TASMANIA DEPARTMENT OF MINES

1976

GEOLOGICAL SURVEY EXPLANATORY REPORT

GEOLOGICAL ATLAS 1:50,000 SERIES

ZONE 7 SHEET No. 82 (8312S)

HOBART

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

with contributions by F. L. SUTHERLAND, M.Sc., B.Sc. (Hons.), V. M. THREADER, M.Sc. and G. B. EVERARD, M.A., A.M.Aust.I.M.M.

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ISSUED UNDER THE AUTHORITY OF THE HONOURABLE
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PREFACE

The Hobart geological atlas 1:50 000 map sheet was published in 1973. It covers Hobart and its environs, and extends from New Norfolk to Cambridge in the north and from Grove to Opossum Bay in the south.

The results of detailed work on the Cainozoic rocks are given by F.L. Sutherland, formerly of the Tasmanian Museum.

Since the map was published much new information has been obtained on the geology of the bed of the River Derwent. This information is summarised in Appendix 4 and a new geological map is given as Figure 17.

J.G. SYMONS, Director of Mines

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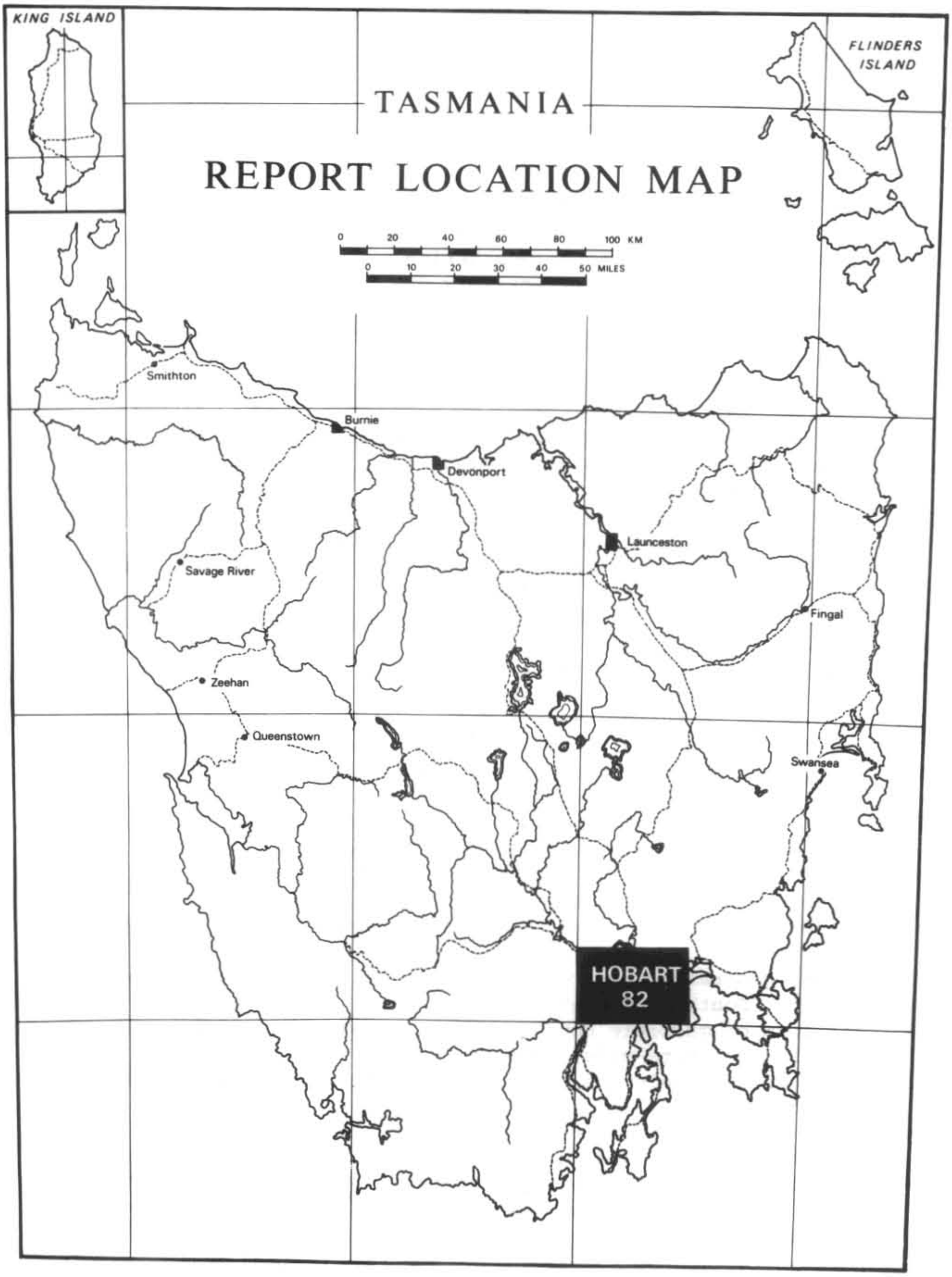


Figure 1. *Location of Hobart quadrangle.*

5 cm

INTRODUCTION

The Hobart Quadrangle includes the Hobart metropolitan area (fig. 1), and is characterised by rugged topography of moderate to high relief. The city nestles at the foot of Mt Wellington along the estuary of the River Derwent.

The region is not noted for its agricultural activity, although limited areas are responsible for much fat-lamb and wool production, and dairying. Some horticulture and small fruits industries are carried on in the Kingston, Longley and Collinsvale areas. A large proportion of Tasmania's hops are produced in the New Norfolk-Lachlan region. Generally the topography, variable rainfall and poor or thin soils restrict agriculture. In addition, much fertile land has been used to accommodate the suburban sprawl of Hobart.

No metallic mineral deposits occur within the area, but coal, clay, sand, gravel and limestone deposits have been worked. Roadmaking materials are available in abundance.

Apart from the elevated Mt Wellington-Collins Bonnet-Mt Marian plateau, access is excellent. There are good outcrops of most formations, a function of moderate to low rainfall and steep slopes.

Mapping was executed on 1:15 840 dyelines supplemented by aerial photographs. Field work was undertaken intermittently between January 1966 and June 1970 concurrent with a gravity survey (Leaman, 1972*a*).

PREVIOUS LITERATURE

Although Hobart was first settled in 1803, it was not until 1865 that the first geological work was published (Harrison, 1865). He provided general descriptions of the Triassic rocks and dolerite, and brief mention of the Permian rocks and fossils. The gravel deposits between Bridgewater and New Norfolk were described and thought to be due to tidal variations during periods of tectonic activity.

Some thirty years earlier Charles Darwin on the voyage of the *'Beagle'*, visited Hobart and gave good geological descriptions of localities at Bellerive, Sandy Bay, New Town and Glenorchy. He correctly described the age-relationship between the dolerite and the Permo-Triassic rocks, a feat not accomplished again until Hills *et al*. (1922). These observations remained unknown until Banks (1971) published annotated extracts from Darwin's diaries.

Wintle (1865) described some 'anthracite' at the Cascades. Krausè (1884) gave a generalised description of aspects of the New Town Coal deposits and envisaged a large syncline through Hobart. The first major work to appear (Johnston, 1888) recognised the step faulting about Mt Wellington and gave some order to the Permian stratigraphy, but was inaccurate concerning the dolerite. Johnston believed much of the dolerite to be 'pre-Carboniferous' and not intrusive. His conclusion appears to have been based on thoughts by Jukes (1847) and the results of a drill hole at South Hobart (DH1-see map). If the observations stated are correct and metamorphism was not observed in this case, the likely solution is that the hole was not vertical and was drilled through one of the small nearby faults. A dolerite feeder and sill occur in the Lower Permian rocks of this region.

Hills *et al*. (1922) dealt with small parts of the area while studying the occurrence of coal. The dolerite was thought to have the form of a massive sheet with plugs and dykes intruding overlying rocks. Nye (1922, 1924) developed this idea which was probably based on work by Strzelecki (1845), Milligan (1849) and Selwyn (1855). Voisey (1938) summarised the Permian stratigraphy. More detailed and definitive accounts of parts of the sequence are given by Banks and Hale (1957) and Banks and Read (1962).

Edwards (1942) used the intrusions at Mt Wellington and Mt Nelson as key parts of a study on the differentiation of dolerite. The validity of many of his conclusions and assumptions have been questioned (Leaman, 1971*a*, 1972*a*).

Lewis (1946) presented the first detailed map and text of the geology of the Hobart district. The present work does not seek to replace the observations made by Lewis, but rather, it is intended to provide a summary revision of his conclusions and of more recent observations.

Subsequent workers have mapped small sections of the area, for example, Mather (1955), Rodger (1957), Woolley (1959), McDougall (1962), Read (1960), Hastie (1961), Green (1961), Sutherland (1964), Moore (1965, 1968), Gatehouse (1967). The map of Banks *et al.* (1965), incorporated much of the earlier work and Spry (1955) examined the basalt centre at Lower Sandy Bay.

PHYSIOGRAPHY

Two physiographic features dominate the Hobart district, the Mt Wellington-Mt Marian plateau and the Derwent lowlands. Relief is generally moderate to high and without exception, elevated country is dominated by dolerite bodies which give protection against erosion (fig. 2)

In detail, the topography is marked by fault-controlled features, such as escarpments and straight, narrow valleys. The Derwent lowlands with the Coal River valley and Pitt Water, represent a graben some 32 km across. Step faulting within the graben has produced linear blocks at various elevations. The Mt Direction and South Arm Peninsula blocks represent a central zone elevated with respect to the eastern escarpment and downthrown compared with the western escarpment. Topographic regimes are generally north-south, and few streams of any magnitude cross this system. The River Derwent is an exception, trending west-east from New Norfolk to Bridgewater across the main north-south range. The river follows fault trends north of New Norfolk and south of Bridgewater but there is no obvious structural control between these areas for such a course change. Several streams show meander incision and quite possibly the course change of the River Derwent is an incised feature, inheriting an earlier determined course and dating from Mesozoic times, as the faulting is rejuvenated Jurassic faulting.

HISTORY OF THE RIVER DERWENT

The following summary of the history of the valley of the River Derwent briefly integrates the known facts and deductions given elsewhere (Leaman, 1975*b*). The inferred stages in the evolution of the valley are tabulated and no extensive explanation is offered.

(1) The River Derwent produced a deep V-notch valley from Elwick Bay to Cornelian Bay via Moonah and then south between Rosny Point and Macquarie Point. The valley is engraved in a thick dolerite sheet to a base level at least 200 m below present sea level. Valley side slopes of 15° or more were common. By Early Tertiary times the valley and its tributaries were well formed. The position of the valley was controlled by first order graben faulting and the actual line of excavation by a series of nearly N-S trending faults in the New Town-

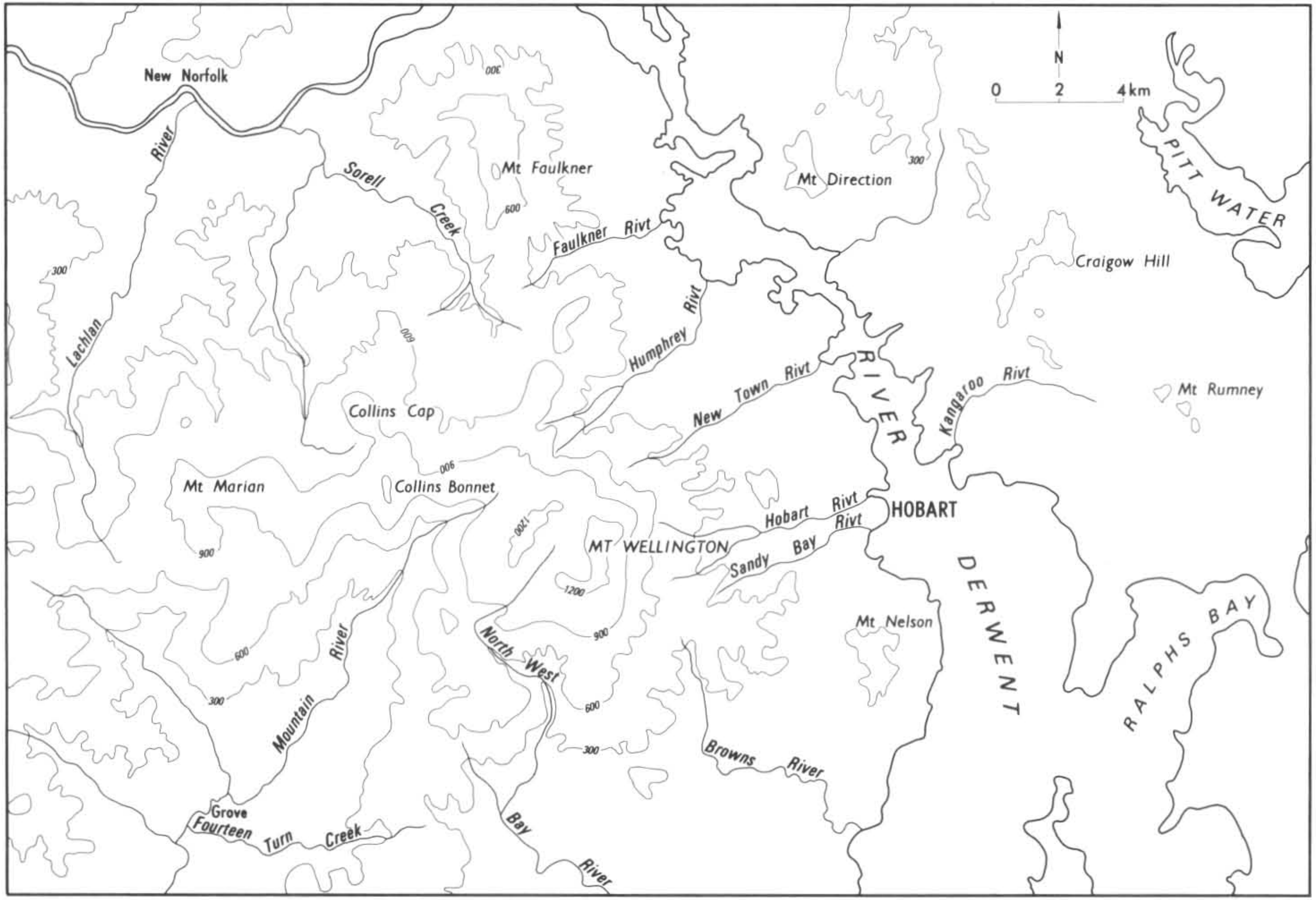


Figure 2. *Generalised topography, Hobart Quadrangle.*

5 cm

Moonah area. Present outcrop distribution can only hint at this factor.

(2) Subsequent to valley engravure the base level rose and a cycle of deposition began. Periods of volcanism were associated with the sedimentation but the number, duration and location of flows, activity and centres can only be surmised at lower levels.

(3) The base level rose ultimately to around +50 m and the whole sedimentary sequence was capped with basalt. However, before this occurred there were several fluctuations of base level between 0 and -80 m in which reworked sediments were deposited. All this sedimentary activity was restricted to the Tertiary valley system via Moonah.

(4) It is likely that with a base level at +50 m the ridge between the hills at East Risdon and the Zinc Works-Lutana would have been submerged. Quite recent faulting in this region, typified by the Bedlam Walls Fault which has many youthful features, made is possible for the river to cut through the ridge from above at a time of high base level. Having done so the original path was totally short circuited. With a substantial base level fall in the early Pleistocene erosion of the ridge was accelerated and the present valley position confirmed. The Pleistocene base level in this section of the river was at least -50 m. (It is possible that some of the less consolidated materials found west of pier 8 at the Tasman Bridge could be early Pleistocene but the absence of such materials north of Selfs Point and basic geomorphologic evidence tend to exclude this conclusion).

(5) Recent silt, including Pleistocene gravel and silt, were then deposited in the fresh Pleistocene valley directly on newly exposed and often very steep sided slopes. No deep weathering was possible due to climatic and flow factors.

(6) During the Pleistocene, base levels again rose to +10 to +20 m and some higher level gravel may be observed along the valley. In recent times the base level has again dropped slightly but the residual effect is a large deep estuary representing the drowned valley of a moderate sized river.

This history, which allows for all known facts, predicts fresh bedrock profiles between Elwick Bay and Bedlam Walls with a significant cover of silt but an absence of consolidated clays and sands. It also suggests that profiles south of Cornelian Bay Point will consist of weathered dolerite slopes (dating to lower Tertiary times), a substantial fill of clay, sand and basalt with a cover of silt. The older materials (clay, sand, basalt) can be expected to form a symmetrical V-shaped fill in the original valley although in detail there may be complex arrangements of sediment and basalt (Leaman, 1975*b*). The Pleistocene and, or, Recent valley will be a shallow scoop within the older fill and could occur virtually anywhere in the upper levels. At the Tasman Bridge it is toward the eastern side and on basalt, but this need not be general and it is probably the result of recent inflow south of Selfs Point having been on the eastern side of the valley.

In the elevated plateau regions where frost action is common, and where periglacial conditions prevailed in Pleistocene times, there is much evidence of solifluction and congelifraction deposits. Substantial deposits of talus, probably formed at this time, are in places overlain by more recent scree fields (Davies, 1958).

The coastal regions are marked by the presence of higher shoreline levels and raised beaches. These are particularly evident in the Sandford-Cambridge region, and occur between 0.6-2 m above the present sea level

Plate 1. *Low level shoreline surface, Sandford.*

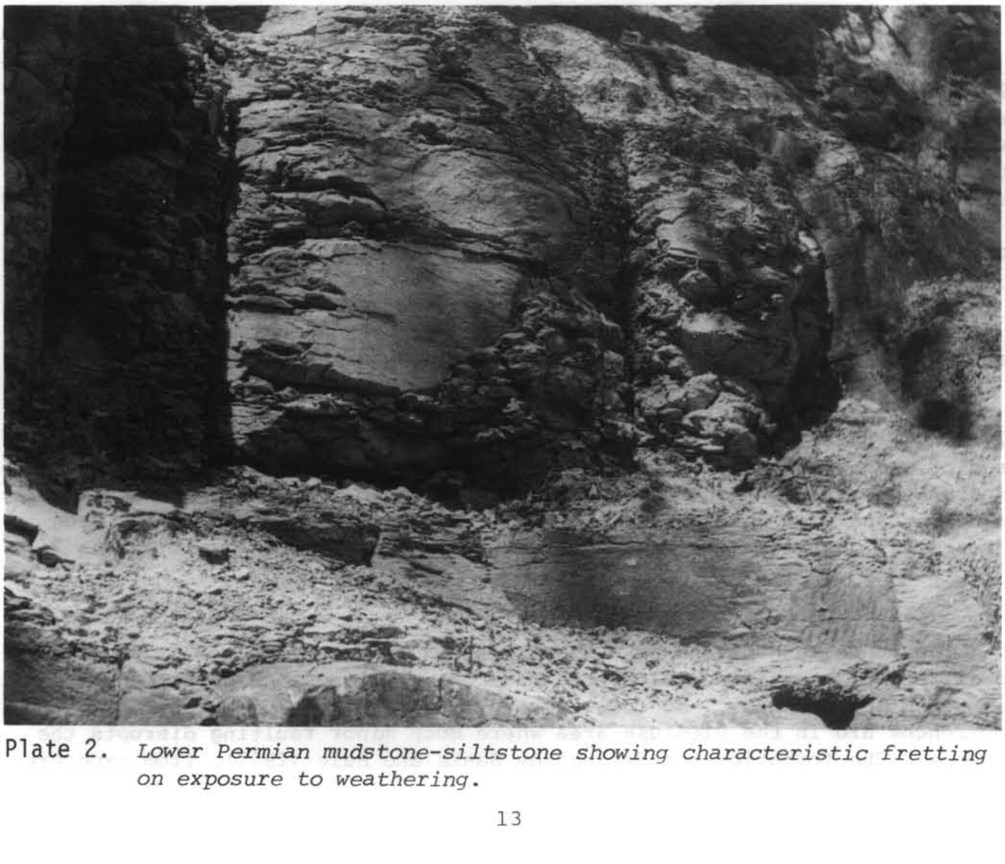


Plate 2. *Lower Permian mudstone-siltstone showing characteristic fretting on exposure to weathering.*

(Davies, 1959) (plate 1). There is also much evidence for variation of erosion and river base levels in the complex of depositional and erosional terraces in the valleys of the Coal and Derwent Rivers. The coastline is generally one of submergence with an inter-island bar connection at South Arm.

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. Solifluction deposits are common in the plateau regions, especially those above 1000 m in elevation.

Permian

The total thickness of exposed Permian rocks is about 600 m. The base of the system is not exposed, but was revealed in a bore hole at Glenorchy, where some 9 m of pebbly mudstone rest unconformably on sheared, Cambrian(?) volcanic rocks. All the Permian formations are apparently conformable.

UNDIFFERENTIATED LOWER PERMIAN

The rocks designated Lower Permian consist of a monotonous mudstone-siltstone sequence, with occasional sandstone units, up to 200 m in thickness. The only exposures are in the Collinsvale-Glenlusk-Berriedale region (see also Sutherland, 1964). These rocks occupy the same stratigraphical position and are lithologically closest to the Quamby Mudstone of the Central Plateau (Wells, 1957; Clarke, 1968*a*). There is no evidence to indicate that they are as old as the basal beds in some other parts of Tasmania where thick tillitic sequences are often present (Gulline, 1967; Clarke, Farmer and Gulline, 1973).

The siltstone, which is pyritic and bluish grey when fresh, weathers to a yellow-brown colour. It is thickly bedded with actual bedding often disguised by fissility induced by weathering. No glendonites have been seen by the author although Sutherland (1964, p. 120) reports cavities suggestive of them. Limonitic concretions are common, but pebbles are rare and are usually of quartzite, up to a few centimetres in diameter. The rocks are composed of quartz and clay. The only fossils seen are rare brachiopods and fenestellids. The siltstone shows a characteristic fretting on exposure to weathering and also when metamorphosed. Good examples of this may be seen in the small quarries along the Collinsvale road west of Chigwell (plate 2).

BUNDELLA MUDSTONE

The Bundella Mudstone is a fossiliferous and somewhat pebbly mudstone and siltstone, containing calcareous mudstone and limestone units, approximately 75 m in thickness. No complete, well-exposed section exists. Most occurrences are in the Glenlusk area where much minor faulting disrupts the sequence. The formation was defined by Banks and Hale (1957), from exposures on the Lyell Highway [140667]*, on the upper pebbly fossiliferous mudstone and siltstone, as the base is not exposed at this locality. In the Glenlusk region, limestone, calcareous siltstone and siltstone up to 35 m in thickness underlie fossiliferous rocks of the more typical Bundella type. Sutherland (1964) correlated the units above the Lower Permian rocks with the Satellite Siltstone (*cf* Banks, Hale and Yaxley, 1955) and Darlington Limestone. However, the present author has grouped all the *Eurydesma*-rich rocks into one formation since their correlations are uncertain at present. The rocks above and below this formation are normally unfossiliferous and it is thus a definite, mappable horizon. Only at Doctors Hill does confusion arise concerning the top of the formation. Here, the overlying unfossiliferous Faulkner Group is absent and Bundella Mudstone, characterised by *Eurydesma cordatum* Morris, *Keeneia platyschismoides* Etheridge, *Myonia morrisi* Etheridge, *Grantonia*, *Strophalosia subcircularis* Clarke and *Deltopecten illawarensis* (Morris) appears to grade imperceptibly into the Cascades Group (see also Moore, 1968; Clarke, 1968*b*).

Around Glenlusk the basal members are composed of dark grey fossiliferous siltstone, with most beds being 0.3-1 m in thickness (beds are taken as distinguishable units of layering, which normally reflect compositional and textural variations). These are overlain by alternations of bryozoal siltstone (0.3-1 m) and calcareous siltstone with occasional beds of limestone 0.6-1 m in thickness. Definite limestone first appears about 18-25 m above the base. Many rock fragments and pebbles are included, which may be up to 0.3 m across. 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 (see also Banks and Hale, 1957) and the upper beds may be quite barren (*e.g.* the north slope of Mt Faulkner). Calcareous siltstone and sandy limestone units, both richly fossiliferous occur below high water mark on the shore south of Blinking Billy Point. The remainder of the section near the Channel Highway is obscured. Drilling has proved at least 74 m of this formation at west Glenorchy, and only the upper 27-30 m is sandy siltstone. The remainder is calcareous, with some units of definite but impure limestone. Drilling also revealed a gradational boundary with the Lower Permian siltstone (fig. 3).

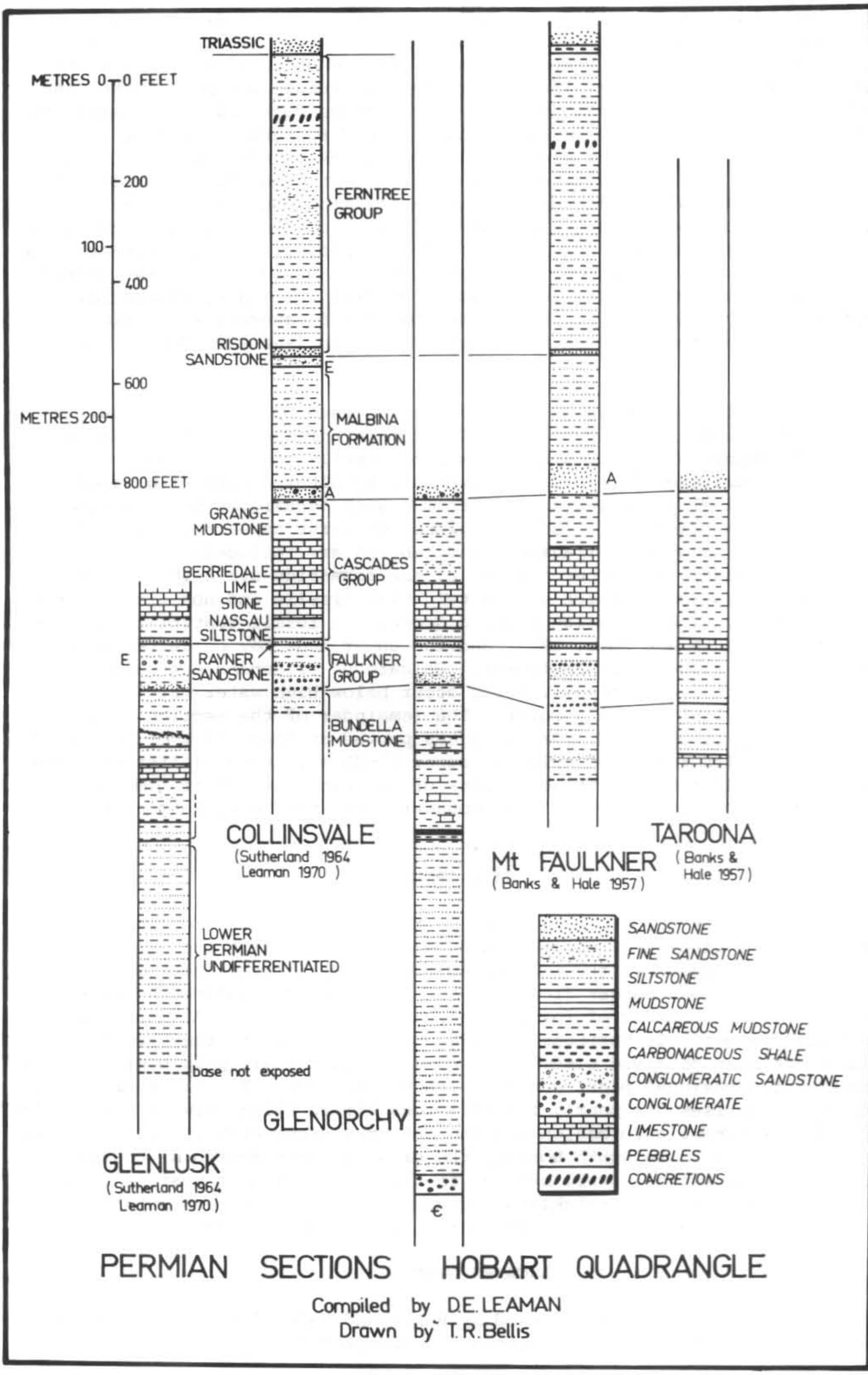
FAULKNER GROUP

Rocks of this group are variable in thickness, facies and lithology. They consist of sandstone, mudstone and conglomerate. With the exception of the Cygnet Coal Measures, the only non-marine Permian rocks occur in this group. Its thickness ranges from 0-30 m. The group was defined by Banks and Hale (1957), and a number of formations were named by them. Although these formations are mappable horizons locally about Mt Faulkner, they are thin and have not been observed elsewhere. As a whole, the group is poorly fossiliferous, but occasional plant and wood fragments occur. The Faulkner Group, as mapped, comprises the poorly fossiliferous strata lying between the richly fossiliferous Bundella Formation and the Cascades Group with their respective distinctive faunas. In South Hobart, the group is represented by coarse quartz siltstone which is well exposed in the Hobart Rivulet west of the bus terminus and big bend in Strickland Avenue. It appears to lens out to the south and no comparable units occur near Kingston (Moore, 1968).

CASCADES GROUP

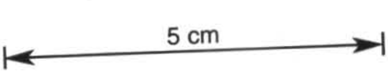
The Cascades Group was defined by Banks and Hale (1957) to include the Nassau Siltstone, Berriedale Limestone and Grange Mudstone. All three units

*All localities lie within 100 km grid square EN.



TRIASSIC
METRES 0
0 FEET
200
100
400
600
METRES 200
800 FEET
FERNTREE GROUP
RISDON SANDSTONE
E
MALBINA FORMATION
A
GRANGE MUDSTONE
CASCADES GROUP
BERRIEDALE LIMESTONE
NASSAU SILTSTONE
RAYNER SANDSTONE
FAULKNER GROUP
BUNDELLA MUDSTONE
E
COLLINSVALE
(Sutherland 1964
Leaman 1970)
Mt FAULKNER
(Banks & Hale 1957)
TAROONA
(Banks & Hale 1957)
LOWER PERMIAN UNDIFFERENTIATED
base not exposed
GLENORCHY
GLENLUSK
(Sutherland 1964
Leaman 1970)
€
SANDSTONE
FINE SANDSTONE
SILTSTONE
MUDSTONE
CALCAREOUS MUDSTONE
CARBONACEOUS SHALE
CONGLOMERATIC SANDSTONE
CONGLOMERATE
LIMESTONE
PEBBLES
CONCRETIONS
PERMIAN SECTIONS HOBART QUADRANGLE
Compiled by D.E. LEAMAN
Drawn by T. R. Bellis

Figure 3



5 cm

Plate 3. *Pinch and swell effects, possibly due to ripple marking. Berriedale Limestone, Glenlusk.*

are richly fossiliferous. The Rayner Sandstone was separately defined, but the present author has included this formation in the Cascades Group. It is fossiliferous and marks an abrupt change from Faulkner Group sedimentation and is a good marker horizon over the area from South Hobart to Mt Faulkner.

The Rayner Sandstone (Banks and Hale, 1957) is a pebbly, grey feldspathic sandstone with thick massive beds. Normally about 3 m in thickness, it occurs beneath the fossiliferous grey-black Nassau Siltstone in the type section on Mt Faulkner and in the Hobart Rivulet west of Strickland Avenue, South Hobart.

Around Mt Faulkner the maximum thickness of the Nassau Siltstone is about 18 m. At South Hobart poor exposures do not permit reliable estimates to be made, but it is more than 10 m thick. *Wyndhamia preovalis* (Maxwell), *Cancrinella farleyensis* (Etheridge and Dun), *Martiniopsis profunda* (Campbell), *M.ovata* (Campbell) are important brachiopod species although other spiriferids, crinoid plates, pectinids, *Eurydesma,* stenoporids and fenestellids are also common.

The Berriedale Limestone and Grange Mudstone appear as facies variations with a total thickness of 58-64 m. At Glenorchy, Collinsvale and Mt Faulkner the limestone appears as the basal member and contains thin siltstone units. Limestone units or beds of calcareous mudstone occur at various levels in the Grange Mudstone, which as a unit, normally overlies the Berriedale Limestone. On the north face of Mt Faulkner the proportion of limestone to mudstone is 3:2, whereas on Mt Dromedary across the Derwent River (6 km north of the quadrangle boundary) the mudstone is absent. At Collinsvale the limestone, mudstone proportion is 2:1 and at South Hobart it is 1:10. No limestones have been seen in the Doctors Hill section west of Kingston and there is a rapid thinning of the limestone south of Glenorchy.

The Berriedale Limestone consists of thickly bedded calcarenites and calcilutites. The siltstone is very minor and thinly bedded, whereas the coarse limestone beds are occasionally 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) (plate 3). Pebbles up to 5 cm across are common and the clastic content of the limestone increases upward. Montmorillonite horizons observed in the limestone are thought to be due to distant volcanic activity (Brill, 1956; Hale and Brill, 1955). The chemical composition of the limestone is given by Hughes (1957).

The Grange Mudstone is a generally fossiliferous association of fenestellid mudstone and siltstone which is often very pebbly. Bedding is marked and usually only a few centimetres in thickness. The fossil content diminishes toward the top, and in some localities, Lenah Valley and South Hobart, barren siltstone occurs. Lithologically such siltstone is similar to the siltstone of the Malbina Formation or Ferntree Group. Beds of quite pure limestone may also occur near the top of the unit as at Guy Fawkes and Hobart Rivulets west of the Cascade Brewery, and also in the higher reaches of Guy Fawkes Rivulet. In the southern region of the quadrangle Grange Mudstone, as a lithological unit, dominates the group and at Taroona about 80 m is present (see also Banks and Hale, 1957, p. 58).

An indication of the variations in thickness is shown in Figure 3. The Berriedale Limestone ranges in thickness from 0-45 m within the quadrangle and the Grange Mudstone from 22-90 m. Characteristic fossils include *Grantonia cracovensis* 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 of the type section.

MALBINA FORMATION

The Malbina Formation was defined by Banks and Read (1962) at a section near the Malbina cemetery [135652]. It consists of about 85 m of alternating sandstone and siltstone and five members have been described. Basal Member A is a pebbly, fossiliferous sandstone and is well exposed on the northern flank of Mt Faulkner, Glenlusk and in road sections along Strickland Avenue. The thickness of this member ranges from about 5 m west of Lachlan to more than 18 m on Mt Faulkner. The sandstone is often interbedded with calcareous siltstone. In many places Member A is differentiated from the Cascades Group merely by a coarsening of grain size, slight increase in pebble content and an increase in bed thickness. Examples of such changes may be observed along the Huon Highway west of Neika, near Mt Mather, and south of Grove. On occasions, the fossil content may be low, as for example west of Lachlan, and fossils are restricted to a few beds, the whole sequence being a coarse and pebbly sandstone. Members B and D are defined as pebbly siltstone and are not normally separable if Member C, a thin (1-2 m) very pebbly sandstone, is not present or not observed. No sandstone that might clearly represent Member C, has been located except in the immediate region of the type section.

Member E consists of 5-10 m of fossiliferous mudstone, siltstone and intermittent sandstone. Occasionally, as in Humphrey Rivulet, Glenorchy, there is a pyritic, silty limestone. Characteristic fossils from Member A include *Aperispirifer wairakiensis* (Waterhouse), *Martiniopsis undulosa* (Campbell), *M.* cf *magna* (Campbell), *M. strzeleckii* de Koninck, *Terrakea concava* Waterhouse, *T. brachythaera* (Morris), *Wyndhamia dalwoodensis* Booker and *Deltopecten illawarensis* (Morris). Member E is richly fossiliferous and characteristic forms include *Astartila intrepida* Dana, *Megadesmus grandis* (Dana), *Vacunella curvata* (Morris), *Fusispirifer avicula* (Morris), *Sulciplica transversa* Waterhouse, *Terrakea brachythaera* (Morris), *Wyndhamia ovalis* (Maxwell), *Walnichollsia subcancellata* (Morris) and *Warthia micromphala* (Morris) (Clarke, 1971; 1973; pers. comm.).

The formation thins to the south-west. In the New Norfolk-Lachlan-Mt Faulkner region the thickness is of the order of 85 m, whereas in the Huonville-Lucaston-Grove region it is approximately 65 m. On South Arm Peninsula the formation is 90 m in thickness.

A small block of siltstone is exposed beneath the talus on the face of Mt Wellington. It has been identified as undifferentiated Permian as there is insufficient outcrop to establish the formation, but it is possibly of Malbina Formation. South of Kingston and in certain other areas, lithologies characteristic of both the Grange Mudstone and the Malbina Formation are interbedded. Biostratigraphically most of these sequences are approximate age equivalents of *Malbina* Member A, but at two localities in Whitewater Creek *Cancrinella farleyensis* (Etheridge and Dun) occurs in abundance and indicates age equivalence with the Cascades Group (Clarke, pers. comm.). However, complex faulting prevents the clarification of the stratigraphical details (Moore, 1968 *et seq.*).

FERNTREE GROUP

The base of the group is marked by beds of pebbly, feldspathic (more than 15% feldspar) sandstone 3-6 m in thickness. (Risdon Sandstone; see

Banks and Hale, 1957; Banks, 1962). It is a thickly bedded unit sometimes containing rare brachiopod moulds. The base of the sandstone is usually very abrupt, although it may be interbedded with siltstone, as near Lachlan [013 578] (plate 4). The top of the unit grades imperceptibly into the typical siltstone lithology of the group (plate 5). Pebbles are normally angular and of quartz or quartzite derivation. On South Arm peninsula the basal sandstone is 3-5 m in thickness, commonly pebbly with an average grain size of 2-3 mm. Pebbles of granite and quartzite are often seen up to 20 cm across. The overlying Ferntree Mudstone is 165-180 m thick but good sections which can be measured are rare. The lithology exhibited by the Ferntree Mudstone is quite variable and although predominantly a coarse siltstone, commonly with alternating fissile and non-fissile bands, sandstone and occasionally conglomerate occur. For example, Sutherland (1964) reported conglomerate at 15 and 135 m above the base. A series of thin conglomeratic bands occur near the top of the formation south of Kingston. Fossils are also present, but these are rare and generally restricted to one or two horizons. The best developed fossil horizon is located 30-40 m from the top of the formation and is always associated with coarsely bedded sandy siltstone, containing numerous concretionary structures. The fauna is essentially similar to, and of the same age as, that of Member E of the Malbina Formation, (Clarke, 1973). Worm casts and woody fragments are common through the formation.

On South Arm peninsula two fault blocks have been assigned to this group. Petrologically the rocks of the Maria Point block are similar to the siltstone of the Malbina Formation to the north on Mt Mather. However, the thickness of such rocks exceeds that of the Malbina Formation by at least 50 m. Member E of the Malbina Formation and Risdon Sandstone units are present at the northern end of Mortimer Bay. This section is faulted, and thickness determinations indicate that the bulk of the region is of the Ferntree Group.

On the headland south of Mortimer Bay, siltstone similar to that on Maria Point again crops out. In this case it was necessary to inspect the ridge to the south in order to determine whether the rocks present belong to the Malbina Formation or Ferntree Group. No marker sandstone or distinctive fossil horizons have been seen and it is concluded that the rocks belong to the Ferntree Group. The minimum implied thickness of 140 m supports such a conclusion and further suggests a fault between Mortimer Bay and Mt Augustus.

CYGNET COAL MEASURES

This formation, in the past, has caused several problems of classification, dating and separation with respect to the overlying rocks (*e.g.* Banks and Naqvi, 1967). It is regarded here as that non-marine sequence, consisting of coal, carbonaceous mudstone and shale and, or, feldspathic sandstone containing carbonaceous fragments which usually disconformably overlies the Ferntree Group. The carbonaceous rocks have an irregular basal surface and show marked lithological variation near their base. Erosion is normally indicated. The thickness of the formation ranges up to 30 m. This definition not only allows separation from the overlying quartz series, believed to be of Lower Triassic age, but it is also a truly Permian formation as determined by spore analysis (Davidson, 1969).

Thin carbonaceous mudstone and shale beds are found at Sky Farm (Claremont) [166629], Grasstree Hill, New Town Creek and at Silver Falls, Fern Tree [203478]. Many exposures display only the feldspathic sandstone (*cf* Barnetts Member - Leaman and Naqvi, 1968; Banks and Naqvi, 1967). Excellent exposures of this sandstone which carries occasional carbonaceous fragments may be seen on a southern spur of Grasstree Hill.

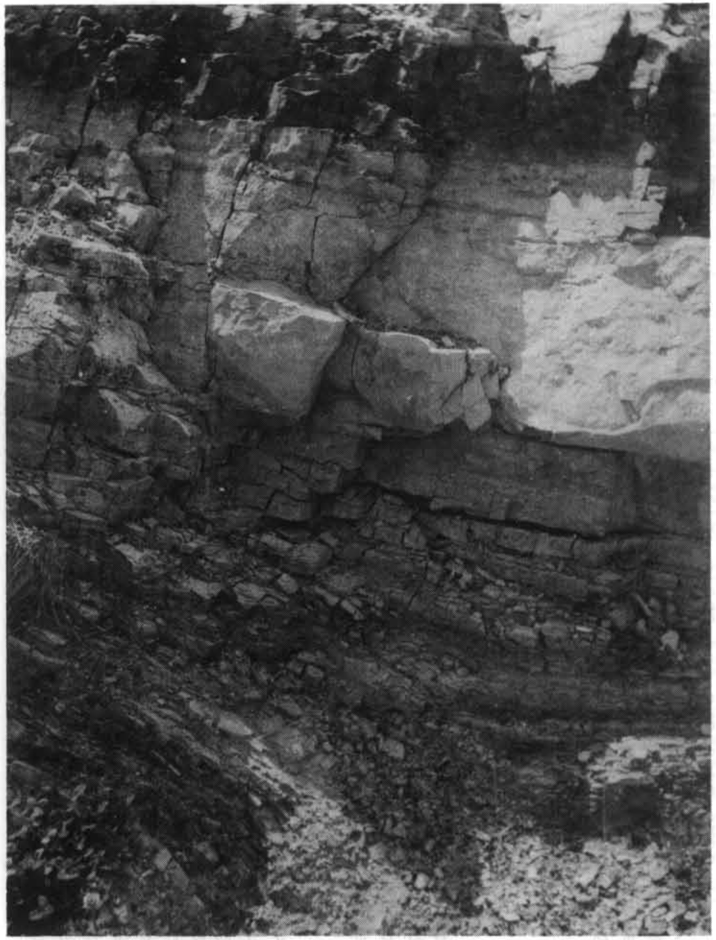


Plate 4. *Risdon Sandstone with interbedded siltstone at its base, Lachlan.*

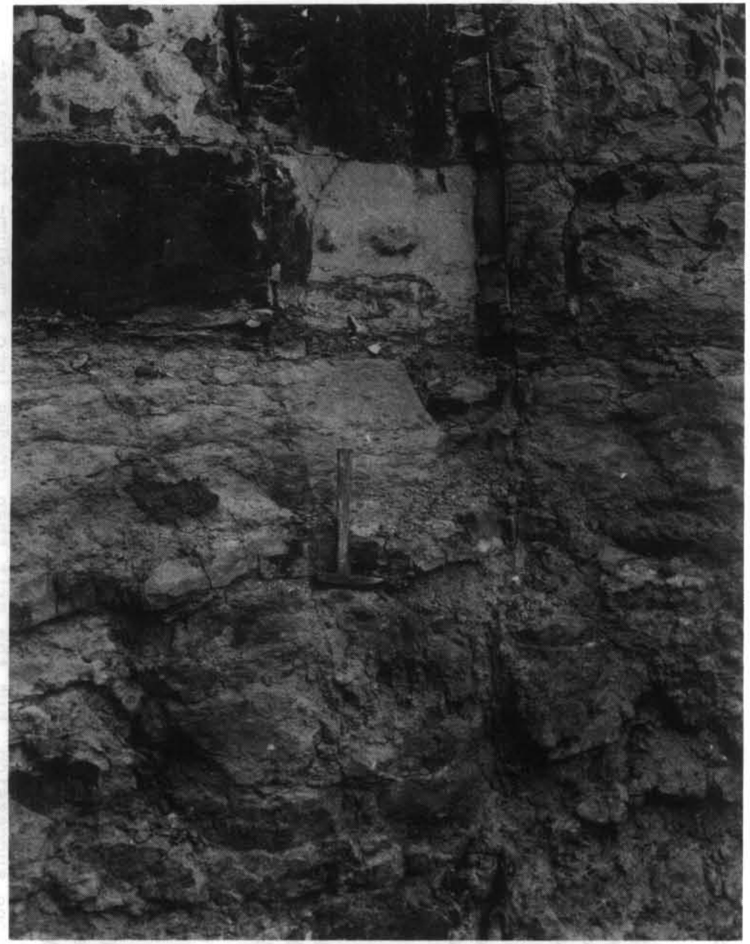


Plate 5. *Risdon Sandstone grading into siltstone of the Ferntree Group, Eastern Outlet Road.*

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 whilst the second association of Upper Triassic-Rhaetic age (Hale, 1962; Townrow, 1962) at least 150 m in thickness, contains 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. The terminology is based on Turner and Verhoogen (1960).

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 on the eastern slope of Grasstree Hill. Normally they are found scattered throughout the sandstone succession, but the grit then grades into a medium- to coarse-grained sandstone.

Assemblage 2. Massively bedded, medium- to coarse-grained quartz sandstone with some mudstone and shale (plate 6). This unit is dominantly sandstone, the sandstone to shale ratio normally exceeding 10:1, 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 (*e.g.* Glen Dhu Rivulet).

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.

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 also shows pink blotches on unweathered faces and is grey-green when fresh. Substantial exposures occur on Mt Faulkner, Mt Marian and at Old Beach. 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 only in the Old Beach region and there are good exposures in the cutting north of the Old Beach Post Office. Red coloured mudstone beds are most common at this level, for example at Knocklofty and Old Beach.

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 (plate 7).

The quartz rocks show a great variety of sedimentary structures (plates 8, 9). Current and festoon bedding is common and overturned current bedding is not unusual. 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 shales to thick massive mudstone.

The sandstone and mudstone beds in Assembages 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.

The only complete section occurs west of Collins Cap in Glen Dhu Rivulet, where there is 450 m of sandstone and mudstone. The region north of Mt Marian is almost inaccessible 'cliff and valley' country. However, good exposures of Assemblages 2 and 5 are present. Elsewhere only partial or faulted sections occur.

LITHIC ASSOCIATION

Lithic feldspathic sandstone and mudstone have previously been called salt and pepper rocks (Hale, 1962), and are greenish grey in colour when fresh. The sandstone-mudstone ratio is often 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 to be 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

The principal Tertiary deposits are of clay and fine sand, and are primarily found in the eroded fault troughs of the Coal and Derwent Valleys. The deposits conform to the shape of wedge-shaped troughs in depth but have filled and lapped over from these. Adjacent to the faults near the margins of the basin these deposits often contain large boulders broken or weathered from the up-faulted block. At Sandy Bay, near the foot slopes of Mt Nelson, the predominant boulders are of dolerite although fragmented Permian rocks appear at the fault (plate 10). Excavations at Wrest Point revealed that the dolerite boulder material is a thin, near-surface covering with a very irregular lower surface. The whole form is suggestive of late stage landslides. Some crumpling of the underlying mudstone, which is very pure and interbedded with occasional sandstone and ironstone (siderite cemented sandstone), is also evident. The boulder beds may be much more recent in age. Dolerite boulders are also common throughout the Tertiary sediment at Taroona. Near Pitt Water there are no exposures which display the collapse from the basin

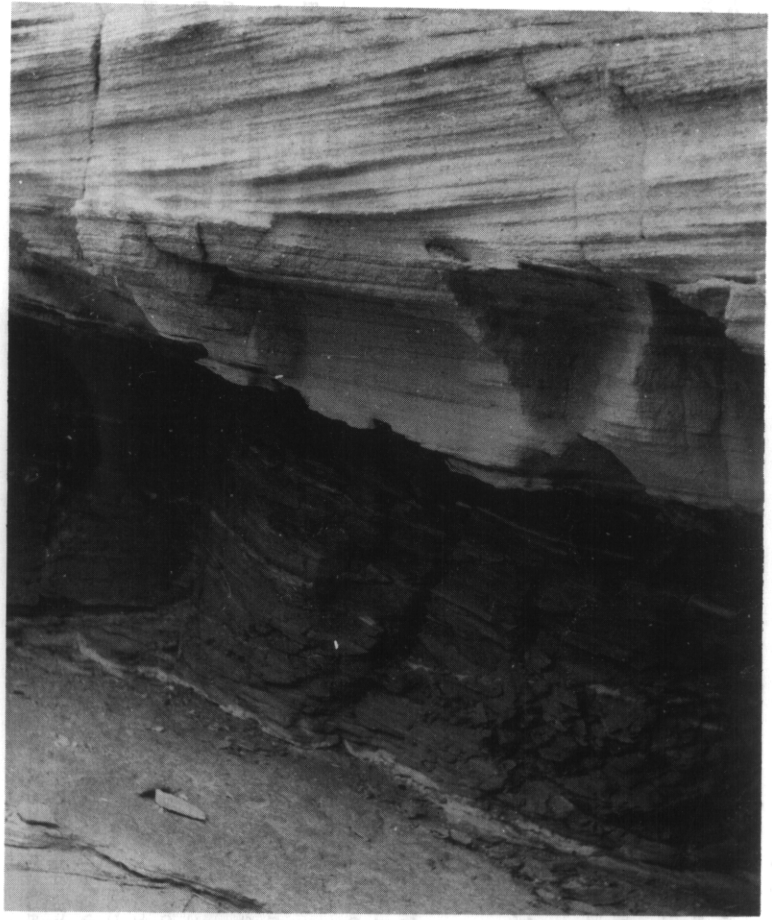


Plate 6. *Massively bedded medium- to coarse-grained quartz sandstone with mudstone and thinly bedded shale. Lower Triassic, Midway Point.*

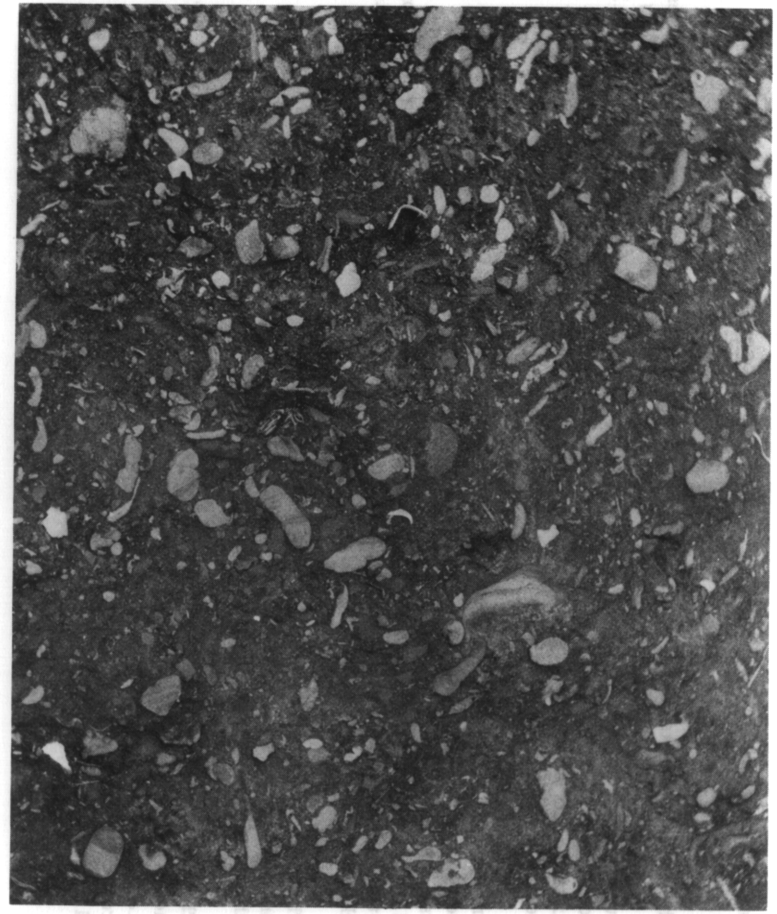


Plate 7. *Clay pellet conglomerate, Lower Triassic, Midway Point.*

Plate 8. *Sedimentary folding, Lower Triassic, Midway Point.*

Plate 9. *Typical sedimentary structures, Lower Triassic, Midway Point.*

walls and only lap-over features are visible. The gravity survey of Leaman (1972*a*) clearly demonstrates the form of the basin. Around Pitt Water the deposits contain rare bands in which sand grade material predominates, the overall composition being a sandy silt. No marine fossils have been observed in these deposits and only leaf remains, wood fragments, the chelid *Emydura* (Warren, 1970), seed cases and pollens have been recorded. The evidence of the age of these deposits (which are mainly pre-basalt) is rather limited, but Harris (1968) records definitive Palaeocene microfloras at Taroona. Younger horizons may also be present (Cookson, *in* Gill, 1962).

Basalt flows are interdigitated with these deposits in the Derwent Valley as was revealed by drilling for the Tasman Bridge foundations. Similar interdigitations occur near New Norfolk (plate 11).

The thickness of these deposits is, in most cases, unknown. A seismic survey at Sandy Bay proved more than 180 m and drilling in the Derwent River has shown more than 90 m. East of Craigow Hill in the Pitt Water deposits, a base of Triassic sandstone was encountered at a depth of 148 m (Leaman, 1971*b*). A complex history of erosion and deposition is implied by the form, level and composition of many deposits (see Moore, 1972).

Occasionally such sediments contain lignite horizons, as for example near Richmond (Leaman, 1971*b*).

A filled channel of the Derwent River passes through Elwick Bay and Moonah to Cornelian Bay (fig. 10).

SUB-BASALT TUFF

Sub-basalt tuffs are commonly associated with basalt flows in most parts of the quadrangle and well exposed examples occur at Lower Sandy Bay (Spry, 1955; plate 12) and Kingston. Tuffaceous and brecciated materials are less commonly seen but may be found associated with basalt centres in Acton Road and Cambridge, at Kingston, Moonah and Risdon.

SUPER-BASALT GRAVEL

Gravels commonly occur at 15-30 m above present sea level over much of the quadrangle and are consequently often found overlying basalt. In most cases the gravels are very poorly consolidated and obviously related to higher stream flows and levels.

Moore (1968, 1971) has shown by drilling, the presence of a valley cut into basalt at Kingston which was then refilled. The history is complex but at least two periods of erosion and deposition are implied.

Quaternary

MARY ANN BAY SANDSTONE

The Mary Ann Bay Sandstone was defined by Green (1961, p. 26) as a friable, fossiliferous marine sandstone. It is well-sorted, fine- to medium-grained and up to 12 m in thickness. Probably of Pleistocene age, it is an overlay deposit which laps onto an irregular dolerite surface.

TALUS AND SCREE

Talus is defined as that material containing more than 10% soil, silt or other fine fragments. Scree is generally devoid of fine fragments.

Plate 10. *Fault (slope ?) debris, Churchill Avenue, Sandy Bay.*

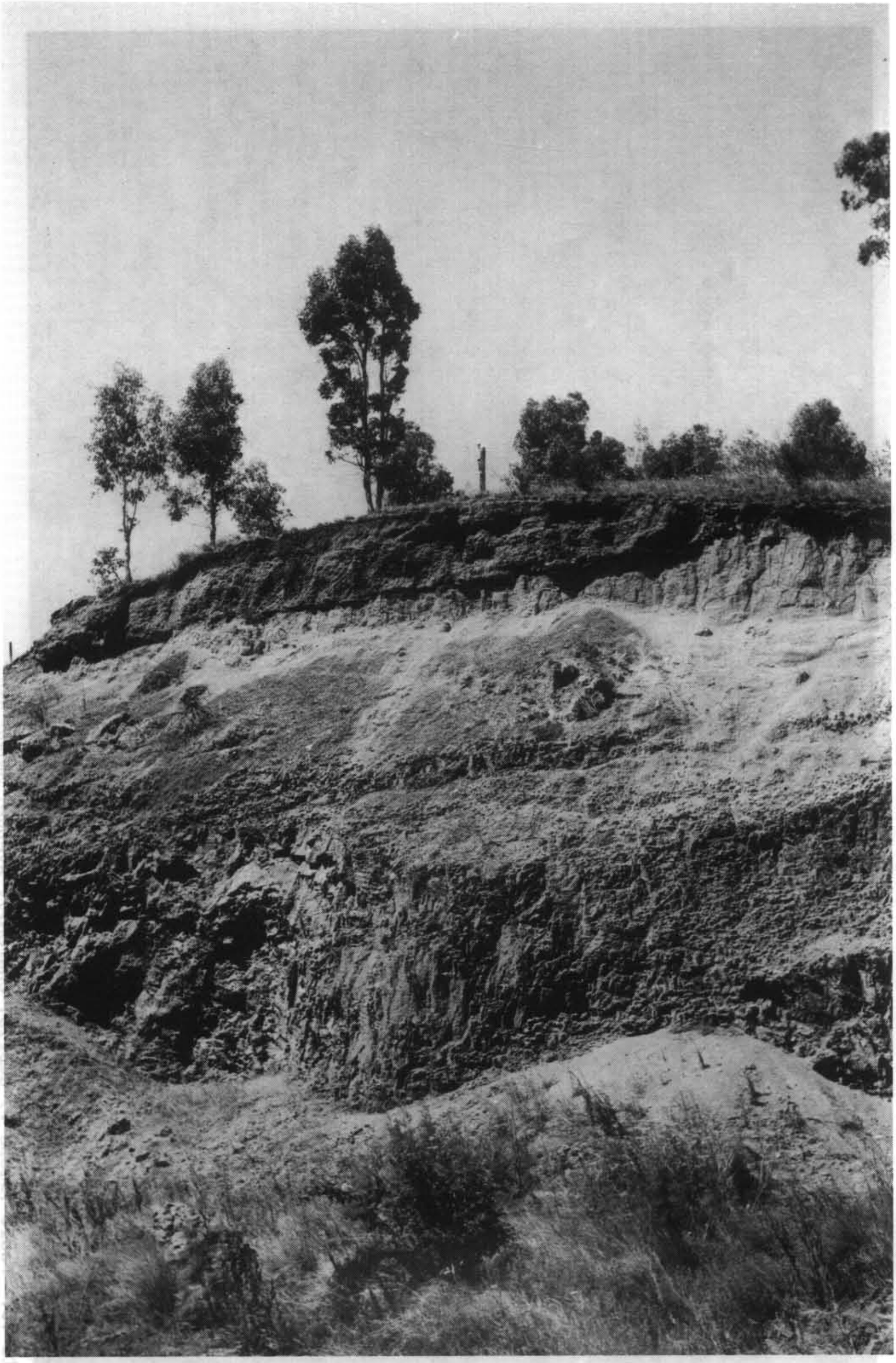


Plate 11. *Basalt flow with interbedded Tertiary sediments, New Norfolk.*

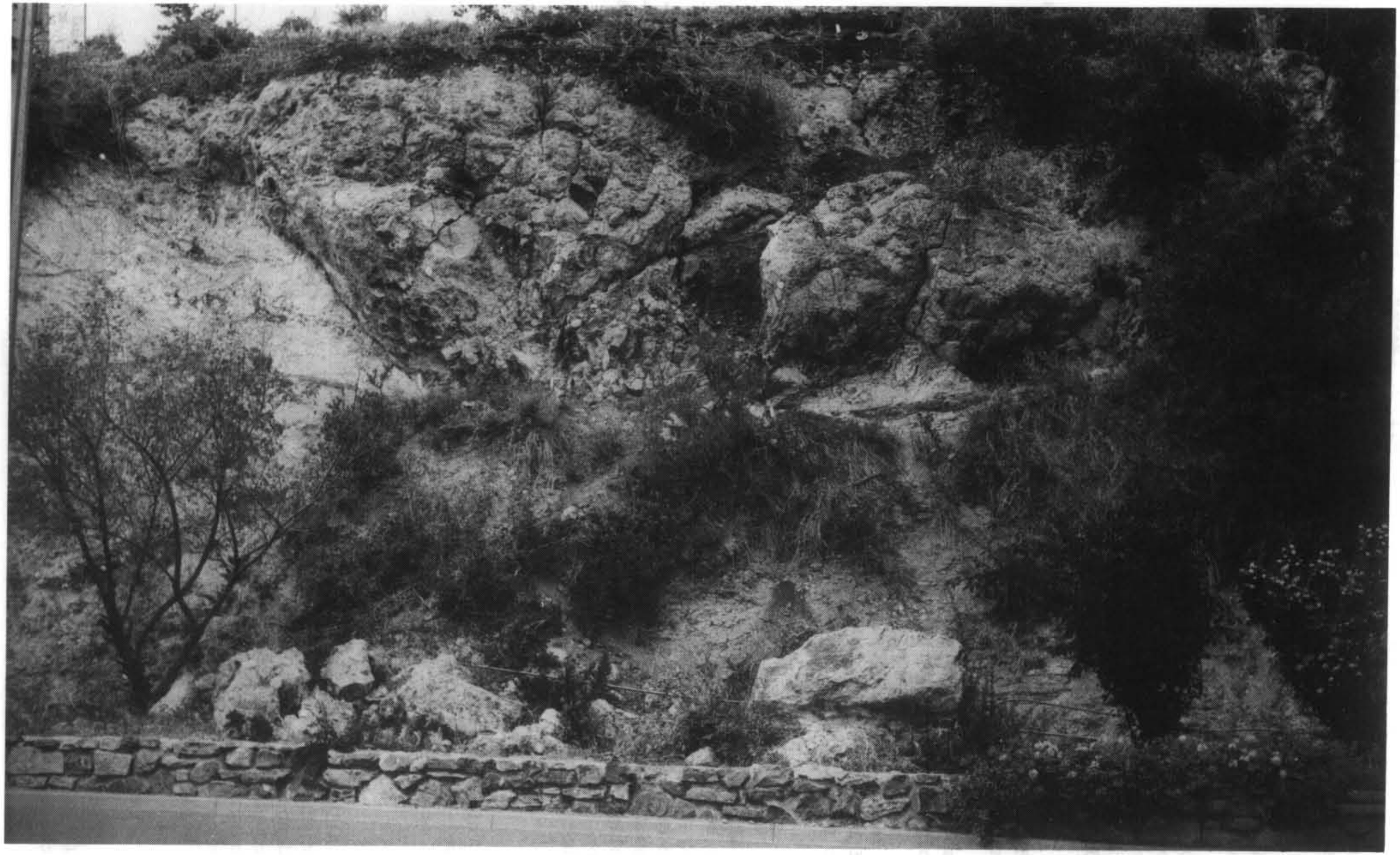


Plate 12. *Sub-basalt tuff, Lower Sandy Bay.*

Three classes of talus have been mapped; Permian siltstone, Jurassic dolerite and Tertiary basalt. Dolerite scree has also been indicated. All such materials are probably related to the greater influences of physical weathering and run-off during Pleistocene times.

Talus deposits derived from Permian siltstone are only extensive in the valleys of the Kangaroo Rivulet, Barilla Rivulet and Faulkners Rivulet. At Kangaroo Rivulet and Barilla Rivulet the source material is the Ferntree Group rocks, and the deposits coat the steep slopes of the valley sides. In the lower part of the deposits there is some evidence of reworking by water as imbrication is present. In Faulkners Rivulet, where the deposits are much thicker, the principal source material is Lower Permian siltstone. Evidence that these deposits have been reworked by water is also present, as traces of bedding can be seen.

Dolerite talus deposits are to be found at high altitude about mountains capped with dolerite. A very large tongue of such material extends from Mt Wellington to Strickland Avenue, South Hobart. Locally superimposed on the talus deposits and very rarely separable from them are screes or 'ploughed fields'. Most of this material is recently derived due to ice action and probably moved during the glacial period (Davies, 1958).

Basalt talus deposits are rare as a result of the restricted distribution of basalt. Only at Risdon, Droughty Point and Cambridge do such deposits become noteworthy.

OLDER GRAVELS

Gravel deposits occur 15-30 m above present sea level in the Derwent Valley between Cornelian Bay and New Norfolk. Remnants of comparable deposits may be found on the margins of Pitt Water. Such deposits are poorly compacted and contain material up to 30 cm in diameter in a matrix of sand grade. Some evidence of rounding and abrasion is usually present. Bedding is occasionally distinct, and these materials presumably reflect greater river flows and, or, the higher sea levels of Pleistocene times. Boulders appear to be very locally derived, for example at Glenorchy and Glenlusk (plate 13).

ALLUVIAL DEPOSITS

Thin deposits of alluvial material, usually less than 2 m thick, with a gravel base are to be found in most of the larger streams. The gravel deposits are mainly of dolerite boulders.

MARSH AND SWAMP DEPOSITS

Alluvial silt has accumulated in the middle portion of the River Derwent where the river becomes tidal. Other smaller streams have produced similar deposits. In addition, many of the coves and bays which resulted from the drowning of the topography in Pleistocene times are slowly filling with silt carried to the estuary by tributaries. This process has been assisted, in the case of Lindisfarne Bay, Sullivans Cove, Prince of Wales Bay and Marieville Esplanade, by reclamation.

DUNE SAND

Thick deposits of dune sand occur on the South Arm peninsula but no significant deposits occur elsewhere. The deposits on South Arm are derived from the beaches and windblown across the peninsula.

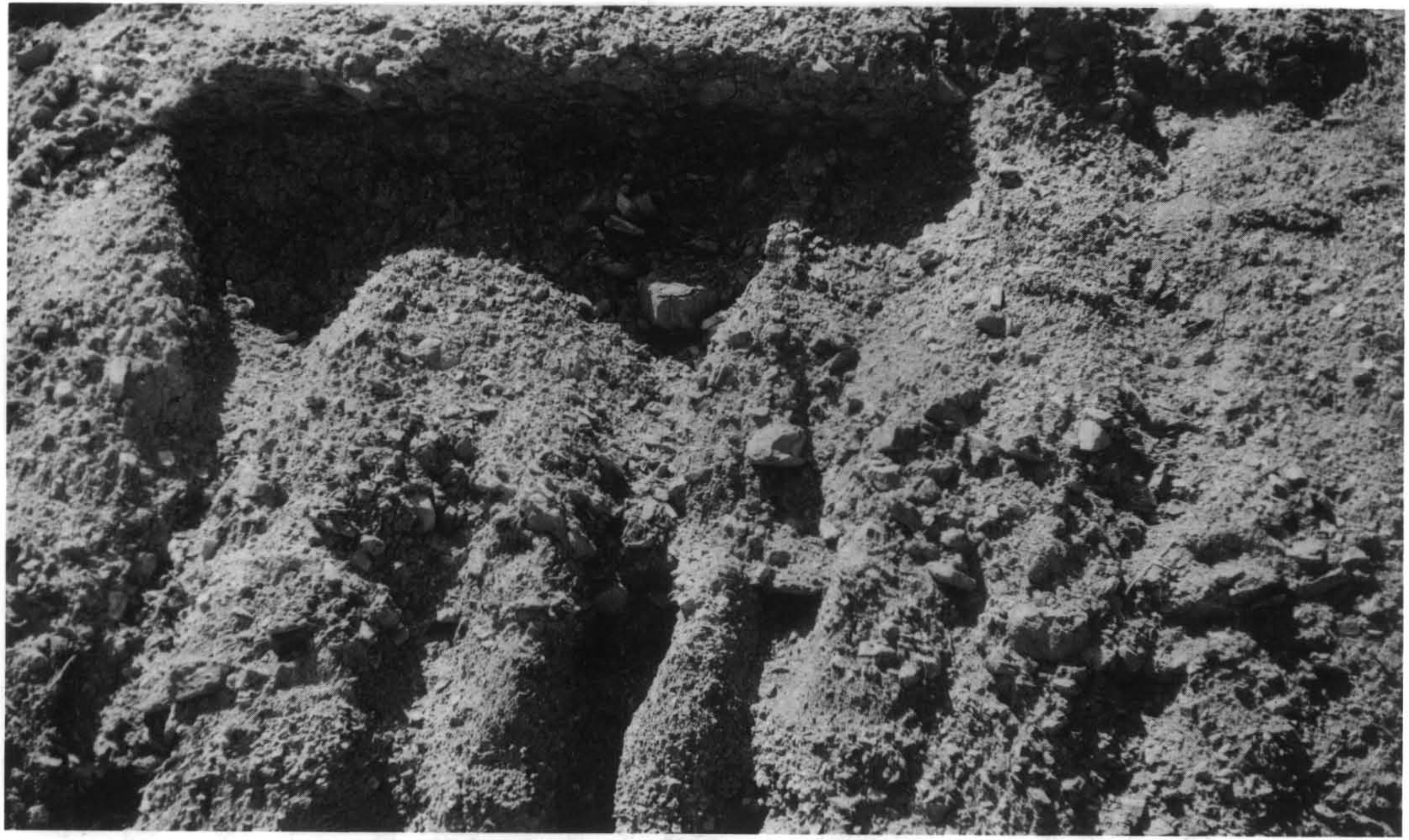


Plate 13. *Locally derived boulders in Pleistocene gravels, Glenlusk.*

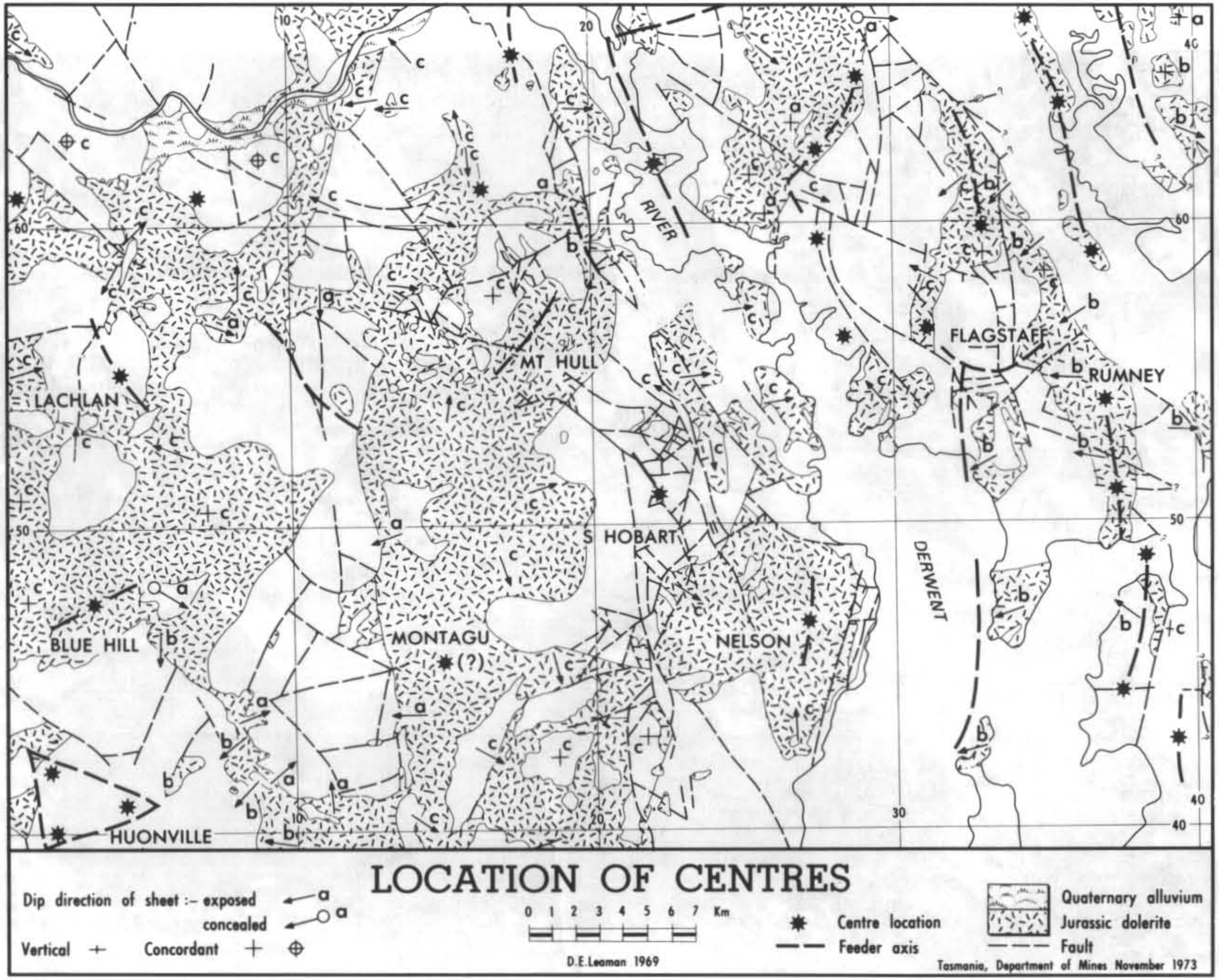

LOCATION OF CENTRES
LACHLAN
BLUE HILL
HUONVILLE
MONTAGU
MT HULL
S HOBART
NELSON
RIVER
DERWENT
FLAGSTAFF
RUMNEY
Dip direction of sheet :- exposed
concealed
Vertical
Concordant
0 1 2 3 4 5 6 7 Km
D.E.Leaman 1969
Centre location
Feeder axis
Quaternary alluvium
Jurassic dolerite
Fault
Tasmania, Department of Mines November 1973

Figure 4.

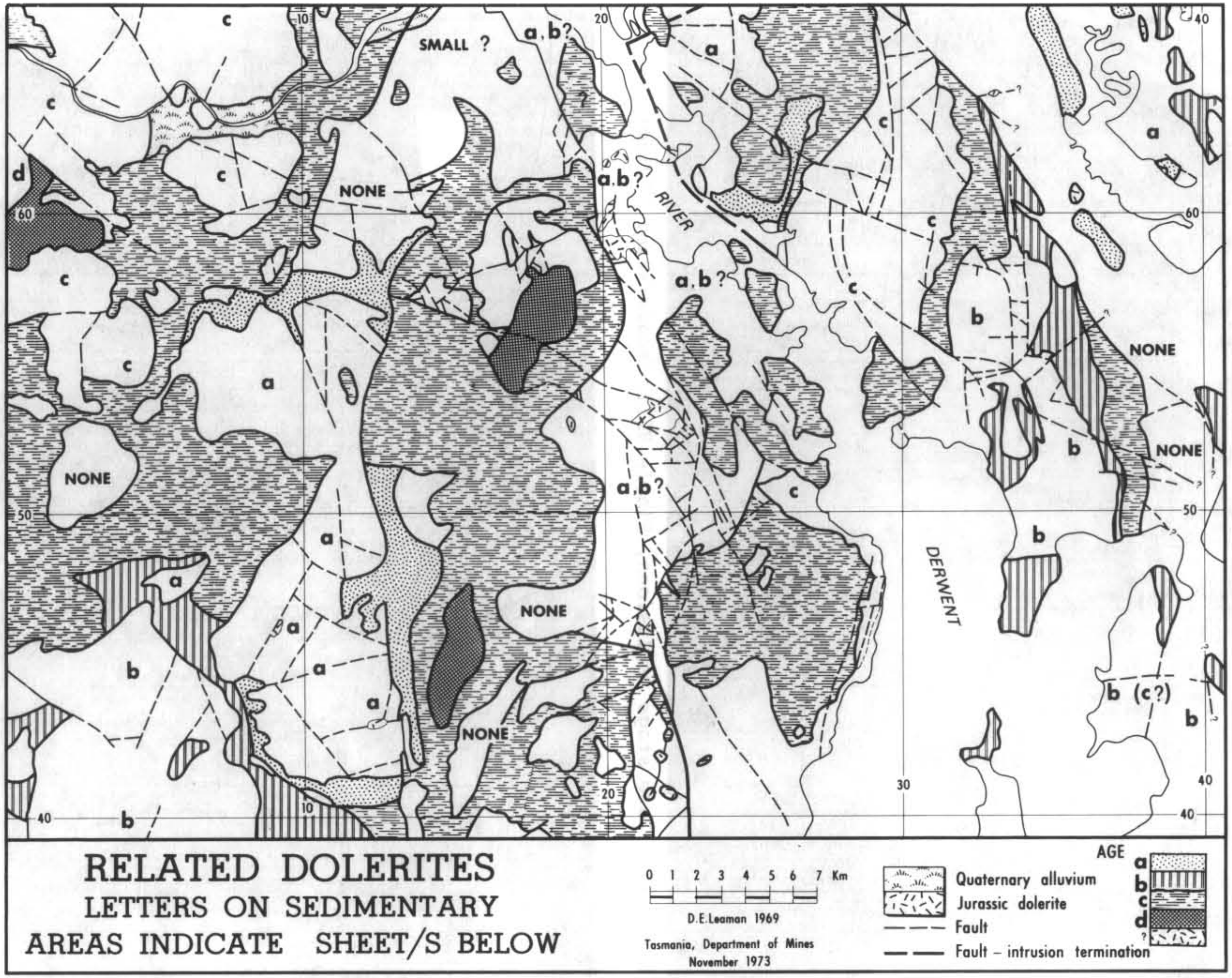

RELATED DOLERITES
LETTERS ON SEDIMENTARY
AREAS INDICATE SHEET/S BELOW
0 1 2 3 4 5 6 7 Km
D.E.Leaman 1969
Tasmania, Department of Mines
November 1973
Quaternary alluvium
Jurassic dolerite
Fault
Fault – intrusion termination
AGE
a
b
c
d
?
SMALL ?
NONE
a.b?
RIVER
DERWENT
b (c?)

Figure 5

5 cm

Plate 14. *Late stage inclusions, Single Hill. (scale size: 10 cm)*

Plate 15. *Late stage intrusion, Single Hill, with joint relationships indicating partial solidification prior to injection.*

IGNEOUS ROCKS

Jurassic dolerite

Jurassic dolerite (McDougall, 1961) crops out over nearly half the area of the quadrangle and forms a key structural unit. The dolerite is of tholeiitic basalt magma origin and some petrological studies have been made of it within the Hobart region. Edwards (1942) sampled the Mt Wellington and Mt Nelson intrusions (see also Spry, 1962; Joplin, 1958, 1964). Edwards' conclusions about the Mt Nelson intrusion must now be considered carefully in view of the structural evidence deduced concerning this body by Leaman (1972*a*). A complete description of intrusion form and relevant literature on this intrusion appears elsewhere (Leaman, 1972*a*, 1970; see also fig. 9).

The initial sill-differentiation work undertaken on the Tasmanian dolerites needs careful re-examination in light of the properties of the sill encountered in a deep bore hole in west Glenorchy. It was the first complete sill to be sampled and displayed a number of interesting properties. Its composition and density variations are listed in Appendix 3.

The classification of the intrusions with respect to their place of injection is shown in Figure 5 and the location of centres is summarised in Figure 4. The structural sections (fig. 11) give further information on the intrusions. Granophyres have been located at Craigow Hill, south of New Norfolk and Flagstaff Hill and there is an obvious relationship with the source.

Pod-like inclusions of highly differentiated material may be found in lower zone or contact dolerites (plates 14, 15). One has been described by G. Everard in Leaman (1971*b*). Others may be observed in the quarries behind Salamanca Place and at Flagstaff Hill.

Where possible, all known relevant information about a dolerite boundary has been indicated on the Hobart Map Sheet. Only in the cases of intrusions at Mt Mather, Flagstaff Hill, Gladstone Street, Longley West and the Southern Expressway is it possible to actually measure the angle of discordance. In most cases it is a near-vertical or concordant boundary.

Cainozoic volcanic rocks

F.L. Sutherland

Early observations on the Hobart volcanic rocks were made in 1802 near Doctors Hill (Péron, 1807; von Buch, 1814) and in 1836 at Lower Sandy Bay (Darwin, 1844), while Harrison (1865) recorded several basalt occurrences between Hobart and New Norfolk. The many scattered observations on the volcanic rocks published by numerous subsequent workers are detailed later under the different localities. A number of the occurrences were reviewed by Johnston (1888) and regional distribution and descriptions have been given mainly by Nye (1922, 1924), Lewis (1946), Edwards (1950), Woolley (1959), Green (1961), Spry (1962), Banks *et al.* (1965) and Paxton (1968).

The report on Cainozoic volcanic rocks was greatly assisted by the kind co-operation of officers of the Tasmania Department of Mines, Hobart, through E. Williams and I.B. Jennings, and by the analytical work carried out by the Department of Mines Chemical Laboratories in Launceston. Information was also supplied by staff and students of the Department of Geology, University of Tasmania, in particular M.R. Banks, R. Varne, D. Parkinson and W. Cromer. Other assistance is acknowledged in the text as personal communications and the work was carried out in the Tasmanian Museum, Hobart.

The basic volcanic rocks crop out sporadically within the main zone of Late Mesozoic/Early Tertiary fracturing in the northern and eastern parts of the Hobart Quadrangle. They issued from more than twenty centres, structurally located mainly on or near faults, fault intersections and dolerite margins, but apparently not penetrating the main dolerite feeder structures (fig. 6). Many centres show explosive features and pyroclastic rocks are associated with lavas at Coal River, Claremont, Risdon, Acton, Rokeby, Droughty Hill, Lower Sandy Bay, Kingston, Pickett Hill, Parks Hill, Neika and Doctors Hill. The volcanoes erupted over an irregular landscape, generally similar to the present one, and vents are located from altitudes of at least 1200 m (on Mt Wellington) down to present sea level. Volcanic flows fill old channels of the River Derwent around New Norfolk and south of Bridgewater down to 90 m below present river level (Lewis, 1945, p. 37; 1946, p. 52; Trollope, Freeman and Peck, 1966, p. 122; Public Works Department drill logs). Accidental inclusions of underlying dolerite, Permo-Triassic strata and Tertiary beds appear in the volcanic rocks, and phyllitic fragments in the Acton rocks may represent the sub-Permian folded basement.

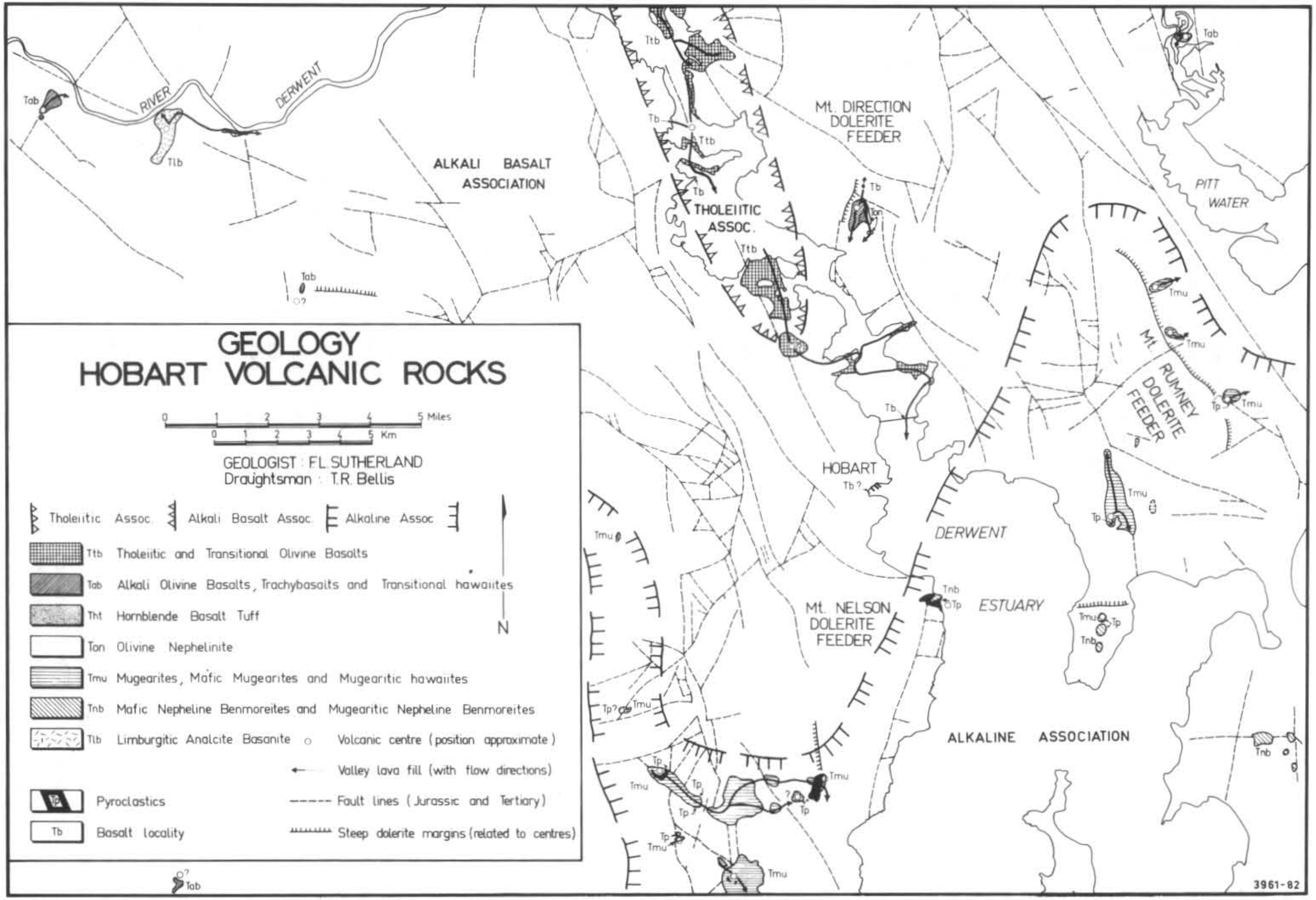
The volcanic rocks include members of the tholeiitic and alkali olivine basalts and more undersaturated and alkaline rocks. The tholeiitic centres (7% of the total volcanic rock types) are confined to a structural low bounding the Jordan River-River Derwent axis. They erupted from several sources aligned along a north-west trending lineament lying east of the northern extension of the Cascades Fault line and possibly intersecting it at depth. The alkaline centres are more prevalent and tend to be concentrated around the deep seated dolerite feeder structures such as the Mt Nelson and Mt Rumney bodies.

Mugearite and mugearitic hawaiite form the most common rocks amongst the alkaline centres (55%), followed by alkali olivine basalt and transitional hawaiite (20%), mafic nepheline mugearitic benmoreite (10%), basanite (10%) and olivine nephelinite (5%). Over half of the alkaline centres contain rocks with peridotitic xenoliths and xenocrysts and in some cases other megacrysts of deep derivation (table 1).

Most of the centres are isolated and age differences between originally separate sequences are difficult to establish in the absence of detailed dating. However, distinctive suites have been noted as at Risdon where a flow of olivine nephelinite underlies hornblende basalt tuff which in turn is capped by alkali olivine basalt, and at Kingston where a mafic mugearite flow with common peridotitic inclusions is intruded by pyroclastic rocks and dykes of non-peridotitic mugearitic hawaiite. At New Norfolk limburgitic basanite overlies both interbasalt sediments and a lower flow of tholeiitic olivine basalt.

AGE

Evidence for precise ages of the eruptions is sparse. At Taroona prebasalt sediments yield definitive Palaeocene microfloras (Harris, 1968). At Geilston Bay, unconsolidated sediment yields microfloras of probable Pleistocene age (W.K. Harris, pers. comm.), and rests against basalt which appears to be interbedded with fossiliferous travertine. The latter has been assigned to the Early Tertiary or younger (Moore, 1965) and contains a probable pre-Late Pliocene flora (M.R. Banks pers. comm.). At Blinking Billy Point, volcanic rocks overlie tilted and faulted beds. Similar beds at Sandy Bay have yielded post-Eocene and probable Yallournian (Oligocene) floras (Cookson, *in* Gill, 1962). The main lava of the Brighton basalt, which extends into the Derwent estuary and appears to overlap the Claremont lava flows, is generally considered to be a relatively young and little dissected flow and probably



GEOLOGY
HOBART VOLCANIC ROCKS
0 1 2 3 4 5 Miles
0 1 2 3 4 5 Km
GEOLOGIST : F.L. SUTHERLAND
Draughtsman : T.R. Bellis
Tholeiitic Assoc.
Alkali Basalt Assoc.
Alkaline Assoc.
Ttb Tholeiitic and Transitional Olivine Basalts
Tab Alkali Olivine Basalts, Trachybasalts and Transitional hawaiites
Tht Hornblende Basalt Tuff
Ton Olivine Nephelinite
Tmu Mugearites, Mafic Mugearites and Mugearitic hawaiites
Tnb Mafic Nepheline Benmoreites and Mugearitic Nepheline Benmoreites
Tlb Limburgitic Analcite Basanite
Volcanic centre (position approximate)
Valley lava fill (with flow directions)
Fault lines (Jurassic and Tertiary)
Steep dolerite margins (related to centres)
Pyroclastics
Tb Basalt locality
N
RIVER
DERWENT
ALKALI BASALT ASSOCIATION
THOLEIITIC ASSOC.
Mt. DIRECTION DOLERITE FEEDER
PITT WATER
Mt. RUMNEY DOLERITE FEEDER
HOBART
DERWENT
ESTUARY
Mt. NELSON DOLERITE FEEDER
ALKALINE ASSOCIATION
3961-82

Figure 6

5 cm

Late Tertiary in age (McDougall, 1959). These relationships suggest volcanism from at least Oligocene into late Cainozoic time.

Lewis (1945, 1946) recognised two volcanic phases around Hobart, represented by the older higher level residual basalt and the younger lower valley fills of the Derwent estuary. This relationship appears to apply in some cases, but indications of at least three separate ages of tholeiitic eruption into the estuary suggest a more complex situation. Edwards (1939) and Lewis (1945, 1946) considered that some of the higher level outcrops particularly those descending from Mt Wellington to Kingston were faulted residuals. However, the present identification of separate extrusions from different points does not necessarily indicate post-basalt faulting (Sutherland, 1971). Lewis (1945, 1946) assigned the younger lower valley filling basalt to periods of excavation at periods of low sea level during the Pleistocene glaciation. This correlation will need strict confirmation, as strong marine regressions are also known in the Tertiary sedimentary-volcanic sequences in northern Tasmania (Sutherland and Corbett, 1967; Sutherland, 1969) and there is a recent suggestion of a pre-Glacial low sea level (Galloway, 1970). Furthermore, the entrail (flow foot) breccias around Claremont (Sutherland and Hale, 1970; plates 16, 17) suggest that some of these lavas erupted into the River Derwent during past higher sea levels (up to 30 m above the present level) and thus were not all contemporaneous.

Silicified wood, up to 12 m in length and including *Eucalyptus*, has been found in sediments overlying basalt around Elwick, Claremont and Bridgewater (Yaxley, 1956; Pryor, 1959; Gill, 1962, p. 237) and has also been observed by the writer. The precise origin and age of this wood in relation to times of subsequent silicification and incorporation into the sediments is uncertain, but some wood may date back to the basaltic volcanism, as silicified woods are known within basalt horizons elsewhere in the Derwent valley (Banks, 1955).

BASALT PETROLOGY

SUMMARY

The Hobart lavas cover a wide spread of the basaltic spectrum and range from strongly undersaturated and alkaline rocks to saturated types (table 2, fig. 7, 8). The olivine nephelinite-basanite-alkali olivine basalt-olivine tholeiite series shows a trend of increasing silica with diminishing alkalies, but these rocks are subordinate to the more alkaline rocks of the hawaiite-mugearite-benmoreite-trachyte and equivalent feldspathoidal lineages (Coombs and Wilkinson, 1969). Mugearitic types are the most abundant of the alkaline rocks and form a separate association extending through most of the Hobart area (Southern Hobart Group). There is a transitional development into the alkali olivine basalt (Risdon Group) and tholeiitic (Claremont Group) associations in the northern part of the area (fig. 6) where these associations continue into the Brighton basalt (McDougall, 1959) outside the quadrangle.

Petrological relationships between the Hobart rocks, in the context of the known range of the Tasmanian Cainozoic volcanic province, are indicated in Figure 7. The relationships of the alkaline association are unusual and Spry (1962) noted that the rocks were low in silica and the ratio of iron to magnesia gave a negative compositional slope on the chemical index of Wager (1956). These mafic rocks do not follow the typical alkaline fractionation trends of Coombs and Wilkinson. Typical end members are absent and those present appear to trend across the main lines of alkaline fractionation. The known eruptive successions around Hobart and the distribution of peridotitic inclusions in the rocks suggest that the less mafic rocks were derived by

Table 1. CHEMICAL ANALYSIS, MEGACRYSTS AND XENOCRYSTS, KINGSTON AND RISDON TUFF.

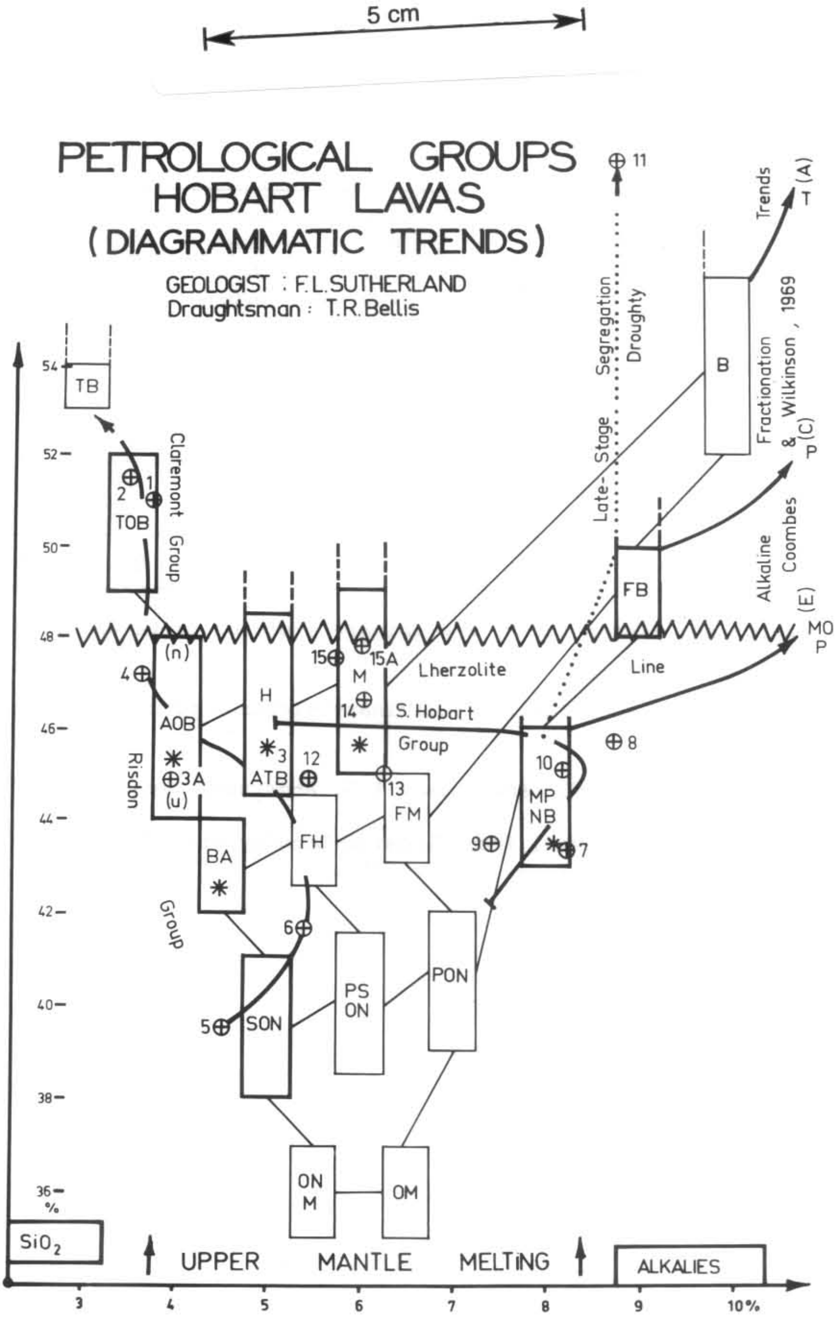
Analysis	1	2	3	4	5	6
SiO_2	53.5	56.6	52.8	50.0	38.3	
TiO_2	0.1		0.2	0.6	4.5	
Al_2O_3	5.4	2.1	5.2	9.1	15.1	32.9
FeO	{6.2	5.2	2.5	6.6	7.8	
Fe_2O_3					6.3	29.2
MnO	0.2	0.1	0.1	0.2	0.13	
MgO	33.9	36.1	17.6	14.3	12.2	21.4
CaO	0.7	0.7	21.4	18.5	9.9	
Na_2O	0.1	0.1	1.0	1.7	2.6	
K_2O	0.1	0.1	0.1	0.1	1.2	
Cr_2O_3						17.9
Loss on ignition					1.9	
Total	100.2	101.0	100.9	101.1	99.93	101.4

1-2. *Orthopyroxene,* Risdon Tuff. Preliminary electron probe analysis per R. Varne.

3-4. *Clinopyroxene,* Risdon Tuff. Preliminary electron probe analysis per R. Varne.

5. *Amphibole,* Risdon Tuff. Analysis: R.G. Anderson, Department of Mines.

6. *Chromian spinel,* Alluvial from Kingston-Longley area (W.E. Baker, pers. comm; *Rec.geol.Surv.Tasm.* 9:94, 1970).



The alkaline association is represented by the Southern Hobart Group, the alkali basalt association by the Risdon Group and the tholeiitic basalt association by the Claremont Group. Hobart rocks are illustrated by thick lines and Tasmanian lavas outside of the Hobart Sheet by thin lines. Circled crosses indicate chemical plots with their analysis number. Asterisks represent rocks containing lherzolitic inclusions and may occur in rock types below the lherzolite line. ONM olivine nepheline melilitite, OM olivine melilitite, SON sodic olivine nephelinite, PSON potassi-sodic olivine nephelinite, PON potassic olivine nephelinite, MPNB mafic potassic nepheline benmoreite, MOP mafic olivine phonolite, BA basanite, FH feldspathoidal hawaiite, FM feldspathoidal mugearite, FB feldspathoidal benmoreite, P phonolite, AOB alkali olivine basalt (under-saturated, U, to near-saturated, N), ATB alkali olivine trachybasalt, H hawaiite, M mugearite, B benmoreite, T trachyte, TOB tholeiitic olivine basalt, TB tholeiitic basalt. The rocks are set out as petrologic lineages related to those of Coombs and Wilkinson (1969).

Figure 7.

Table 2. CHEMICAL ANALYSES AND CIPW NORMS OF HOBART VOLCANIC ROCKS

	Tholeiitic Association (Claremont Group)		Alkali Olivine-Basalt Association (Risdon Group)						Alkali Association (South Hobart Group)									
Analysis	1	2	3	3A	4	5	6	7	8	9	10	11	12	13	14	15	15A	Analysis
SiO_2	50.8	51.48	44.7	44.95	47.0	39.4	41.6	43.3	45.49	43.5	45.0	58.3	44.7	45.0	46.64	47.5	47.90	SiO_2
Al_2O_3	13.8	14.18	13.4	12.93	14.4	12.5	12.4	13.3	12.48	12.3	11.8	12.3	11.0	13.0	13.22	14.7	15.65	Al_2O_3
Fe_2O_3	2.6	1.56	2.8	2.49	6.8	10.3	8.1	10.1	9.93	8.5	8.2	5.6	3.1	5.8	9.81	4.1	4.60	Fe_2O_3
FeO	7.8	9.61	8.1	10.27	6.8	6.6	7.4	3.3	2.84	4.1	4.5	4.4	9.1	7.0	4.16	8.7	7.58	FeO
MnO	0.15	0.15	0.17	0.19	0.17	0.21	0.21	0.19	0.16	0.19	0.21	0.15	0.18	0.17	0.19	0.18	0.17	MnO
TiO_2	1.5	1.60	2.2	2.43	1.9	3.0	2.9	1.8	2.10	2.1	2.2	1.3	2.2	2.8	2.50	2.3	2.35	TiO_2
P_2O_5	0.32	0.29	0.86	0.56	0.41	1.2	2.0	1.3	1.65	1.7	1.7	0.17	1.5	1.4	1.00	1.4	0.84	P_2O_5
CaO	9.4	8.95	9.7	9.69	9.8	10.9	10.6	8.0	8.26	9.9	8.3	4.9	7.2	8.3	7.33	7.3	6.96	CaO
MgO	7.4	8.18	10.1	10.23	8.1	8.5	5.6	5.4	4.71	8.4	7.3	2.3	12.9	7.8	7.01	5.4	5.26	MgO
Na_2O	3.1	2.61	3.1	2.82	3.0	3.2	4.1	5.5	5.51	5.2	5.5	4.2	3.6	4.4	4.11	4.1	4.36	Na_2O
K_2O	0.70	0.82	2.0	1.15	0.62	1.3	1.3	2.7	3.16	2.2	2.7	4.6	1.8	1.8	1.35	1.6	1.70	K_2O
Loss on ignition	3.0	1.24	2.6	2.11	1.1	3.6	4.4	4.4	3.70	2.4	2.4	2.0	2.4	2.4	2.66	2.6	2.08	Loss on ignition
Total	100.57	100.67	99.73	99.82	100.10	100.71	100.61	99.29	100.09	100.49	99.81	100.22	99.68	99.87	99.98	99.88	99.45	Total
K_2O/Na_2O	0.23	0.31	0.65	0.41	0.21	0.41	0.32	0.49	0.57	0.42	0.49	1.10	0.50	0.41	0.33	0.39	0.39	K_2O/Na_2O
CIPW Norm																		CIPW Norm
Q	0.21	0.11	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	6.86	0.00	0.00	0.00	0.00	0.00	Q
Or	4.14	4.85	11.82	7.00	3.66	7.68	7.68	15.96	18.62	13.00	15.96	27.19	10.64	10.64	7.98	9.46	10.34	Or
Ab	26.23	22.09	12.71	19.34	25.39	11.32	21.55	16.98	21.48	13.14	18.81	35.54	20.57	24.90	34.78	34.69	35.01	Ab
An	21.67	24.56	16.74	19.83	24.00	15.91	11.59	3.63	0.83	3.72	0.00	1.12	8.54	10.41	13.64	16.98	18.69	An
Ne	0.00	0.00	7.33	2.77	0.00	8.54	7.12	16.02	12.50	16.72	14.55	0.00	5.36	6.68	0.00	0.00	1.68	Ne
Di Wt	9.54	7.50	10.76	10.45	9.16	12.67	11.66	11.51	12.15	14.32	12.56	8.02	7.26	9.03	6.76	4.21	4.62	Di Wt
Di En	5.85	4.25	7.27	8.01	6.87	10.95	8.87	9.95	10.53	12.37	10.85	5.73	4.99	6.80	5.84	2.40	2.98	Di En
Di Fs	3.17	2.92	2.67	2.44	1.38	0.00	1.59	0.00	0.00	0.00	0.00	1.59	1.68	1.32	0.00	1.63	1.63	Di Fs
Hy Et	12.58	16.12	0.00	0.00	7.96	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	4.03	1.81	0.00	Hy Et
Hy Ft	6.79	11.03	0.00	0.00	1.59	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.22	0.00	Hy Ft
Ol Fo	0.00	0.00	12.54	14.86	3.75	7.16	3.56	2.45	1.68	5.99	5.13	0.00	19.02	8.85	5.32	6.47	8.78	Ol Fo
Ol Fa	0.00	0.00	5.08	4.42	0.83	0.00	0.70	0.00	0.00	0.00	0.00	0.00	7.08	1.88	0.00	4.84	4.74	Ol Fa
Mt	3.77	2.26	4.06	2.48	9.86	13.26	11.74	6.04	3.71	7.75	8.81	8.12	4.50	8.41	6.78	5.95	2.32	Mt
Hm	0.00	0.00	0.00	0.00	0.00	1.15	0.00	5.94	7.36	3.16	1.86	0.00	0.00	0.00	5.13	0.00	0.00	Hm
Ilm	2.85	3.04	4.18	4.76	3.61	5.70	5.51	3.42	3.93	3.99	4.18	2.47	4.18	5.32	4.75	4.37	4.57	Ilm
Ap	0.76	0.69	2.04	1.37	0.97	2.84	4.74	3.08	3.86	4.03	4.03	0.40	3.55	3.32	2.37	3.32	2.04	Ap
Ac, Wo	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	Ac 0.77	Wo 1.19	0.00	0.00	0.00	0.00	0.00	Ac, Wo
Other	3.00	1.24	2.60	2.11	1.10	3.60	4.40	4.40	3.70	2.40	2.40	2.00	2.40	2.40	2.66	2.60	2.08	Other
Total	100.56	100.66	99.80	99.84	100.13	100.78	100.71	99.38	100.35	100.59	99.91	100.23	99.77	99.96	100.04	99.95	99.48	Total

Localities of analysed lavas, with differentiation index and AMG approximate reference.

1. Tholeiitic olivine basalt (D.I. 30.6) Lower flow, Derwent shore below Keynsham Rd, Claremont [EN215627].
2. Tholeiitic olivine basalt (D.I. 27.1) Bridgewater (Edwards, 1950; McDougall, 1959) north of quadrangle.
3. Alkali olivine trachybasalt (D.I. 31.9) east bank, Coal River, 3 km south of Richmond [EN368658].

3A. Alkali olivine basalt (D.I. 29.1) below Lucaston Road bridge, Mountain River, south of quadrangle (P. Beasley and E. Kiss, analysts).

4. Alkali olivine basalt (D.I. 29.1) top flow, west of Risdon Brook dam, East Risdon [EN265615].
5. Olivine nephelinite (D.I. 27.5) bottom flow, west of Risdon Brook dam, East Risdon.
6. Limburgitic analcite basanite (D.I. 36.4) quarry opposite Boyer, Lyell Highway [EN075628].
7. Mafic nepheline mugearitic benmoreite (D.I. 49.0) Blinking Billy Point, Lower Sandy Bay [EN293484].
8. Mafic nepheline benmoreite (D.I. 52.6) Lower Sandy Bay [EN290483] (Aurousseau, 1926; Spry, 1955).
9. Mafic nepheline mugearitic benmoreite (D.I. 42.9) Droughty Hill [EN344474].
10. Mafic nepheline benmoreite (D.I. 49.3) peak south of Droughty Hill [EN343468].
11. Nepheline benmoreite segregation (D.I. 69.6) [EN343468].
12. Mafic mugearite (D.I. 36.6) Pickett Hill [EN205428].
13. Mugearite (D.I. 42.2) peak north of Droughty Hill [EN344477].
14. Mugearite (D.I. 42.8) Rokeby (Edwards, 1950; Green, 1961).
15. Mugearitic hawaiite (D.I. 44.2) 'Dyke', east side of Southern Outlet Road, north-west of Kingston [EN254426].

15A. Mugearitic hawaiite (D.I. 47.0) quarry, north bank of Whitewater Creek, 500 m north-west of Kingston [EN247422]. (P. Beasley and E. Kiss, analysts).

Analyses 3A and 15A per D.H. Green, Australian National University, Canberra.

Other analyses, unless otherwise indicated, by R.G. Anderson, Department of Mines Laboratories, Launceston. All Department of Mines analyses determined by means of chemical break up with A.A.S. and spectrophotometer being used with classical methods of determination. Ignition loss was corrected for complete ferrous iron oxidation. A.N.U. analyses largely by X-ray fluorescence. CIPW Norms were calculated by Department of Geology, University of Tasmania, computer programme U1060 with the exception of analyses 3A and 15A.

fractionation from the more mafic, undersaturated and potassic magmas. Such magmas are represented by the mafic mugearites and nepheline benmoreites which appear to trend back towards potassic olivine nephelinites in composition. Thus the undersaturated types appear to represent part of a suggested alkaline lineage derived from olivine nephelinite, but for which Coombs and Wilkinson had insufficient data to establish (lineage E, p. 495). This lineage ranges from sodic olivine nephelinite through more potassic types to mafic potassic nepheline benmoreite as illustrated in Figure 8.

Preliminary studies of the peridotitic (lherzolitic) inclusions in the Tasmanian volcanic rocks suggest deep-seated xenoliths and disaggregated xenocrysts, probably derived from the mantle (R. Varne, pers. comm.). Their considerable abundance in some of the mugearites and nepheline benmoreites infers that these magmas arose from deep melting and fractionation from the upper mantle, producing relatively unusual petrogenetic trends. In contrast, further fractionation at higher levels and differentiation within individual lavas produced some trends more typical of the normal alkaline fractionation lineages. The late-stage segregation in the nepheline benmoreite at Droughty Hill is an example.

Strontium isotope, K, Th, U and Rb determinations on some Tasmanian basalts included three rocks from the area of Hobart Sheet; the nepheline benmoreite from Sandy Bay, limburgitic basanite from New Norfolk and tholeiitic olivine basalt from the Brighton flow (Compston, McDougall and Heier, 1968). Initial $Sr^{87}:Sr^{86}$ values of the unsaturated alkaline rocks are uniformly low (0.7026) and suggest probable origin from sub-crustal regions, but the tholeiitic basalt gave a much higher value (0.7078), suggesting the possibility of crustal contamination within its generation. Th, U values for the Sandy Bay rock are anomalous compared with the other rocks (23.5 and 4.2 ppm respectively), perhaps indicating the unusual chemistry of the rock.

In summary, the alkaline and alkali basalt associations (South Hobart and Risdon Groups), with their scattered distribution of relatively small and frequently explosive vents, low initial $Sr^{87}:Sr^{86}$ ratios and the common presence of lherzolitic and other megacrystic materials, suggest a broad, deep-seated underlying zone that sporadically generated volatile alkaline undersaturated magmas, and which sometimes fractionated at higher levels. Regional gravity surveys indicate a crustal thickness of about 35 km below much of the Hobart area (D.E. Leaman, pers. comm.), suggesting that these magmas were generated at depths greater than this. In comparison, the tholeiitic association (Claremont Group), with its more concentrated volume of lava, less abundant pyroclastic rocks, some higher initial $Sr^{87}:Sr^{86}$ ratios and a lack of lherzolitic inclusions, suggest a narrow zone of increased higher level melting which generated saturated, less alkaline magmas.

THOLEIITIC AND TRANSITIONAL OLIVINE BASALTS

Claremont-Old Beach area

The lavas form over 15 m of massive to vesicular basalt exposed in shoreline cliffs near Cadbury's factory. Three flows form the section north of the factory where the two lower flows intertongue with tachylytic breccia. The lowest flow shows hackly jointing and contains secondary carbonate and limonite. Its vesicular top forms an undulating, undissected ropy surface and minor pillowy entrails intercalate with bedded sandy and silty tuffites and vitric tuffs at least 0.3 m thick below Keynsham Road. The overlying breccia, up to 2 m thick, forms clastic dykes over one metre in depth into the cracked, lower flow surface. The breccia shows crude, finer to coarser alternations of angular vesicular tachylytic lapilli ranging into sporadic flattened fragments up to 0.3 m across, with rarer rounded pieces of indurated

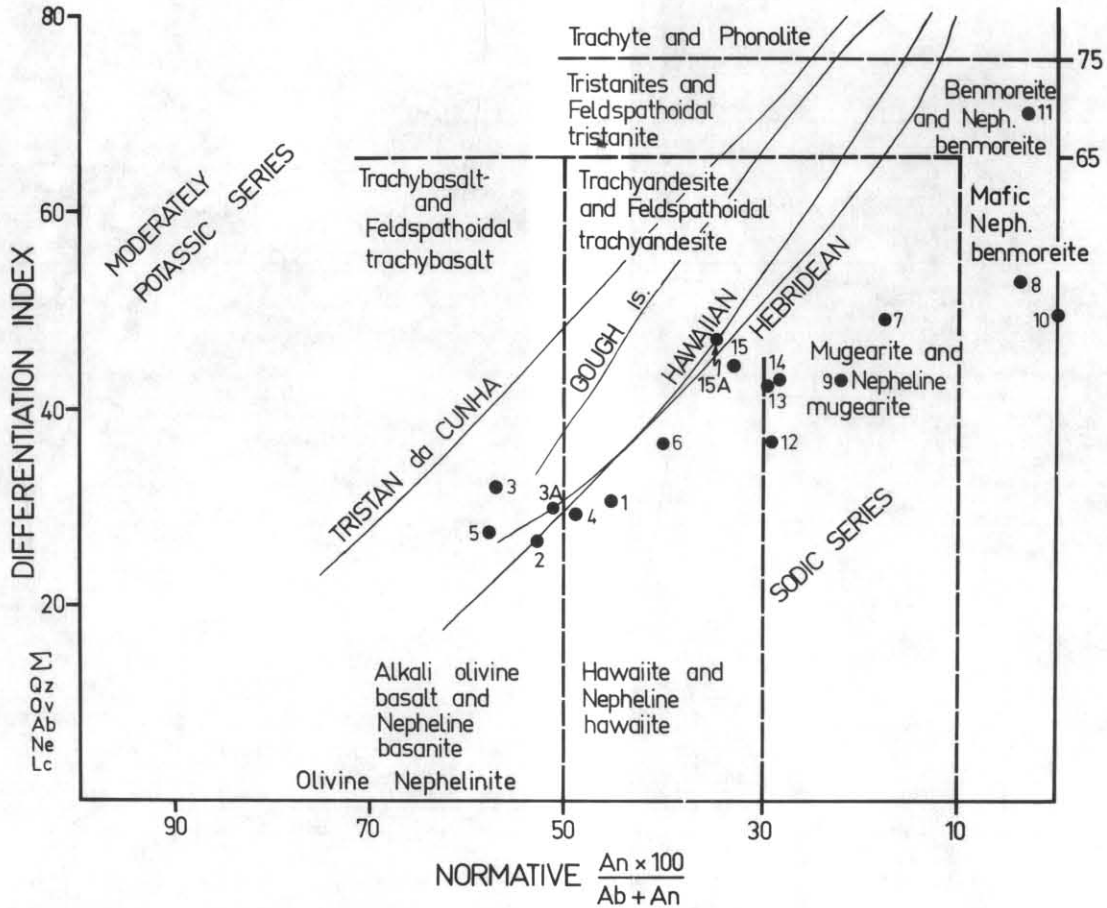


Figure 8. *Chemical variation diagram, Hobart Lavas: Differentiation Index v Normative Plagioclase Composition. Nomenclature and trends of the sodic and moderately potassic series after Coombs and Wilkinson, 1969. Numbered plots determined from listed analyses and norms of the Hobart lavas (see Table 2, p.41).*

5 cm

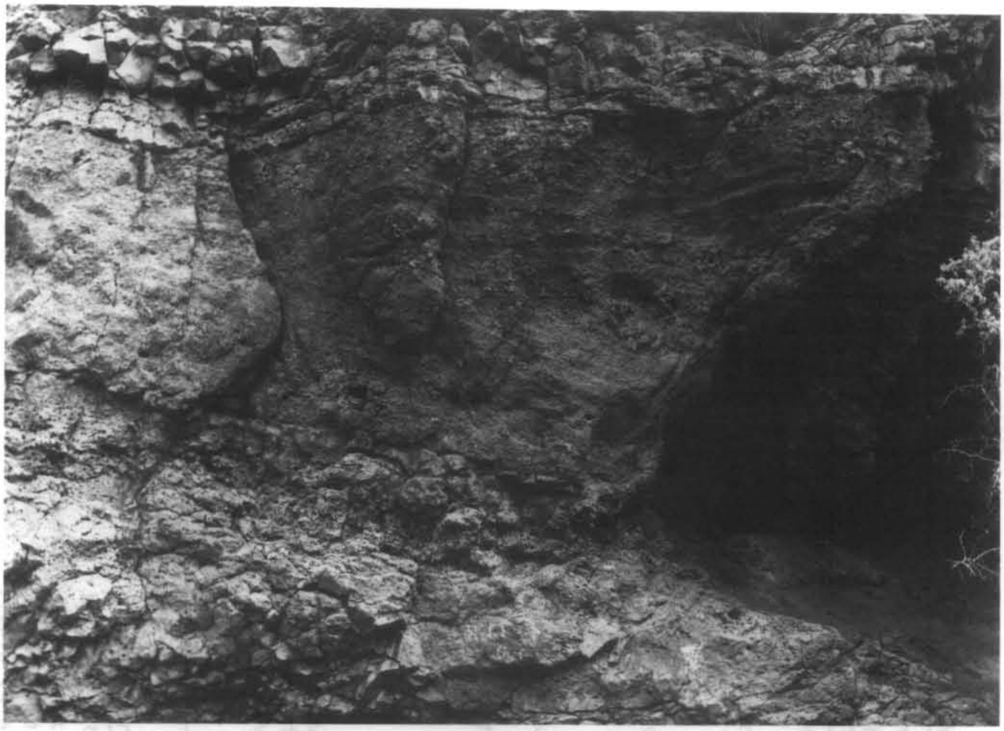


Plate 16. *Tachylytic breccia showing large scale current bedding interbedded with lavas, Claremont.*

Plate 17. *Entrail (flow foot) breccias with multiple cooling crusts embedded in tachylytic breccia, Claremont.*

sediment, shale, sandstone and weathered basic rock. Well developed, truncated, large scale current bedding (plate 16) suggests water currents flowing dominantly north (330°-10°), but with some flowing south-east. The breccia and the overlying flow occupy a channel in the lower flow surface below Keynsham Road, where they intermix to form elongate entrails up to 3 m across with tachylytic and multiple cooling crusts (plate 17). The breccia lenses out to the north and the base of the overlying flow shows sporadic large entrails. Orientations of the entrails generally suggest lava flow from the north-east, but some variation occurs.

In similar lava cliffs south of the factory, the lowest flow is overlain by discontinuous lenses of tachylytic tuffite or sands and silts up to 1 m thick. Current bedding suggests currents mainly from the north-west. The tuffites may represent an extension of the breccia north of Cadbury's factory, but they are finer grained, contain a greater proportion of rounded, indurated mudstone fragments and grade into a coarser, siliceous pebbly sediment towards the top. The lavas gradually overlap and pass below the river level to the east, except at the western end where the lower flow passes under entrail lava which formed in a channel filled by the overlying flow. The entrail lava, with minor fragmentary tachylytic matrix, overlies bedded sand and silt lenses up to 0.3 m in thickness and indicates lava flow from the north.

Entrail breccias fill a small embayment in Triassic sandstone on the shore south of Austins Ferry Yacht Club and show abundant fragmentary tachylytic matrix. Entrail lava occurs on the eastern shore directly opposite Austins Ferry within two flows. Here massive basalt grades into entrails 6 m long and 1.3 m in diameter with rough dark tachylytic crusts up to 30 mm in thickness. Larger entrails show scoriaceous margins 0.3-0.6 m thick, but smaller entrails may be completely scoriaceous. Vesicles tend to be ovoid and elongate parallel to the entrail periphery, but become rounder further in. Minor fragmentary tachylytic matrix and gritty sand intercalate with some entrails. Crudely bedded and jointed tachylytic breccia, associated with thin lenses of friable argillaceous grit and sand, forms a discontinuous horizon up to 2 m thick between the two flows and it resembles and may correlate with the breccia north of Cadbury's factory. Both flows are deeply weathered, seamed with mineral veins and amygdales and the lower flow contains radiating carbonate up to 150 mm in length.

The entrails, tachylytic matrix and tachylytic breccias in these lavas resemble lavas erupted into water elsewhere in Tasmania (Sutherland and Corbett, 1967; Sutherland and Hale, 1970). Thus eruption of lavas into a higher former Derwent estuary or lake is envisaged, arising from an emergent eruptive fissure probably located north-west of Claremont. The cause of the predominant upstream current flow exhibited in the breccia north of Cadburys is uncertain, but returned circulation in a dammed reservoir or current wash down the slope of a volcanic apron could be suggested. The lavas here apparently diverted the Derwent to the west through Windermere Bay, where post-basalt gravel and sand overlie the basalt south of Knights Point. Since this time the River Derwent has cut back through the lavas at Claremont to form its present course.

The olivine basalts are tholeiitic types (table 2, analysis 1), and are related to the Ouse, Bridgewater, Pontville and Jordan types of McDougall (1959).

Herdsmans Cove-Gage Brook area

Massive basalt over 50 m thick fills an old deep valley mouth of the Jordan River in this area. It appears to overlie tachylytic entrail breccia and pillow lava on the western side around Bridgewater and to terminate against older lavas north of Claremont. A scoriaceous horizon overlying decomposed basalt can be traced down to 5 m above river level in the southern part of Herdsmans Cove suggesting two possible flows. The basalt is the southern extension of thick lava erupted near Brighton (McDougall, 1959) and is a tholeiitic olivine basalt resembling the lavas around Bridgewater (table 2, analysis 2).

Elwick-Selfs Point-Lindisfarne area

Massive columnar to strongly amygdaloidal lavas up to 15 m thick are exposed in this area. Amygdaloidal carbonate is common at Elwick, chabazite occurs at Goodwood and limonite and opal-jasper are prominent at Selfs Point and Lindisfarne. At least three flows are exposed at Selfs Point, where well developed entrail structures and dyke extensions are exposed at the base of the overlying flows, particularly where they fill depressions and cracks in the underlying flow surface. Entrail orientations are somewhat variable along this section, but suggest some south-westward lava flow into the northern end of this area and south-eastward flow out from the southern end.

At Geilston Bay, an alkali basalt overlies fossiliferous travertine deposits partly metamorphosed into cherty hornfels (Strzelecki, 1845; Jukes, 1847; McCormick, 1847; Allport, 1874, 1877; Johnston, 1880, 1882, 1885, 1888; Nye, 1924; Hughes, 1957; Moore, 1965; Sutherland, 1972). Other lavas extend south of Lindisfarne Bay, where 4 m of massive decomposed basalt with a thin scoriaceous base overlies weathered, crudely bedded argillaceous grit and sand at least one metre thick and dipping 3-4° to the west. Incipient entrail-like bodies are developed where the basalt base has caught up the underlying sediment. Gravel, sand and boulder beds of the post-basalt channel of the River Derwent disconformably overlie the basalt, which originally diverted the river west through Glenorchy, Moonah and Cornelian Bay. The basalt has since been cut through at Elwick and New Town Bay.

An alkali basalt was intersected below the river under the Tasman Bridge, in drill cores from 45 m to 90 m below mean sea level, where it underlies silt and gravel and rests on dolerite (Trollope, Freeman and Peck, 1966). Minor basalt flows interbedded with Tertiary sediments were recovered in bores from about sea level in Hobart city (Longman, 1966), but their relationship to the upstream basalts is uncertain as the core could not be relocated for detailed examination.

These basalts superficially resemble, and have been considered as downstream extensions of the Claremont flows (Edwards, 1939), but they differ in the absence of any fragmentary tachylytic material and in some petrographic details. In thin section most tend to lack the dark glassy mesostasis typical of the Claremont basalts and are intergranular olivine basalt transitional between tholeiitic and alkali basalt. This suggests separate eruption, possibly in the vicinity of Bowen Road, where the basalt reaches its highest elevation (30 m). Opal veins and deposits in the Permian beds opposite at Shag Bay may also relate to a nearby centre.

New Norfolk

Recent bridge foundation investigations at New Norfolk have located a lower basalt flow 11 m below river level (Public Works Dept drill logs; P.R. Cook, pers. comm.). The basalt shows a vesicular, near-level top in cross-section and was penetrated to over 4.5 m without reaching its base. The flow is overlain by up to 4.5 m of basaltic conglomerate and basaltic sandstone, within 6 m below river level (m.s.l.), then by up to 6 m of interbasaltic sandstone, mudstone and gravel, capped by an upper flow extending from 2.7 m below river level to above it.

The lower flow is tholeiitic olivine basalt resembling the Bridgewater and Pontville types (McDougall, 1959) and vesicles may be coated with pyrite or opal. The overlying conglomerate contains predominantly rounded fragments of vesicular to non-vesicular basalt ranging to over 150 mm across, associated with some rarer and smaller dolerite fragments, in a sparse, fine-grained dark matrix. The basalt fragments consist of varieties of tholeiitic to transitional olivine basalts, only some of which directly match and could derive from the underlying flow. The source of this flow and associated sediment is uncertain. They are older and petrographically distinct from the upper flow, which is limburgitic basanite, and probably do not originate from the same eruptive centre. They may come from tholeiitic olivine basalts which erupted further upstream from a centre near Plenty, where lava outcrops pass below the river level and alluvial deposits, 7 km from the New Norfolk bridge.

ALKALI OLIVINE BASALTS, TRACHYBASALTS AND TRANSITIONAL HAWAIITES

Lucaston area

A massive basalt flow, at least 5 m thick is exposed in the Mountain River close to the Lucaston Road bridge (Mather, 1955). It lies near a fault line and may have erupted upstream near the intersection of faults and intrusive dolerite.

In thin section it is a porphyritic alkali olivine basalt (table 2, analysis 3A) with an intergranular groundmass of plagioclase (zoned from An_{54}) and faintly titaniferous augite. It contains sporadic, generally small lherzolitic, partly altered Jurassic dolerite and Permian sedimentary xenoliths and their disaggregated xenocrysts. Amygdales contain opal, chalcedony and carbonate.

Lawitta area

A small massive flow of dense fine-grained basalt, at least 20 m thick, appears to have erupted from a fault intersecting the Lawitta Fault of Woolley (1959). In thin section the rock is porphyritic with olivine and microphenocrysts of titaniferous augite set in an intergranular groundmass of plagioclase (mostly zoned from An_{48}), augite and iron oxide, with amygdaloidal opal, carbonate and hematite.

Coal River

Massive basalt and underlying pyroclastic rocks over 30 m thick form an isolated peak on the eastern bank of Coal River, 3 km south of Richmond. The pyroclastic rocks crop out on the northern side with a thickness of 12 m and extend below river level. They are poorly bedded, irregularly jointed, agglomeratic lapilli tuffs, striking at about 150° and dipping up to 25°W. They contain sporadic fragments of Tertiary ferruginous concretions and leaf-bearing mudstone (to 250 mm across), fine-grained scoriaceous to dense basalt (to 150 mm across) and rare pyroxenite (to 30 mm across) in a matrix composed of minutely vesicular basalt fragments (mostly less than one centimetre across).

The western side is intruded by a massive basalt dyke with a partly rubbly, partly platy contact (trend 10°, dip 60°W). The eastern pyroclastic rocks are intruded and baked by three small steep dykes (trend 108-130°, dip SW) and a transgressive sheet (strike 10°, dip 50°S). The pyroclastic rocks are cut by minor movements forming weathered seams up to 50 mm across. The structure appears to represent the eroded southern flank of a small volcanic cone that intruded through the Tertiary sediments.

In thin section the rock contains glomeroporphyritic olivine and titan-augite in a fine-grained groundmass of plagioclase (zoned from An_{54}), clino-pyroxene and iron oxide, with a glassy mesostasis and secondary zeolites. Chemically the rock is an undersaturated alkali olivine basalt approaching a basanite, but contains 2% K_2O (table 2, analysis 3) and may be considered an undersaturated trachybasalt variant (fig. 8).

Collins Cap

A small outcrop of massive lava overlies dolerite 3.5 km north-west of Collins Cap township. It probably represents a flow remnant erupted from the Collinsvale Fault line (Sutherland, 1964).

In thin section it contains glomeroporphyritic olivine and titanaugite in a fine-grained and sometimes fluidal groundmass of clinopyroxene, olivine, plagioclase, minor nepheline and iron oxide, passing into a dark, glassy meso-stasis. Petrographically it resembles the Coal River basalt.

Risdon

Coarse, lithic crystal tuff, at least 30 m in thickness, is interbedded with lavas at the Risdon centre west of the Risdon Brook reservoir (Moore, 1965). It is a massive, reddish brown, friable rock consisting mainly of angular fragments of dense to vesicular, chilled, oxidised basalt and indur-ated Permian sediments, mostly up to 30 mm across, in a fine-grained matrix. Hornblende megacrysts (showing some euhedral faces, but also fragmented or partially fused), altered lherzolite fragments and subordinate orthopyroxene, clinopyroxene and rare spinel xenocrysts, up to 20 mm across, appear through-out the tuff and occasionally in the basalt fragments.

The hornblende is kersutitic pargasite, the orthopyroxene is aluminous enstatite and the clinopyroxenes include aluminous diopside and aluminous augite (table 1). The aluminous diopside resembles clinopyroxene from lher-zolite xenoliths and the aluminous augite resembles megacrysts known from Tasmanian basalts elsewhere (Sutherland, 1968; R. Varne, pers. comm.). This mineralogy suggests explosive eruption of hydrous magma which was crystall-ising hornblende and augite at depth At Butlers Hill, 33 km north of the Risdon centre, a plug of lherzolite bearing alkali olivine basalt with sim-ilar kersutitic pargasite megacrysts presumably represents an effusive phase of the explosive magmatic episode at Risdon.

Massive lava, over 20 m in thickness, with a strongly vesicular base caps the Risdon hornblende tuff and fills a small valley cut in Permian strata. The lava originally flowed both upstream to the small remnant north of the Risdon Brook reservoir and downstream to the south below the 60 m contour towards the Derwent, forming a twinned lateral drainage pattern. In thin section the rock contains olivine phenocrysts (iddingsitised in the more ves-icular zones) in an intergranular groundmass of plagioclase (mostly zoned from about An_{48}), colourless augite and iron oxide. Chemically the rock is not particularly alkaline and it resembles a near saturated alkali olivine basalt (table 2, analysis 4), but it plots as a transitional hawaiitic type (fig. 8).

OLIVINE NEPHELINITE

Risdon

This forms small flow remnants underlying the tuffs and the capping flow at the Risdon centre. It is a dense, massive lava and appears to have flowed south from 100 m a.s.l. down to below 20 m.

In thin section the rock contains small partly iddingsitised olivine phenocrysts in a fine-grained groundmass of clinopyroxene, nepheline, abundant iron oxide, some late-stage potash feldspar and amygdaloidal zeolite. It has the lowest SiO_2 and the highest iron content of the Hobart rocks (table 2, analysis 5).

New Norfolk

Massive lava crops out around New Norfolk and east of Milbrook Rise, The separate outcrops appear to represent a single flow that issued from the intersection of several faults at New Norfolk and flowed into the old Derwent valley diverting the river to the north. Cooling columns are well developed but somewhat irregular. The flow extends 3 m below river level at New Norfolk bridge (Public Works Dept drill logs, P.R. Cook, pers. comm.), suggesting an original thickness in excess of 30 m. It overlies interbasaltic sediments and clearly post-dates the apparently unrelated lower tholeiitic basalt beds and flow described earlier.

The rock contains small lherzolitic, sedimentary and weathered dolerite(?) xenoliths. In thin section, small, usually iddingsitised olivine phenocrysts are set in an abundant, rusty brown glassy base containing prismatic augite, variable proportions of plagioclase laths (zoned from about An_{52} and sometimes absent), scattered iron oxide and sporadic patches of analcite, clay and chalcedony. Xenocrysts of olivine, enstatite, clinopyroxene and spinel derived from the lherzolitic fragments may be present. Mineralogically it is a limburgitic analcite basanite, but chemically it is a strongly understaurated and sodic rock (table 2, analysis 6) and it plots with feldspathoidal hawaiites (fig. 8).

MAFIC NEPHELINE MUGEARITIC BENMOREITES

Lower Sandy Bay

This volcanic complex and its unusual petrology had attracted considerable detailed description (Darwin, 1844; Johnston, 1882, 1888; White and MacLeod, 1900; Petterd, 1911; Noetling, 1914; Aurousseau, 1926; Edwards, 1950; Spry, 1955). Spry (1955) inferred that the asymmetrical folding in these interbedded lavas and pyroclastics, which overlie clay, resulted from slumping of wet unconsolidated sediment and hot plastic lavas. This is supported by recent preliminary measurements of the hard magnetic components of the thickest lava (W.D. Parkinson and N.J. Turner, pers. comm.). These suggest that the directions of the palaeomagnetic moments were assumed whilst the lava was in its present disposition indicating that it was folded at a temperature above its Curie Point.

The rocks have generally been termed basanites, but chemically they are very alkaline (table 2, analyses, 7, 8) and more specifically plot from mafic nepheline mugearite to mafic potassic nepheline benmoreite (fig. 8).

Droughty Hill area

Droughty Hill and the peaks 500 m to the north and south form separate outcrops of massive lava. In comparison with the northern mugearitic neck, Droughty Hill and the southern peak show no noticeable ground magnetic anomalies suggestive of plugs and may be eroded flow cappings (W.C. Cromer and C. Watt, pers. comm.). The lavas contain accidental Jurassic dolerite and Permian sedimentary inclusions. They also display considerable variation in petrographic detail (information provided mainly by W.C. Cromer).

The Droughty Hill outcrop shows very local development of agglomerate on its north-eastern base. The lava is porphyritic with xenocrysts and phenocrysts of olivine (10%, 4 mm max., 2Vγ 85–100 ± 3°, Fo_{95-66} ± 6% mol. Fo; commonly iddingsitised), zoned clinopyroxene (2Vγ 44-55°, 3 mm max.; some with reaction borders), corroded orthopyroxene (En_{96-84}, 3 mm max.; commonly with reaction rims of clinopyroxene and iddingsitised olivine) and reddish brown spinel. Associated small lherzolitic inclusions are only prominent in chilled lava on the north-west side. The groundmass contains clinopyroxene (40%), iron oxide, olivine and apatite in a dense hypocrystalline to coarser poikilitic base (up to 30%) of potash feldspar, nepheline and minor sodic plagioclase. Some chilled vesicular phases are potassic olivine nephelinites in mineralogy, but generally potash feldspar predominates over nepheline. Mineralogically, it is mafic nepheline benmoreite (table 2, analysis 9), but chemically it plots as mafic nepheline mugearite (fig. 8).

The rock of the southern outcrop is similar, but is less mafic, generally lacks xenocrystal inclusions and contains some coarse late-stage segregations up to 40 mm across. The chilled phases carry iddingsitised olivine and prismatic titaniferous augite phenocrysts, up to 0.5 mm across, and grade into coarser, distinctive poikilitic rocks with clinopyroxene, iron oxide and apatite in interlocking late-stage potash feldspar and nepheline. The clinopyroxene tends to be concentrated densely in the nepheline leaving relatively clearer areas of feldspar and the groundmass may include minor, small, prismatic yellowish brown amphibole and olivine. Chemically the rock plots as mafic potassic nepheline benmoreite (table 2, analysis 10; fig. 8). The late-stage segregations mainly contain potash feldspar (to 8 mm across) and some nepheline, poikilitically enclosing clinopyroxene and minor iron oxide. The clinopyroxene is partly altered to aegirine-augite (strongly pleochroic from pale lime to deep emerald green) and there are fibrous and acicular tufts of dark green aegirine. Modally some segregations approach nephelinites, but most approach mafic phonolites, or are chemically saturated rocks (table 2, analysis 11) plotting as nepheline benmoreite (fig. 8).

The Droughty rocks petrologically match lavas of the Lower Sandy Bay complex. They may represent lava remnants that flowed east from that cone and as such they give minimum heights of at least 120 m above the river level for the cone, prior to its collapse on the western side and prior to dissection by the Derwent. However, the possibility of local plugs cannot be dismissed without more detailed geophysical work.

Sandford area

Small outcrops of scoriaceous basalt, south of Sandford, may represent eroded remnants of a nearby volcanic centre (Green, 1961). In thin section the rocks closely resemble those at Lower Sandy Bay and the southern peaks in the Droughty Hill area. They crop out at lower levels than the Droughty lavas and the possibility of a flow tongue extending from there cannot be discounted on present evidence.

MAFIC MUGEARITES, MUGEARITES AND MUGEARITIC HAWAIITES

Pickett Hill-Kingston area

Poorly bedded agglomerate, lapilli tuff and tuff, at least 6 m in thickness are interbedded and capped with lavas on Pickett Hill and appear to mark a vent located near fault intersections. Coarse agglomerate is most common at the top of the pyroclastic horizon. It contains lava fragments and bombs up to 0.3 m across and pieces of quartzite, quartz and indurated Permian sediment, sometimes as the nucleus of a bomb. Massive, blocky jointed lava, at least 40 m in thickness, underlies these pyroclastic rocks and forms the ridge to Cades farm. Further coarse agglomerate, agglomeratic tuff and lapilli tuff, at least one metre thick overlies Permian beds under this lava in road cuttings below Cades farm, but whether a further vent lies in this area is uncertain. A quarry on the old Longley Road shows massive sheet jointing in the lava, dipping 15-45° SE in the direction of flow. Several residuals lie to the east in the direction of Kingston and form extensions of the Pickett Hill-Cades lava which overflowed to form steep valley fills in old courses of Whitewater Creek and Browns River and caused minor lateral diversions (fig. 6).

The rocks contain considerable xenocrystal material derived from common lherzolitic inclusions which reach 100 mm across. Olivine megacrysts may show iddingsitised margins, resorbed ortho- and clinopyroxenes are typically outgrown with titaniferous augite and olivine brown spinel is replaced with opaque oxide. The phenocrystic olivine may be completely iddingsitised and as with sporadic titaniferous augite is set in an intergranular to dusty dark, fine groundmass of sodic plagioclase (somes zoned from about An_{38}, but mostly more sodic than An_{30}), augite, iron oxide and late-stage alkali feldspar. The rock is undersaturated mafic mugearite, and the high MgO and low alkali content (table 2, analysis 12), reflect the abundance of lherzolitic xenocrysts. Alluvial chrome-spinel in the Kingston-Longley area is presumably derived from the lherzolitic material in the basalt and a chemical analysis (table 2) gives a theoretical spinel formula of $(Mg^{2+}_{0.88}, Fe^{2+}_{0.12})(Al^{3+}_{0.54}, Fe^{3+}_{0.27}, Cr^{3+}_{0.19})_2O_4$ (W.E. Baker, pers. comm.).

Kingston

An elongate pyroclastic complex is located near the dolerite contact north of Kingston. It appears to represent a fissure eruption of hawaiite, intruded through the older valley filling flow of mafic mugearite that descended from Pickett Hill. It is well exposed in the new cuttings of the Southern Outlet road, and difficulties in matching some structures across opposite sides of the cutting indicates the variable nature of the deposit. A good illustrative section can be seen in the eastern cutting from its northern end to the overpass bridge to the south. A description of the sequence in the cutting is given below.

Distance 0-70 m (from north). Massive to crudely bedded pyroclastic rocks forming a broad downwarp occur in this section.

At the northern end, the lower 6 m (strike ∿50° dip up to 35°E) consists of generally rubbly agglomerate with angular pieces of Permian sediment, dolerite and mafic mugearite (up to 230 mm across, but mostly <80 mm) in a finer grained matrix. Fragments of scoriaceous lava tend to be small and rare.

The overlying tuffs, 240 mm in thickness, pass up into coarser tuffaceous agglomerate (3 m thick) with pieces of country rock up to 0.6 m across, dense to scoriaceous lava and rarer inclusions of underlying pyroclastic rocks. The tuffaceous agglomerate thickens southwards to form massive compact beds totalling more than 6 m in thickness and containing large angular blocks up to 1.2 m across.

The overlying deposits to the top of the cutting are similar to the above, but are less consolidated and more rubbly, with local pockets of lava-rich material.

Distance 70-85 m. The pyroclastic rocks are dragged up against dykes of steeply bedded, loosely consolidated rubbly breccia. The breccia contains country rock fragments, mostly <80 mm across, with little tuffaceous matrix. The dykes separate a block of the older tuffaceous agglomerate 2 m wide and include an inner zone of vertically bedded, finer grained granular breccia. This zone, 2-5 m wide, strikes at about 50° and contains sporadic larger fragments up to 250 mm across, aligned towards vertical positions.

Distance 85-128 m. Scoriaceous agglomerate showing a steep but irregular contact against the rubbly breccia. It consists of sporadic large blocks up to 3 m across in a coarse, rubbly, partly welded(?), matrix of lava. Some blocks show well developed flow surfaces, some include a nucleus of country rock and others are steeply inclined.

Distance 128-139 m. A massive 'dyke' filling that shelves upwards to the south and shows sub-horizontal platy jointing.

Distance 139-142 m. Further scoriaceous agglomerate.

Overpass bridge. Contact of scoriaceous agglomerate marked by fine-grained, reddish tuff up to 0.3 m wide and underlain by coarser rubbly breccia up to 1.5 m wide, mostly with pieces of mafic mugearite. This shelves upwards and to the south and is underlain by scoriaceous agglomeratic lapilli tuff containing sporadic pieces of country rock up to one metre across and extending south for some distance.

This complete section indicates the following eruptive phases:

(1) Initial explosive eruption clearing the fissure of country rocks (dolerite, Permian hornfels) and older mafic mugearite flows, but contributing an increasing quantity of lava with continuing eruption.

(2) Gas blasting and lava injection forming steeply banded eruptive throats ascending through the older pyroclastic rocks, and passing from sides of rubbly breccia composed of the country rock through scoriaceous, partly welded(?) agglomerate to massive 'dyke' fillings.

A small dyke-like plug of massive dense lava is exposed just north-west of the pyroclastic rocks in the quarry near the bridge over Browns River. The east side of the plug has intruded along a dolerite contact dipping 70° west against a sleeve of rubbly breccia (2 m wide) composed of angular fragments of hawaiite, dolerite and some Permian hornfels. Its west side intrudes steeply westward-dipping, faulted, Permian hornfels which are penetrated by irregularly trending subsidiary dykes. In thin section the rocks of the pyroclastic complex are sodic hawaiites, which plot chemically as mugearitic hawaiite (table 2, analysis 15; fig. 8).

Steeply dipping, massive dense lava, over 20 m in thickness, is also exposed 200 m west of the pyroclastic centre and lies between a small dolerite plug and Permian strata in a quarry on Whitewater Creek. It shows slabby, steeply inclined, curved jointing and may form a neck. It closely resembles the above rocks (table 2, analysis 15A), but differs in the presence of sporadic lherzolitic inclusions up to 80 mm across and this may suggest an earlier extrusion than that represented in the Southern Outlet exposures. Everard (1968) described the petrology of an intermediate tuff from this area and pyroclastic float has been observed on the eastern side of the outcrop.

Doctors Hill

Interbedded lavas and pyroclastic rocks over 50 m in thickness form a poorly exposed complex here. The Channel Highway cutting immediately east of Doctors Hill exposes a massive to scoriaceous flow at least 3 m thick with an irregular rubbly top. It is overlain by and terminates vertically against tuffaceous agglomerate to the north. South of this, road cuttings show agglomerate and tuffaceous agglomerate interbedded with at least three lavas or dykes at least 3 m in thickness. These dip shallowly south-west at 15°, then steeply north-east and finally near-vertically, suggesting an asymmetrically folded syncline or valley-fill structure. The southern margin of the volcanic rocks forms a steep contact dipping 40-50° north against gently north-east dipping Permian strata. The contact is marked by a scree-like breccia of Permian fragments overlain by lapilli tuffs one metre thick, grading into agglomerate, 1.7 m thick, containing common blocks of Permian sediments up to 250 mm across, scoriaceous to dense lava up to 0.5 m across and rare weathered dolerite. A massive lava with platy jointing and a chilled contact follows and overlaps the pyroclastic rocks up-dip to form a rubbly scoriaceous base.

The main vent appears to be located on the North West Bay Fault near the highest peak of the volcanic rocks, where coarse agglomerate crops out with the lavas. There may be some complications due to folding, but the rocks appear to have erupted into an old Tertiary valley north-west of Parks Hill (fig. 6) and descended towards North West Bay where silicified sub-basalt sediment crop out on the shore west of Coffee Creek (Sutherland, 1972). Detailed drilling investigations have provided further sections through the north side near Whitewater Creek and indicate up to 27 m of volcanic rocks and interbedded valley-fill sediment representing a complex history of erosion, deposition and several periods of lava extrusion (Moore, 1968, 1971).

In thin section, the lavas are sodic hawaiites and mugearites, olivine is often iddingsitised. Detailed petrographic descriptions are given by Everard (1971).

Mount Wellington

A small outcrop of massive dense lava south-west of the Pinnacle on Mt Wellington contains sporadic inclusions of dolerite, Permo-Triassic sediments and rare lherzolitic xenoliths. It appears to represent a small plug with some banded flow structure and in thin section is a mugearitic hawaiite with a strong fluidal texture.

Neika

Massive, dense lava, up to 30 m in thickness, overlies weathered dolerite along a fault. It was probably extruded locally as Lewis (1946) reported some ash and scoria in the area. The base of the flow in the Huon Highway cutting is scoriaceous and weathered and contains common fragments of weathered dolerite up to 0.3 across and rare pieces of Triassic sediment. In thin section, it is mafic mugearitic hawaiite with prominent olivine grains which show straining and are associated with some reacted enstatite and spinel xenocrysts, suggesting derivation from the small lherzolitic xenoliths.

Parks Hill

Similar rock forms a small neck on the northern side of the spur north-west of Parks Hill. Here a massive dyke, 10 m wide, dips steeply to the west against crudely bedded, folded and rubbly agglomerate, 6 m wide, on its western side. Bedding in the agglomerate is mostly 1-1.5 m in thickness and forms a sharp syncline plunging steeply south. The agglomerate consists dominantly of finely scoriaceous to dense basalt (with rare bombs) up to 0.3 m but mostly less than 30 mm across in a finer lapilli matrix, with some sporadic baked Permian sediment and rare dolerite fragments. A basal bed is composed entirely of Permian fragments (150-300 mm across) and may represent an old talus deposit rather than pyroclastic material. Lava also caps the spur and it contains rare small peridotitic xenoliths and fragments of dolerite and sediment up to 80 mm across.

Cambridge area

Dense, massive to scoriaceous and rubbly lava forms three separate extrusions that erupted along a dolerite margin and flowed east towards Cambridge aerodrome. In thin section the rocks are typically sodic hawaiites transitional towards a mugearite. Pyroclastic rocks, country rock inclusions and lherzolitic xenoliths are only significantly abundant in the southermost centre at Acton.

Here, a capping lava, largely scoriaceous, shows a rubbly base dipping gently to the east and containing abundant accidental inclusions of dolerite up to 200 mm across, less common baked Permo-Triassic sediments and rare small lherzolitic xenoliths. It is underlain on its northern side by poorly exposed agglomerate about one metre in thickness. This contains numerous dolerite inclusions to one metre across, lesser scoriaceous to dense basalt to 200 mm, but mostly one centimetre across and sporadic Permo-Triassic fragments in a variable tuffaceous matrix making up about half the rock. Its base grades into finer lapilli tuffs showing crude bedding dipping 2-3°E. Further agglomerate, 1.5 m in thickness, crops out on the south-eastern side, but here angular to rounded basalt fragments predominate, including numerous bombs containing cores of sediment up to 150 mm across, and dolerite is rare. Below this at least 30 m of massive to scoriaceous and rubbly lava descends to the road cutting. The lava is notable for the numerous sedimentary inclusions (Triassic sandstone up to 1.5 m across) and for fragments of thinly bedded, folded quartz-veined phyllitic rock. The latter also appears in the adjacent agglomerate bed and may represent examples of the folded basement under the Permo-Triassic cover of the area.

Rokeby area

These volcanic rocks were described by Green (1961). Recent examination suggests that their eruptive centre lies under the hill north-west of Rokeby township, where several interbedded lavas and pyroclastic rocks form crescentic outcrops in plan and dip steeply west into the hillside. The lowest outcrop on the eastern slope is a massive lava with a rubbly base and a dip to the east. This change in dip suggests backward slumping of the lavas into the vent forming an anticlinal arch now eroded through into the underlying agglomerate. The base of the lowest flow can be traced in excavations for a new subdivision and it descends into the township. The lavas apparently poured into the broad Clarence Plains Rivulet valley, backing upstream for 500 m and then flowing downstream towards Ralphs Bay diverting the drainage to the east.

A small perched lava residual lies to the south-east at 120 m a.s.l., a higher level than the present lavas at the Rokeby centre. It either came from a separate centre, or indicates a minimum height attained by the Rokeby cone prior to collapse into the vent. All the lavas are closely similar in thin section, and are mugearites related to the Rokeby Type of Edwards (1950), which plots chemically as a transitional type (table 2, analysis 14; fig. 8).

Droughty Hill area

Detailed investigations suggest that the volcanic peak 500 m to the north of Droughty Hill is probably an eruptive neck, penetrating the dolerite of the area (magnetometer survey, W.C. Cromer and C. Watt, pers. comm.). Tuff with enclosed angular lava blocks occurs on the eastern rim as an irregular fringe around massive to scoriaceous, irregularly jointed lava containing accidental inclusions of dolerite to 250 mm across and rare sediment.

Plate 18. *Metamorphosed Triassic sandstone, Kingston.*

Thin section determinations (mainly by W.C. Cromer) show olivine (5%, 2Vγ 87-93 ±3°, Fo_{90-67} ±6% mol. Fo; sometimes altered and iddingsitised) and clinopyroxene phenocrysts (2Vγ 64°). These lie in a sub-fluidal to locally intergranular groundmass of andesine-oligoclase (40%, zoned from about An_{35}), pale green clinopyroxene (30%), granular titano-magnetite, minor apatite and sometimes olivine, with interstitial potash feldspar, feldspathoid and zeolite. Rare megacrysts of orthopyroxene ($\sim En_{75-93}$) and spinel occur, but may be derived from fragmented lherzolite and dolerite xenoliths.

The rock resembles the Rokeby mugearite, but takes a strong cobaltinitrite staining and is a more potassic and slightly more undersaturated variety with up to 5% feldspathoidal and zeolitic material. Chemically, it approaches a nepheline mugearite (table 2, analysis 13; fig. 7, 8), but is distinctly less undersaturated and less potassic than the two volcanic peaks directly to the south.

METAMORPHIC ROCKS

Rocks produced by thermal metamorphism are not uncommon within the quadrangle. The heating agent is almost always dolerite. The effect of either basalt or dolerite upon intruded rocks is generally minimal as both magmas were deficient in volatiles and aqueous solutions. Most rocks show little change, other than hardening and flintiness adjacent to igneous boundaries (plate 18). The quartz mudstone-siltstone of the Permian succession is typical in this respect. The sandstone of the Triassic rocks occasionally shows some remelting effects and recrystallisation. A good example may be seen on the Acton Estate, in a road cutting parallel to the igneous contact. Only the calcareous rocks of the Permian system show any broad effect. Where the obviously affected zone of most rocks is less than 3 m, within rocks of the Bundella Mudstone and Cascades Group it is often up to 12 m. Such rocks are commonly converted to chert and display mineralogical changes, particularly where locally purer calcareous horizons are present. Wollastonite is a common mineral in these situations.

Metamorphic effects are always greater for those blocks either included in an intrusive body or immediately above the roof. Noticeable effects are to be found over much of the Collinsvale area as a result of the major intrusion below. The roof remnants of the Cascades Group in Proctors Road are good examples.

Schist has been recovered from the 590-614 m level in the drill hole at Chapel Street, Glenorchy. The schist is believed to be Lower Cambrian in age. Petrologic descriptions of samples are given in Appendix 3.

STRUCTURAL GEOLOGY

The location and general relationships of major structural features are shown in Figure 9.

Attitude of sedimentary rocks

With the exception of a narrow belt immediately east of the Mt Wellington-Mt Faulkner block, rocks commonly dip to the west. The dips are normally of the order of 5-10°, although 15-25° is typical in the Pitt Water region in association with Tertiary step faulting. Dips are generally east at about 10° in the crushed warp-monocline flanking Mt Wellington and extending southward to Kingston.

Within the monoclinal area there is great variability of dip. This

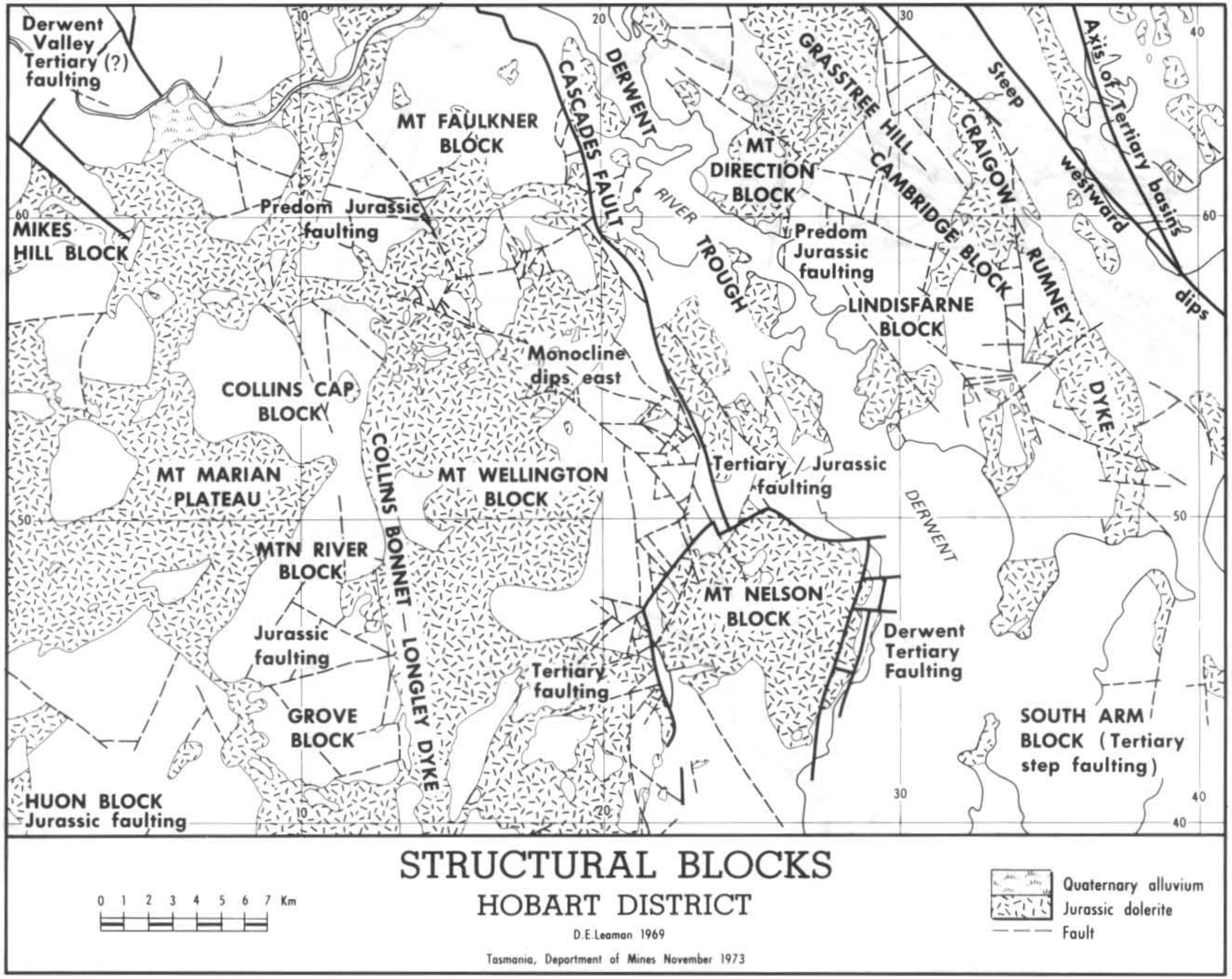

Derwent Valley Tertiary (?) faulting
MT FAULKNER BLOCK
CASCADES FAULT
DERWENT RIVER TROUGH
MT DIRECTION BLOCK
GRASSTREE HILL
CAMBRIDGE BLOCK
CRAIGOW
RUMNEY
DYKE
Steep westward dips
Axis of Tertiary basins
MIKES HILL BLOCK
Predom Jurassic faulting
Predom Jurassic faulting
LINDISFARNE BLOCK
Monocline dips east
COLLINS CAP BLOCK
MT MARIAN PLATEAU
COLLINS BONNET — LONGLEY DYKE
MT WELLINGTON BLOCK
Tertiary / Jurassic faulting
DERWENT
MTN RIVER BLOCK
MT NELSON BLOCK
Jurassic faulting
Derwent Tertiary Faulting
Tertiary faulting
GROVE BLOCK
SOUTH ARM BLOCK (Tertiary step faulting)
HUON BLOCK Jurassic faulting
STRUCTURAL BLOCKS
HOBART DISTRICT
D.E.Leaman 1969
Tasmania, Department of Mines November 1973
0 1 2 3 4 5 6 7 Km
Quaternary alluvium
Jurassic dolerite
Fault

Figure 9.

5 cm

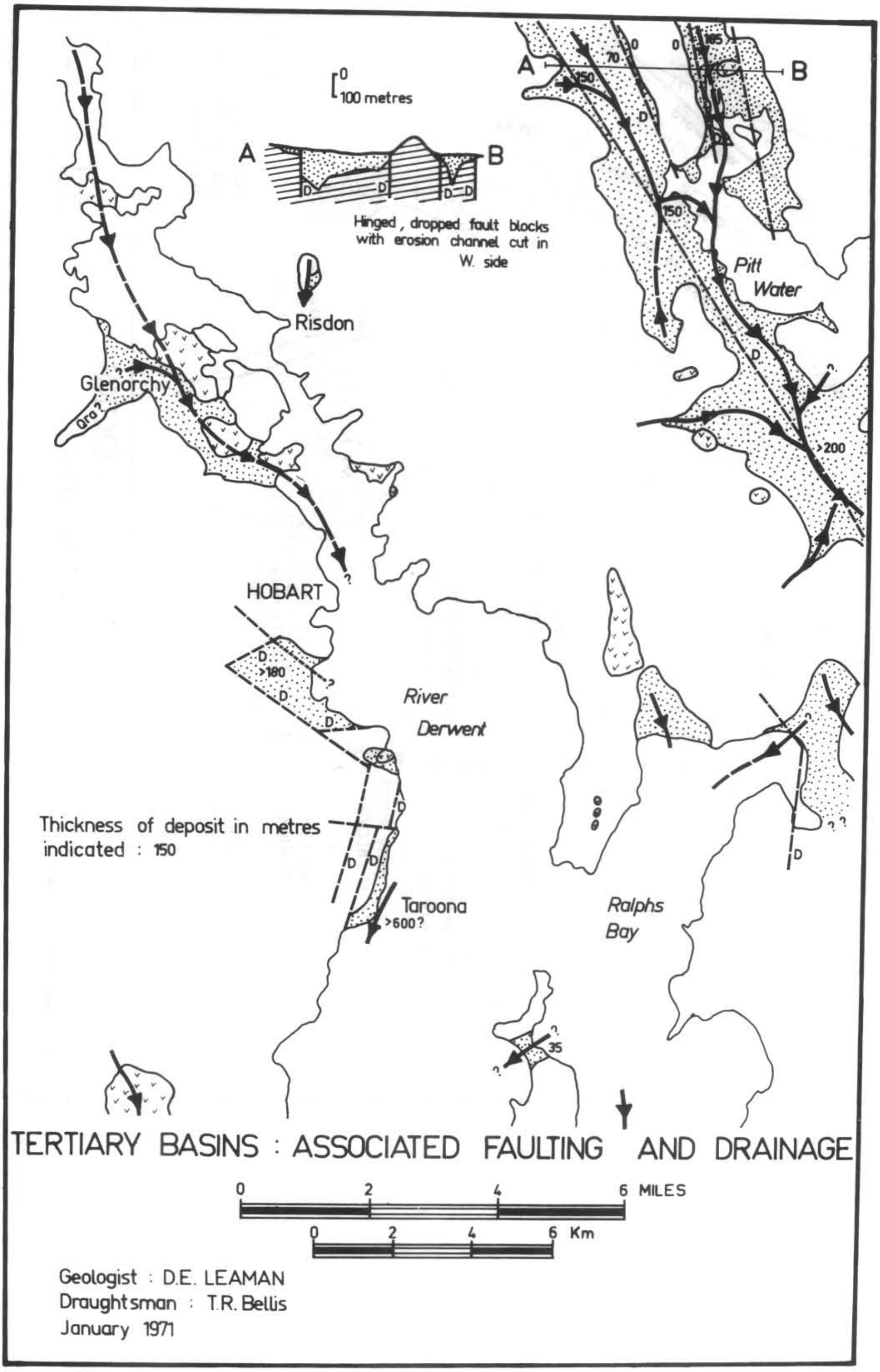


Figure 10

5 cm

Plate 19. *Cainozoic fault, Alexandra Battery, Lower Sandy Bay.*

Plate 20. *Planar concordant contact section in Cascades Group, Southern Outlet.*

is probably related to individual block movement, some fault-dragging and the effects of small dolerite intrusions. The monocline itself is possibly a large scale drag effect induced by the Tertiary movements along the Cascades and associated faults. The basement structure beneath the Wellington-Faulkner region, thought to be a granite stock, could give support to one block while allowing another to warp.

Seismic 'sparker' profiles near Blinking Billy Point, Sandy Bay show that the Tertiary sediments dip eastward for some distance into the estuary. The deposit as a whole has the form of a large sag and may reflect subsequent movements, one of which at least is recorded in the cutting at the Alexandra Battery and at Wrest Point well-bedded mudstone units dip west at 5-6°.

Faulting

Normal faulting of Jurassic and Tertiary age has contributed greatly to the complexity of the geology. Jurassic faulting includes all faulting directly associated with, or immediately preceding, the dolerite intrusions. Such faults are indicated by many sharp intrusive boundaries, or by faults containing dykes and plugs in the slip surface. The younger faults are indicated by disruption of such intrusions. The age of later movements may be impossible to date if there is more than one pulse of intrusion as each pulse may activate or re-activate faults. A fault-contact in Huon Road shows both metamorphic and fault properties. It is not known whether all properties were concomitant or whether the faulting was pre- or post-intrusion. This is typical of many of the problems faced in classifying such structures. A further example occurs on Knocklofty at Mt Stuart. There is commonly insufficient evidence to show that a fault disrupts one intrusion and not another. Jurassic faulting has produced north-south trending horst and graben structures. The Coal and Derwent Rivers occupy such grabens for part of their lower courses. The width of the central trough is often less than one kilometre, as near Richmond and Grasstree Hill.

Superimposed on the Jurassic structures is Tertiary step faulting, which commonly downthrows to the east, with a trend slightly west of north (fig. 10). The age ascribed to the later faulting is reliant on circumstantial evidence based on its relationships to basalt and sediment of known Tertiary age. Although there have been rejuvenations throughout the Cainozoic (plate 1), the major post-dolerite movements appear to have been Cretaceous-Eocene (*cf* Solomon, 1962).

Johnston (1888) described faulted Tertiary beds in Sandy Bay in the approximate position of King Street and Russell Crescent. As such, this observation may reflect continuation of the fault indicated in West Hobart. This exposure is no longer visible, and there is no indication of the magnitude of movement. A fault was exposed in excavations at Wrest Point which dipped west at 60°, dragged Tertiary sediment and had a minimum Tertiary throw of about 6-7 m. Faults of the same type can be seen in the road cutting at Alexandra Battery, Lower Sandy Bay (plate 19). Such faulting is pronounced only in the Pitt Water region and adjacent to the Mt Nelson and Mt Wellington blocks. In many cases Tertiary movements have been deflected about major Jurassic structures, for example, Mt Nelson, Mikes Hill. A shallow rotational origin is indicated by the fault-dip relationship about Pitt Water.

Faulting along the channel of the River Derwent is not clearly understood, and only limited geophysical and drilling information is available. Between Risdon and Bellerive parallel faults pass along each bank. However, the throw of these faults has not been determined. An additional large fault or deep erosion trough occurs close to the west bank at the Tasman bridge. South of Bellerive the asymmetry of structures and lack of correlation between

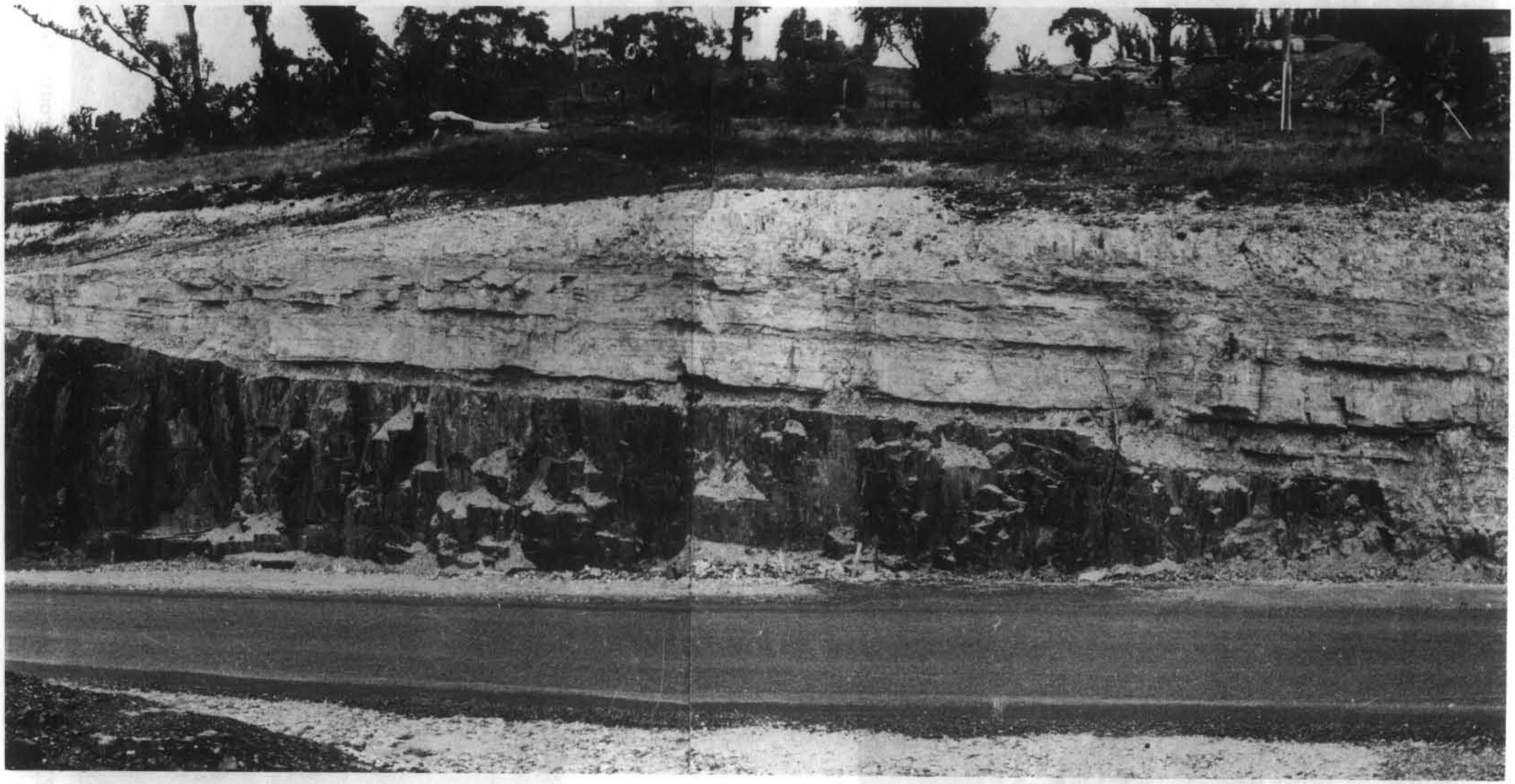


Plate 21. *Major, generally concordant intrusion with small transgressive steps, Southern Outlet.*

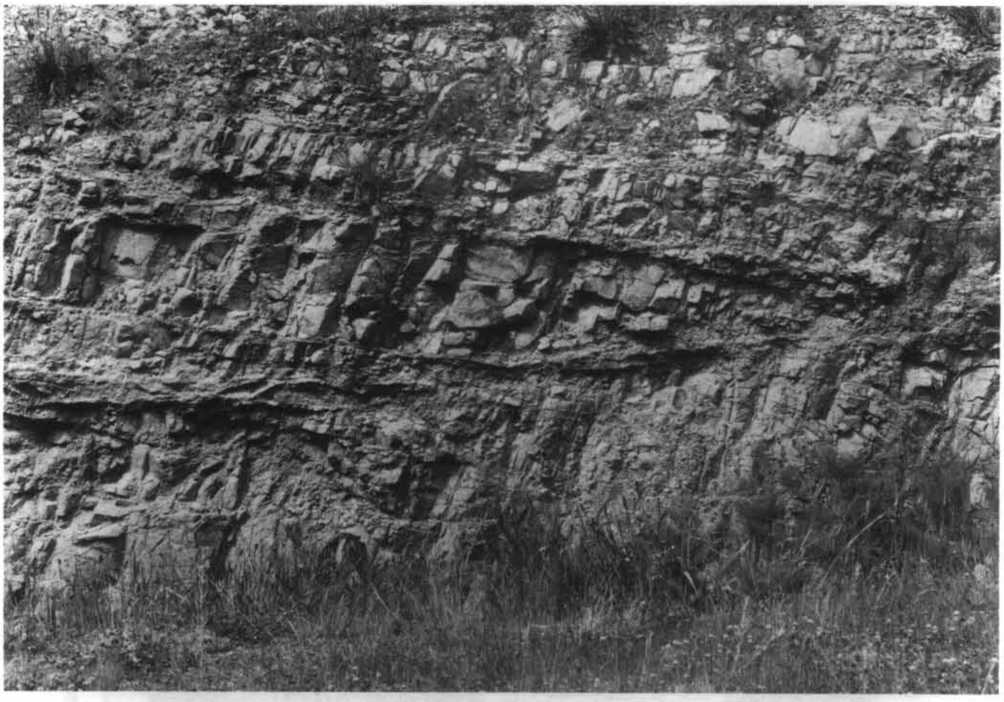


Plate 22. *The form of multiple contacts within the roof of the Mount Nelson dolerite mass, Nelsons Saddle.*

Plate 23. *Transgressive dolerite dyke intruding Cascades Group, Nelsons Saddle.*

Plate 24. *Small transgressive sheet displaying dilation, Single Hill. Both horizontal and vertical components of dilation are present.*

Plate 25. *Detail of Plate 24, showing an erratic of grey granite cut by the intrusion, implying that the dolerite occupied a pre-existing fracture. (scale size: 10 cm)*

shores is such that no definitive pattern can be established. It is obvious, however, that many east-west trending faults are terminated on structures which pass through Bellerive and Howrah. The Sandy Bay Tertiary trough must be terminated in this way and is thus seen in perspective as a dropped block. There is also an indication of a NNE-trending structure parallel to Droughty Point and South Arm peninsula (see Leaman, 1972*a*).

In most parts of the quadrangle evidence of faulting is normally excellent. However, considerable faulting must be concealed beneath the sandy and swampy area at and south of Lauderdale. North trending faults approach this region from either side of Mt Augustus. Further, as Mays Point to the east of the quadrangle margin repeats the structure seen south and east of Mt Augustus there must be an additional fault between Sandford and Lauderdale. A few minor outcrops of Malbina Formation(?) siltstone occur in the sand covered region south of Lauderdale.

Igneous emplacement

Dolerite dykes, sheets and plugs are common and generally produce large undulating interconnecting sheets. Several pulses of intrusion are represented and details of the interpretation of the structure and mode of emplacement are covered at length elsewhere (Leaman, 1970, 1972*a*; see also plates 20, 21, 22, 23). Large dykes are less prominent, but as equally abundant in exposures as sills and sheets of dolerite.

Small dykes of dolerite are intrusive into major bodies at Mt Nelson, Single Hill and Flagstaff Hill (plates 23, 24, 25).

Basalt centres are usually small dykes 2-15 m in width, associated with Tertiary faults or fault junctions and large Jurassic structures.

ECONOMIC GEOLOGY

V.M. Threader

The mineral resources of the Hobart Quadrangle are restricted to non-metallic construction materials. Coal is present but occurs only in narrow seams in a restricted area, and hence is uneconomic and no longer worked. Semi-precious stones have been reported from various localities near Hobart; the occurrences are mainly of interest to collectors and only occasional specimens of chalcedony, common opal and wood opal have been found. Low grade limestone is abundant and was once quarried and burnt to produce agricultural lime, but is now only used as an aggregate for filling and road-making.

Production statistics of construction materials are only reliable over the previous 12-15 years, and an analysis of the figures for this period is hampered by an apparent reluctance of producers to furnish accurate or completed returns. The rapid depletion of resources of construction materials, particularly in urban areas, has necessitated the efficient operation of pits and quarries to ensure full utilisation of these resources. The *Mining Act* 1929 states that a mining lease must be held over any land being mined and that quarterly returns of production must be submitted to the Department of Mines. The working of all mining tenements is subject to certain conditions under the provisions of the *Environment Protection Act* 1973, in addition to the holding of a mining lease.

The provisions of these Acts are to ensure the safety and efficiency of workings, that the environment is safeguarded, and that essential information is recorded.

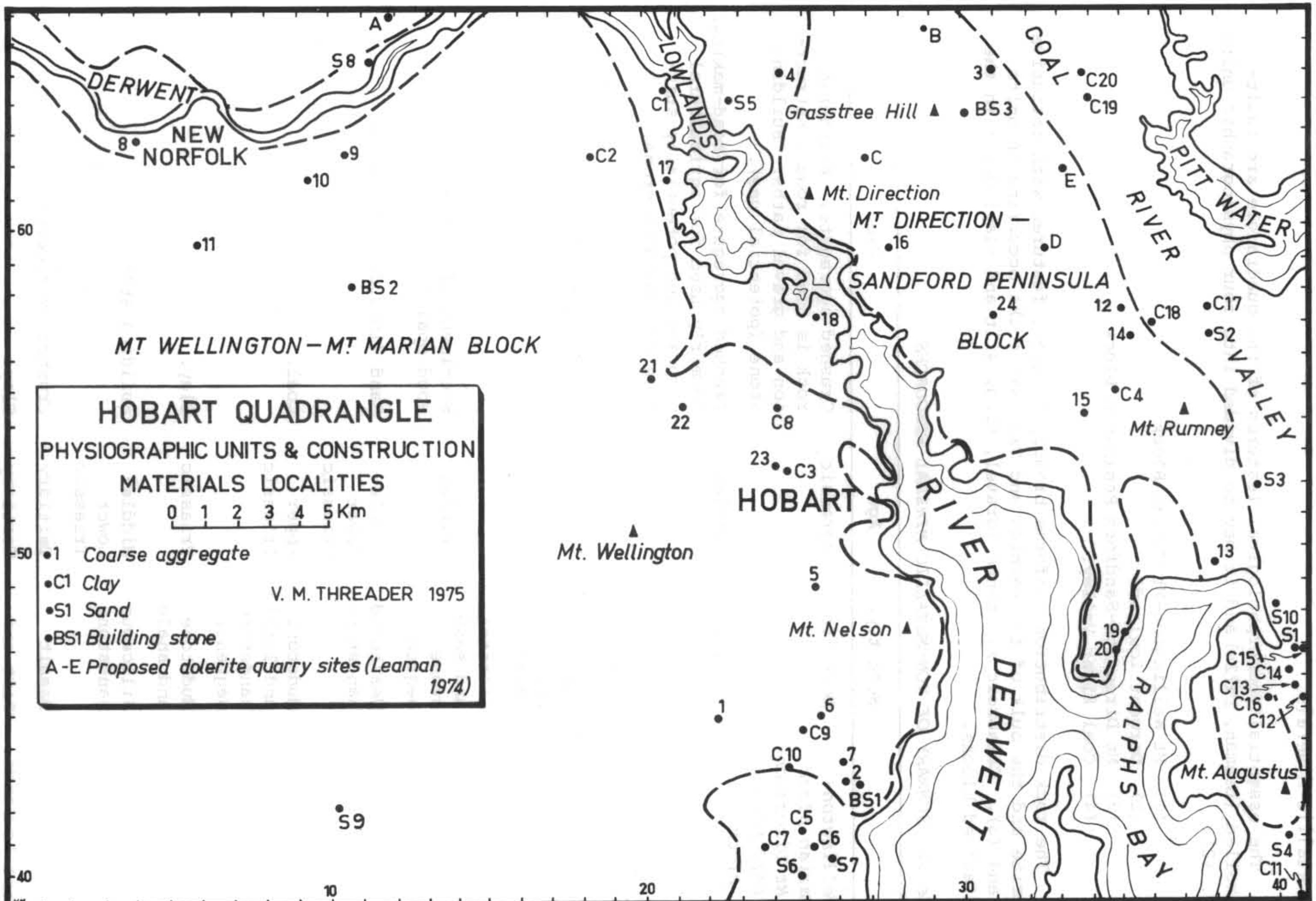


Figure 12.

5 cm

Non-metallic Minerals

The essential geomorphological features of the quadrangle are fault-controlled (Leaman, 1972*a*) and it may be divided into four physiographic units (fig. 12):

(1) Mt Wellington-Mt Marian Block
(2) Derwent Lowlands
(3) Mt Direction-Sandford Peninsula Block
(4) Coal River Valley.

The rock distribution conforms broadly to these features with intrusive dolerite and the bulk of the Permian and Triassic rocks occurring in units (1) and (3). Cainozoic sediments (gravel, sand, silt and clay) occur in the downfaulted blocks.

Table 3. SUMMARY OF NON-METALLIC MINERAL RESOURCES

	Rock type	Age	Use
Mt Wellington-Mt Marian Block and Mt Direction-Sandford Peninsula Block	Dolerite	Jurassic	Crushed aggregate. Weathered rock is used for road construction and gravel paths. Building stone (potential use).
	Limestone	Permian	Crushed aggregate for road-making. Formerly used for agricultural purposes and potentially suitable for building stone.
	Indurated sediments along dolerite contacts	Permian	Road construction.
	Siltstone and sandstone sequence	Permian	Specimens of common opal and wood opal occur.
	Weathered sandstone	Middle-Lower Triassic	Sand (including fat sand).
	Mudstone and lithic sandstone sequence	Upper Triassic	Coal.
	Mudstone and shale	Triassic	Clay.
	Siliceous sandstone	Middle-Lower Triassic	Building stone.
	Basalt	Tertiary	Crushed aggregate.
Derwent Lowlands-Coal River Valley	Silt and clay sequence	Tertiary	Clay.
	Sand	Tertiary-Quaternary	Silica for glass manufacture.

Table 3. (continued)

	Rock type	Age	Use
Derwent Lowlands-Coal River Valley	Dune sand	Quaternary	Sand for the building industry.
	Talus of mixed origin	Quaternary-Recent	Road and path construction.

CONSTRUCTION MATERIALS

An attempt has been made to analyse annual production figures for construction materials over the period 1963-1973, to predict the production over two successive 25 year periods and to predict the annual production at the close of each of these periods. Bowen (1971) made a detailed analysis of quarrying trends in Victoria (table 4) and deduced an overall annual growth rate of 5% for the production of most quarry products. This would result in a five fold increase in the annual output in 25 years, and at the end of this period the total output would be close to eighty times the annual output at the beginning of this period.

Table 4. USE OF CONSTRUCTION MATERIALS, COMPARISON OF MELBOURNE AND HOBART STATISTICAL DIVISIONS

	Melbourne Statistical Division	Hobart Statistical Division
1968		
Population	2 300 000	146 000
Crushed rock production (m^3)	7 000 000 (3.0)*	323 000 (2.2)
Sand production (m^3)	2 360 000 (1.0)	62 000 (0.42)
1971§		
Population	2 503 450	153 216
Crushed rock production (m^3)	9 339 532† (2.7)	594 800 (3.9)
Sand production (m^3)	3 954 316† (1.6)	69 368 (0.45)

*Figures in parentheses represent per capita consumption.
†Figures from 1971 Annual Report, Department of Mines, Victoria, adjusted for Melbourne Statistical Division, *i.e.* 70% of State total (Bowen, 1971).
§Year of last census.

The population of the Melbourne Statistical Division is approximately sixteen times that of Hobart, and in 1968 had a higher per capita consumption of quarry products. However, a comparable increase exists in the production of crushed stone and sand and in the 25 year period from 1973 crushed stone production is estimated to be 2 million cubic metres (3.4 times the production in 1973). During this period the output will be approximately 25 million cubic metres, or 47 times the output during 1973. These figures are calculated on the basis of a 5% growth rate, but if calculated on the production for the period 1963-1973 a 9% growth rate is indicated and the increase would thus be considerably higher. Predictions of production figures for a further

25 year period (1998-2023) are also given (tables 5 and 6), together with those of other quarry products.

Increases will occur both in population and per capita consumption, but it is not possible to determine at what stage the two rates will level out and hence the predictions made are strictly hypothetical. Other factors affecting production are the relative abundance of materials, trends in the use of materials and the state of the economy which significantly affects the demand for building materials.

The materials listed in Tables 6, 7, 8 and 9 are not all produced within the boundaries of the Hobart Quadrangle, but are processed and used there.

Localities for construction materials are shown in Figure 12.

Table 5. PER CAPITA CONSUMPTION OF CRUSHED ROCK AND SAND IN THE HOBART AREA

Year	Population Hobart Statistical Division	Crushed rock production (m^3)	Per capita consumption (m^3)	Sand production (m^3)	Per capita consumption (m^3)
1963	135 000	229 000	1.70	41 000	0.30
1964	137 000	209 000	1.53	45 000	0.33
1965	139 000	221 000	1.59	35 000	0.25
1966	141 000	232 000	1.64	52 000	0.37
1967	143 000	271 000	1.90	48 000	0.34
1968	146 000	323 000	2.21	62 000	0.42
1969	149 000	354 000	2.38	50 000	0.34
1970	151 000	454 000	3.01	68 000	0.45
1971	153 000	595 000	3.89	69 000	0.45
1972	155 000	482 000	3.11	54 000	0.35
1973	158 000	528 000	3.34	69 000	0.44
1998*	203 000	1 800 000	8.86	230 000	1.13
2023*	248 000	6 000 000	24.00	530 000	2.13

*Predictions assuming a per capita consumption annual growth rate of 7.0% for crushed rock and 3.9% for sand.

AGGREGATE

Crushed rock

This is quarried to a greater extent than any other product and is used in concrete manufacture, road-making (construction and bitumen sealing of pavements) and in concrete block manufacture. The materials used in order of importance are: dolerite, basalt, limestone and indurated sediments (table 7).

Dolerite. Current annual production is 400-500 thousand cubic metres. The requirements for the next 25 years are estimated to be 25-45 million cubic metres and for the following 25 year period the requirement will be 86-381 million cubic metres, depending on the growth rate. By the year 1998, the annual requirements are likely to be of the order of 1.8-4.5 million cubic metres and by the year 2023 60-381 million cubic metres. From an appraisal of 35 possible quarry sites in the Hobart area Leaman (1975*a*) concluded that only 5 sites warranted serious consideration.

They are shown on Figure 12 and designated:

Table 6. SUMMARY OF THE PRODUCTION OF QUARRY PRODUCTS IN THE HOBART AREA AND FUTURE PREDICTIONS

	Crushed Rock (m^3)		Sand (m^3)	Gravel (m^3)	Silica (t)	
Annual Growth Rate	5%	9%	5%	5%	5%	10%
Year						
1962	184 700		41 456	-	3351	
1973	527 700		69 368	125 000*	8488	
1998	1 800 000	4 500 000	230 000	420 000	30 000	90 000
1974-1998	25 000 000	45 000 000	3 300 000	5 700 000	400 000	830 000
2023	6 000 000	39 000 000	530 000	1 420 000	102 000	980 000
1999-2023	86 000 000	381 000 000	11 000 000	19 000 000	1 400 000	9 000 000
2048	20 000 000		1 800 000	4 800 000	350 000	
2024-2048	287 000 000		25 400 000	65 000 000	4 900 000	

*Estimate of actual production

These predictions have been calculated using the compound interest formula:

$$Pn = P(1 + r)^n$$

where r = growth rate
n = number of years
P = production in the base year
Pn = production in the year n

The total production (Sn) during any period is given by the formula:

$$Sn = P[(1 + r)^n - 1]/r$$

		Grid reference
A	Dromedary	EN115672
B	Bourbon Creek	EN285667
C	Risdon Brook	EN266622
D	Craigow	EN324595
E	Belbin Rivulet	EN330620

Leaman considered sites B and D to be the most suitable.

Dolerite covers almost half of the quadrangle and although it appears that a shortage of it for quarrying would be unlikely, Leaman's appraisal of available sites together with the projected requirements indicate that the industry should lose little time in securing adequate reserves and ensuring that the required areas of land are zoned accordingly by the planning authority.

Table 7. ANNUAL PRODUCTION OF CRUSHED ROCK IN THE HOBART AREA

Year	Basalt '000 m^3	Dolerite '000 m^3	Limestone '000 m^3	Other '000 m^3	Total '000 m^3
1962	15.9	145.0	16.3	7.5	184.7
1963	24.2	163.8	19.6	21.4	229.0
1964	16.8	152.6	11.8	27.5	208.7
1965	16.8	182.4	11.2	11.0	221.4
1966	17.1	201.2	9.6	4.6	232.5
1967	16.4	243.2	10.2	1.6	271.4
1968	11.8	289.0	13.6	9.1	323.5
1969	11.4	318.2	18.3	6.2	354.1
1970	22.4	331.5	23.9	76.8	454.6
1971	61.4	479.7	28.8	24.9	594.8
1972	76.1	385.9	3.6	16.6	482.2
1973	72.4	404.0	18.5	32.8	527.7
1974	97.3	285.3	16.1	3.7	402.4

At present the bulk of the production comes from Giblin Street (Hobart Quarries Ltd) and Flagstaff Gully (Pioneer Quarries Ltd), with lesser amounts from Mornington (C.R. Johnson) and Jackson Street (Glenorchy Quarries).

Basalt. There are no quarries currently producing basalt in the quadrangle, and there are no basalt flows large enough nor sufficiently well sited for exploitation. The thickest basalt flows are located in the Jordan Valley within the Brighton Quadrangle. The Bridgewater quarry (Hobart Quarries Ltd) lies 2 km to the north of the Hobart Quadrangle and at present produces approximately 100 000 m^3 annually, most of which is used in concrete production and road-making in Hobart.

Limestone. The current annual production of limestone in Hobart is 16 100 m^3, from Glenorchy (G.J. Weily). It is used for a variety of purposes including pavement material by local councils, as railway ballast and as back filling in cable trenches. It is a minor crushing product and output remains relatively steady.

Indurated sediments from dolerite contacts are sometimes used in pavement construction. The indurated zone seldom exceeds a few metres in width and large quantities are only obtainable where the dolerite-sedimentary contact is shallow dipping and exposed. The material was used in the construction of the Southern Outlet Road near Mt Nelson where indurated calcareous mudstone of the Cascades Group occurs. Induration is likely to be more

Table 8. ANNUAL PRODUCTION OF SAND IN THE HOBART AREA

Year	Sand (m^3)											Silica sand (t)
Producer	Atkinson	Churchill	Cure	Grubb	Harrison	Hobart Quarries	Johnson	Long	Males	Priest	Total	Lazenby
1963				5058	2 930			30 868	2 601		41 457	
1964		3978		6427			4337	24 327		5768	44 837	3418
1965				6427			6574	17 632	3 902		34 535	3590
1966							5606	39 362	6 541		51 509	3703
1967	5033							37 962	4 648		47 643	4998
1968	8200			4611				42 694	6 724		62 229	
1969	2004			4213				36 341	7 203		49 761	3652
1970				6027	9 218			43 506	8 970		67 721	6357
1971			2008	3177	25 094			29 222	9 876		69 377	5165
1972				1756	2 295	15 858	2046	22 457	9 914		54 326	9522
1973	3106					26 432	1961	25 270	12 599		69 368	8488
1974						21 545		20 768	2 488		44 801	

extensive in calcareous beds due to their chemical reactivity. The production is minor and likely to remain so.

Sand

Production figures for sand are given in Table 8, while estimates of future production are given in Table 6.

Actual production is higher than the recorded figure due to the large number of small operators who do not submit returns to the department. This also affects the estimates which are based on production returns.

The grading (grain size distribution) of most of the sand renders it unsuitable for use in the manufacture of concrete (Australian Standard A77-1957; fig. 13) without blending it with coarser material (usually crushed products). The recorded production is therefore not a true indication of the requirements.

There are three sources of sand in the Hobart area.

Triassic sandstone. This decomposes on weathering with leaching of contained clay leaving deposits of surface sand grading down into fat sand and eventually into unaltered sandstone. In some instances sand talus forms on the margins of such deposits if sufficiently elevated. The sand deposits at Boronia Hill, Kingston are of this type. Here *in situ* weathering deposits of sand occurs on the tops of hills and sand talus slopes occur on their flanks. The grading of this material is poor due to its derivation from well sorted sandstone.

The terms grading and sorting are self explanatory but are often confused. Grading is employed by engineers and soil scientists to denote grain size distribution. A well graded sand contains a large range of particle sizes which is desirable if the material is required to compact well with a minimum porosity. Sorting is a term employed by geologists and also denotes grain size distribution. A well sorted sand is one which contains a small range of particle sizes due to the sorting action of the sedimentary environment in which it was formed. The two terms are therefore opposite in meaning.

Tertiary-Quaternary sand overlies Tertiary silt and clay of the Coal River sequence in the area around Seven Mile Beach, Roches Beach, Sandford Peninsula and South Arm Peninsula. The maximum measured thickness was 13 m in the Calverts Lagoon area (one kilometre south of the quadrangle) and the total area covered is approximately 40-50 km^2. It has been estimated that there are approximately 410 million cubic metres of Tertiary sand in these areas (Threader, 1974), although much of it would be unavailable to industry due to zoning of the land for other purposes.

A small area of coarse sand at the eastern end of the South Arm-Sandford tie bar (Males sand pit, south of quadrangle) conforms to AS A77 and is used in concrete block manufacture. This sand was probably derived from the decomposition of Permian and Triassic sandstone in the Coal River valley. The grain size distribution is similar to that of the *in situ* weathered Triassic sand of Boronia Hill. This coarse sand deposit probably marks the course of an old stream, the material representing the load of a higher energy system. Deposits of this nature are more likely to occur as shoestring gravels and the finer sands as sheet deposits in alluvial plains. The age of the sand is not accurately known, although it is younger than the Tertiary clay of the Coal River valley which it overlies. Peaty layers which may indicate a Tertiary age are contained within it, but age determinations have not yet

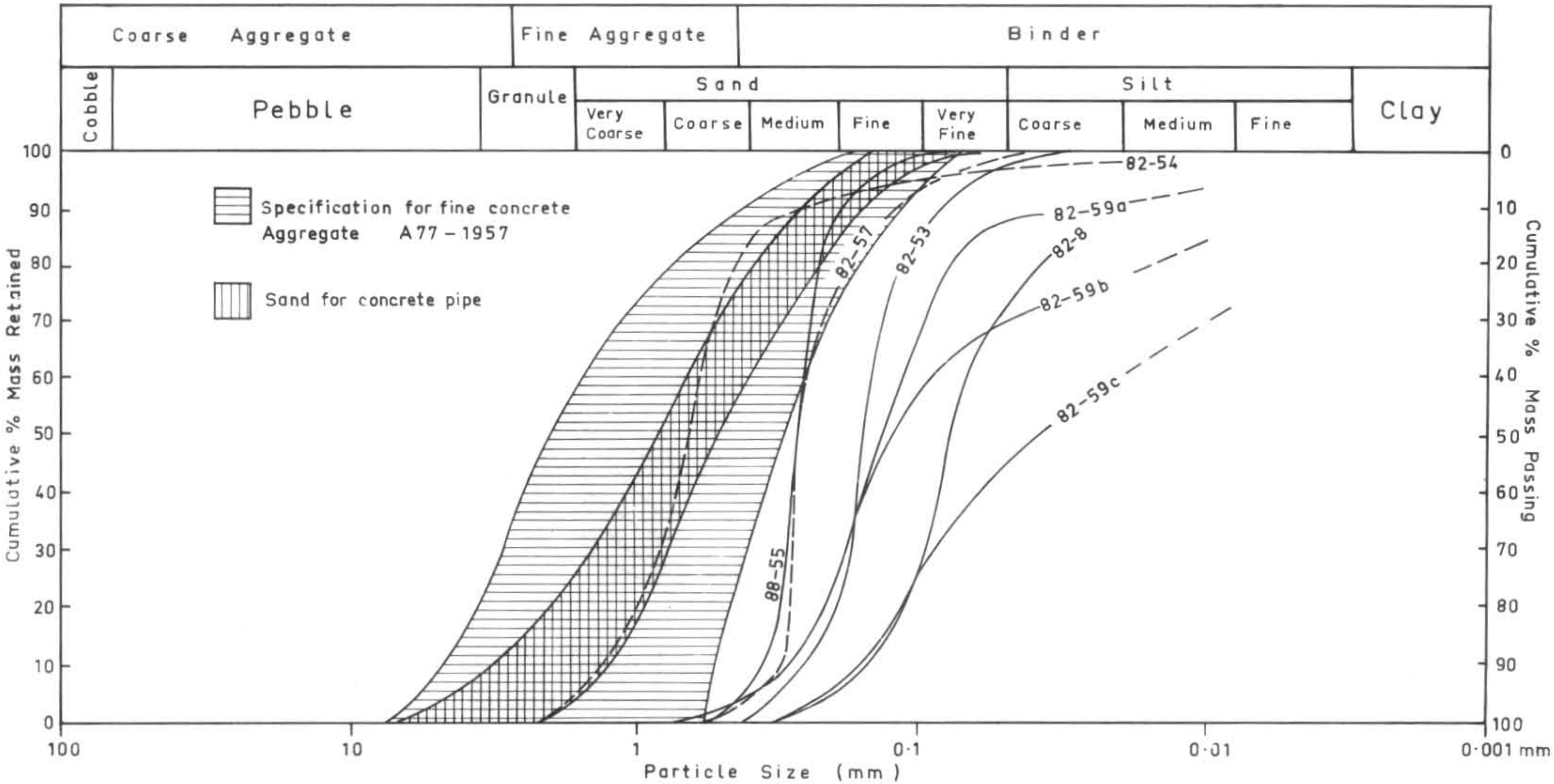


Figure 13. *Grain size distribution of sand suitable for use in the manufacture of concrete.*

5 cm

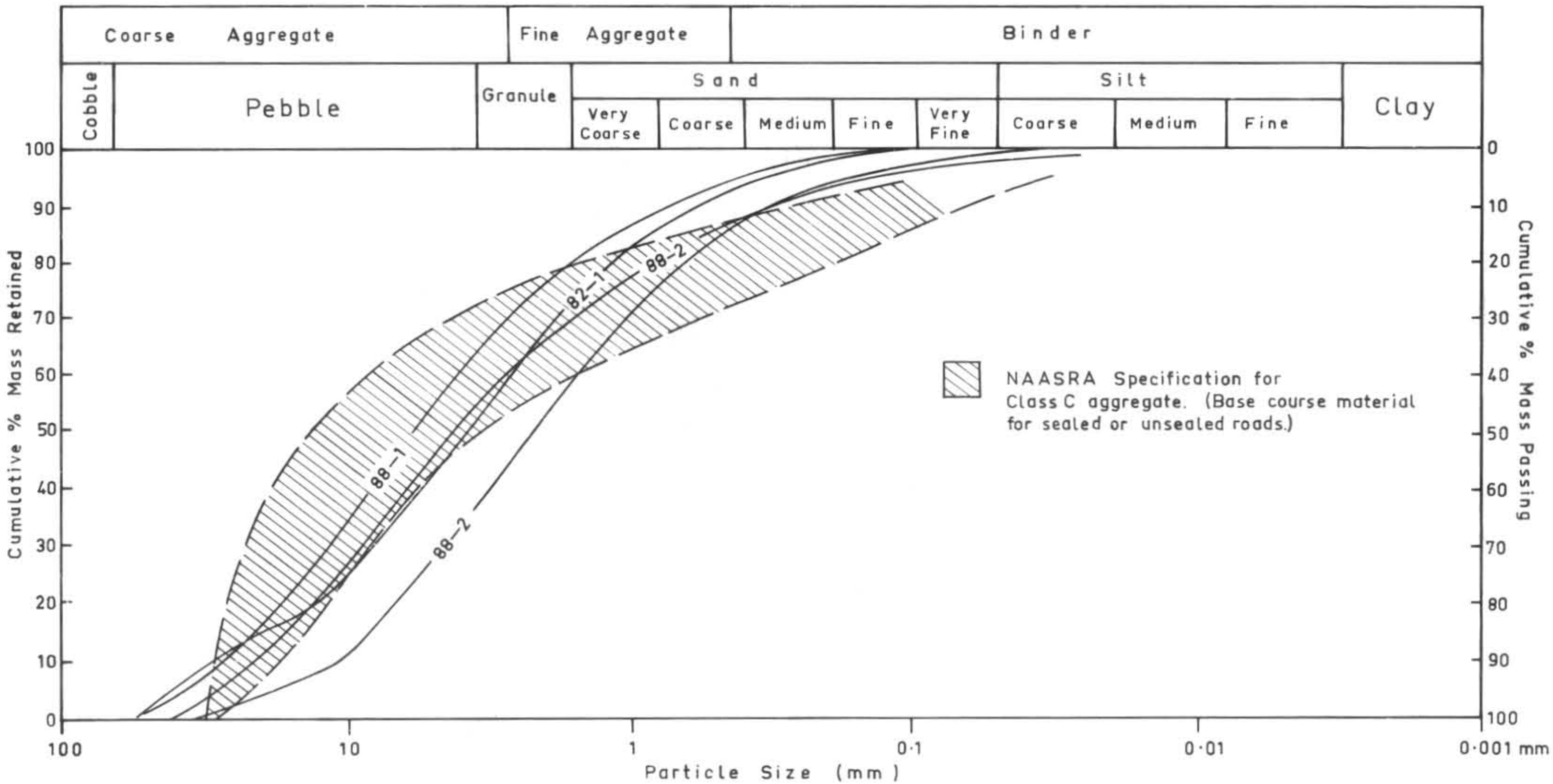


Figure 14. *Gradings of some gravels relative to NAASRA specification for Class C aggregate.*

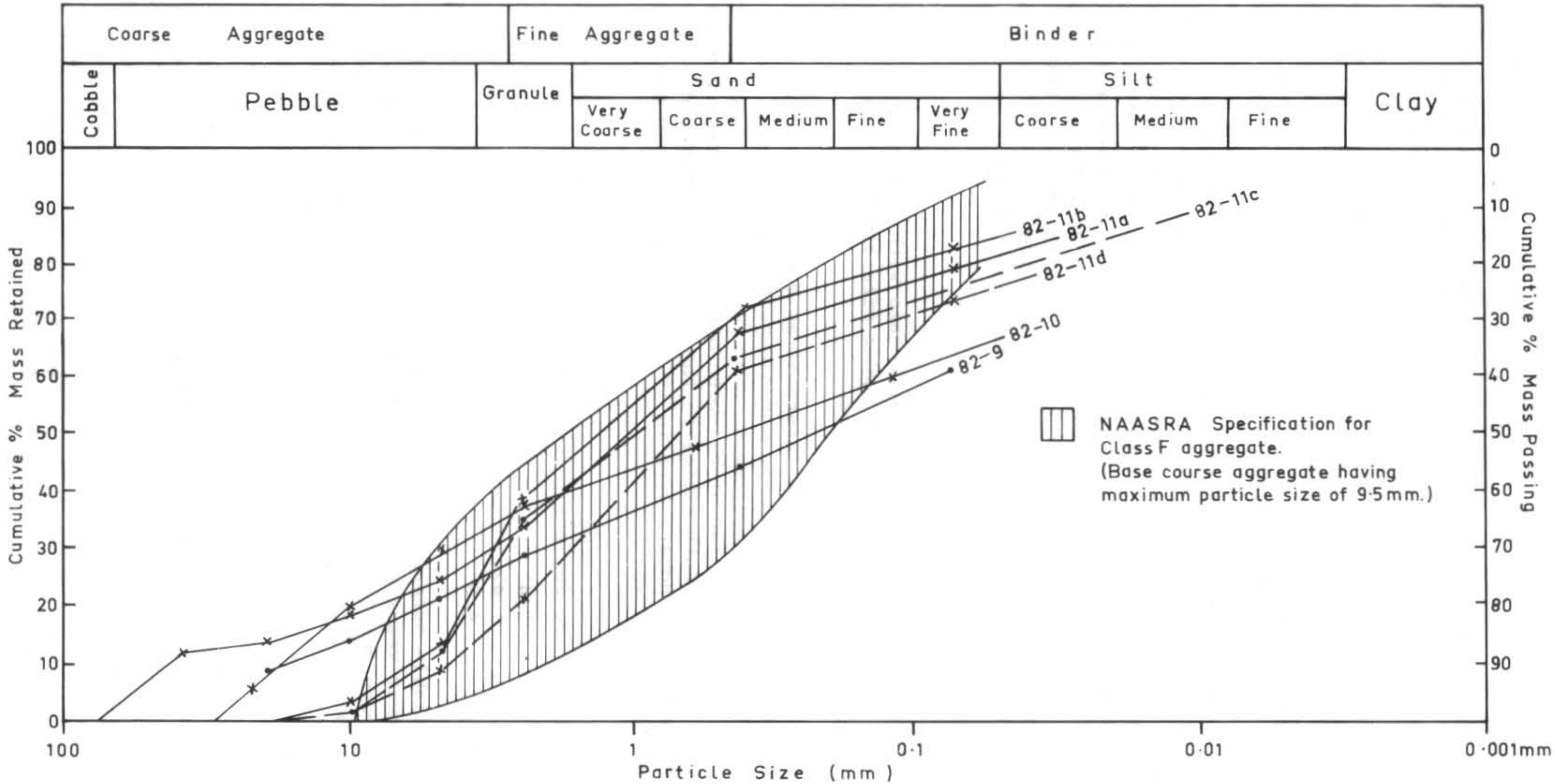


Figure 15. *Gradings of some gravels relative to NAASRA specification for Class F aggregate.*

been made. It occurs from 60 m above to 13 m below mean sea level, with the maximum thickness developed at the lower levels. Green (1961) suggested that the higher level deposits were windblown accumulations during periods of higher sea level which would suggest Pleistocene (post-Tertiary) dunes. This matter cannot be resolved until their absolute age is determined.

Dune sand. Threader (1974) estimated that dunes in the Sandford-South Arm area cover 5 km^2 and contain 49 million cubic metres of sand. The mining of dune sand is a controversial issue and there are sound reasons for protecting the frontal area of dune systems. This is ensured by a 100 m Crown reservation. Additional areas are protected from mining by zoning for other purposes and it is unlikely that more than one-third of the total reserves would be available for mining (approximately 6 million cubic metres). According to estimates already given this will be exhausted within 50-75 years, or sooner if the growth rate increases. There is therefore, an urgent need to find alternative materials or new sand deposits. The obvious alternative is to use crusher products from dolerite quarries to a greater extent than at present; this may prove to be very costly. As additional sand deposits are unlikely to be discovered on land in the Hobart area an offshore exploration programme should be carried out. Likely areas for search are Ralphs Bay, D'Entrecasteaux Channel, Storm Bay and Frederick Henry Bay.

Gravel

Gravel is defined as a natural aggregate with a minimum particle size of 4 mm. For production purposes the upper size limit is 76 mm and larger particles are screened out and crushed.

Production is difficult to determine as most of the gravel is supplied by small contractors to the Public Works Department and local councils, and records of production are unreliable. For the purpose of assessing future requirements, a 5% growth factor has been applied to the requirements estimated by the road-making authorities in the area. An estimated 125 000 m^3 of gravel was used in the Hobart area in 1973 and from this the projected requirements are as follows:

Year	*Requirement ('000 000 m^3)*	*Period*	*Total requirement ('000 000 m^3)*
1998	0.42	1974-1998	5.7
2023	1.42	1999-2023	19.0
2048	4.8	2024-2048	65.0

The available materials in the Hobart area are of poor quality and the trend over recent years has been to use aggregates prepared from crushed rock for pavement construction. If a good natural aggregate was available in the Hobart area then production of gravel would be much higher. Some gradings are shown in Figures 14 and 15. There are no quartz pebble gravels in the Hobart area and natural coarse aggregate is restricted to dolerite and indurated sediments.

Dolerite. The normal fine- to medium-grained tholeiitic dolerite decomposes on weathering to form clay mixtures which are too plastic for use as road-making aggregates. Dolerite of granophyric composition however forms a feldspathic grit on weathering which is frequently used for road-making purposes. Dolerite of this composition appears to be associated with intrusive centres. Known localities of granophyre in the Hobart Quadrangle are Johnson's quarry at Mornington and the Pioneer quarry at Flagstaff Gully. Other occurrences are most likely to be found in the vicinity of dolerite feeders or centres (Leaman, 1972*a*, fig. 11).

Dolerite boulder beds are common on the flanks of Mt Wellington (*e.g.* North West Bay River and Mountain River in the south-west of the quadrangle). They have been used locally for road construction.

Indurated sediments have already been discussed under crushed rock. It is sometimes necessary to blast and, or, crush these sediments to acceptable sizes for pavement construction. A layer of indurated mudstone has, in the past, been stripped from the underlying dolerite at Flagstaff Gully and crushed for use as a road aggregate. A deposit at Mt Nelson of indurated calcareous mudstone has already been discussed. Talus slopes of indurated siltstone have developed in some areas, notably on the eastern shore of the River Derwent in the Mornington, Barilla Rivulet and Risdon areas. This material is of periglacial origin and is found on lower slopes and 'alluvial' fans (Threader, 1973). It has also been used extensively for road-making and for gravel paths and driveways. It has a high fines content and is not a suitable material for main roads.

Other materials. A variety of sedimentary and igneous rocks have occasionally been used for road-making (using lime or cement stabilisation) throughout Tasmania, especially in the south where good natural aggregate is scarce. The results are not satisfactory however, and there is an increasing trend towards the use of crushed aggregates that are prepared by the larger quarries to meet AS A77. Exploration for offshore gravel deposits may offer an alternative solution. It may be possible to locate deposits which would satisfy both fine and coarse aggregate requirements, and if found outside the intertidal zone their exploitation would be unlikely to cause coastal erosion. Exploration and environmental impact study is considered to be important if the future needs of the construction industries are to be met in the Hobart area.

BUILDING STONE

The three main types of potential building stone within the quadrangle are Permian limestone, Triassic sandstone and dolerite.

Permian limestone

Permian limestone crops out over a distance of 24 km from Glenorchy to Mt Dromedary. The limestone was once burnt to produce agricultural lime, but is now only quarried as a crushed aggregate (*q.v.*). The limestone may be quarried in large blocks, has a high crushing strength and would be suitable either as a structural unit or facing stone. Reserves of this stone are large and accessible, and numerous disused quarries exist along the River Derwent between Granton and New Norfolk.

Triassic sandstone

Triassic sandstone has been used for building since the early days of European settlement. It occurs throughout the Triassic succession; siliceous sandstone is mainly confined to the lower part and lithic feldspathic sandstone is more common. The deposition of oxides of iron in the sandstone by groundwater has acted as a bonding and therefore strengthening agent in the stone and has also led to the formation of attractive banding patterns. When iron oxides appear to be absent the rock is noticably weaker and more friable. In the past, sandstone has been quarried wherever it was required or was exposed and as a result some poor quality stone has been used. There has been little use of Triassic sandstone for building since the early colonial days until recent years except for purposes such as paving and walling. Etna Stone Ltd commenced marketing cut stone for building in 1969 and their current annual production is approximately 500 m^3. Testing of Triassic sandstone by the Public Works Department has shown a compressive strength which is comparable with other building materials.

Material	*Compressive strength (MPa)*	*Source*
Triassic sandstone (Etna Stone)*	20-28	P.W.D. tests
Concrete (4:2:1/28 day cured)	21-28	BS CP114 1969
Clay brick	36	Average Tas. pdn 1973 Brick Report
Concrete block	4-20	AS 1500 1974

Other tests

Density	2140-2480 kg/m^3
Water absorption	3.84-6.53%
20-cycle wetting and drying test	0.19-0.69% loss by mass
6-cycle accelerated wetting and drying test using magnesium sulphate solution	31.6-66.4% loss by mass

*The white sandstone is generally inferior to yellow sandstone, although a greater range of tests on more samples is needed for a thorough evaluation.

Dolerite

There is a demand in Australian and world markets for 'black granite', by which is meant a dense, coarse-grained igneous rock. Granophyric varieties of dolerite occur in various parts of the Hobart Quadrangle and would be likely to satisfy the market, provided the rock could be quarried in large enough blocks. Fine-grained black dolerite also occurs and would be suitable for use as a building stone. Both varieties however, are only local variants of normal tholeiitic dolerite, and new sources may therefore be difficult to locate. Granophyre occurs near feeder centres and the fine-grained variety near dolerite contacts. Jointing is prevalent in most quarries and the dolerite extracted is often limited to small blocks. Jointing also provides access for groundwater and hence weathering and staining by iron oxides occurs to considerable depths.

CLAY

A downward trend has occurred in the production of clay during the period 1958-1974 (tables 9, 10). Part of this decrease is due to a change in the method of production from pressed (solid) bricks to extruded bricks which require 12.4% less clay in their manufacture. The actual decrease in brick production from 1958 to 1974 was 26.4%. Competition from imported bricks and from alternative building materials, and also more recently environmental considerations have restricted expansion of the industry. In 1958 three brick manufacturers were producing 6.2, 5.3 and 3.2 million bricks per year. The two smaller brick makers have since ceased production and the larger producer (Hobart Brick Company) has a current output of approximately 11 million bricks. Recent plant expansion has enabled an expanded annual capacity of over 20 million bricks and therefore an increase in clay production may occur in the ensuing years.

All the clay utilised in brick manufacture (table 9) is derived from weathered Triassic mudstone, most of which is obtained from outside the boundaries of the Hobart Quadrangle. Small deposits of Tertiary clay have been worked at Forcett, Kingston and Hamilton. Permian beds in the Hobart area are usually too siliceous for use as a ceramic material.

Table 9. ANNUAL PRODUCTION OF CLAY IN THE HOBART AREA ('000 m^3)

Year	Producer											
	Bones, Kingston	Crisp & Gunn, Knocklofty	Fenton, Kingston	Grierson, Forcett	Hazell, Margate	Hobart Brick Co., Austins Ferry, New Town	Humes Ltd, Austins Ferry	Humes Ltd, Hamilton	Kings Bay Contractors, Kingston	Noonan, Forcett	Wells, Electrona	Total
1958		16				19	10					45
1959		20				14	12					46
1960		19				14	12					45
1961		14				15	11					40
1962		12				8	9	0	4			33
1963		13				8	9	2	5			37
1964		13			4	9	9	1	13			49
1965		7	3		4	8	9	2	9		1	43
1966			4		8	8	10	1			4	35
1967			3		11	8	11	3			3	39
1968			6		12	7	9				2	36
1969			4		11	6	10				6	37
1970	1		4		17	7	2			2		33
1971	4				15	6				3		28
1972	3			2	13	8	4			3		33
1973				5	13	10	3					31
1974				4	13	9	3					29
Total												639

Table 10. CLAY PRODUCTION IN THE HOBART AREA, 1958-1974

	1958	1974	% Decrease
Clay production (m^3)	45 000	29 000	35.6
Clay used per 1000 bricks (m^3)	3.06	2.68	12.4
Brick production x10^6 (calculated)	14.7	10.8	26.4

Triassic mudstone

Two lithological associations are recognised in the Hobart area and consist of an upper sequence of lithic sandstone and mudstone and a lower sequence of siliceous sandstone and mudstone (Leaman, 1972*a*). The system is entirely of freshwater origin. Sediments from both associations have yielded brick-making materials, but in general the upper association contains thicker sandstone units as at Austins Ferry (fig. 12, C1), Tunnel Hill (C4) and Giblin Street, Lenah Valley (C8).

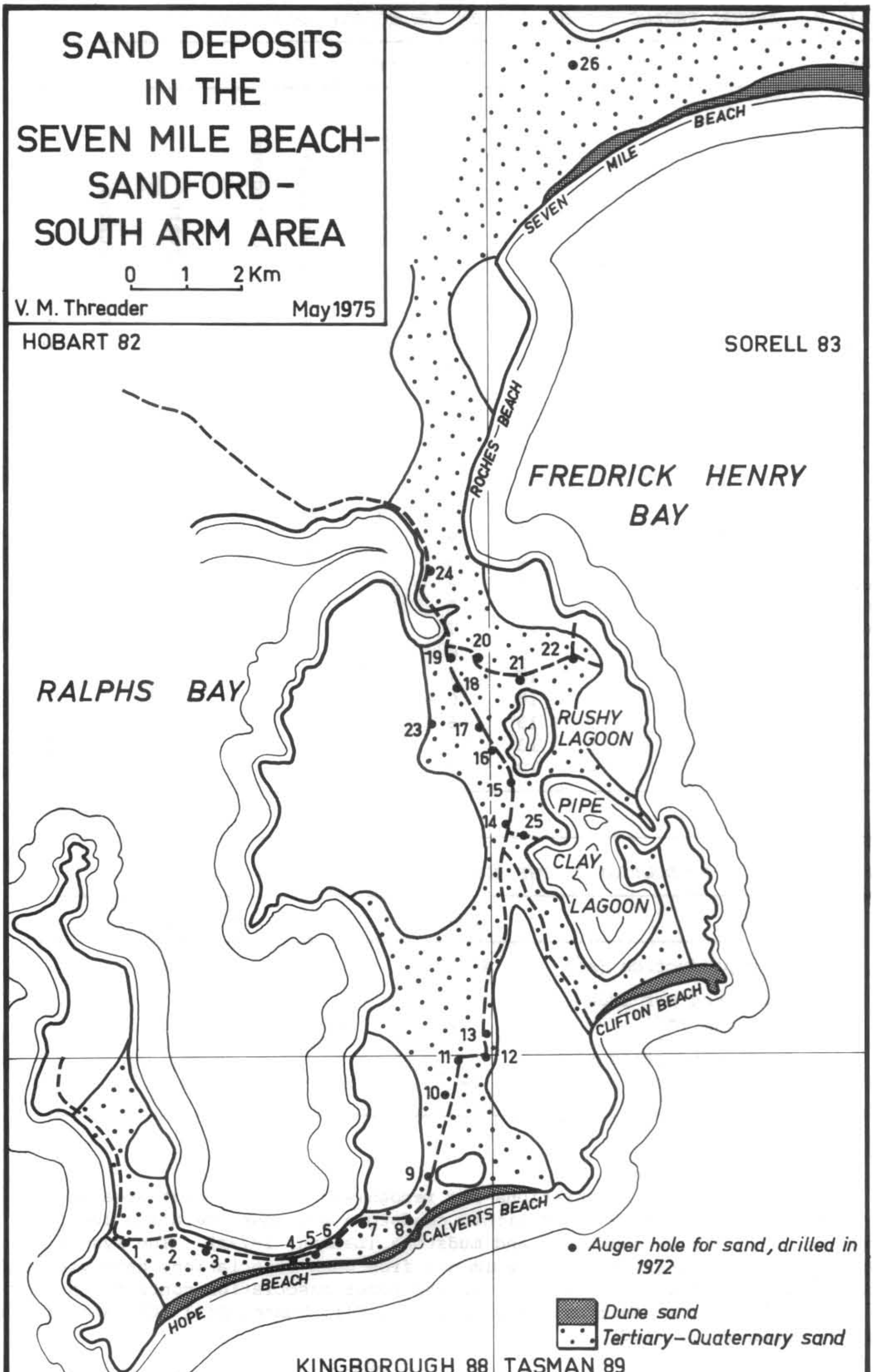


Figure 16.

5 cm

The expanding urbanisation around Hobart has made it difficult to secure reserves of this material within an economic distance of the New Town plant. An area of land should be reserved as a future brick-making site and the north-west flank of the Mt Direction-Gunners Quoin Block is suggested as being sufficiently far from urban development and reasonably close to the factory. This distance would be of the order of 10 km if a second Derwent bridge is constructed.

Tertiary clay

Non-marine sand and clay has been deposited in fault-drainage-erosion troughs in the Coal and Derwent Valleys (Leaman, 1972*a*), and thicknesses of up to 205 m have been recorded. A scout augering programme in the Cambridge-Richmond-Sorell triangle proved more than 12 m of clay near Cambridge and more than 15 m near Richmond. Clay of unknown thickness occurs in the South Arm-Sandford area, but the results of ceramic tests were variable and generally unsatisfactory (table 11, fig. 16). The boring programme was carried out by 'Gemco' auger during prospecting work for sand deposits and samples may possibly have been contaminated by sand. A re-examination of the area for clay using more refined drilling, sampling and laboratory procedures should be considered. The Tertiary pipeclay used by Humes Ltd is extracted from pits at Hamilton in the Derwent Valley, outside the quadrangle. Tertiary clay deposits near Maranoa Road, Kingston have been worked from pits and shafts (Blake, 1927), but this is now a residential area and the material is no longer available. The white clay deposits at Spring Farm, Kingston [234413] were originally considered to be of Triassic age, but are in part at least, a Tertiary sediment derived from Triassic and probably Permian beds Some of this clay is still being extracted from a neighbouring pit owned by the Hobart Brick Company.

Table 11. SUMMARY OF BORE HOLE DATA, SANDFORD-SOUTH ARM AREA

BH No.	Depth (m)	Average mean grain size (mm)	Description	<0.075 mm grain size content (%)	<0.02 mm grain size content (%)	Pressed brick fired at 1000°C
1	0-8.23	0.14	Very fine sand	54.0	-	-
2	0-8.23	0.14	Very fine sand	50.2	-	-
	8.23-9.15	0.05	Silt	79.3	-	-
3	0-12.81	0.15	Very fine sand	37.7	-	-
	12.81-14.33	0.08	Silt	66.7	-	-
4	0.91-2.74	0.22	Fine sand	32.3	-	-
	2.74-5.49	0.47	Medium sand	10.0	-	-
	5.49-12.81	0.27	Fine sand	19.4	-	-
	12.81-13.72	0.09	Silt	65.4	-	-
5	0-8.23	0.19	Fine sand	25.0		
6	0-2.74	0.25	Fine sand	22.4	-	-
	2.74-8.23	0.16	Very fine sand	49.0	-	-
	8.23-9.15	0.04	Silt	74.1	-	-
7	0-2.74	0.63	Coarse sand	6.1	-	-
	2.74-5.49	0.29	Medium-fine sand	21.7	-	-

Table 11. (continued)

BH No.	Depth (m)	Average mean grain size (mm)	Description	<0.075 mm grain size content (%)	<0.02 mm grain size content (%)	Pressed brick fired at 1000°C
7	5.49-10.06	0.18	Very fine sand	35.0	-	-
	10.06-10.98	0.09	Silt	72.5	-	-
8	0-1.83	-	Very fine sand	-	21.5	-
	1.83-8.23	-	Silt/clay mixture	-	46.7	Bonded
	8.23-10.06	-	Silt/clay mixture	-	43.5	No bond
	10.06-14.33	-	Silt/clay mixture	-	41.8	No bond
9	0-11.89	0.16	Very fine sand	29.5	-	-
10, 11	Permian sediments			-	-	-
12*	0-3.35	-		-	54.5	Bonded
13*	Permian sediments			-	-	-
14	0-7.93	0.14	Very fine sand	49.2	-	-
15	Permian sediments			-	-	-
16*	0-9.15	-	Silt/clay mixture		56.0	No bond
17*	0-2.74	-	Very fine sand	-	12.0	-
	2.74-8.23	-	Silt/clay mixture	-	57.0	No bond
18*	0-4.57	-	Silt/clay mixture	-	49.6	No bond
	4.57-10.98	-	Silt/clay mixture	-	37.4	No bond
19*	0-7.32	-	Very fine sand	-	17.5	-
	7.32-16.47	-	Very fine sand	-	23.5	-
20*	0-3.66	-	Silt/clay mixture	-	69.34	No bond
	3.66-7.32	-	Silt/clay mixture	-	68.25	No bond
21	0-2.74	-	Silt/clay mixture	-	43.67	No bond
	2.74-4.57	-	Silt/clay mixture	-	80.34	No bond
	4.57-11.89	-	Silt/clay mixture	-	80.17	No bond
	11.89-15.55	-	Silt/clay mixture	-	80.75	No bond

Table 11. (continued)

BH No.	Depth (m)	Average mean grain size (mm)	Description	<0.075 mm grain size content (%)	<0.02 mm grain size content (%)	Pressed brick fired at 1000°C
21	15.55-16.47		Very fine sand	-	18.0	-
22	0-8.23	0.17	Very fine sand	27.5	-	-
	8.23-14.64	-		-	43.8	No bond
23*	0-2.74	-	Silt/clay mixture	-	40.67	No bond
	2.74-7.32	-	Silt/clay mixture	-	69.2	No bond
	7.32-10.98	-	Silt/clay mixture	-	46.3	Bonded
	10.98-14.03	-	Silt/clay mixture	-	32.67	No bond
24*	0-8.23	0.14	Very fine sand	57.2	-	-
	8.23-10.98	0.05	Silt	73.5	-	-
25	0-6.40	-	Very fine sand	-	18.5	-
	6.40-10.06	-	Silt/clay mixture	-	52.75	Bonded
	10.06-12.81	-	Silt/clay mixture	-	48.67	Bonded
	12.81-16.47	-	Silt/clay mixture	-	24.50	Bonded
26	0-3.66	0.21	Fine sand	-	-	-
	3.66-9.15	0.14	Very fine sand	-	-	-

*Bore holes within the Hobart Quadrangle.

Notes

Sand samples were screened and the clay samples were subjected to a 0.02 mm sedimentation test. Material containing 50% or more of <0.02 mm particles was tested as a possible ceramic material. From the above results it appears to be an unsatisfactory test as some material (bore holes 12, 16, 20, 21 and 23) contained a relatively high <0.02 mm fraction and did not bond on firing at 1000°C, whereas other material (bore holes 8, 23 and 25) containing relatively low <0.02 mm fractions did bond.

The use of a finer particle size would be more suitable in distinguishing ceramic materials as the <0.02 mm fraction contains a high proportion of free silica. The obvious choice would be <2 µm which is the generally accepted upper limit for clay particles.

COAL

Four thin seams of Triassic coal were worked at New Town for approximately 10 years in the latter part of the last century. An estimated twelve collieries produced 50 000 t during this period. The seams ranged in thickness up to 0.76 m and were worked from shafts, although the first workings were presumably adits from outcrops on hillsides. All workings are now inaccessible. The coal is a bituminous steam raising coal but is in part semi-anthracitic due to metamorphism.

The quantity present is estimated to be approximately 900 000 t (Hills *et al.*, 1922).

GEMSTONES

Common opal has been recorded from Upper Permian beds on the shores of the River Derwent at Shag Bay and from the Tertiary volcanic rocks at Cornelian Bay and Sandy Bay.

Wood opal (silicified wood) is common in areas where volcanic lava has flowed over vegetation and may be found at Cornelian Bay and Rose Bay.

Chalcedony (cryptocrystalline silica) is often associated with Tertiary volcanism and possibly also occurs at dolerite contacts. Varieties of chalcedony have been recorded at Rose Bay and Cornelian Bay.

These occurrences are only of interest to students and collectors.

LIMESTONE

Permian limestone is plentiful in the Hobart region particularly in the Glenorchy-Granton area. The composition range of 39 samples taken from Mt Nassau (Hughes, 1957) is as follows:

	%
SiO_2	15.6-59.5
Fe_2O_3	0.4- 3.1
Al_2O_3	1.3-11.7
CaO	10.7-45.0
MgO	0.5- 1.2
Loss on ignition	10.4-35.1

Its use as a coarse aggregate and as a possible building stone has already been discussed (pp.70, 77).

It was once used as a source of lime, but it has not been worked for this purpose for many years.

SILICA SAND

Fine white Tertiary-Quaternary sand was formerly won from numerous pits on the Sandford Peninsula, but is now only worked on Lazenby's [403402] property and is used exclusively in the glass-making industry. This material has already been discussed as a sand for construction purposes. However, it is somewhat finer than dune sand and consequently is no longer used. This sand and the dune sand which overlies it have been the subject of an earlier report (Threader, 1974). Annual production is currently between 8000 and 9000 t. The total volume of this material is estimated to be 410 million cubic metres although the actual amount available for mining is less than one-quarter of this figure due to the problems of access and other associated factors. At the present rates of usage, the total consumption in the next 75 years will be less than 5 million cubic metres, and hence reserves are considered adequate.

Table 12. KEY TO CONSTRUCTION MATERIALS LOCALITY MAP FOR HOBART QUADRANGLE

No.	Grid reference	Locality	Rock unit	Use	Reference
Coarse aggregate					
1*	220446	Summerleas Rd, Kingston	Dolerite	Road-making	C.M.R.†
2*	260426	Proctors Rd, Kingston	Dolerite	Road-making	C.M.R.
3	310648	Downham, Grasstree Hill Rd	Permian	Road-making	C.M.R.
4*	240650	Fouché, Old Beach	Dolerite	Road-making	C.M.R.
5	250489	Bains, Proctors Rd	Metamorphosed calcareous Permian beds	Road-making	C.M.R.
6	252448	Fenton, Kingston	Decomposed dolerite	Road-making	C.M.R.
7*	260432	Proctors Rd, Kingston	Dolerite	Road-making	C.M.R.
8*	034630	Glenora Rd, New Norfolk	Quaternary river wash	Road-making	C.M.R.
9	101625	Sorell Ck, Molesworth Rd	Dolerite	Road-making	C.M.R.
10*	091618	Molesworth Rd, New Norfolk	Permian siltstone	Road-making	C.M.R.
11*	054587	Clark, Lachlan Rd	Dolerite	Road-making	C.M.R.
12	347572	Barilla Rivulet, Cambridge	Permian siltstone	Road-making	C.M.R.
13	378493	Stanfield Hill, Rokeby Rd	Dolerite	Road-making	C.M.R.
14	352567	Old Cambridge Road	Permian siltstone	Road-making	C.M.R.
15*	337542	Johnson, Mornington	Dolerite	Road-making	C.M.R.
16	274597	Shones Corner, Grasstree Hill Rd	Dolerite	Road-making	C.M.R.
17*	205617	Dalgety St, Claremont	Metamorphosed Triassic sandstone	Road-making	C.M.R.
18	252574	Russell Rd, Lutana	Dolerite	Road-making	C.M.R.
19	345467	Droughty Point Rd, Rokeby	Dolerite	Road-making	C.M.R.
20	349473				
21*	198553	Glenorchy Quarries, Jackson St	Dolerite	Crushed aggregate	C.M.R.
22*	208544	Weily, Glenorchy	Limestone	Crushed aggregate	C.M.R.
23*	237526	Hobart Quarries, Giblin St	Dolerite	Crushed aggregate	Leaman, 1974
24*	306574	Pioneer Quarry, Flagstaff Gully	Dolerite	Crushed aggregate	Threader, 1968*a*
Building stone					
BS1*	264425	Kingston Stone, Kingston	Triassic sandstone	Paving and walling	Blake, 1958
BS2*	102584	Pontville Freestone, Molesworth	Triassic sandstone	Paving and walling	C.M.R.
BS3	299638	Plumstead, Grasstree Hill	Triassic sandstone	Paving and walling	C.M.R.

Table 12. (continued)

No.	Grid reference	Locality	Rock unit	Use	Reference
Sand					
S1	405464	Forest Hill Rd, Sandford (disused sand pits)	Tertiary-Quaternary sand	Building (poor) and moulding sand	C.M.R.†
S2	376567	Acton Road, Lauderdale (disused sand pits)	Tertiary-Quaternary sand	Building (poor) and moulding sand	C.M.R.
S3	390520	Acton Road, Lauderdale (disused sand pits)	Tertiary-Quaternary sand	Building (poor) and moulding sand	C.M.R.
S4*	403402	Lazenby, Sandford	Tertiary-Quaternary sand	Silica sand for glass manufacture	Threader, 1974
S5	224641	E. bank Derwent R., Old Beach Rd	Quaternary-Recent river silt	Silica sand for glass manufacture	C.M.R.
S6	248397	Pearsall, Boronia Hill, Kingston	Weathered Triassic sandstone	Building sand	Threader, 1965*a*
S7*	257403	Quinn, Boronia Hill, Kingston	Weathered Triassic sandstone	Building sand	C.M.R.
S8	110654	E. bank Derwent R., Boyer	Quaternary-Recent river silt	Moulding sand	Threader, 1968*b*
S9	100420	Dip Road, Grove	Weathered Triassic sandstone	Building	C.M.R.
S10	396480	Lauderdale BH 24, 'Gemco' hole	Tertiary-Quaternary		Threader, 1974
Clay					
C1*	202646	Hobart Brick Co., Austins Ferry	Triassic mudstone	Brick§	Hughes, 1959 and 1960
C2	181620	Woolnough, Claremont	Permian siltstone	Brick§ (not tried)	Blake, 1961*a*
C3	246522	Crisp & Gunn, Mt Knocklofty	Triassic mudstone	Brick§	Blake, 1960
C4	347549	Hobart Brick Co., Mt Rumney	Triassic mudstone	Brick§	Hughes and Blake, 1959
C5	247412	Maranoa Rd, Kingston	Tertiary clay	Brick§	Blake, 1927
C6	248406				
C7*	235402	Spring Farm, Kingston	Tertiary clay	Brick§	Threader, 1971*b*
C8	238544	Hobart Brick Co., New Town	Triassic mudstone	Brick§	Hughes, 1950
C9	248443	Fenton, Kingston	Triassic mudstone	Brick§	Threader, 1965*b*

Table 12. (continued)

No.	Grid reference	Locality	Rock unit	Use	Reference
Clay					
C10	237429	'Bowenwood', Kingston	Triassic mudstone	Brick§	Blake, 1961*b* Longman, 1962
C11	409390	BH 12			
C12	406450	BH 16			
C13	404455	BH 17 } South Arm-Sandford drilling (1972)	Tertiary sand and clay	Brick (see table 11)	Threader, 1974
C14	402460	BH 18			
C15	406466	BH 20			
C16	395455	BH 23			
C17	376577	BH 39			
C18	360570	BH 66 } Cambridge-Richmond-Sorell drilling (1968)	Tertiary clay	Brick	C.M.R.
C19	338643	BH 69			
C20	338651	BH 70			

*Currently in production
†Construction Materials Register (unpubl.), Tasmania Department of Mines
§See Table 9.

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GROUNDWATER

Groundwater is in little demand over much of the area covered by the Hobart Quadrangle as the population is essentially urban and served by reticulated supplies.

Detailed information on the groundwater resources of the rural area east of Mt Rumney, Craigow and Grasstree Hill is given by Leaman (1971*b*).

A few water bores have been put down in the rural areas around Old Beach, South Arm and south of New Norfolk (appendix 1, tables 13-15).

The New Norfolk-Lachlan area is served in part by a reticulated supply and there are also reliable surface water supplies. Good quality groundwater supplies could be obtained in any part of the region where the topography is gentle, irrespective of rock type. All groundwater in the region with the exception of the large alluvial flat south of Lachlan, is contained in fractured Permian rocks and dolerite, and yields of 75-150 *l*/min would be anticipated. Around Lachlan a number of small springs indicate that the water table is relatively flat.

Some water bores have been drilled in the South Arm Peninsula. The water recovered has been of relatively poor quality (1000 ppm T.D.S.) possibly due to a higher evaporation rate and a subsequent heavier concentration of salts in the soil. In addition salt spray has been observed over much of the area on windy days and this would further increase the salt content. Good sites for bores occur over much of South Arm, however dip slope conditions determine that they should be at a low elevation. Past yields have been less than 40 *l*/min which may be due to drilling techniques. Much water could be recovered from the windblown sands (see also Leaman, 1972*c*), although nearly all bores have tapped the fractured Permian siltstone.

At Old Beach some bores have been drilled in Triassic rock and one in dolerite which yielded 50 *l*/min of good quality water. The Triassic rocks in this area have not yielded reliable supplies due to the cable-tool drilling technique which caused sealing in rocks with a high mudstone and shale content. With hole cleaning or hammer drilling such problems should be avoided, but water quality would rarely be better than 1500-2000 ppm T.D.S.

ENGINEERING GEOLOGY

The engineering geology of the Hobart district is relatively straightforward in terms of the small number of rock types. However each has distinctive weathering and structural properties and the situation can be complicated by the patchwork nature of the geology.

The depth of soil cover is generally less than one metre on Permian rocks and dolerite and less than 3 m on Triassic rock, each of which can provide solid foundations. The Triassic rocks normally show some weathering effect to at least 5 or 6 m, whilst the other rock types are fresh at shallow depth in most cases. The Tertiary rocks require special consideration as compaction can occur under load.

All sites for major constructions whether bridges, cuttings, or buildings should be closely examined geophysically and geologically to determine rock properties, hidden faults and other features. Hidden faults were located on the site of the State Library and Rosny Matriculation College (Longman, 1966; Leaman, 1972*b*) and allowances were then made in building design.

Complete details of engineering-rock properties and aspects of interest to site investigation are presented in the Hobart Engineering Geology Map Series (Leaman, 1971*a*). These maps, at scales of 1:25 000 and 1:10 000, are not intended to replace site investigations but rather to guide such investigations, permit more comprehensive correlation of available data and allow prediction of engineering problems.

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APPENDIX 1

Groundwater Bore Holes

The information contained in Tables 13-15 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.

Table 13. SOUTH ARM-ROKEBY WATER BORE HOLES

Owner	Date drilled	AMG reference	Depth water struck (m)	Total depth (m)	Yield *l*/min	T.D.S. (ppm)	Altitude (m)	Drillers' log (m)
K. Chancellor	12.9.1956		22	25	22.8	-	-	0-21 clay, 21-22 shale, 22-25 weathered mudstone
A. Wicks	7.12.1960		10	45	6.2	'salty'	32	0-1 soil, 1-10 clay and mudstone pebbles, 10-18 sand, 18-45 clay and mudstone pebbles
H. Manson	26.6.1963	354511	18	38	4.7	4117*	32	0-1 clay and gravel, 1-38 mudstone and sandstone
G. Cripps	14.7.1963		14	16	14.0	8400		0-1.5 soil, 1.5-15 sandy clay, 15-16 mudstone
V. Wheeler	26.10.1963		14	18	4.2	-	18	0-2 soil, 2-10 sand, 10-14 clay, 14-16 mudstone, 16-18 sand
G. Griffiths	29.10.1963		14	14	2.3	'salty'	14	0-1 soil, 1-14 sandy clay, 14 mudstone
J. Heywood	16.12.1963	342540	-	19	-	-	68	0-10 clay and gravel, 10-18 mudstone, 18-19 dolerite

Table 13. (continued)

Owner	Date drilled	AMG reference	Depth water struck (m)	Total depth (m)	Yield *l*/min	T.D.S. (ppm)	Altitude	Drillers' log (m)
M. Dennett	21.10.1965		-	21	-	-	-	0-1 clay, 1-21 mudstone
G. Morrisby	22.10.1965		-	11	-	-	-	0-11 clay

		ppm		*ppm*
*Analysis:	CO_3	325	Mg	252.0
	Cl	1906	Fe + Al	1.2
	SO_4	1306	Na	1013.0
	SiO_2	48.4	T.D.S.	4117
	Ca	123.8	Total ions	3774

Table 14. OLD BEACH WATER BORE HOLES

Owner	Date drilled	AMG reference	Depth water struck (m)	Total depth (m)	Yield *l*/min	Drillers' log (m)
F. Fouche	18.8.1948	224637	48	57	15	0-1 clay, 1-57 sandstone
	3.9.1948	219638	27	39	15	0-1.5 clay, 1.5-3 weathered sandstone, 3-39 sandstone.
	18.10.1948	228639	18	90	3	0-1.5 clay, 1.5-2 pug and boulders, 2-6 sandstone, 6-11 mudstone, 11-15 sandstone, 15-20 mudstone, 20-24 sandstone, 24-26 mudstone, 26-35 sandstone, 35-90 shale
H. Jones & Co.	18.9.1964*		11	12	4	0-1 soil, 1-12 dolerite
	18.9.1964*		18	24	15	0-5 soil, 5-6 dolerite boulders, 6-24 sandstone.
	22.10.1964*	255595	20	23	25	0-2 soil, 2-23 sandstone
	25.11.1964*		-	33	-	0-1 soil and clay, 1-18 sandstone, 18-33 shale
	18.12.1964*		-	42	-	0-2 soil and clay, 2-42 mudstone and clay

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

Table 15. NEW NORFOLK-MAGRA WATER BORE HOLES

Owner	Date drilled	AMG reference	Depth water struck (m)	Total depth (m)	Yield *l*/min	Drillers' log (m)
P. Harper	31.10.1962	054617	-	10	-	0-3 ferruginous sandstone, 3-8 mudstone, 8-10 limestone
L. Lisner	13.11.1962		20	23	23	0-1.5 soil, 1.5-3 dolerite boulders, 3-5 sandstone, 5-23 mudstone
R. Graham	7.3.1963		4	6	37	0-0.5 soil, 0.5-2 clay, 2-4 mudstone(?), 4-6 boulders of dolerite.
T. Pearcey	6.11.1965		18	20	30	0-0.5 soil, 0.5-4 clay, 4-6 sandstone, 6-20 mudstone

APPENDIX 2

Corrections to the Hobart 1:50 000 geological atlas series sheet

Geological corrections

AMG Reference	*Correction*
092465	Upper Triassic (Ru) improperly coloured.
105567	Faults should join to form block in Pm.
108640	Fault symbol omitted, line connecting Pf to small eastern block omitted and line connecting Jdl to small intrusion in fault omitted.
155467	Qdt should read Qds.
191643 to 191651.	Road cuts for the Northern Outlet reveal deeply weathered dolerite at these points. Between, but under cover of dolerite fragments and soil, is intensely faulted and weathered Rlm. Much of the dolerite mass in this area may thus be illusory. Major faulting nearby is suggested.
210634	Tb.
213438	Dolerite colour partly omitted.
214407	Colour should be as for P and not Pf.
214614 to 216615.	Ts not Rlf.
215650 to 218649.	Recent - Pleistocene wind blown sand deposited on basalt. The basalt surface is very irregular.
223398	Dolerite colour ommission.
225635	Tg should be Qrg?
237427	Basalt should extend over fault and overlie Triassic (Rlq).
238636	Tb on shore
252448 to 254432.	Outlet road displaced west w.r.t boundary. (Did not exist at time of mapping and base map preparation). Small fault and boundary displacement at Northern reference.
255543, 248549, 251552.	This area should be shown as dolerite.
271514	Granophyre.
275420	Pm should be shown on Alum Cliffs coastline.
293475	Pbu should be Pf, Pbu on shore.
372667	Ru not Qra (colour fault).
373428 to 376421.	Fault line.
375460	Dolerite colour omitted.
377421, 375420, 376423.	This are should be shown as Pm, and the coastline boundary as Pf.
LEGEND	Pu should read Pl under 'Stratigraphic bore hole with log summary'.

Corrections to locality names

The correct spellings are as follows: Cathedral Rock [154462], Dowsings Point [249586], Mortimer Bay [373407], Mt Montagu [140478] and The Stony Creek [324626].

Date of publication

The geological map sheet was published in 1973.

APPENDIX 3

Chapel Street Bore Hole

G.B. Everard

A summary of the drill log is shown in Table 16, the sedimentary rocks are of Lower Permian age.

Table 16. LOG OF BORE HOLE, UPPER CHAPEL STREET, GLENORCHY [209562]

Description of strata	Depth (m)
Fossiliferous sandy siltstone with subordinate limestone	0- 17.5
Calcareous sandstone	17.5- 24.4
Sandy siltstone	24.4- 28.9
Calcareous sandstone, limestone	28.9- 69.5
Pyritic fine siltstone	69.5- 71.0
Calcareous sandstone	71.0- 74.3
Pyritic siltstone	74.3-198.0
Dolerite sill	198.0-492.0
Pyritic siltstone	492.0-564.0
Dolerite sill	564.0-579.0
Siltstone	579.0-582.0
Siltstone with occasional pebbles	582.0-591.0
Unconformity	
Albite-epidote schist (probably Cambrian)	591.0-616.0

JURASSIC DOLERITE

Density measurements on core samples and brief descriptions of the types of dolerite encountered are given in Table 17.

Dolerite was encountered at 198.4 m and drilled through at 493.1 m. In hand specimen the whole body was noted to be extremely uniform in appearance and texture.

The main mass of rock, especially that from about 300-470 m, is a fine- to medium-grained dolerite made up of a mass of labradorite laths 0.25-0.5 mm in length and interspersed groups of pyroxene crystals, each crystal averaging 0.5 mm in length. The pyroxene is a yellowish-green or greyish-green faintly pleochroic augite or pigeonite depending on the optic axis angle. A little disseminated magnetite and traces of pyrite occur. Secondary minerals are biotite, amphibole and chlorite. The small amount of interstitial material consists of micrographic intergrowth and quartz.

The variations in density are due mainly to different proportions of feldspar and pyroxene. At 472.2 m there is an increased proportion of magnetite, but apparently this mineral is not plentiful enough to give any marked increase in density. The values show a rapid increase to a maximum at about 228.6 m followed by a gradual decrease to a minimum at about 259 m. An increase then occurs until the curve flattens out at about 304.8 m. At 472.2 m the values decrease to a minimum at the lower contact (493.1 m).

From 257.6-280.4 m the coarsest grained rock types appear, consisting of large pyroxene crystals enclosing labradorite laths. Some large feldspar crystals also occur.

Table 17. DENSITY DETERMINATIONS AND DESCRIPTIONS OF DOLERITE FROM THE UPPER CHAPEL STREET BORE HOLE, GLENORCHY [209562]

Depth (m)	Density (kg/m^3)	Description
198.6	2670	Very fine-grained with intersertal texture. Labradorite laths up to 0.2 mm long with rare biotite.
199.1	2840	Slightly coarser grain and less glass.
199.6	2920	Little glass, average length of labradorite laths 0.2 mm.
204.3	2850	Fine-grained holocrystalline, sub-ophitic texture, labradorite laths 0.3 mm long.
207.0	2920	Labradorite laths 0.5 mm long, biotite rather common, patches of micrographic intergrowth.
211.1	2830	Fine-grained, sub-ophitic texture; plates of biotite common.
213.3	2690	Similar to the above sample. In both samples, pyroxene, possibly bronzite, has a pronounced schiller structure. The density is due to chloritic bands.
215.5	2960	Fine- to medium-grained with pyroxene crystals up to 1.5 mm in length.
217.8	2900	Fine-grained with some pyroxenes up to 1 mm in length.
220.9	2950	Fine-grained sub-ophitic texture. Agglomeration of crystals gives the effect of a medium-grained rock in hand specimen.
224.1	2930	Similar to the above sample.
227.2	2960	Labradorite laths up to 0.25 mm long.
229.7	2970	
230.1	2930	Some alteration of pyroxene to hornblende, chlorite and biotite.
230.4	2950	
238.4	2900	Medium-grained rock with micrographic intergrowth of feldspar, pyroxene crystals up to 2 mm in length. Alteration to hornblende and chlorite occurs.
240.8	2880	Medium-grained (crystals up to 3 mm). Granophyric intergrowths in groundmass, alteration of pyroxene to hornblende and chlorite.
243.8	2980	Fine-grained rock with a sub-ophitic texture.
249.9	2910	Fine-grained rock with a sub-ophitic texture, but appearing coarser because of agglomeration.
253.0	2920	Similar to the above sample.
257.6	2800	Coarse- to medium-grained rock, because of skeletal pyroxene crystals up to 10 mm or more in length, but labradorite crystals average 0.25 mm in length.
265.2	2890	Similar to the above sample but with some large feldspar crystals and micrographic intergrowth.
272.8	2920	Coarse pyroxene common but coarse labradorite rare.

Table 17. (continued)

Depth (m)	Density (kg/m^3)	Description
280.4	2910	Coarse-grained rock, similar to the above sample.
288.0	2890	Medium-grained sub-ophitic dolerite with some micrographic intergrowth.
295.7	2770	Similar to the above sample. The density is unreliable as the specimen was damaged.
303.3	2970	Medium-grained dolerite with pyroxenes up to 3 mm in length.
318.5 326.1	2970 2994	Similar to the above sample.
333.8	2940	Fine-grained sub-ophitic texture, but appearing medium-grained due to agglomeration.
341.4	3000	Fine-grained, sub-ophitic texture.
349.0	2840	Similar to the above sample but pyroxenes semi-opaque white with alteration.
356.3	2920	Similar to the above sample but pyroxenes a little larger and more numerous.
364.2	3000	Fine-grained, but more pyroxene than the above sample.
371.9 379.5 388.6 402.3 410.0 417.6 432.8 440.4 449.6 455.7 463.3	2970 2940 2960 2950 2980 2970 2970 3000 2930 2980 2920	Fine-grained sub-ophitic texture.
472.4	2980	Increased amount of fine-grained disseminated magnetite.
480.1	2840	Magnetite and a chlorite vein occur.
487.7	2830	Fine-grained, sub-ophitic and intergranular texture.
492.3	2850	Very fine-grained, sub-ophitic and intergranular texture.
492.9	2670	Very fine-grained intergranular texture and a little dark glass.

CAMBRIAN? SCHIST

The following are descriptions of rock specimens taken from the lower section of the core.

Depth (m) *Description*

591.3 The hand specimen is a mottled, yellowish-green, sheared, granular rock with a density of 2920 kg/m^3. It consists of a confused assortment of irregular crystals of feldspar, granular

Depth (m)	Description

591.3 aggregates of epidote and dark masses of chlorite in a fine-grained schistose matrix. Opaque white carbonate is common and the rock as a whole effervesces with acid in minute bubbles.

Schistose structure is very prominent in thin section and the lines of schistosity in the matrix show mild microfolding and crenulation. The matrix is so fine-grained as to be semi-opaque but under high magnification is resolved into granular feldspar, partly sericitised and mixed with flakes of chlorite and grains and aggregates of epidote.

The larger crystals of feldspar show lamellar, carlsbad and pericline twinning. They are cloudy with alteration and diagonally oriented so as to give lozenge-shaped tailing off into brushes of sericite. Extinction angles perpendicular to albite lamellae average 11° which, taken with a refractive index very close to that of balsam, indicates an albite oligoclase. Some of the crystals have been sheared in pieces along diagonal planes and the pieces moved to give lenticular and distorted aggregates.

A pale yellowish-green epidote is very common as minute disseminated crystals and patches of mosaic 2-3 mm in length.

Chlorite occurs in elongated masses of small plates and as minute flakes in the matrix. It shows anomalous Berlin blue interference colours and is therefore penninite.

Calcite is common and occurs in fine-grained distorted masses and as small patches of mosaic twinning.

Sericite occurs as an alteration product of feldspar and is common in small flakes and masses showing distortion

The rock is an albite-epidote-chlorite schist.

596.5 The hand specimen is a sheared greenish yellow rock with irregular patches of bright green chlorite up to 20 mm long. Carbonate is present in pale pink or purple veinlets. There is much quartz and the density is 2810 kg/m^3.

In thin section the rock is an intergrowth of minute books of sericite and penninite with veinlets and patches of carbonate and a little disseminated epidote. The chlorite is strongly pleochroic with the absorption scheme X deep green > Y green > Z yellowish. The birefringence is very low and the colours anomalous Berlin blues. The mineral is therefore penninite. It is intergrown with sericite, easily distinguishable by its lack of colour and higher birefringence. Carbonate occurs in veinlets and patches often with very indefinite margins and is brownish by transmitted light. Vein quartz is present.

The rock is a chlorite-sericite schist.

598.9 The hand specimen (density 2900 kg/m^3) is a greenish rock with colourless crystals of feldspar, rounded aggregates of yellowish-green epidote and books of dark green chlorite all about 1-2 mm long in a fine-grained matrix. Effervescence with acid indicates the presence of calcite and there are rare crystals and aggregates of pyrite. Alignment of the larger grains, which are very plentiful, emphasises that the rock has been strongly sheared.

Depth (m)	Description
598.9	In thin section the rock has a schistose structure due to the shape and orientation of the larger grains and crystals and to the texture of the matrix which is semi-opaque white, due to the difference in refractive index of the epidote and feldspar of which it is largely composed.

The larger grains are elongate sub-rounded masses consisting largely of fine-grained structureless sericite with a few traces of original feldspar. A few grains contain unaltered feldspar with extinction angles of about 14° normal to the lamellar twin plane and refractive indices about the same as that of balsam and therefore indicating albite

Deformed and twisted books of penninite are common and there is much moderately fine-grained feldspar and calcite, and epidote mosaic.

The rock is an albite-epidote-chlorite schist.

599.2 The hand specimen (B) is a sheared, medium-grained pale greenish rock consisting of orientated feldspar crystals 2 or 3 mm long with occasional rounded masses of yellowish-green epidote in a dark green matrix. The density of the rock is 2860 kg/m^3.

In thin section the texture is porphyroclastic consisting of slightly worn and rounded crystals of sodic oligoclase with occasional fractures and veins of calcite in a very fine-grained semi-opaque matrix of feldspar, epidote, chlorite, calcite. The feldspars show complex twinning and some alteration with numerous inclusions of epidote. There are also occasional grains of similar size and shape but consisting of epidote and chlorite with minor calcite and feldspar.

The rock is an albite-epidote-chlorite schist.

599.2 In hand specimen this rock (A) is very similar to the preceding but the larger feldspar crystals are less prominent and there is more epidote. The density of the rock is 2940 kg/m^3.

In thin section the rock appears at first to be an almost structureless mixture of fine crystals of epidote, feldspar, chlorite and calcite, and the porphyroclastic texture is perceived with some difficulty, the larger crystals of feldspar being obscured by the masses of epidote grains. Penninite is also very common together with calcite and very fine-grained opaque white material.

The rock is similar to Specimen (B) but the similarity is obscured by the widespread development of epidote.

The rock is an albite-epidote-chlorite schist.

600.8 The hand specimen is a strongly sheared, yellowish green, granular rock, consisting of irregular feldspar crystals up to about 3 mm long, granules and flattened masses mainly of epidote up to 20 mm long, and patches of chlorite and calcite.

In thin section shearing is apparent in the alignment and fracturing of twinned oligoclase crystals and the flow texture of the semi-opaque, very fine-grained interstitial material. Brownish epidote occurs in granular and sub-radiating crystalline masses, sometimes with selvedges, and chlorite in platy

Depth (m)	Description
600.8	masses associated with carbonate and epidote.
	The rock is an oligoclase-epidote-chlorite schist.
609.6	The hand specimen is a grey schistose rock with a silken lustre on the cleavage faces. It is fine-grained and has a density of 2870 kg/m^3. Rounded and lenticular porphyroblasts up to 5 mm across are fairly common. The rock effervesces with acid.
	In thin section the rock is a finely banded fine-grained mass of sericite, chlorite, feldspar and a little quartz. The prophyroblasts consist largely of epidote and calcite with some penninite.
	The rock is a chlorite-sericite schist.
610.2	The hand specimen is a grey fine-grained schistose rock having a density of 2830 kg/m^3. Lenticular masses of calcite up to 5 mm across occur and there are also fine bands of calcite. Epidote occurs in a few small porphyroblasts.
	In thin section the schistosity is pronounced and the minerals are sericite, albite, carbonates, epidote and a little penninite. Epidote also appears in granular masses. As in the rest of the core crenulations are common.
	The rock is an epidote-albite-sericite schist
613.9	The hand specimen is a grey schistose rock having a density of 2800 kg/m^3 and is similar to the specimen from 609.6 m. It contains porphyroblasts of feldspar and epidote about one millimetre across and veinlets of calcite.
	In thin section the fine-grained banded groundmass is dominantly feldspathic with granular epidote and a little sericite and chlorite. Calcite occurs in bands consisting of a mosaic of angular grains.
	Albite occurs as lenticular porphyroblasts altered partially to sericite and associated with penninite. Patches of fine-grained quartz-albite mosaic occur.
	The rock is an albite-sericite schist with chlorite and epidote.

In general the specimens from depths of 591-600 m consist of low grade metamorphic rocks belonging to the greenschist facies and consisting essentially of chlorite, epidote and albite, or their products. The parent rocks would appear to have been tuffs and crystal tuffs associated with spilitic lavas. The metamorphism was of epizone type, producing cataclastic and dynamothermal textures. The suite shows strong affinities with rocks of the Dundas Group and Mt Read Volcanics as exposed in the Rosebery area, at Beaconsfield, in the Lake River district and elsewhere.

The age suggested is therefore Early Cambrian.

Examination of the core down to the bottom of the hole, (609-613 m), may indicate a change in rock type and provenance from chlorite-epidote schist derived from basic tuffs to sericite schist of purely sedimentary origin. The rocks described seem to be intermediate between the two and as well as sericite and a little quartz, also contain albite, epidote and chlorite with a tendency of one of the other assemblage to predominate over a small area of thin section.

The more sericitic rocks have a slightly lower density.

APPENDIX 4

The geology of the Lower Derwent.

D.E. Leaman

The Hobart Quadrangle includes a large part of the Derwent Estuary and consequently the distribution of structures and rock masses is only partially known. Many key features lead into the axis of the drowned valley and are hidden from view.

Several geophysical surveys and some drilling have been undertaken along the valley between Dowsings Point and the Tasman Bridge. Some of this information is given in the Engineering Geology maps (Leaman, 1971*a*) and a complete summary to March 1975 is provided by Leaman (1975*b*). Subsequent work is detailed in Leaman (1975*c, d*). These surveys have enabled a partial compilation of the history of the river (see Leaman, 1975*b*); some details of which were given in the main body of these notes.

A detailed magnetic survey covering the Derwent River north of John Garrow Light, off Lower Sandy Bay, has provided a basis for a general interpretation of rock distribution. Details of the survey and its interpretation are given by Leaman (1975*e*) and a summary of conclusions is shown in Figure 17. The figure omits all details of offshore Quaternary materials but does indicate Tertiary sediments. Only basalt and dolerite boundaries are to be regarded as reasonably reliable although many deductions concerning the distribution of Permian and Triassic sediments appear quite straightforward and sound. The magnetic survey provided no information about the Tertiary sediments and Figure 17 thus includes data from all other sources. For these reasons Tertiary materials are indicated but with an additional symbol to indicate the underlying 'magnetic basement'. It is probable that only part of the Cainozoic sedimentation is indicated but none is known to exist between Otago Bay [245600] and Shag Bay [270572]. A similar notation is given in respect of Triassic areas where dolerite is implied at shallow depth. The faults indicated (fig. 17) have been deduced from the disruption of magnetic anomalies.

APPENDIX 5

Cainozoic volcanic rocks: Isotopic dating and implications.

F.L. Sutherland

Recent K/Ar isotopic determinations on basalts from the eastern shore of the River Derwent confirm the early Tertiary age previously suggested for some of the eruptions on stratigraphical and palynological grounds. The basalt flow at Geilston Bay gave a minimum age of 22.4 ±0.5 *m.y.* (Oligocene-Miocene boundary) and was shown to post-date the oldest marsupial remains known in Australia, recovered from the underlying Geilston travertine (Tedford *et al.*, 1975). Amphibole megacrysts collected from the Risdon Brook pyroclastic rocks yielded an apparent age of 29.4 *m.y.* (Isotope laboratory determination Hbl QA 157, Department of Geology, University of Queensland; K_2O : 1.82%; $^{40}Ar^*$ cm^3NTP/g : 1.7899 x 10^{-6}; %^{40}Ar : 86.6; D.C. Green, pers. comm.).

These dates have possible implications in respect to circular features interpreted from satellite coverage (ERTS-1). Two such features span the Derwent Estuary from Lower Sandy Bay to Tranmere and from Chigwell to Mt Direction. They are considered to represent aligned volcanic ring fractures post-dating the main jointing in the pre-Tertiary rocks (K.R. Burns, pers. comm., C.S.I.R.O. Division of Mineral Physics, Sydney). Supporting evidence for such ring fractures is found in the Sandy Bay-Tranmere region where flat-lying lavas petrologically characteristic of the Lower Sandy Bay centre, cap the hills just outside the feature, while the lavas and pyroclastic rocks within are folded and collapsed in near contemporaneity with the underlying Oligocene(?) sediments. Some plugs, necks and other suspected eruptive points, including the Risdon Brook vent, are also located in circumferential positions along the ring features. This suggests some structural control on eruptive sites by these features and at least an Oligocene age for them.

APPENDIX 6

Structural re-interpretation of the Glenorchy-Collinsvale region.

D.E. Leaman

Exposure of some new contacts at Glenorchy Quarries, together with the information obtained from the Chapel Street bore hole, has enabled a re-interpretation of the structure of dolerite intrusions in the Glenorchy-Collinsvale region. The structure of this region has been previously described by Sutherland (1964) and re-interpreted following a gravity survey by Leaman (1972*a*).

Recent evidence has indicated that the major frontal contact in the area from Elliot Road, Glenorchy to Mt Arthur dips shallowly and consistently to the east, rather than to the west as deduced by previous writers. On extrapolating the average visible dip to the Chapel Street bore hole, an excellent agreement between predicted and observed depths is obtained.

INTERPRETATION

The new observations alter prior deductions concerning these intrusions and the gravity field has thus been re-interpreted. The major factors utilised in this re-interpretation are listed below.

(1) Immediately north of the section (at A), a dolerite sheet crops out in a deep valley cut. The dolerite intrudes the Permian Cascades Group rock. Sheet thickness is unknown.

(2) South of the section (near B) dolerite caps Collins Cap. The dolerite intrudes Lower Triassic rocks in the form of a relatively small, detached fragment of a concordant sheet.

(3) A major north-south trending fault/contact (between B and C), separates the Collinsvale structures from the elevated plateau region to the west. This fault has been mapped on the Hobart Sheet as an intrusive contact and appears to have had a history of complex movement during the intrusion period. There is no known evidence of Cainozoic displacement.

(4) From Collins Cap to the east across southern Collinsvale and to Mt Hull (C, D, E), all observations indicate a simple, shallow transgressive sheet disrupted by small faults. There are many roof remnants commonly of mid-Permian rocks (D, E), but some Triassic rocks are included (C).

(5) A displacement of 350-400 m is required by any fault to place mid-Permian rocks and Triassic rocks at a comparable topographic level. There is no evidence of a fault with a throw of this magnitude in the area, so an additional intrusion with an equivalent thickness could contribute the necessary displacement in the section. Such a body would be required to extend no further west than D and must extend to about E. It would also pre-date the upper intrusion. Alternatively there could be an intrusion of similar age limited to the region of C and extending no further east than D. The selection of such alternatives must be resolved in interpretation, although the dilation factor is mixed and does impose limits.

(6) The situation in the region of Mt Hull (F) and the Goat Hills range is complex. Dolerite contacts exposed along the north-western side of the range are sheet roofs (E-F), but at the eastern end

evidence exists of a sheet base contact. This implies the exposure of a basal section of an intrusion which originally rose from one side of the present range and intruded over the top of it. The surface evidence is insufficient to determine the sheet involved. This factor amongst others (see also 4 and 5), precludes general acceptance of the single sheet concept.

(7) The southern side of the Mt Hull-Goat Hills range is characterised by the presence of another group of mid-Permian roof fragments (G). This may suggest two simple, approximately concordant sheets located close together toward the south, due to the roughly equivalent topographic position and stratigraphic level of the roof fragments on either side of the range. Alternately the situation may fortuitously rely on the suitability of one or two formations to sill injection-horizons, which have been occupied from two sides in a sedimentary slab. Interpretation is necessary to test the validity of these alternatives whilst maintaining the dilation-stratigraphy balance.

(8) The Chapel Street bore hole, petrographical information and contact observations suggest that the sheet section from H-J has a roof-dip slope. This solution accommodates the roof fragments observed at G.

(9) The dolerite exposed in the fault block east of the Cascades Fault (J-K), is of unknown thickness, but less than one kilometre to the south of the section it is intrusive into Lower Triassic rocks.

(10) In the Springfield-Moonah area (L), dolerite is intrusive into Upper Triassic rocks. The observation of this and the dolerite intrusion into Lower Triassic rocks in the fault block (K) immediately to the west, appears to indicate either an abrupt transgression or the involvement of two separate sheets. This is especially relevant since the fault (K-L) is downthrown to the east.

A detailed discussion of the interpretation is given in Leaman (1975: Structural re-interpretation of the Glenorchy-Collinsvale region. *Unpubl.Rep. Dep.Mines Tasm.* 1975/18).

CONCLUSIONS

Only the structures of the type represented in Figure 18 satisfactorily explain the gravity field in this area. This model is a simple variation of the initial interpretation given by Leaman (1972*a*), but adapted to satisfy the new observations. The model maintains the established forms west of B, but presents a simple two sheet concept for Mt Hull together with a roof dip slope from H-J, a feeder at G as deduced in earlier interpretations and increased thickness of the sheet from G-H.

The new model is thought adequate for several reasons:

(1) It is of a more simple concept.
(2) Sedimentary fragments, in relation to topography, correspond over a wide area in the vicinity of Mt Hull, an unlikely situation with overlapping sheets.
(3) No interpretive difficulties arise with the allowance of a lower sheet and feeder lateral to the section.

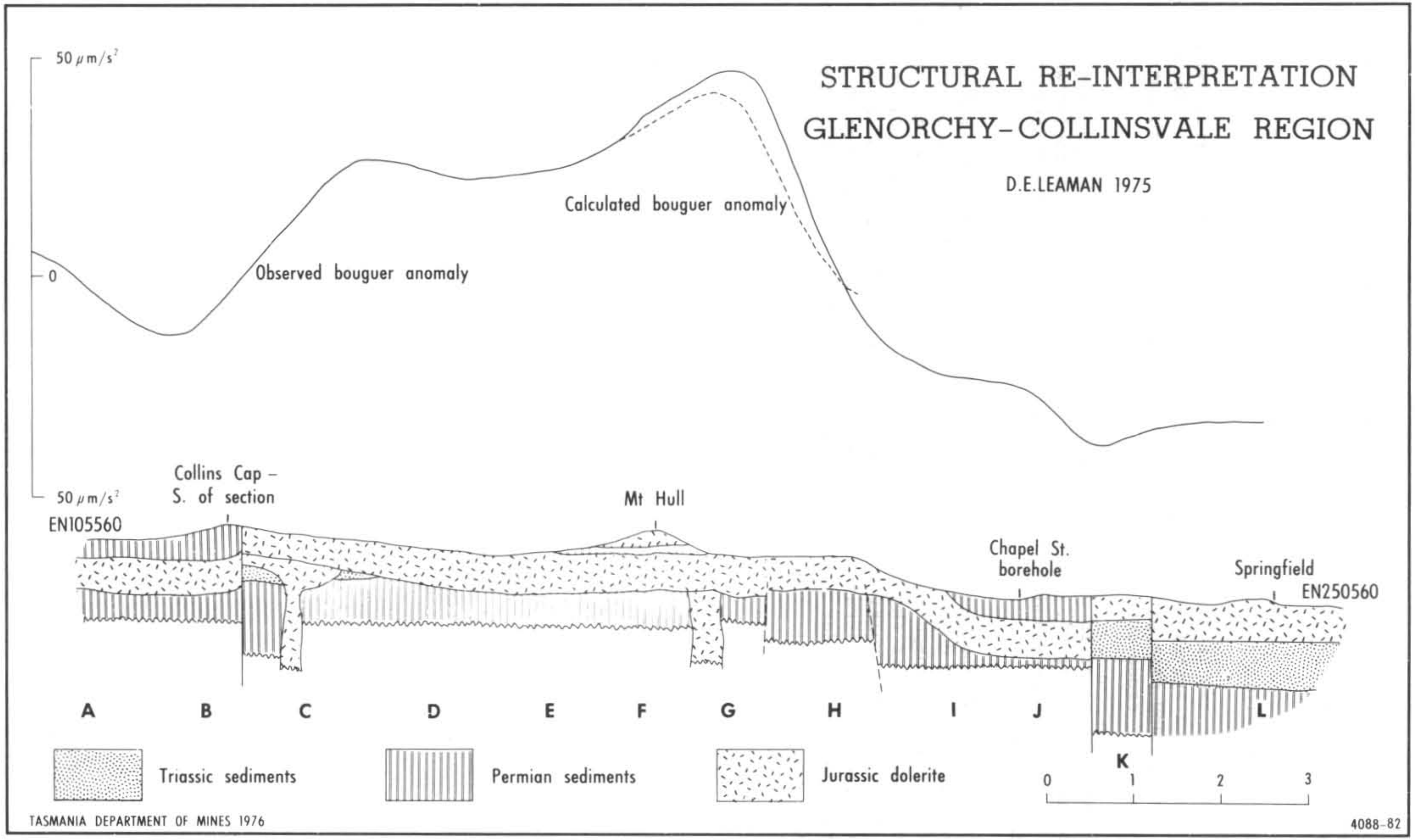

Figure 18.

5 cm

DEDUCTIONS

The main Collinsvale sheet is related to the Collins Cap sheet above the section at B. The Collinsvale sheet may also have a feeder axis slightly to the east of the Mt Hull topographic axis.

Mt Hull is not composed of an elevated, cone dyke-feeder as regarded in earlier interpretations.

At least two intrusions are involved in the Collinsvale area, assuming that the feeder system at C is related to the upper Mt Hull body. The system at C must in any case pre-date the major intrusion, as there is no petrographic evidence of cross-cutting.

Only one sheet is present in the Triassic rocks in the Springfield-Moonah area (east of K). This implies major upsteps near the faults which pass through the area and further suggests a complex history of activation for these faults.

The Collinsvale sheet is transgressive from the south-east and is possibly related to the dolerites which project to the south-west in Lenah Valley. The feeder system suspected in South Hobart (*S18*, Leaman, 1972*a*) may be the basic centre for this sheet with the pipe at G being subsidiary to, or part of a higher sheet. Multiple pipes are probably a better solution because of the requirements of intrusion mechanism. The additional thickness of the dolerite near the feeder at C appears to exclude such conditions in that vicinity.

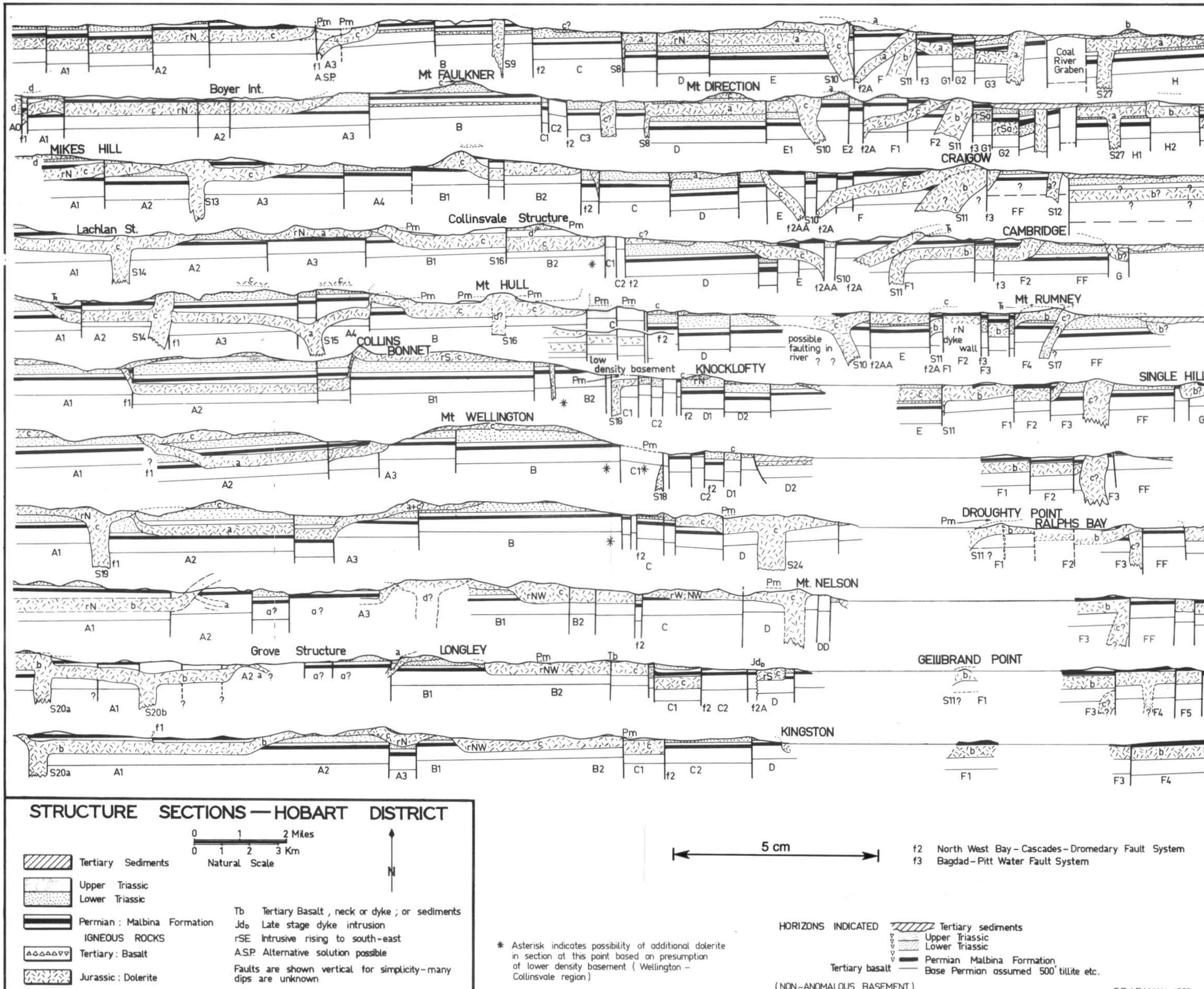
STRUCTURE SECTIONS — HOBART DISTRICT
0 1 2 Miles
0 1 2 3 Km
Natural Scale
N
Tertiary Sediments
Upper Triassic
Lower Triassic
Permian : Malbina Formation
IGNEOUS ROCKS
Tertiary : Basalt
Jurassic : Dolerite
Tb Tertiary Basalt , neck or dyke ; or sediments
Jd$_D$ Late stage dyke intrusion
rSE Intrusive rising to south-east
A.S.P. Alternative solution possible
Faults are shown vertical for simplicity - many dips are unknown
* Asterisk indicates possibility of additional dolerite in section at this point based on presumption of lower density basement (Wellington - Collinsvale region)
5 cm
f2 North West Bay - Cascades - Dromedary Fault System
f3 Bagdad - Pitt Water Fault System
HORIZONS INDICATED
Tertiary sediments
Upper Triassic
Lower Triassic
Permian Malbina Formation
Tertiary basalt
Base Permian assumed 500' tillite etc.
(NON-ANOMALOUS BASEMENT)
D.E. LEAMAN 1969
Mt FAULKNER
Mt DIRECTION
Coal River Graben
Boyer Int.
MIKES HILL
CRAIGOW
Lachlan St.
Collinsvale Structure
CAMBRIDGE
Mt HULL
Mt RUMNEY
COLLINS BONNET
low density basement
KNOCKLOFTY
possible faulting in river
dyke wall
SINGLE HILL
Mt WELLINGTON
DROUGHTY POINT
RALPHS BAY
Mt. NELSON
Grove Structure
LONGLEY
GELLIBRAND POINT
KINGSTON

Figure 11

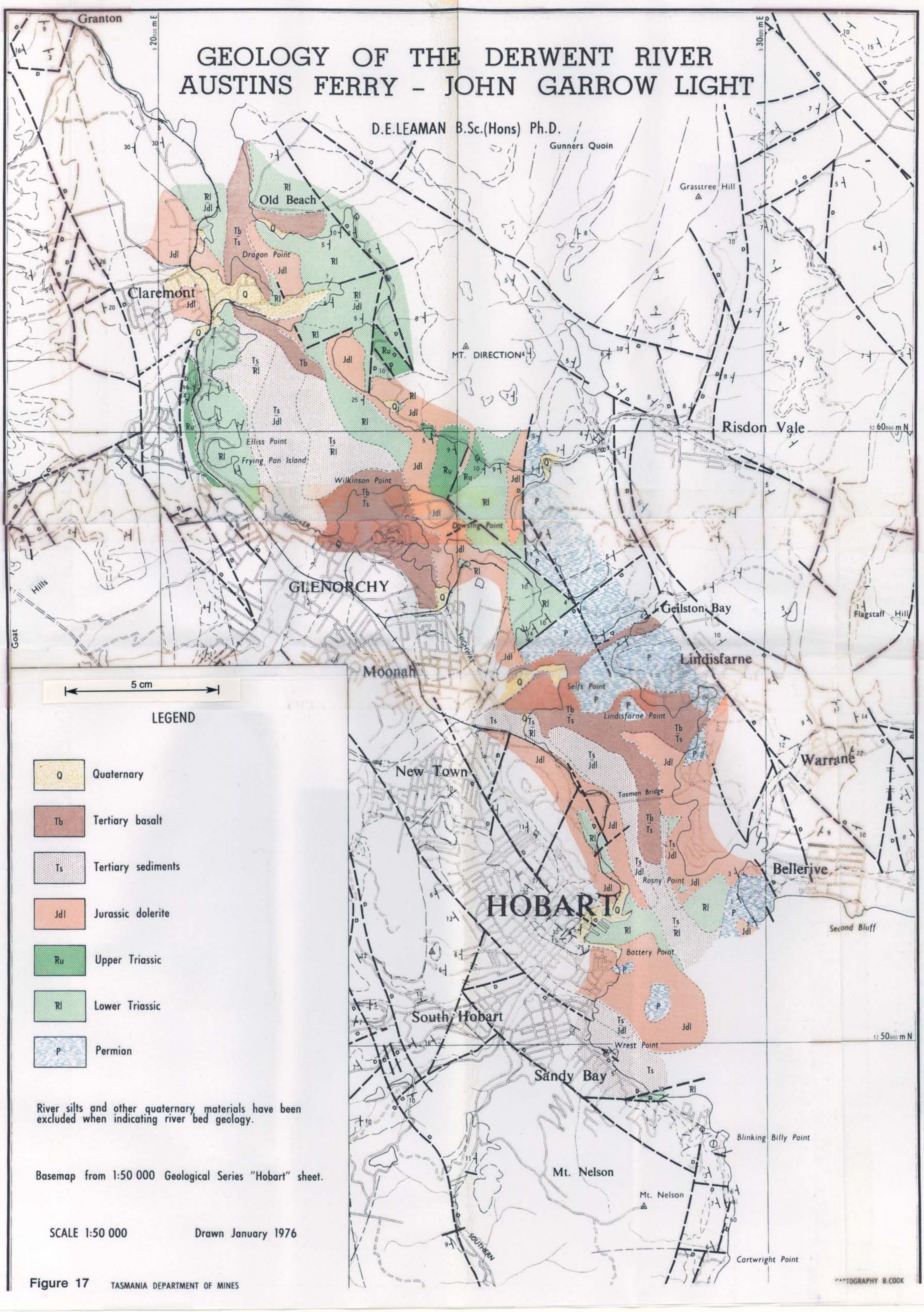

Figure 17 TASMANIA DEPARTMENT OF MINES

5 cm

Plate 26. *Eastern section of Hobart Quadrangle from Mt Wellington. Bold line is approximate boundary of quadrangle.*