within the talus and at least two movements are implied (plates 11-13). The situation is similar to that shown in Plate 14, as the underlying mudstone is involved in the failures and stringers are included along the slip surfaces and in some of the slumps. The major visible slump is up to 100 m wide. Although dolerite or dolerite-derived material is not directly involved in the situation of Plates 9 and 10, it is possible that mass slumping of large volumes of material has induced sympathetic failure or that partial décollements have included near-surface bedrock; in this case a relatively plastic carbonaceous mudstone sequence. The entire section is further complicated by the presence of a dyke-like dolerite projection, unquestionably *in situ*, between Hilton Road and Black Snake Road. While the southern part of the section has certainly suffered mass movement and the northern part is coated with talus, the contortions shown in Plates 9 and 10 cannot be definitely related either to dolerite intrusion or recent mass movement.

SECTION 2. Old Beach Road, Mt Direction (Hobart Quadrangle). Situations resembling Plate 15 are common. Again there is evidence of recent mass movement involving dolerite talus along a section which also includes definite dolerite intrusions. Plate 14 shows a structure which appears related to a contact but the sense of movement is compatible with simple push - slumping.

In general the underlying mudstones do not show the intense contortion or thrusting of Section 1, or indicate any severe movements other than in those zones where mass surface movement has certainly taken place.

SECTION 3. Road cutting, Midlands Highway, Dysart (plates 15, 16). Parts of this cutting are either wholly of dolerite talus or contorted carbonaceous mudstone with sandstone providing a minor component. Most of the section displays a mix of disturbed mudstone and talus (plate 15). As at the Hilton Road exposure, simple mass movement provides an explanation with multiple and variably scaled failure surfaces including the original 'bedrock'. A small dolerite plug has been mapped to the immediate south-east

and since there is no apparent disturbance in this region, as observed in the next cut south, it appears that this is not a factor in the disturbance.

Igneous emplacement

Dolerite dykes, sheets and plugs are common and generally produce large, undulating interconnecting sheets representing several pulses of intrusion. Details of the interpretation of the structure and mode of emplacement are covered at length elsewhere (Leaman, 1972, 1975).

Large dolerite dykes are less prominent, but equally abundant in exposure as sills and sheets. Small dykes intrude the major bodies at Mangalore Tier and Brown Mountain. Basalt centres are usually small dykes 2-15 m in width and are generally associated with Tertiary faults or fault intersections, and large Jurassic structures.

Intrusion margins are rarely exposed and seldom appear definitive. Most appear to be readily classified on the basis of topographic relationships as either concordant or near vertical; the former if parallel to contour and the latter if bearing no relationship to contour. Such a simple division may be totally incorrect and only geophysical methods, drilling or excavation can confirm the true nature of a boundary. Many boundaries, which appear concordant and which form the margin of an elongate or large body may be very steep. This results from topographic dominance by the dolerite mass with few stream intersections. Determination of form in this very common mode is rarely possible by regional mapping alone. Talus, scree or soil may well confuse or obscure boundaries in other potentially easier cases. Plates 17 and 18 show the type of problem which may arise in the mapping of simple, even apparently uncomplicated and well exposed boundaries.

On the southern side of the Eastern Outlet Road at Cambridge (Hobart Quadrangle) a concordant top to the dolerite body is apparent and a fault is exposed part way along the section, with further siltstone included in the centre of the section (plate 17). On the northern side of the road (plate 18), the contact is irregular but dips overall steeply east. A small fault occurs further east. The obvious discordant limbs are not apparently compatible, dipping steeply east on the north side and steeply west on the south side. There is no suggestion of concordancy to the north where the land drops to the nearby valley. Regional mapping of the area located two small faults and implied an overall transgressive boundary. As the plates show, exposure of half or part of the cutting would have appeared consistent with this implication but, depending on what was seen, quite different conclusions may have been made.

A gravity survey (Leaman, 1972) suggests that the overall structural form in this area is quite complex, but that a major sheet is transgressing steeply upward from the west (compatible with plate 17) and that the boundary irregularity of Plate 18 is a local aberration of a very common type. In more strongly bedded rocks even the most continuous concordant boundaries show small discordant steps and limited exposures may be very misleading if applied to the whole boundary without independent controls. In more homogenous rocks, such as the Permian siltstone intruded at Cambridge, these steps may be of the order of 25 m.

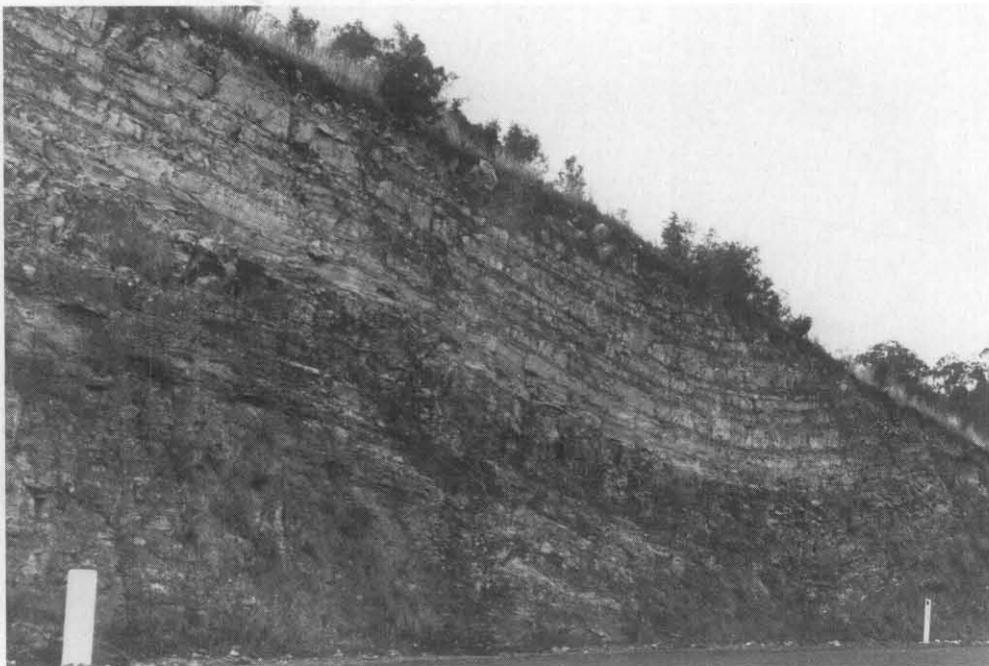


Plate 7. *Warped upper Cascades Group rocks, Boyer Road.*

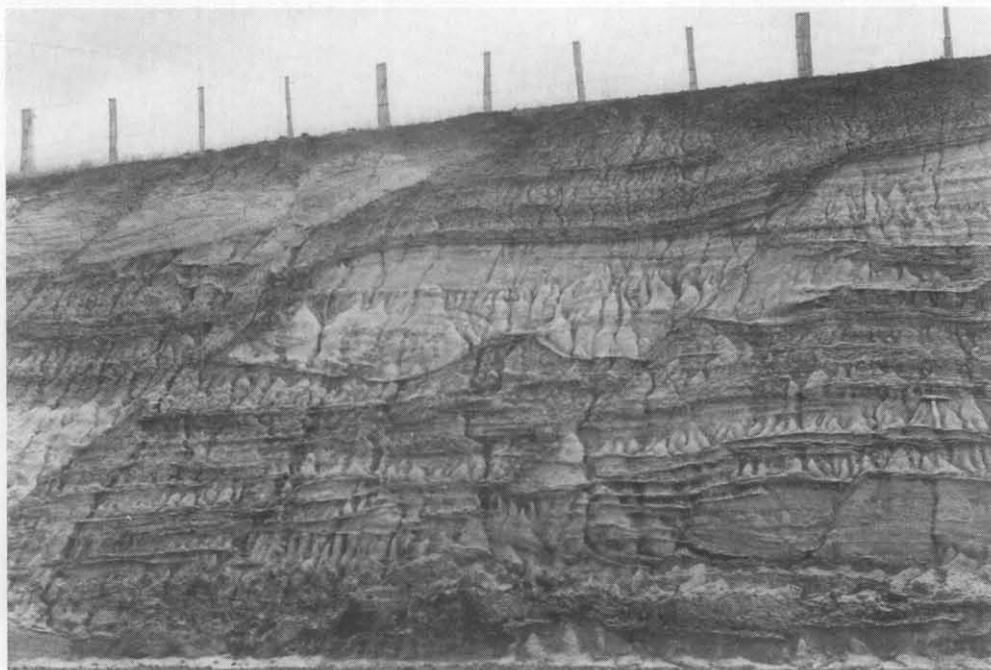


Plate 8. *Faulting in Tertiary sediments, Campania.*



Plate 9. *Faulting in Triassic rocks, Northern Outlet Road, Granton.*



Plate 10. *Severely contorted Triassic rocks, Northern Outlet Road, Granton.*

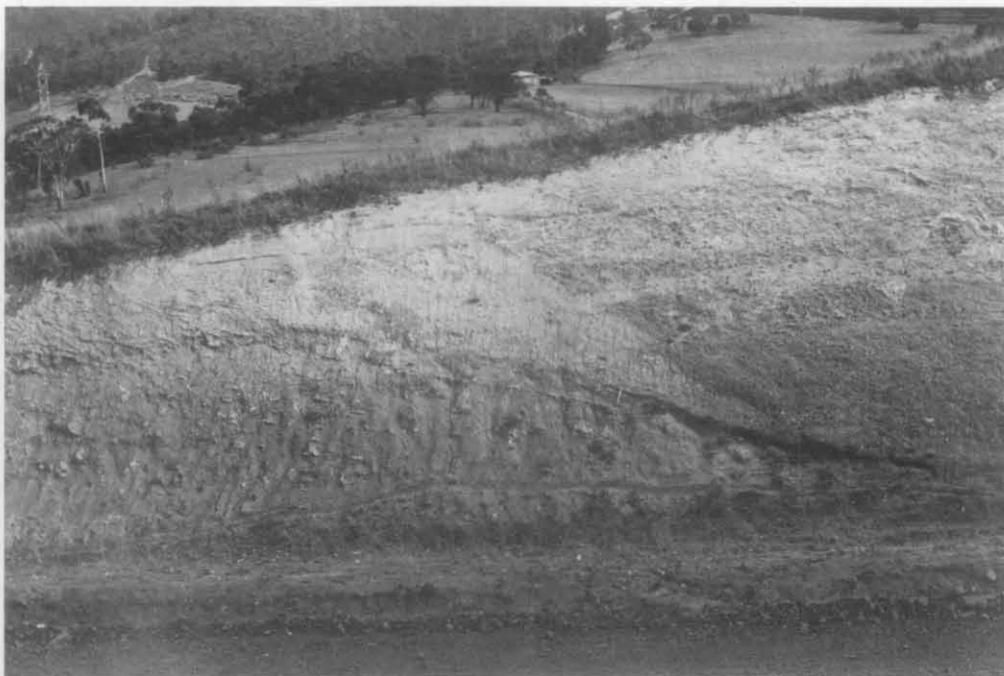


Plate 11. *Mudstone remnant and slip surface, Northern Outlet Road, Austins Ferry.*



Plate 12. *Major slip section, Northern Outlet Road, Austins Ferry.*

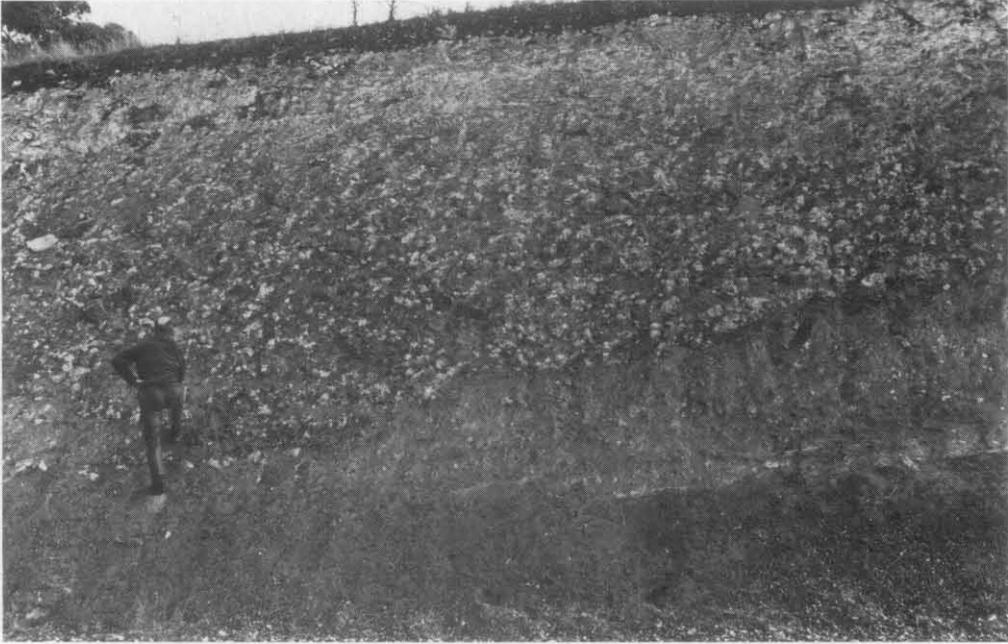


Plate 13. *Relationship of talus and slip (?) surface, Northern Outlet Road, Austins Ferry.*



Plate 14. *Thrust in Triassic sediments, Old Beach Road, Mt Direction*

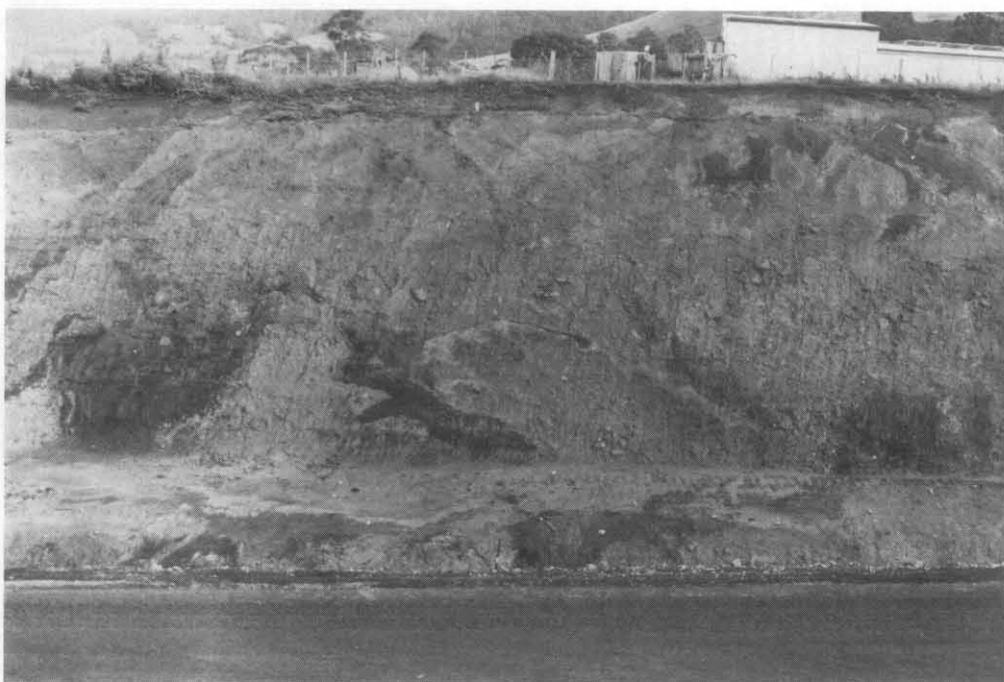


Plate 15. *Disturbed mudstone and talus, Midlands Highway, Dysart.*



Plate 16. *Typical failure, Midlands Highway, Dysart.*



Plate 17. *Dolerite contact, southern side, Eastern Outlet Road, Cambridge.*



Plate 18. *Dolerite contact, northern side, Eastern Outlet Road, Cambridge.*

ECONOMIC GEOLOGY

V.M. Threader

COAL

Coal occurs in the interbedded mudstone and lithic, feldspathic sandstone of the upper part of the Triassic sequence. The beds are poorly preserved and the coal-bearing areas are consequently limited in extent. The coal is of marginal quality and occurs only in narrow seams.

Production

Limited mining of coal occurred at Coalmine Creek north of Colebrook and at the Coal River south of Richmond in the 1840s (Strzelecki, 1845; Milligan, 1849). No records exist of coal production at Richmond.

The Jerusalem Coal Mine at Coalmine Creek was worked sometime in the period 1843-1849 and between 1879-1890. All production records were destroyed in a fire at the mine office. The Tasma Coal Mine near Colebrook worked for limited periods for the production of 487 tonnes in 1910-1911 and 2194 tonnes in 1918-1919 (Hills *et al.*, 1922).

FINE AGGREGATE

Sand, derived from weathered Triassic sandstone, occurs in small deposits at the foot of sandstone hills. Two areas have been examined in more detail. At Native Corners Road, six auger holes drilled in the vicinity of S3 (fig. 8) passed through 1-2 m of fine sand into a mixture of partially decomposed sandstone, fine sand and clay. A sand pit of similar material occurs on Brown Mountain Road (fig. 8, S2). This sand was tested by the Public Works Department and was found suitable as admixture to surface coarse materials used in road construction. It is also suitable for use in low strength concrete. The clayey sand beds which occur under the fine sand would be suitable for use in mortar sand. A disused pit in a pre-basalt Tertiary sand at Bridgewater (S1) has been backfilled and the site is now part of a housing estate.

COARSE AGGREGATE

Poorly sorted alluvial and colluvial gravel occurs along the major water courses. Its use as an aggregate is limited due to the extreme range of particle size, resulting in excessive amounts of both coarse and fine grades.

Decomposed dolerite is abundant throughout the area and is used extensively for road making. There are 19 dolerite quarries in the quadrangle (tables 4, 5), but only one quarries rock which is satisfactory as a road-making material. The majority of quarries have material with excessive clay content, making them too plastic as indicated by their excessive Atterberg limits. The grading curves (figs 9-15) do not always indicate the high clay content, possibly because the clay fraction does not break down into clay sized particles during the sizing analysis. With a few exceptions, the dolerite gravels have satisfactory gradings in the middle part of the grading curves (figs 9-14).

Permian siltstone is also used as coarse aggregate. This rock produces a fine-grained material which is low in clay content and therefore generally non-plastic. The bulk of the material consists of composite grains which are inclined to fragment under load. Satisfactory blendings of dolerite and siltstone can be achieved for use in road making.

Table 4. SUMMARY OF ROAD GRAVELS

No.	Type specification	Grading Limits		DR	LL	PI	LS
		Coarse	Fine				
<i>Doleritic material</i>							
1	A	x	✓	x	x	x	x
2	B	✓	✓	✓	x	x	x
6	A	x	✓	✓	-	-	-
8	B	✓	x	-	-	-	-
9	A	✓	✓	✓	x	x	x
10	A	x	✓	✓	-	-	-
11	A	x	✓	✓	x	x	x
12	A	x	✓	✓	x	x	x
14	A	x	✓	✓	x	x	x
15	A	x	x	✓	x	x	x
17	B	x	x	(✓)	✓	✓	(✓)
18	A	x	x	✓	x	x	x
23	A	✓	✓	✓	x	x	x
24	D	x	✓	✓	x	x	x
25	A	x	✓	✓	x	x	x
28a	A	x	✓	x	x	x	x
28b	A	x	x	x	x	x	x
29	A	x	✓	✓	✓	x	x
30	A	✓	x	✓	x	x	x
<i>Permian siltstone</i>							
3	D	✓	x	✓	✓	✓	✓
4	B	x	x	x	x	x	x
5	D	✓	✓	✓	✓	x	x
7	A	✓	✓	(✓)	✓	✓	✓
13a	B	✓	✓	✓	(✓)	✓	✓
13b	A	x	x	x	✓	✓	✓
16a	A	x	(✓)	✓	✓	✓	(✓)
16b	F	x	x	(✓)	✓	✓	(✓)
19a	B	✓	x	x	✓	x	x
19b	B	x	x	✓	✓	x	x
20a	D	✓	x	(✓)	✓	(✓)	x
20b	B	x	x	(✓)	✓	✓	✓
21	D	✓	x	x	✓	x	x
22	D	✓	x	✓	✓	x	x
26	D	✓	x	x	✓	x	x
27	D	✓	x	(✓)	x	x	x

✓ satisfactory, (✓) marginal, x unsatisfactory

Table 5. SIZING ANALYSIS AND PHYSICAL PROPERTIES OF CONSTRUCTION MATERIALS, BRIGHTON QUADRANGLE

No.*	AMG Reference	Locality	Sizing analysis									Plot	
			Cumulative % retained (mm)										
			75	53	37.5	26.5	19	9.5	4.75	2.36	0.425	0.075	
1	EN340710	Richmond		0	3	25	37		65	74	83	88	A
2	EN177719	Brighton			0	10	25	48	59	66	75	83	B
3	EN392849	Brown Mountain Rd		0	2	4	5	12	20	28	41	58	D
4	EN341926	Colebrook			0	4	9	22	33	40	49	63	B
5	EN345930	Colebrook			0	2	6	14	23	29	34	46	D
6	EN336851	Colebrook Rd	0	18	20	34	47	71	87	94	97	98	A
7	EN344917	Colebrook		0	4	10	12	51	74	83	88	91	A
8	EN335700	Richmond	0	4	6	8	12	16	21	27	58	70	B
9	EN178853	Dysart		0	2	23	36	47	62	76	88	92	A
10	EN150860	Dysart	0	10	27	52	58	64	74	78	86	92	A
11	EN286896	Yarlington Rd	0	10	16	37	56	66	73	77	86	94	A
12	EN117876	Clifton Vale Rd	0	22	22	39	49	58	66	73	84	97	A
13a	EN080900	Clifton Vale Rd		0	5	9	15	43	58	67	74	81	B
13b	EN083899	Clifton Vale Rd		0	13	20	27	46	58	65	71	77	A
14	EN153900	Kempton Sugarloaf	0	11	31	37	40	47	54	72	92	95	A
15	EN184915	Kempton		0	36	52	61	67	71	74	79	88	A
16a	EN107926	Clifton Vale Rd	24	24	31	39	46	58	69	76	82	88	A
16b	EN105922	Clifton Vale Rd			0	1	3	12	21	26	30	49	F
17	EN375690	Richmond	0	9	42	46	50	52	54	55	66	84	B
18	EN025687	Black Hills	0	15	29	37	44	48	52	55	64	81	A

*Pit locations on Brighton Construction Materials map (fig. 8)

Table 5. (continued)

No.*	Name	Locality	Dust Ratio	Liquid Limit	Plasticity Index	Linear Shrinkage	Classification†	Material
1	Gray	Richmond	0.73	59	38	18	GC	Dolerite
2	Boden	Brighton	0.67	42	26	10.5	GC	Dolerite
3	Dunbabin	Brown Mountain Rd	0.70	19	2	1	SM	Siltstone
4	PWD	Colebrook	0.73	30	15	8	GC	Siltstone
5	Housey	Colebrook	0.82	33	6	9	CL	Siltstone
6	PWD	Colebrook Rd	0.53	-	-	-		Dolerite
7	PWD	Colebrook	0.78	22	0	1	GP-GM	Siltstone
8	Baker	Richmond	-	-	-	-		Dolerite
9	Swan	Dysart	0.63	50	33	12	GP-GC	Dolerite
10	Howfield	Dysart	0.57	-	-	-	GR-GC	Dolerite
11		Yarlington Rd	0.45	60	14	16	GP-GC	Dolerite
12		Clifton Vale Rd	0.44	44	26	11	GW-GC	Dolerite
13a	Allwright	Clifton Vale Rd	0.72	21	2	2	GM	Siltstone
13b	Allwright	Clifton Vale Rd	0.78	25	3	1.5	GM	Siltstone
14		Kempton Sugarloaf	0.59	41	25	12	GP-GC	Dolerite
15		Kempton	0.58	51	35	14	GC	Dolerite
16a	Cox	Clifton Vale Rd	0.69	24	6	5	GM-GC	Siltstone
16b	Cox	Clifton Vale Rd	0.74	18	6	4	CL	Siltstone
17	Crane	Richmond	0.48	39	20	10	GC	Dolerite
18		Black Hills	0.54	73	48	18	GC	Dolerite

*Pit locations on Brighton Construction Materials map (fig. 8)

†S = sand, C = clay, G = gravel, W = well graded, P = poorly graded, L = low plasticity, M = mixed non-clay fines.

Table 5. (continued)

No.*	AMG Reference	Locality	Sizing analysis									Plot	
			Cumulative % retained (mm)										
			75	53	37.5	26.5	19	9.5	4.75	2.36	0.425	0.075	
19a	EN155707	Cobbs Hill			0	4	10	19	26	32	40	47	B
19b	EN153707	Cobbs Hill		0	11	11	12	18	28	40	55	70	B
20a	EN100695	Mt Dromedary				0	2	6	16	24	33	49	D
20b	EN099694	Mt Dromedary	0	6	16	18	22	28	38	47	56	66	B
21	EN098694	Mt Dromedary		0	2	4	9	17	26	33	40	49	D
22	EN095694	Mt Dromedary		0	6	10	10	11	18	34	66	78	D
23	EN269749	Tea Tree		0	6	25	44	65	76	82	88	94	A
24	EN187717	Brighton		0	5	12	26	40	49	57	72	87	D
52 25	EN166742	Pontville	0	16	37	58	64	69	74	78	84	92	A
26	EN117769	Elderslie Rd		0	2	2	9	24	39	46	52	59	D
27	EN110904	Clifton Vale Rd			0	1	2	4	15	44	70	78	D
28a	EN163817	Bagdad	0	12	26	41	58	79	88	92	94	96	A
28b	EN166818	Bagdad	0	7	25	62	76	80	83	85	87	89	A
29	EN165847	Dysart	0	23	30	42	47	50	57	74	88	93	A
30	EN165844	Dysart		0	12	20	29	39	51	67	83	89	A
S1	EN195683	Bridgewater					0	1	1	2	28	83	A77
						2.36	1.18	0.60	0.30	0.15	0.075	0.038	
S2	EN382801	Brown Mountain Rd				0	1	1	8	76	98		A77
S3a	EN340761	Native Corners				3.8	5.8	7.3	9.3	53.7	91.7	96.4	A77
S3b						13.3	17.3	19.9	23.1	57.2	72.0	75.5	A77

*Pit locations on Brighton Construction Materials map (fig. 8)

Table 5. (continued)

No.*	Name	Locality	Dust Ratio	Liquid Limit	Plasticity Index	Linear Shrinkage	Classification†	Material
19a		Cobbs Hill	0.88	30	15	9	CL	Siltstone
19b		Cobbs Hill	0.67	35	18	7.5	SC	Siltstone
20a	Robertson	Mt Dromedary	0.77	27	11	6	CL	Siltstone
20b	Robertson	Mt Dromedary	0.77	21	3	3	GM	Siltstone
21	Ikin	Mt Dromedary	0.84	30	13	6.5	CL	Siltstone
22	Collins	Mt Dromedary	0.64	27	11	5.5	SC	Siltstone
23	Webberley	Tea Tree	0.48	67	43	14.5	GP-GC	Dolerite
24	Taylor	Brighton	0.47	58	29	12	GC	Dolerite
25	Clark	Pontville	0.51	43	29	12	GP-GC	Dolerite
26	'Strathelie'	Elderslie Rd	0.84	30	17	9.5	GC	Siltstone
27	Allwright	Clifton Vale Rd	0.73	53	38	16.5	SC	Siltstone
28a	Gangell	Bagdad	0.78	55	38	13.5	GW-GC	Dolerite
28b	Gangell	Bagdad	0.81	89	67	22	GC	Dolerite
29	Swan	Dysart	0.63	35	22	8.5	GW-GC	Dolerite
30	Shearing	Dysart	0.64	44	28	13	GP-GC	Dolerite
S1		Bridgewater						Tertiary sand
S2	Bevan	Brown Mountain Rd						} Decomposed Triassic sandstone
S3a		Native Corners						
S3B		Native Corners						

*Pit locations on Brighton Construction Materials map (fig. 8)

†S = sand, C = clay, G = gravel, W = well graded, P = poorly graded,
L = low plasticity, M = mixed non-clay fines.

REFERENCE No.	LAB. SERIAL No.	LOCALITY			SEDIMENT ANALYSIS PARAMETERS									
					M =	V =	Sk =	K =						
COARSE AGGREGATE			FINE AGGREGATE						A77-1957 (concrete)					
COARSE AGGREGATE		FINE AGGREGATE			BINDER		N.A.A.S.R.A. (road materials)							
COBBLE	PEBBLE	GRANULE	S A N D				SILT							
			V. COARSE	COARSE	MEDIUM	FINE			V. FINE					
-6	-5	-4	-3	-2	-1	0	1	2	3	4	5	6 Ø		
75	53	37.5	26.5	19	9.5	4.75	2.36	1.18	0.6	0.3	0.15	0.075	0.038	Aust. Stand. Sieve

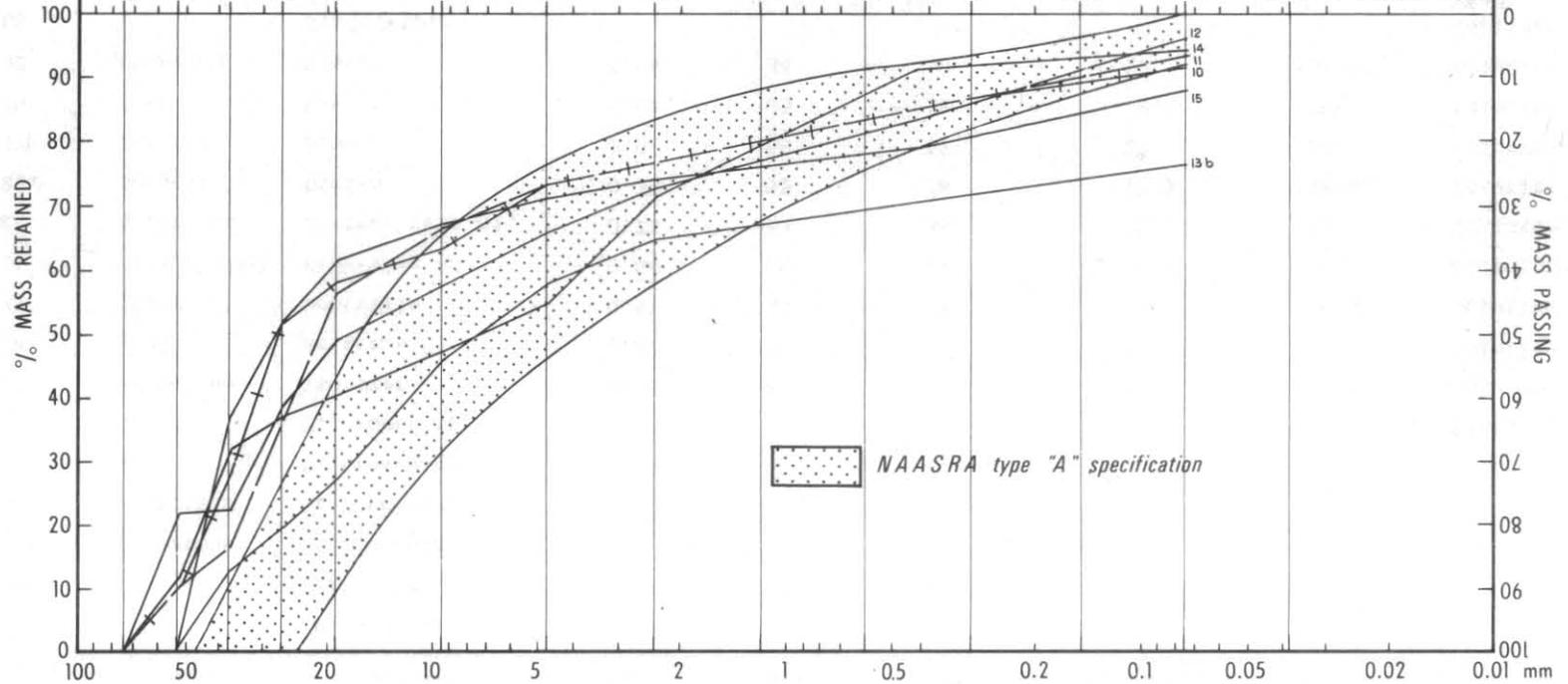


Figure 9. Grading curves for some gravels relative to NAASRA specifications for Class A aggregate.

REFERENCE No.	LAB. SERIAL No.	LOCALITY			SEDIMENT ANALYSIS PARAMETERS									
					M =	V =	Sk =	K =						
COARSE AGGREGATE				FINE AGGREGATE				A77-1957 (concrete)						
COARSE AGGREGATE			FINE AGGREGATE			BINDER			N.A.A.S.R.A. (road materials)					
COBBLE	PEBBLE		GRANULE	SAND			SILT							
				V. COARSE	COARSE	MEDIUM	FINE	V. FINE						
-6	-5	-4	-3	-2	-1	0	1	2	3	4	5	6 φ		
75	53	37.5	26.5	19	9.5	4.75	2.36	1.18	0.6	0.3	0.15	0.075	0.038	Aust. Stand. Sieve

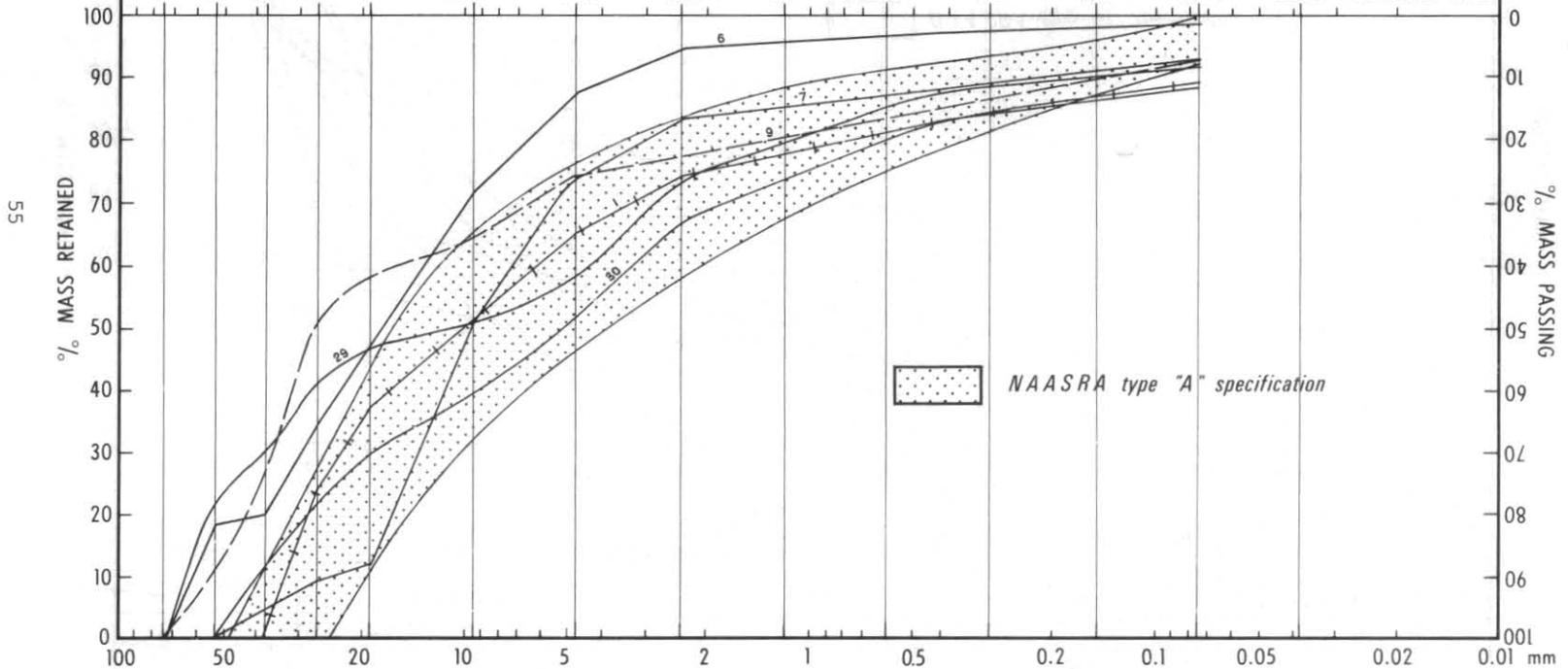


Figure 10. Grading curves for some gravels relative to NAASRA specifications for Class A aggregate.

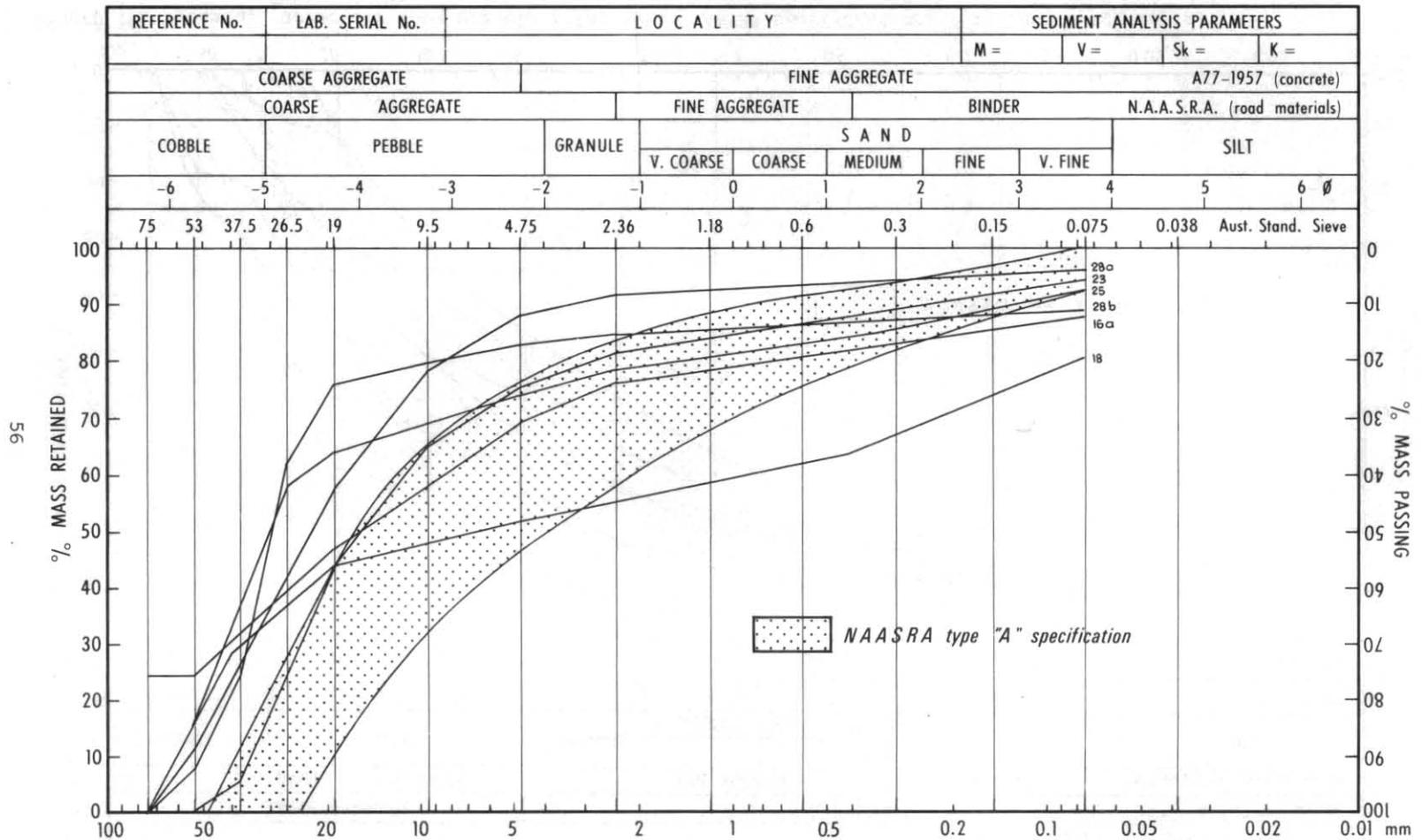
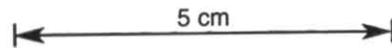


Figure 11. Grading curves for some gravels relative to NAASRA specifications for Class A aggregate.



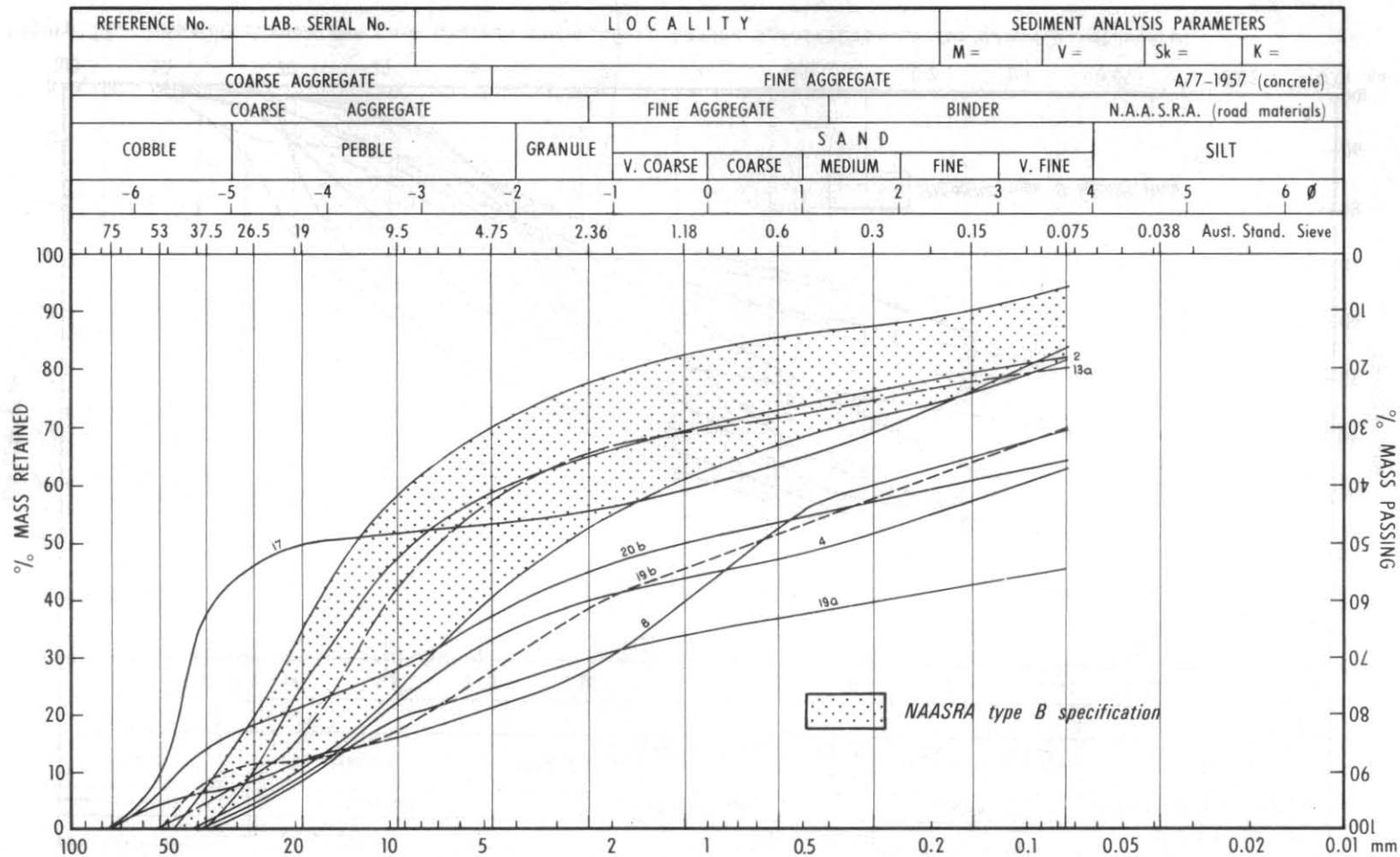


Figure 12. Grading curves for some gravels relative to NAASRA specifications for Class B aggregate.

5 cm

5 cm

REFERENCE No.	LAB. SERIAL No.	LOCALITY				SEDIMENT ANALYSIS PARAMETERS								
						M =	V =	Sk =	K =					
COARSE AGGREGATE			FINE AGGREGATE							A77-1957 (concrete)				
COARSE AGGREGATE		FINE AGGREGATE			BINDER		N.A.A.S.R.A. (road materials)							
COBBLE	PEBBLE		GRANULE	SAND				SILT						
				V. COARSE	COARSE	MEDIUM	FINE	V. FINE						
-6	-5	-4	-3	-2	-1	0	1	2	3	4	5	6 ϕ		
75	53	37.5	26.5	19	9.5	4.75	2.36	1.18	0.6	0.3	0.15	0.075	0.038	Aust. Stand. Sieve

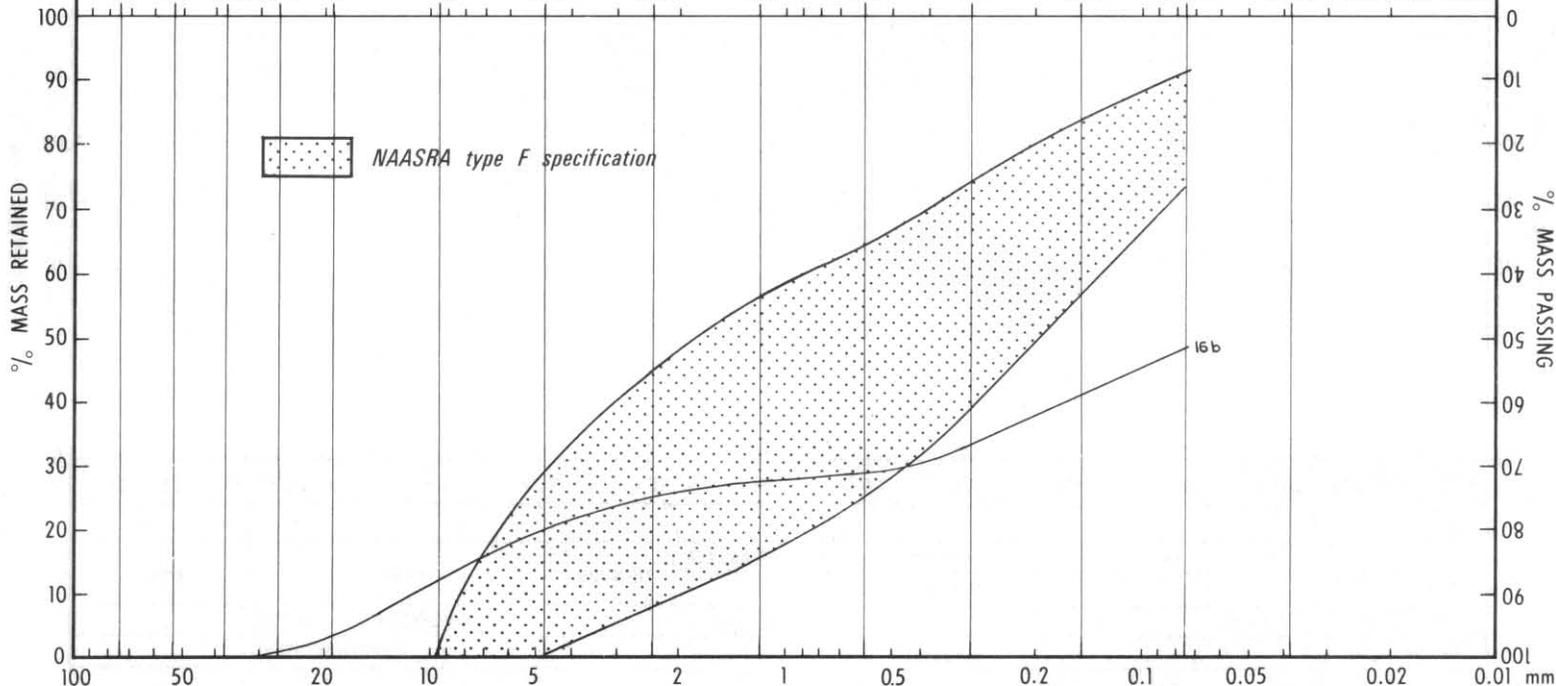


Figure 14. Grading curves for some gravels relative to NAASRA specifications for Class F aggregate.

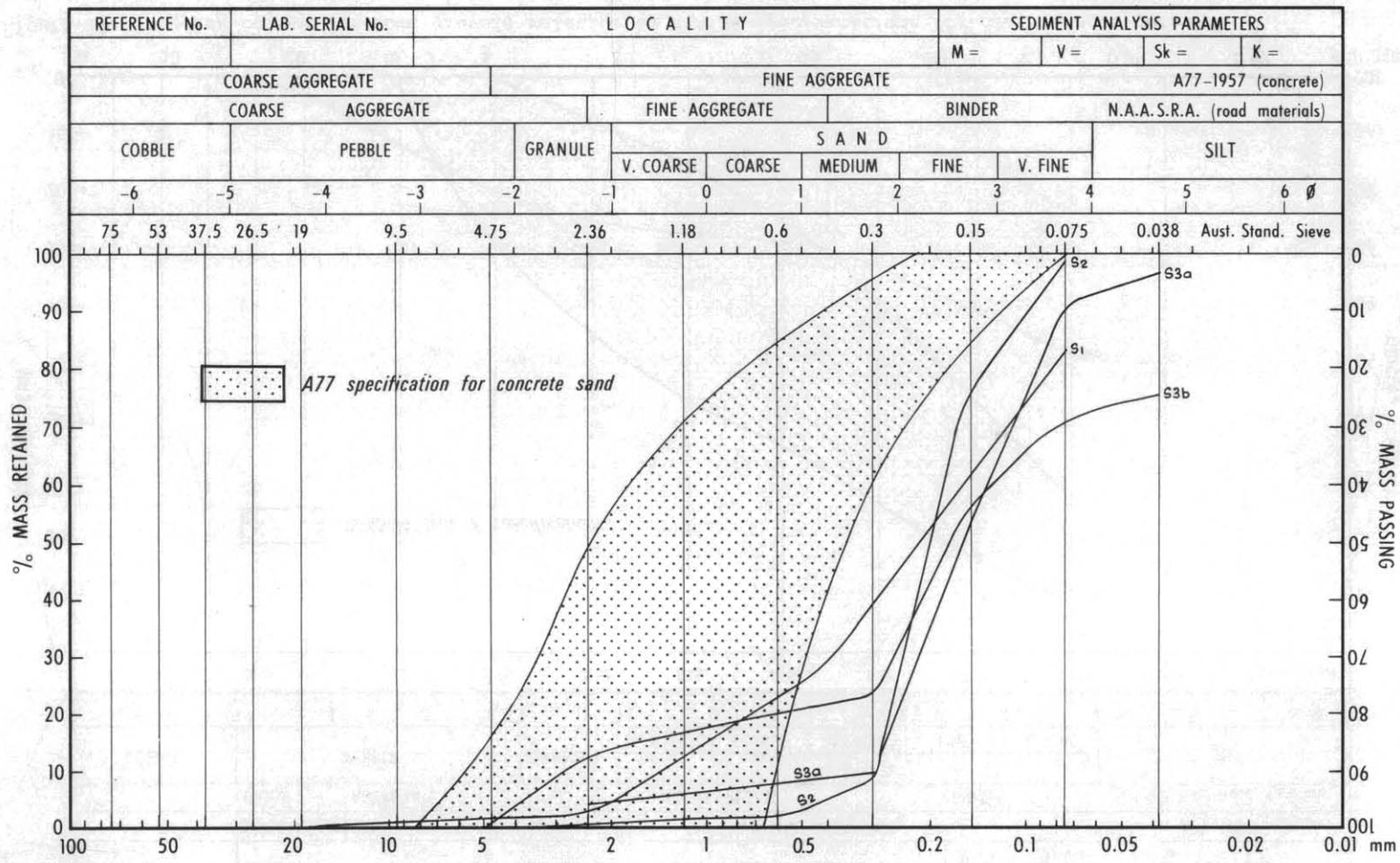
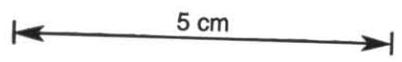


Figure 15. Grading curves relative to A77 specification for concrete sand.



The Public Works Department and the Municipalities of Green Ponds, Brighton and Richmond are faced with the same problem as most other road making authorities in southern Tasmania in that good road-making materials are absent. The problem is in part overcome by using thicker hot mix sealants to protect the pavements from weathering agents. Some municipalities find it more economic to purchase prepared aggregates which meet NAASRA specifications and are supplied at correct moisture content for maximum compaction and stability.

Crushed basalt. The Hobart Quarries operation at Bridgewater is the largest in the State and produced 163 038 m³ of crushed basalt in 1975. Most of the material quarried is transported to Hobart for the making of ready mixed concrete. It is also used as a prepared aggregate and sealing aggregate.

CLAY

Triassic mudstone is the traditional brick-making material in the Hobart area and has been obtained from Kingston, Howden, Austins Ferry and New Town. Although similar beds occur in the Brighton Quadrangle, there are no known large reserves and the distance to Hobart does not give the area any advantage over existing supplies.

Tertiary clay of freshwater or possibly estuarine origin occurs in the vicinity of Richmond and thicknesses exceeding 200 m have been recorded (Leaman, 1971a). Similar Tertiary deposits in Launceston have been used for many years for the brick, tile and pipe industry while material from Hamilton in the Derwent Valley has been used for pipe manufacture.

Four water bores in the Richmond-Campania area (fig. 8) indicated a considerable thickness of Tertiary sediments: DH11, 61 m of clay and sand bottoming on dolerite; RC4, 28 m clay; RC5, 79 m clay with coal beds and 122 m of clay (a total of 201 m) and RC6, 189 m sand, clay and gravel bottoming on dolerite. The area between Richmond and Campania is partially overlain by basalt but sufficient Tertiary sediment is exposed on the margins to warrant a clay prospecting programme. Similar ground extending up Pages Creek from Richmond is also worth investigating.

There are adequate supplies of brick-making material in the areas of Triassic mudstone reserved by the Hobart Brick Company, but as production costs rise it can be foreseen that a better quality material that fabricates more easily and requires less fuel to bond will be sought by the industry. It is with this object that a drilling programme in the Coal River Valley has become desirable.

BUILDING STONE

Practically all the old homes, churches and bridges in the quadrangle have been built of Triassic sandstone. The quarries were numerous because the stone was quarried locally to minimise transport. There is considerable variation in the quality of Triassic sandstone and it is evident that some poor material has been selected in the past, judging from the state of some of the old buildings. The sandstone ranges from quartz sandstone at the base of the Triassic System through a range of lithic and feldspathic sandstone up the succession. A certain degree of skill and knowledge is required to assess the quality of freshly cut stone. Other factors such as coarseness of bedding and the presence of clay or micaceous seams and the degree to which iron oxides have been precipitated in the stone by percolating groundwater also have some bearing on the durability of the stone.

Physical tests on Triassic building stone have been carried out by the Public Works Department (Threader, 1976). Results of tests on sandstone from Etna Stone Quarry at Pontville gave compressive strengths of around 20+ mPa which compares favourably with other building materials such as clay brick, concrete and concrete block. The stone was little affected by wetting and drying cycle tests, but a 6-cycle wetting and drying test with magnesium sulphate solution resulted in losses up to 66% by mass.

It appears that this area of investigation requires further research. Reserves of stone are huge and a detailed study and testing programme should result in a better material being marketed, thus ensuring a good future for the industry. At present there are three quarries producing sandstone for paving and walling in the Hobart area, while Etna Stone at Pontville also produces sawn and bolstered blocks for building. Production for 1975 was 339 m³.

LIMESTONE

Permian limestone from the Cascades Group has been mined at Rathbones Quarries near Granton (fig. 8, L1) and at Mt Dromedary (L2 and L3). The rock was burnt for agricultural lime. Limestone at Mt Dromedary contains 55-77% CaCO₃ and 21-41% acid insoluble material (Hughes, 1957).

There is currently no production of Permian limestone in the Brighton Quadrangle but similar material is crushed for road making at Weily's quarry at Glenorchy (Hobart Quadrangle). Small deposits of travertine, derived from dolerite by percolating groundwater during Tertiary to Recent times occur near Richmond, Rekuna and Lowdina. The Richmond deposit was once mined and burnt to produce agricultural lime. Similar occurrences are known in the Dromedary and Broadmarsh areas. These deposits are not large enough to warrant exploitation under present economic conditions.

GEMSTONES

Varieties of chalcedony, including wood opal and agate, have been found at Campania, Mangalore and Richmond in the Brighton Quadrangle. They are derived by silicification of material overlain by basalt.

Specimens are sought by amateur lapidaries and rock collectors but are not mined economically.

GROUNDWATER

Groundwater is in substantial demand over much of the quadrangle as the population is mainly rural and the average rainfall is generally low.

Details of the underground water resources of the Coal River Basin, in the eastern portion of the quadrangle, are published elsewhere (Leaman, 1971a). The general comments made in the above publication apply to the whole quadrangle and it is reasonable to assume that the information on water quality is valid overall. Reasonable water yields, for example 2000 l/h, can be expected from the Triassic rocks with probably a slightly greater volume from dolerite or basalt, provided the hole is well sited. The Tertiary materials yield more water but the quality is much poorer. The above comments apply to those areas where relief is not high and a bore hole should never be sited in difficult topographic situations. All aspects of bore reliability and siting are discussed by Leaman (1971a) in addition to the restrictions on use demanded by variable water quality.

Details of water boring in the portion of the quadrangle not considered in the aforementioned report are given in Appendix 1.

ENGINEERING GEOLOGY

Due to the predominance of agriculture, the range of engineering problems faced within the Brighton Quadrangle has been limited although this will change with expansion of the Bridgewater-Brighton growth centre. With the exception of this area most future engineering works will be road works. The rock types present in the Brighton Quadrangle are comparable with those in the Hobart Metropolitan area (Hobart Quadrangle), the general rock properties and problems of which are described in the Hobart Engineering Geology Map Series (Leaman, 1971b). All general comments made in the Hobart study apply to the Brighton Quadrangle.

More detailed studies have been made in some areas and these are listed:

<i>Craigbourne</i>	Proposed dam sites, Coal River. Blake (1960), Stevenson (1970).
<i>Broadmarsh</i>	Dam site. Leaman (1968a).
<i>Dysart</i>	Highway re-alignment. Moore (1968a, b).
<i>Kempton</i>	Dam site. Leaman (1968b). 'Grange' dam site. Leaman (1968c).
<i>Pontville</i>	Stone quarry. Threader (1969).

The Brighton-Bridgewater town area will require careful treatment when it is developed. Part of this area is covered by Leaman (1971b) but in this discussion reference is made to the area within the Brighton Quadrangle only. The problems associated with dolerite and Permian and Triassic rocks will be similar to those encountered in the Hobart area, but the basalt and breccia occurring widely around Bridgewater may create a set of unique problems due to the extensive distribution of these materials (Class 6 in the engineering study). The materials present are variable, with the basalt ranging from very solid and massive north of Bridgewater, to very patchy and scoriaceous elsewhere. The volcanic breccias adjacent to the River Derwent are variable, but are generally friable and crumbly with interbedded basalt flows. Excavations for house foundations may need to be up to 2 m or more deep on weathered breccia, while excavations for other purposes should be preceded by seismic work and some drilling. Geophysical work is recommended, both on a cost and reliability basis. Water seepages are also likely to be a problem in the breccia areas and planned drainage may be necessary.

The Tertiary sediments and many of the dolerite-derived talus and scree deposits are subject to landslips. The section shown in Plate 8 has long been hidden under soil, vegetation and several generations of collapsed drains and sand bags. Slopes less than 10° appear safe but insufficient examples are available to adequately specify slope criteria. Plates 15 and 16 provide an example of major failures on the Midland Highway at Dysart (Sloane, 1977). The collapse material includes previously slumped and weathered sandstone and mudstone with a cover of talus slides from the north-east. The entire hillside in this region is hummocky, reflecting the various slides and creep zones. Dolerite talus is the presently active material.

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APPENDIX 1

Groundwater Bore Holes

The information contained in this Appendix provides only a general indication of the type of factors affecting groundwater recovery within the quadrangle. Grid references are not available for many bores due to lost or insufficiently detailed records. Enquiries for information on the groundwater potential of a specific area should be made to the Director of Mines.

Owner	Date drilled	AMG reference	Depth water struck (m)	Total depth (m)	Yield l/min	Drillers' log (m)
<i>Brighton-Pontville area</i>						
B.P. Munnings	10.10.1962		9	18	22.7	0-8 soil, rubble clay, 8-16 sandstone, 16-18 dolerite.
G. Brown	15.2.1963	140720	43	55	15.2	0-18 sandstone, 18-22 shale, 22-55 sandstone.
H. Clarke	12.2.1968*	166737	9	22	90.8	0-5 gravel, 5-22 sandstone.
R.D. Gunn	26.3.1968*	256715	5.5	9.8	54.5	0-0.5 soil, 0.5-2 clay, 2-9.8 mudstone.
C.J. Harvey	14.1.1970*		3	9	43.3	0-2 soil and clay, 2-9 dolerite boulders.
<i>Mangalore-Bagdad area</i>						
Wybra Hall	3.2.1954	202760	3.5	8	abandoned	0-2 soil and clay, 2-3 dolerite boulders, 3-6 basalt boulders, 6-8 basalt(?)
			4	5	abandoned	0-2 soil and pug, 2-5 basalt boulders.
			5	12	36	0-1.5 soil and pug, 1.5-12 basalt boulders.
T. Newman	13.3.1956		8	26	15.2	0-1.5 clay, 1.5-23 marl, 23-26 white marl.

Owner	Date drilled	AMG reference	Depth water struck (m)	Total depth (m)	Yield l/min	Drillers' log (m)
D. Munnings	10.10.1962		9	18	22.7	0-9 clay, rubble, 9-18 sandstone.
P. Loney	1.2.1966*		12	15	76.2	0-6 clay, 6-7 dolerite boulders, 7-15 mudstone.
<i>Dysart area</i>						
G. Allwright	17.12.1962	118882	17	24	22.7	0-14 soil, clay, shale, 14-24 shale and sandstone.
Foster Bros.	12.1.1963	137879	-	29	-	0-14 clay and shale, 14-29 shale.
	19.1.1963	137879	36	42	21.7	0-6 clay, 6-31 solid mudstone, 31-42 grey mudstone.
E. Jones	19.2.1963	120870	14	52	13.3	0-24 sandstone and shale, 24-52 grey and blue shale.
<i>Kempton area</i>						
H.S. Thompson	27.7.1953		15	20	22.7	0-3 soil and clay, 3-4 dolerite boulders, 4-20 mudstone and sandstone.
M. Bresneham	6.8.1953		23	30	19	0-2 soil, sand and clay, 2-30 mudstone and sandstone.
J. Bresneham	19.8.1953		46	50	19	0-2 soil, clay, 2-50 mudstone mainly with sandstone.
	4.9.1953		24	61	-	0-2 sand and clay, 2-9 mudstone, 9-14 sandstone, 14-48 mudstone, 48-61 sandstone.
M. Bresneham	22.6.1954		12	20	19	0-1 soil, 1-12 mudstone, 12-13 sandstone, 13-15 mudstone, 15-17 sandstone, 18-20 sandstone.

Owner	Date drilled	AMG reference	Depth water struck (m)	Total depth (m)	Yield l/min	Drillers' log (m)
B.C. Johnston	21.10.1954		11	27	15.2	0-1 soil, 1-4 gravel, 4-27 mudstone.
<i>Broadmarsh area</i>						
M. McShane	19.9.1962	122756	27	43	21.7	0-6 soil, clay, 6-43 sandstone.
J. McShane	17.10.1962	145762	5	13	21.7	0-1 clay, 1-5 sandstone, 5-13 shale and sandstone.
F. & P. Cripps	28.1.1963	127757	6	43	21.7	0-5 clay and boulders, 5-18 sandstone and shale, 18-43 grey shale.
L.S. Bruce	31.1.1963	098767	6	24	21.7	0-6 clay, 6-24 sandstone.
C. Pennycuick	4.2.1963	102767	-	4	-	0-4 dolerite boulders.
	4.2.1963		-	6	-	0-6 dolerite boulders.
	5.2.1963		-	4.5	-	0-4.5 dolerite boulders.
W. Gunn	25.2.1963	100780	-	7	-	0-4 sand, 4-7 river gravel, 7 dolerite(?).
J. McShane	4.4.1967*		28	32	15	0-1 clay, 1-32 mudstone.
<i>Black Hills area</i>						
D. Bowerman	6.4.1965	009720	-	57	-	0-13 clay and boulders, 13-22 dolerite boulders, 22-57 mudstone.

*Drilled by Tasmanian Drillers Ltd (now Mono Pumps, Tasmanian Drilling Division)

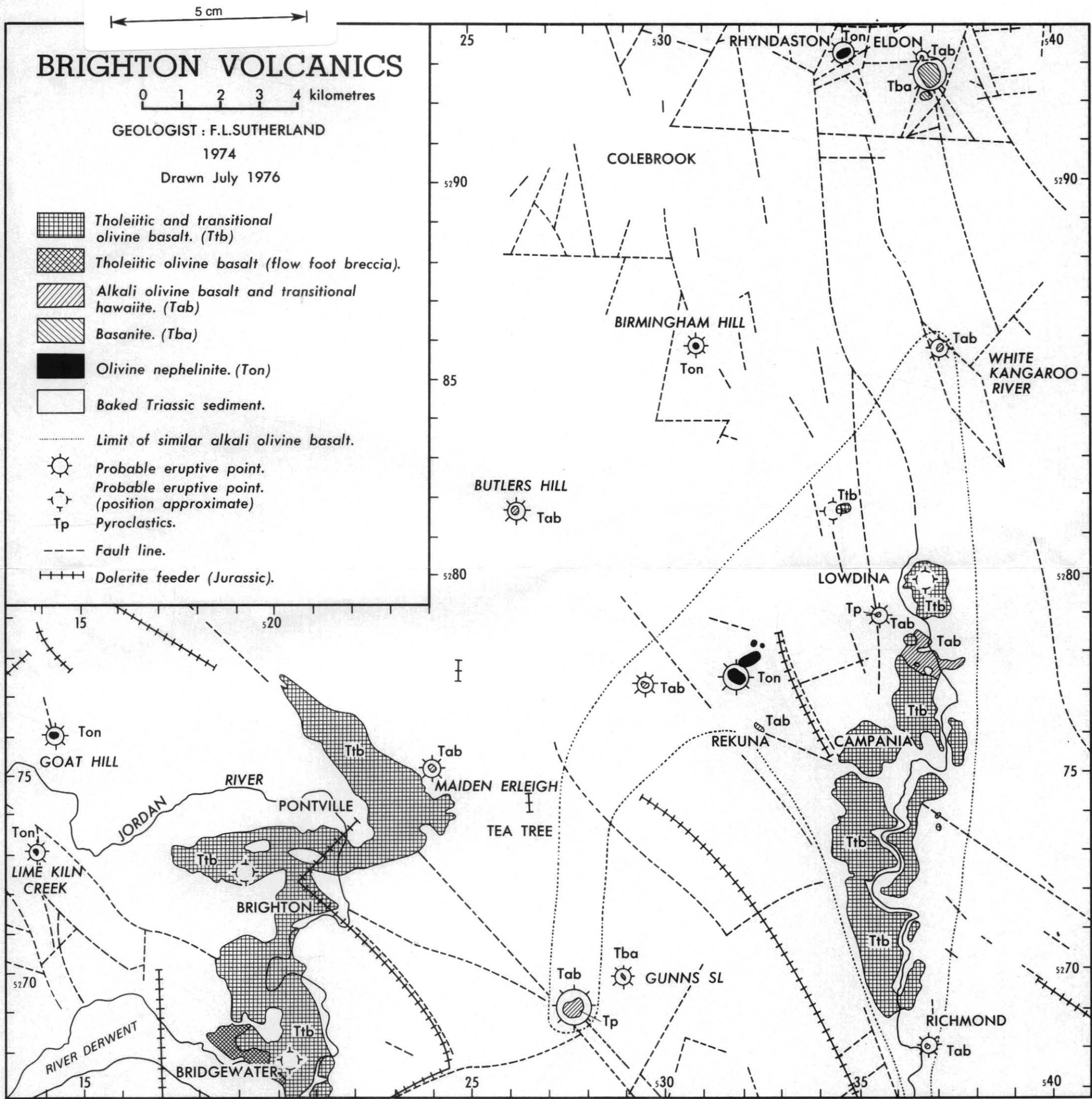


Figure 6.

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