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## DEPARTMENT OF MINES

GEOLOGICAL SURVEY BULLETIN

No. 49

# GEOLOGY AND GEOPHYSICS

of the

# CYGNET DISTRICT

by

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and

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Issued under the authority of

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# PREFACE

The Cygnet District has long been noted for the occurrence of a suite of alkaline rocks sufficiently rare to have attracted considerable attention from geologists, especially petrologists. The emphasis in this bulletin, however, is less on petrology than on stratigraphy and structure, both of which have been studied in detail. The stratigraphic study is mainly concerned with the Permian as sections in this district furnish the greatest thickness of these rocks known in Tasmania above the basal tillite. The structure has been studied by geophysical methods and some interesting data have been produced to assist in the elucidation of the long-standing problem of the emplacement of Jurassic dolerite and Cretaceous alkaline rocks.

In the past the district has produced small amounts of gold and coal but there does not appear to be any possibility of its future development as a mining field. The economic importance of groundwater to agriculture has already been stressed in Underground Water Resources Paper No. 6: "The Groundwater Resources of the Cygnet District", which complements the present geological study of the district.

**J. G. SYMONS, Director of Mines.**
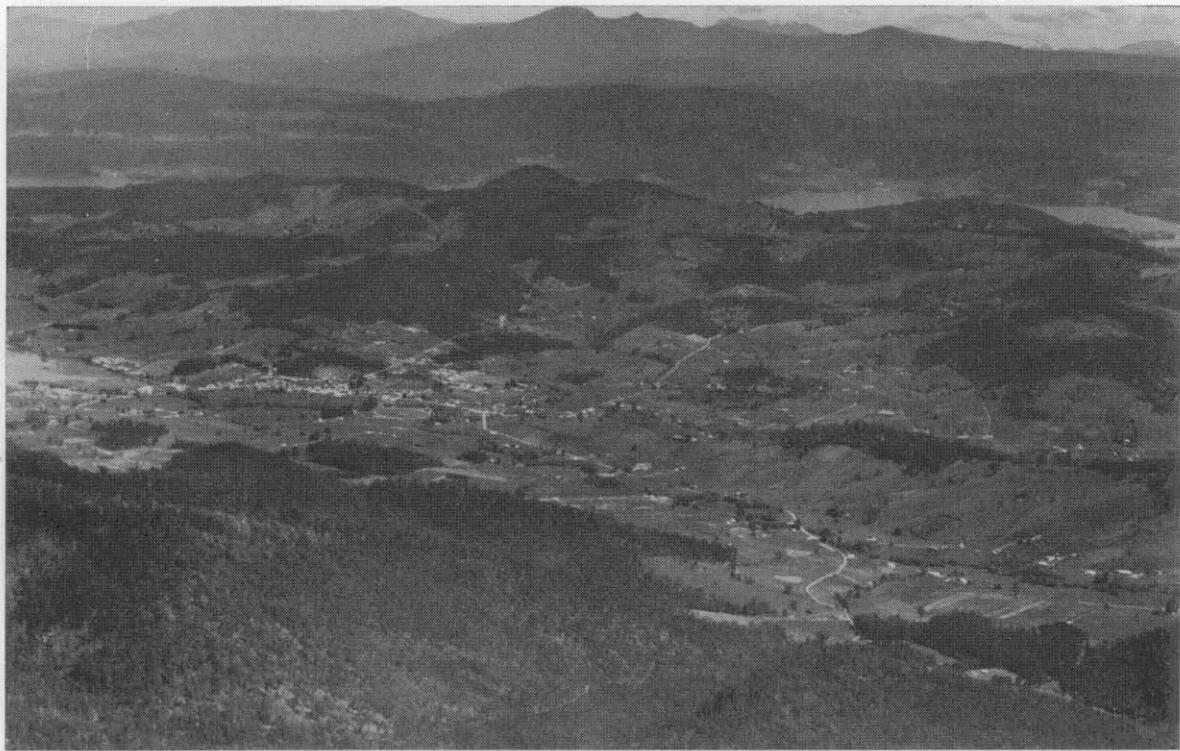
Aerial view of Cygnet District from above Grey Mountain.          [Photo by Vern Reid]

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# GEOLOGY AND GEOPHYSICS OF
# THE CYGNET DISTRICT

## Abstract

In the Cygnet District, Tasmania, 3000 feet of marine and terrestrial Permian sediments, some glacial, are overlain disconformably by 1000 feet of terrestrial Triassic sediments. Stratigraphic distribution of the erratics suggests glacial erosion of a sedimentary terrain overlying metamorphic rocks. Doming and faulting of the sediments preceded and accompanied the intrusion of Jurassic dolerite. The Cretaceous Port Cygnet Alkaline Intrusives had little structural effect. Geophysical surveys (magnetic and gravity) and a study of dilations indicate that the dolerite was injected as multiple sheets and the alkaline rocks as a laccolithic tongue and dyke swarm.

Both gold and coal have been produced in the district but in insignificant amounts.

## Introduction

### GENERAL

The Cygnet District, as defined for the purposes of this publication, is situated approximately 30 miles SW of Hobart, and is bounded by the Huon River to the W and S and to the N and E by the 500,000E and 700,000N State grid lines (fig. 1).

The base map has been prepared from aerial photographs by the slotted template method, using limited triangulation control. This control is not good in the northern parts of the district. All mapping, where outcrop permitted, has been by walking boundaries with all information transferred onto aerial photographs. Exposure is generally poor in the southern half of the district, except along the coastline and a few roads where good sections are available. Access to most parts of the area is excellent.

The stratigraphical studies and mapping of the southern half of the district were undertaken by I. H. Naqvi and the geophysics, structural analysis and remaining mapping by D. E. Leaman. The groundwater resources have been studied by Leaman (1967).

The district has a mild but humid climate with an average rainfall of 30 inches in the lower lying areas and up to 50 inches in the higher areas. The relative variability of rainfall ranges from 12% in the S to 16% in the N. The annual mean temperature range is 41.9°-61.9° F.

Most of the southern areas have been cleared for horticultural purposes. However, in the more rugged uncleared zones, particularly in the NE, there is a dense sclerophyll forest with an understory of low scrub and bracken. The soils are predominantly podzolic, being yellow podzols on the Permian and Triassic sedimentary rocks and Cretaceous igneous rocks but grey-brown to brown podzols on the Jurassic dolerite. Alluvial soils are of little importance (Nicolls and Dimmock, 1965).

The main centre of population is at Cygnet with other smaller communities at Cradoc, Woodstock, Glaziers Bay, Wattle Grove, Petchey Bay, Lymington and Gardners Bay.   The economy of the area is based on orcharding, grazing and dairying.

Thin section and rock specimen numbers refer to the catalogue of the Geology Department, University of Tasmania unless otherwise stated.

## PREVIOUS LITERATURE

The earliest geological report in the area was by Thureau (1881) on the gold deposits near Lymington and the coal mines near Gardners Bay.   The alkaline rocks of the Cygnet Peninsula were first described and classified by Twelvetrees and Petterd (1899), and later by Twelvetrees (1901, 1903a, b) and Paul (1906). MacLeod and White (1900) described a species of garnet considered peculiar to Cygnet.   Smith (1899) reported on gold at Mt Mary, and Twelvetrees (1902, 1907) made a critical evaluation of the gold and coal resources.   The alkaline rocks were thought to be Permian in age until Skeats (1917) showed that related porphyry dykes near Woodbridge are intrusive into diabase (or dolerite), then regarded as Cretaceous. Instances of this relationship were subsequently discovered at Port Cygnet, by Hills et al. (1922). The map produced by these authors, although generalized and approximate, was the first geological map to cover the entire district. In 1927, Scott made what was to by the final report on the Cygnet gold mine (Mt Mary Mine). In 1937, Edwards visited the Cygnet district to study in detail the supposed differentiated stock at Regatta Point. His paper of 1947 remains the best account of the alkaline rocks. A map in Edwards's paper is based on that of Hills et al. (1922) but with modifications by A. N. Lewis of Hobart. Irving (1956) visited the area to sample the dolerite for a palaeomagnetic study and Carey (1958) presented for the first time a coherent theory as to the emplacement of the dolerite and discussed a petrological relationship of the alkaline and tholeiite magmas.   During 1962, Evernden and Richards and Robertson and Hastie studied the alkaline rocks with regard to their radioactive age and palaeomagnetic age, respectively. Finally, McDougall and Leggo ((1965) published further radioactive age determinations on the alkaline rocks.

## ACKNOWLEDGEMENTS

## PHYSIOGRAPHY

The district is one of moderate relief generally, but low elevation.   Rock type and geological structure are the dominant factors controlling physiographic development.

In the southern half of the area the physiography is strongly influenced by the broad, gently dipping dome of Permian rocks. This has resulted in a central ridge along the Cygnet Peninsula

of which Coads Hill (946 ft) and Silver Hill (805 ft) are high points. Syenite porphyry outcrops as large masses over an area W of Cygnet and a group of hills reflect the influence of this rock (Mt Mary, 700 ft; Direens Spur, 846 ft); where the porphyry outcrops on the higher parts of the dome, as at Mt Windsor (1262 ft), the land rises markedly. From these hills which compose the Cygnet Peninsula the land drops to sea level on the W, S and E and to 400 feet in the N at Balfes Hill saddle. From Balfes Hill the land rises eastward toward Cradoc Hill (1049 ft) and falls slowly westward toward the Huon River at Cradoc.

Except for Cradoc Hill, all points in the northern half of the area and E of Cygnet (Catos Hill, 437 ft; Grey Mountain, 2723 ft; Tobys Hill, 600 ft; Mt Morrison, approximately 1200 ft) are composed principally of dolerite. The relief is high in the NE parts of the area.

The outline of the peninsula is strongly controlled by faulting, large faults passing along Port Cygnet and both sections of the Huon River. Indeed, the marked bend in the Huon River and the shape of many of the larger bays (e.g., Deep Bay) is related to faulting. In addition many rivulets follow fault lines (Agnes, Nicholls and Gardners Rivulets).

There are several drainage systems within the district. The northern and western slopes of Grey Mountain and Cradoc Hill drain northward toward Sandfly Rivulet and thence to the Huon River, but their southern and eastern slopes drain southward via Agnes Rivulet to Port Cygnet. There is also limited direct drainage across the Cradoc lowlands to the Huon River. The Cygnet Peninsula drains to Port Cygnet or the Huon River. The hills in the Tobys Hill-Gardners Bay region drain toward Nicholls Rivulet and Port Cygnet. All streams within the area are youthful with only the three rivulets mentioned developing mature or semi-mature tracts. These streams flow in small flood plains in their lower reaches and any meanders present are usually slightly entrenched. Most streams are intermittent and only the larger rivulets are perennial.

The landscape, as a whole, has been influenced by the down-cutting of rivers below present sea level, followed by drowning. Port Cygnet is an example of a drowned estuary slowly filling with silt. There is also evidence of a post-glacial high sea level some 2 or 3 feet above present high water level. This shoreline has been named the Milford level by Davies (1959).

Along the shore of the Huon estuary, river gravel is found up to a height of 100 feet, as at Beaupre Point, Petchey Bay and Cradoc. The gravel probably represents remnants of river mouth terraces associated with higher interglacial sea levels.

The latest development has been the construction of estuarine deltas. These are to be found at the head of Port Cygnet near the mouths of Agnes and Nicholls Rivulets, and in the Huon River.

Considerable numbers of shore platforms are developed S of Cygnet. The platform developed on each geological formation is characteristic of that formation: for example, Member A of the Malbina Formation has a very blocky platform, whereas the Ferntree Formation has a regular, smooth, and often stepped platform (pls. 1, 2, 3).
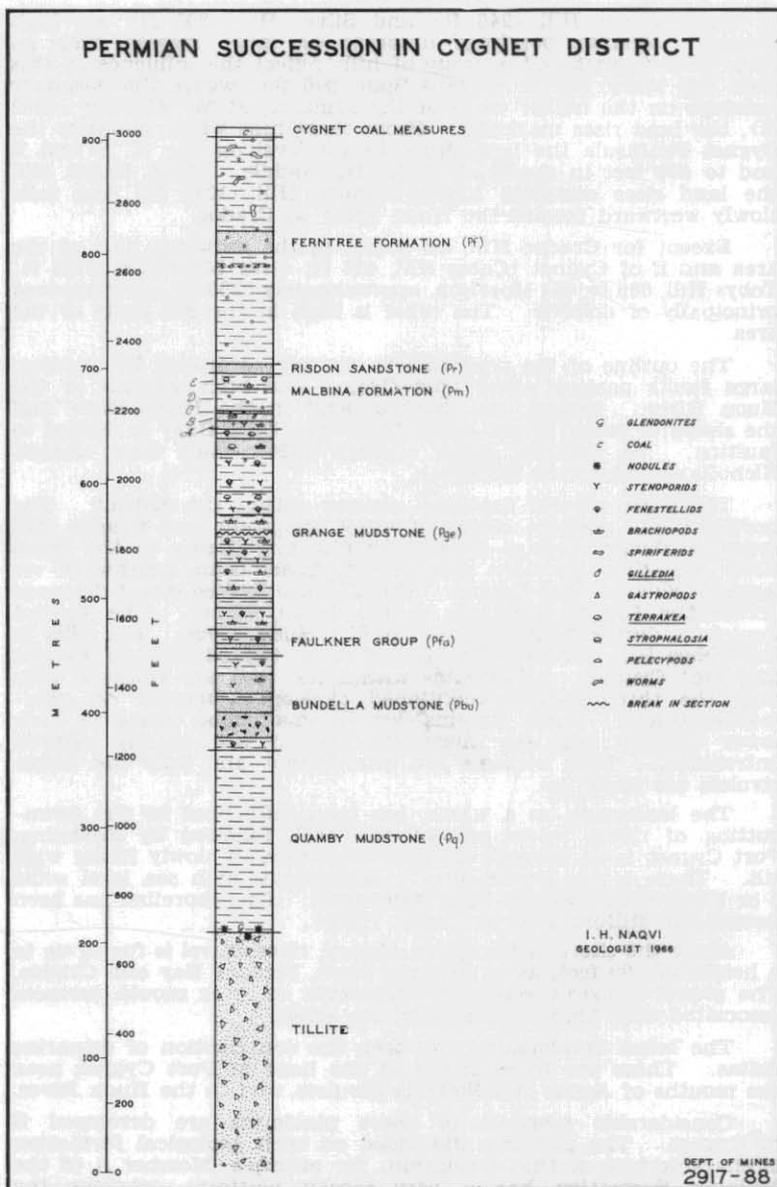
FIGURE 2.

# Stratigraphy

The sedimentary rocks exposed within the Cygnet District are mostly Permian and Triassic in age. No older Palaeozoic rocks are to be seen in this area. The oldest Permian rocks are exposed about Cygnet, whereas the younger rocks are disposed about the periphery of the district. Exposures of Cainozoic sediments are very limited.

Exposure on shoreline benches and cliffs and some road sections permits determination of the detailed stratigraphy of the Permian System. Five sections within the area have been examined and a composite stratigraphy produced. The five sections which have been measured and described are:—

(a) Tobys Hill Road from 49720E, 68756N to 49932E 68822N. Outcrop good.
(b) Deep Bay to Coal Mine Bay Coastal Section (49730E, 67743N to 49880E, 68052N). Outcrop excellent.
(c) Poverty Point to Harleys Jetty Coastal Section (49375E, 67944N to 49175E, 68110N). Outcrop excellent.
(d) Drip Beach Coastal Section (49502E, 68065N to 49550E, 68132N). Outcrop excellent.
(e) Balfes Hill Road Section (49190E, 68990N to 49390E, 69090N). Outcrop reasonably good.

The details of the first 4 sections are given in Appendix 1. The most complete and useful sections are (a) and (b).

A summary of the stratigraphy is given in Table 1. Where a range of thickness is known to exist it is indicated, otherwise the maximum known thickness is given. The stratigraphic nomenclature is essentially that accepted for southern Tasmania.

TABLE 1: STRATIGRAPHY.

| System | Units | Approx. thickness | |
|---|---|---|---|
| | | feet | metres |
| Cainozoic | Alluvium and river gravel | 12 | 4 |
| | Pleistocene(?) gravel | 80 | 25 |
| | Siliceous conglomerate | 50 | 15 |
| Triassic | Triassic undifferentiated | 500 | 150 |
| | Springs Sandstone— | | |
| | Mountain Lodge Member | 65-325 | 20-100 |
| | Barnetts Member | 30-100 | 9-30 |
| Permian | Cygnet Coal Measures | 5-20 | 2-6 |
| | Ferntree Formation | 560 | 170 |
| | Risdon Sandstone | 25 | 8 |
| | Malbina Formation | 90-160 | 28-50 |
| | Grange Mudstone | 360-575(?) | 110-175(?) |
| | Faulkner Group | 65-200 | 20-60 |
| | Bundella Mudstone | 260 | 80 |
| | Quamby Mudstone | 440-500 | 135-150 |
| | Tillite | 700+ | 215+ |

Maximum exposed thickness of Permian and Triassic approx. 4000 feet (1200 metres).

## PERMIAN SYSTEM

A summary of the Permian stratigraphy is given in columnar form in fig 2.

The term " pebbles ", as used here, includes the term " erratics " (see p. 40).

### Tillite

This is a coarse grained, poorly sorted, unfossiliferous, tillitic conglomerate consisting of pebbles (or erratics) of quartzite, slate, schist, phyllite, igneous and sedimentary rocks in a groundmass of grey mudstone enriched with quartz granules and rock flour (Pl. 4). A number of faceted and striated erratics have been found. The pebbles range in size from a fraction of an inch to about 1 foot in diameter. The pebble content of the rock may range from nil to a very high proportion.

There is little overall change in character of the tillite although its composition may vary slightly. For example at Wilsons Yard (49703E, 68470N), at the contact with the Quamby Mudstone, a pebble-rich bed about 2 feet thick marks the top of the formation. It is made up of pebbles (40%) (quartzite 85%, acid igneous rocks 5%, phyllite and schist 5% and sediments 5%), granules (20%) and clay (rock flour) matrix (40%). Pyrrhotite nodules also occur in this area. However, at 49240E, 68675N the rock is composed of pebbles (30%), rock flour matrix (60%) and granules (10%). In this instance 90% of pebbles are less than 1 cm across. On the other hand, at 49320E, 68634N in Hollands Quarry, pebbles are 20%, clay matrix 30% and granules 50%. Pebbles in this latter case include igneous rocks, particularly granite and porphyry (10%), quartzite (75%) and quartz (15%).

A specimen of tillite from Hollands Quarry was also examined in thin section (33742). The rock is medium-dark grey and consists principally of clay matrix (75%) and pebbles including chert and laminated slate (5%), detrital quartz (8%) and chlorite-muscovite schist (12%). The modal grain size is about 0.25 mm with some 30% of the particles within this grade. The grains are dominantly angular with some subangular; a few sub-rounded larger fragments tend to be more rounded than the smaller and some have flat surfaces. The particles vary from equidimensional to very elongate. The matrix consists of quartz, a platy mineral which may be a clay, and some indeterminate material.

Thermal metamorphism near the contact with the syenite on the shore near Wilsons Yard and on the road W from Lymington (49345E, 68408N) results in reaction haloes around the pebbles.

The properties of the rock agree with the salient features of glacial till given by Pettijohn (1957). The formation is only partially exposed and its total thickness unknown but the maximum exposed thickness, at Silver Hill, is at least 700 feet (213 metres). The rock grades imperceptibly into the Quamby Mudstone (e.g., at 49720E, 68450N).

This tillite probably represents the basal formation of the Permian sequence in this area, as it has been shown to do elsewhere (Wynyard, Maydena, &c.). The formation may be correlated with the glacial formation at the base of the Permian System at many localities in Tasmania.

## PALAEOGEOGRAPHY AND AGE.

Tillite occurs in many places W of the meridian of Hobart. However, the thickest development thus far known in SE Tasmania occurs in the Cygnet District suggesting that the sub-Permian surface was lower here than in adjacent areas.

The pebbles in the tillite, as observed in the field, were recognizable or deducible as belonging to Precambrian, Cambrian, Ordovician, Silurian or Devonian Systems as developed in Western Tasmania. This is in accord with other observations (Hogg, 1901; Banks, Loveday and Scott, 1955, p. 216; Banks, 1962, p. 191), suggesting a source area in W or NW Tasmania, or off the present West Coast. Most writers have considered the tillite in Tasmania to be terrestrial, but Carey and Ahmad (1961) suggested that it was deposited below sea level from a wet base glacier. The evidence at Cygnet cannot be said to favour either hypothesis.

Early in the Permian an ice-sheet probably covered the whole area, and as it retreated to the NW it left thick deposits of ground moraine. Poor circulation is indicated by the presence of pyrrhotite nodules in the upper parts of the tillite and this suggests a partially closed, cold-water basin. There is no evidence for any variation in the intensity of glaciation. As the ice retreated completely, the sea flooded in and pyritic siltstone was deposited.

The age of the tillite is uncertain. Hogg (in Twelvetrees, 1902, p. 266) assigned a Permo-Carboniferous age to the "conglomerate" containing striated pebbles which he found on Mt Mary and considered to be of glacial origin. The tillite may be Lower Permian or even Carboniferous (cf. Gulline, 1967).

### Quamby Mudstone

This formation rests conformably on the tillite as seen on the shore at 49720E, 68450N, where the basal 15 inches is a greenish-grey siltstone with quartz granules and a few pebbles; the proportion of granules and pebbles decreases to virtually nil up the section. The best exposures of this formation are to be found in the Tobys Hill and Silver Hill road sections, and on the shore N of Gardners Bay. (See fig. 2, pl. 5.)

When fresh, the rock is a dark-grey, dark greenish-grey, or olive-grey mudstone consisting principally of silt grade material, some mica and some small quartz granules. It is massive with poor porosity, density approximately 2.60 gm/$cm^3$, flaggy and prone to spheroidal weathering. Sorting is moderate to good. Glendonites and pyrite nodules are present, particularly in the lower part of the formation. Pebbles are rare, although 5 quartzite boulders 1-4 feet across were seen on Shag Point. Macrofossils have been seen in only one locality (49570E, 69050N). Such fossils include small brachiopods and echinoid plates. It is noteworthy that the macrofossils occur within a sandy zone. Such zones are unusual in this formation. However, Dr. Conkin (pers. comm.) reported the presence of numerous microfossils in the Tobys Hill section which he regards as characteristic of this formation throughout Tasmania. The finely jointed character of the rock permits it to weather into angular pieces about 2 inches across which tend to blanket the outcrop.

FIGRUE 3.
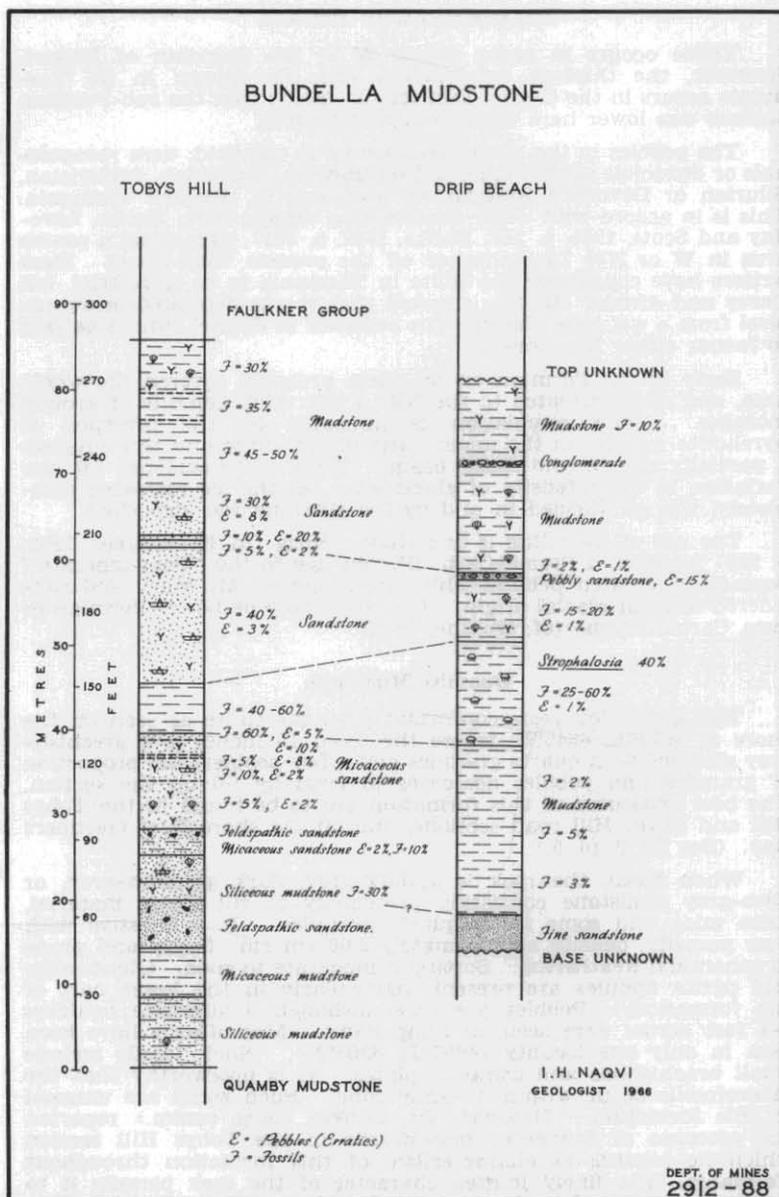
In thin section (33709), the rock consists of clay grade material (80%), silt with detrital quartz grains (12%), and limonite (8%). The silt matrix is rich in sericite and chlorite with some muscovite. Much of the muscovite is altered to sericite.

The thickness of this formation varies between 500 feet (152 metres) at Tobys Hill and 440 feet (134 metres) at Silver Hill.

## CONDITIONS OF DEPOSITION

Following retreat of the glaciers, the sea probably covered the till to a considerable depth, the eustatic rise of sea level being much more rapid than isostatic adjustment. The depth of water is unknown but it appears that the silt of the Quamby Mudstone was deposited in deep water in a gulf between low-lying land areas. Banks (1962, p. 197) suggested a source area toward the SE. The presence of pyrite suggests a reducing environment, the calcareous concretions an alkaline one. The glendonites may indicate cold conditions and this is supported by the presence of erratics which are, however, not common. The fauna, grain size and lack of bedding indicate uniform conditions of deposition with very little current movement.

## CORRELATION

This formation in the Cygnet District can be best correlated with the Quamby Mudstone, as defined by Wells (1957), on its lithological similarity and stratigraphic position. In northern and western Tasmania, as in the Cygnet District, it consists of only one formation, but on Woody Island (Banks, Hale and Yaxley, 1955) and near Maydena it consists of 8 units all of which have been termed formations, and therefore it has been termed the Quamby Group by Banks (1962, p. 194), who discussed its correlation.

## Bundella Mudstone

The Bundella Mudstone (Bundella Mudstone of Banks and Hale, 1957, p. 43) is exposed in the Tobys Hill section between Quamby Mudstone at 49830E, 68795N and Faulkner Group at 49880E 68005N, where it is 278 feet (85 metres) thick. A partly exposed faulted sequence also occurs on the shore in the Drip Beach section, where it is 200 feet (61 metres) thick. Both measured sections are discussed in detail below, together with their correlation. (See figs. 2, 3.)

### TOBYS HILL SECTION

For the most part this formation is a regular alternation of richly fossiliferous mudstone and sandstone units. The latter are unfossiliferous in the lower parts. At the base is a siliceous mudstone which gives way to a micaceous sandstone. This is followed by an alternation of siliceous and micaceous mudstone units with thin units of feldspathic sandstone for another 105 feet (32 metres). This is overlain by 52 feet (16 metres) of fissile and non-fissile mudstone, succeeded in turn by greywacke sandstone. The overlying mudstone is taken to be the top of the formation. Muscovite occurs commonly in the bottom 110 feet (33 metres), varying from 2% to 10%. It is more common in the sandstone, which is also richer in erratics.

The mudstone is green-grey or pale-green in colour and poorly to well sorted. A thin section (33724) of the mudstone from the top of the formation showed that it consists mainly of quartz and mica of coarse silt grade in a fine silt to clay matrix. The grains are dominantly subangular with moderate sphericity. In addition to quartz and muscovite the rock contains rare grains of altered plagioclase, apatite and chlorite. Some of the quartz in the rock shows undulose extinction indicating possible derivation from a metamorphic source.

The sandstone is green-grey and khaki in colour. It consists of quartz (30%), feldspar (5-10%), muscovite (5-10%), groundmass (50-55%), and rock fragments with minor amounts of apatite and garnet. Sorting is good with most of the grains of sand grade (0.04 to 0.2 mm). The grains are equidimensional, bladed and sub-rounded to subangular.

The basal 68 feet (20 metres) and top 34 feet (10 metres) of the section lack pebbles. The proportion of pebbles increases intermittently upward to about 75 feet (23 metres) from the top and then decreases again. Pebbles include quartzite, schist and granite, generally about 1 inch in diameter, quartzite being the most plentiful; sphericity and roundness are moderate. (See also discussion on pebbles (erratics) p. 40.)

The most noticeable feature of the formation is the marked increase in the proportion of mica and pebbles toward the middle of the formation. This may be a reflection of change in source area, or changes in the intensity of current and wave action. The sandstone apparently represents even better conditions of sorting than the siltstone and mudstone, and is richer in pebbles. It probably represents times of fall in sea level producing shallowing of water and an increase in current action and density of icebergs.

Fossils are abundant in both sandstone and mudstone but the bottom 62 feet (19 metres) of the section is very poorly fossiliferous. The feldspathic sandstone lacks fossils. Many phyla are represented but brachiopods and bryozoans are dominant. The brachiopods are predominantly spiriferids. These include *Tomiopsis angulata*, *T. ovata*, *T. ingelarensis*, *T. denmeadi*, " *Spirifer* " *hillae*, *Neospirifer* sp. and *Grantonia hobartensis*. Some *Strophalosia* occur throughout the section, but a *Strophalosia*-rich unit some 17 feet (5 metres) thick occurs in the middle of the section at 49855E, 68795N and contains *S. jukesi* and a species of *Strophalosia* similar to one found by Woolley (1956) in the Brumby Formation at Mole Creek, the Lewis Point Formation at Woody Island and the Darlington Limestone at Berriedale. It is referred to here as *S.* sp. A. Significant bryozoa are *Stenopora johnstoni* and *S. tasmaniensis* which are commonest in, if not restricted to, the lower part of the Permian sequence. Pelecypods include *Eurydesma cordatum*, *Paromphalus ammonitiformis*, *Astartila*, *Myonia carinata*(?), *Aviculopecten squamuliferus* and *A. sprenti*. Gastropods are also common, the main forms being species of *Mourlonia, Platyschisma ocula* and *Peruvispira*. Some crinoid plates are also present in the lower part of the section.

## DRIP BEACH SECTION

In this section the top and bottom of the formation are faulted. The section consists of pale yellowish-brown, greyish-orange and medium grey mudstone with occasional thin pebbly sandstone. It begins with an unfossiliferous, moderately sorted, massively bedded, fine grained sandstone. This is overlain by poorly fossiliferous (2-5% fossils) mudstone. Fossil content increases upward culminating in a unit rich in *Strophalosia* sp. A. Above this level fossils are 10-15% with bryozoa being the most common in the top 80 feet (24 metres). Other fossils include *Neospirifer, Tomiopsis* and *Eurydesma*. Pebbles are rare and are principally of quartzite, generally about 1 inch in diameter. They have moderate sphericity and high roundness.

## CORRELATION

The lithological correlation between the two measured sections is very poor (fig. 3). The palaeontological correlation is reasonable, although fossils are fewer in the Drip Beach section. The lower parts of both sections are poorly fossiliferous. *Strophalosia* sp. A and *Eurydesma cordatum*, both typical of Bundella Mudstone in Tasmania, occur in both sections. Erratics are also fewer in the Drip Beach section.

The abundance of *Stenopora johnstoni* and *S. tasmaniensis* and the presence of *Eurydesma cordatum*, as well as the lithology and stratigraphic position, are evidence for correlation with the Bundella Mudstone of the Hobart section (Banks and Hale, 1957, p. 43). The correlation of this formation within the Hobart area and with other areas in Tasmania has been fully discussed by Banks and Hale (1957, p. 45) and Banks (1962, pp. 197-198).

It should also be noted that the Darlington Limestone does not occur in the Cygnet District. It therefore appears that the limestone facies thins SW from Hobart. The age of this formation is thought to be Upper Sakmarian or Lower Artinskian.

## CONDITIONS OF DEPOSITION

The Bundella Mudstone is a marine formation. The rarity of fossils in the lower parts suggests brackish conditions early in the depositional history. The fossils, particularly *Stenopora johnstoni*, pelecypods and spirifers, all suggest shallow water deposition. The sediments of this formation become finer grained upwards, possibly indicating reduction in relief of the source area. The alternation of sandstone and mudstone in the Tobys Hill section suggests a cyclic sedimentation. The cause of such cyclic sedimentation is obscure but it may be related to eustatic changes in sea level, changing rates of sedimentation reflecting variations in glacial intensity. Icebergs are indicated by the presence of pebbles. The land surface supplying the sediment included schist, quartzite of several types, and some granite masses. The source rocks for pebbles were presumably W of this area.

### Faulkner Group

This group (Faulkner Group of Banks and Hale, 1957, p. 46) consists of at least 67 feet (20 metres) of fossiliferous and unfossiliferous mudstone, siltstone and feldspathic sandstone wherever measured. The principal occurrences are S of Cradoc, Balfes Hill, Tobys Hill and E of Deep Bay. Sections have been measured at Balfes Hill and Tobys Hill (fig. 4).

5 cm

**BALFES HILL**

FAULKNER GROUP

Section faulted

Iron stained siltstone with
some pebbles.

UNIT 6

Coarse siltstone; many pebbles.
UNIT 5

TOBYS HILL

Micaceous silty sandstone

Fine sandstone, many pebbles.

GRANGE MUDSTONE

Siltstone
Sandy siltstone    TRANSITIONAL UNIT 4

Siltstone

UNIT 5

Feldspathic sandstone (coarse)

Sandstone    UNIT 3

TRANSITIONAL UNIT 4

Feldspathic sandstone
UNIT 3

Siltstone, ℱ = 20% UNIT 2

Fine siltstone  UNIT I ──?

P = 10%
Sandy zones
Well sorted siltstone
P = 10%
UNIT 2
Siltstone, well sorted

BUNDELLA MUDSTONE ── ?

Sandy zones

Fine siltstone, P = 20-30%
UNIT I

Break in section.
**BUNDELLA MUDSTONE**

METRES  FEET

40 ─ 120

30 ─ 100

─ 80

20 ─ 60

─ 40

10 ─ 20

0 ─ 0

FIGURE 4.

D.LEAMAN & I.H.NAQVI
GEOLOGISTS  1966

ℱ = Fossils
P = Pebbles

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## TOBYS HILL SECTION

At the base is a massive, fine grained, light greenish-grey, unfossiliferous siltstone containing mica (2%). Examination in thin section (33734) showed that the rock is composed of particles of quartz and muscovite in a fine silt matrix. The rock is poorly sorted and the quartz particles are subangular to rounded and up to 0.16 mm in diameter.

The second unit of the group is a fossiliferous mudstone in which fossils constitute 25% of the rock. Spiriferids, stenoporids and fenestellids are present in equal proportions with lesser numbers of *Peruvispira* and *Schuchertella*. It should be noted that *Schuchertella* has not been seen in Permian rocks in this area below this unit. In thin section (33733) the mudstone is seen to be very similar to that of the basal unit.

The third unit is a medium to fine grained, poorly sorted, massively bedded, feldspathic sandstone which is more coarsely grained at the base. In thin section (33732) it is shown to contain muscovite (2%), magnetite (5%) and subangular to rounded quartz (18%) up to 0.12 mm in diameter in a matrix of feldspar and clay. Most of the feldspar is altered to sericite and mixed with clay which itself contains sericite.

The fourth unit is transitional in that the sandstone of the previous unit becomes finer grained and darker coloured, giving way after 4 feet 8 inches (1.4 metres) to siltstone (unit five). In thin section (33731) this transitional rock contains subrounded quartz grains (15%), 0.21-3 mm in diameter, and hematite (10%) in a matrix of feldspar and clay.

The uppermost unit is a light grey, fissile, micaceous siltstone. Sorting is variable (good to poor). In thin section (33730) the rock is poorly sorted and contains subrounded quartz (30%) up to 0.12 mm, feldspar (5%) and hematite (5%) in a clay matrix. Some quartz shows undulose extinction. This siltstone also contains a species of foraminifera characteristic of the Fergusson Siltstone at Mt Nassau in the Hobart area (Dr. Conkin, pers. comm.). This unit contains at least three coarse beds, one occurring at the top, which consist of quartz (70%), feldspar (5%), matrix (20%) and quartzite pebbles (5%). Pebbles are generally 1 cm in diameter and have moderate sphericity and high roundness. This unit also weathers characteristically to light creamy, square to rectangular pieces about 2 mm across.

## BALFES HILL SECTION

The base of the Faulkner Group on Balfes Hill is taken at the top of the last observed fossils in the Bundella Mudstone. There is a break in the section above this point due to paucity of outcrop. The basal unit is a siltstone rich in sand grade grains. There are occasional sandy bands and some grains reach 3 mm across. All are poorly rounded and of low sphericity. Bedding is indistinct. The sandy zones are composed principally of quartz with some mica and ferruginous material. Pebbles are larger in these zones. Most pebbles are of quartzite, but slate and igneous rocks are also represented.

The second unit in this section also consists principally of siltstone with sandy bands. However, the proportion of pebbles is considerably less (approx. 10%). The lowest 30 feet (9 metres)

of this unit consist primarily of poorly bedded fine siltstone. In the sandy bands the grains are angular, mainly of quartz with some feldspar; sorting is poor. Pebbles exceed 15% and are usually of quartzite, quartz and some greywacke(?). The unit coarsens upward, with sandy zones being more common. There is also an increase in the size of pebbles (5-50 mm). The uppermost portion of the unit is a very pebbly siltstone. Pebbles rarely exceed 5 mm in diameter but may form 25% of the rock. This siltstone also contains a small percentage of mica.

There is an abrupt change in lithology to unit 3 which consists principally of well sorted quartz sandstone showing traces of cross bedding. The grains are moderately well rounded, of fairly high sphericity and consist predominantly of quartz, with a little feldspar. Much of the cement appears to have been removed with the result that the rock is very friable and separates readily into its constituent grains. The lowest parts of this unit are notably micaceous. The well sorted quartz sandstone includes a coarse feldspathic stage in which feldspar is 30% and the grains, particularly those of quartz, are cemented with a siliceous cement, probably due to outgrowth. The grainsize of the rocks in this unit increases up the section and, after a further coarse but non-feldspathic sandstone, the well sorted sandstone becomes notably coarser and better cemented. Pebbles are absent from this unit which resembles the Liffey Sandstone of Wells (1957).

The fourth unit of the group in this section is relatively thin and transitional. No pebbles were seen within it. It grades from a sandy siltstone at the base to a fine siltstone which coarsens toward the top.

Unit 5 consists of fine sandstone or coarse siltstone containing many pebbles. The fine sandstone at the base contains pebbles of slate and quartzite up to 1.5 cm in size. The overlying silty sandstone contains up to 3% of mica but distinctly fewer pebbles. The upper part consists of micaceous coarse siltstone with many pebbles.

Unit 6 consists principally of iron stained siltstone with occasional sandy and pebbly bands.

The top of the section is faulted out and thus the total thickness of the Faulkner Group at Balfes Hill is unknown. This entire section is unfossiliferous.

### OTHER EXPOSURES

Recognition of this Group is commonly difficult due to its marked variations in thickness, lithology and often poor outcrop. At Deep Bay the Faulkner Group is 65 feet (20 metres) thick, incompletely exposed and composed of unfossiliferous mudstone. Along the coast between Glaziers Bay and Cradoc further small sections are to be seen containing quartz sandstone, siltstone and feldspathic sandstone with pebbly zones. The total exposure is approximately 65 feet (20 metres). The sequence in this locality is from pebbly feldspathic sandstone to coarse siltstone and sandstone. Occasional brachiopods are to be found in the upper sandstone units at 49010E, 69270N. The pebbles present consist of fragments of slate, quartzite and basic igneous rocks. The source rocks for the pebbles presumably lay to the W of this area. The Glaziers Bay partial section and that at Balfes Hill cannot be correlated due to lack of continuity of outcrop.

## CONDITIONS OF DEPOSITION

The Faulkner Group is thought to be a deltaic deposit, which might account for the extreme variability of the succession.

The first stage of deposition was shallowing of water, possibly due to glaciation, from the general marine conditions in which the Bundella Mudstone was deposited. During the early stages the Balfes Hill and Deep Bay areas were possibly estuarine, shallower than the Tobys Hill or Glaziers Bay areas where sedimentation was shallow water marine.

The second stage was rise in sea level with marine conditions in the Tobys Hill and Glaziers Bay areas and deposition on an open shelf or continental slope. At this time the Balfes Hill and Deep Bay areas were flood-plains receiving terrestrial deposition.

The third stage comprised a complete regression in which the Tobys Hill-Glaziers Bay area received beach deposits and the Balfes Hill-Deep Bay area formed an arcuate flood-plain behind the coastline with lakes and channels receiving terrestrial deposition, e.g., unit 3, Balfes Hill and Tobys Hill sections.

There was then a gradual transgression of the sea, with deposition of transitional units. All upper units are suggestive of marine conditions, probably open shelf deposition with benthonic foraminifera thriving. The last stage was the complete coverage of the area by the sea prior to the deposition of the deep water marine Grange Mudstone.

## CORRELATION

Some correlation is possible with the type area at Mt Nassau (Banks and Hale, 1957). This is summarized in Table 2 together with the postulated conditions of deposition for each formation.

### TABLE 2: CORRELATION OF FAULKNER GROUP

| Mt Nassau | Tobys Hill | Balfes Hill | Environment |
|---|---|---|---|
| Fergusson Siltstone | Unit 5 | Units 5 & 6 | Marine |
| Altmont Conglomerate | Probably unit 4 | Probably unit 4 | Off-shore bar, beach |
| Parramore Sandstone & Siltstone | Unit 3 | Possibly top unit 2 and unit 3 | Non-marine |
| Jarvis Siltstone | Unit 2 | Possibly part of unit 2 | Marine |
| Byers Sandstone | .... | .... | Non-marine |
| Rathbones Sandstone & Siltstone | Probably unit 1 | Possibly unit 1, part of unit 2 | Non-marine with marine intercalations |
| Geiss Conglomerate | .... | .... | Littoral |
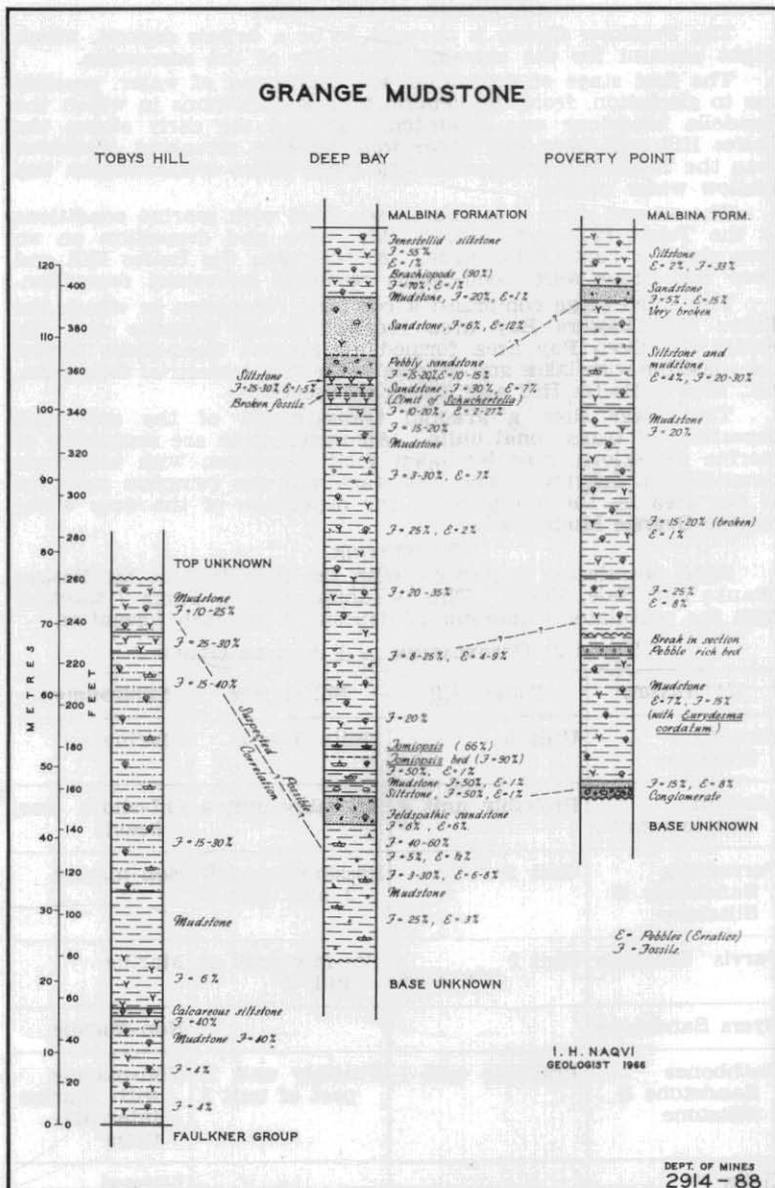
FIGURE 5.

Although there is little evidence for such cyclothems as were found in the Mt Nassau section by Banks and Hale (1957), there is some evidence for a cyclic arrangement of rocks reflecting a cyclic order of environment in the Cygnet District.

## Grange Mudstone

This formation (part of or equivalent to the "Cascades Group" of Banks and Hale, 1957, p. 52) occurs widely in the Cygnet Peninsula. In the Tobys Hill section it overlies the Faulkner Group at 49885E, 68810N and is at least 242 feet (74 metres) thick. The formation in this section is terminated upwards by a dolerite intrusion. In the Deep Bay section it is well exposed on the shore below the basal conglomerate bed of the Malbina Formation. The total exposed thickness in this section is 370 feet (112 metres), with the base faulted out. The two sections have not been observed to overlap, possibly due to lack of marker beds, similar lithology, and poor palaeontological correlation. The top 283 feet (86 metres) are also exposed at Poverty Point between 49364E, 67980N and 49290E, 68040N. The sections are shown in fig. 5. (See also pl. 6.)

The age of the formation is thought to be Middle to Upper Artinskian.

### LITHOLOGY

The Grange Mudstone in this area is considered to be a facies variant of the Berriedale Limestone and the beds above and below it at Mt Nassau (Banks and Hale, 1957, p. 53). It consists of richly fossiliferous siltstone, mudstone with very occasional bands of pebbly sandstone, and feldspathic sandstone. In the Deep Bay section both fissile and non-fissile siltstones occur. Some quartz granules are present and are particularly common on certain horizons in the top part of the Deep Bay section. Bedding is generally poorly developed.

The siltstone from the top of the Tobys Hills section (thin section 33740) consists of grains of quartz, chlorite and zircon. The grains are dominantly of silt grade (approx. 0.015 mm) and are equant, the larger grains being subrounded.

The lowest mudstone unit of the Deep Bay section (thin section 33681) contains quartz grains up to 1 mm in diameter in a siliceous, silt grade matrix consisting of limonite and some rock fragments. Some quartz shows undulose extinction. Quartz grains are subrounded with moderate sphericity. Sorting is poor.

The siltstone from the lower part of the Poverty Point section (thin section 33685) is very similar to the siltstone from Tobys Hill, but the sorting is very poor. Although most of the rock is of silt grade, some quartz grains are up to 1 mm in diameter.

Another thin section (33694) of a siltstone, similar to Quamby Mudstone, from the shore at 49281E, 68072N shows that it is a very fine grained, poorly sorted rock of silt to clay grade in which fragments are difficult to identify.

The Poverty Point section is very similar to the Deep Bay section both lithologically and palaeontologically (Appendix 1).

A fossiliferous calcareous siltstone, 2 feet thick, occurs near the base of the Tobys Hill section at 49890E, 68815N. Other than this, the only occurrence of limestone in the Cygnet Peninsula

is on Silver Hill at 49133E, 68856N and was reported by Everard (1957, p. 202) and Banks (1957, p. 68). It is only about 6 feet (2 metres) thick and cannot be traced for more than a chain along the strike. It appears to pass into mudstone in either direction. The limestone is a fossiliferous, medium grey, foetid rock with pebbles up to 6 inches long. It weathers to a pale cream colour and contains many fossils which include *Stenopora* prob. *crinita*, *Protoretepora*, *Fenestella*, *Polypora*, *Neospirifer*, dielasmids, *Strophalosia*, *Schuchertella*, aviculopectinids, *Mourlonia*, *Platy-schisma*, ostracodes, *Tomiopsis* and *Eurydesma cordatum*. Under the microscope it is seen to consist largely of crypto-crystalline calcite. Angular quartz grains of silt grade are fairly numerous. Feldspar is common, although much is altered to sericite. The stratigraphic position of this limestone is not clear. It is underlain by a considerable thickness of siltstone with a fauna including very alate spiriferids, which occur usually no lower than the Berriedale Limestone. Above the limestone is a siltstone with a few pebbles and many fossils, including *Strophalosia, Fenestella,* alate spiriferids, and a few *Eurydesma cordatum* var. *sacculum*. The fossils and the associated sediments suggest that it is in the upper part of the Grange Mudstone.

Pebbles are rare in the lower part of the Grange Mudstone at Tobys Hill. However, at Deep Bay there is a gradual increase in numbers up the section to a maximum in a bed 8 inches thick at 49690E, 67978N. In this bed, the pale brown rock consists of quartz and quartzite granules (30%), pebbles (27%), clay matrix (33%) and broken fossils (10%). Pebbles include quartzite (70%), black slate (10%) and granite (20%). Some are faceted and the character of the deposit suggests a glacial rather than a turbidity current origin. Above this bed there is a gradual decrease in the proportion of pebbles.

Pebbles of siltstone are common in the lower parts of the Deep Bay section, whereas those of granite and porphyry become abundant in the upper parts. Volcanic pebbles are rare throughout. Quartzite pebbles are the most common type throughout the section, but are most abundant in the upper part. A slaty rock is also prominent in the centre of the section. Overall, pebbles represent 2-5% of the rock in the Deep Bay section, have low to moderate sphericity and high roundness and are generally 1 inch in diameter although pebbles of granite and siltstone up to 1 foot in diameter are known to occur.

In the lower part of the Poverty Point section pebbles are common. Quartzite is the dominant type although intermediate and acid igneous rocks become common in certain horizons and slate and schist are also represented high in the section. Pebbles of volcanic rocks are to be seen commonly in only one horizon at 49284E, 68038N. Pebbles of sedimentary rocks are particularly common in the lower part of the section. The size of the pebbles varies from 1 to 40 cm in diameter, generally 1-2 cm, and usually sphericity is low and roundness moderate. Occasionally some are faceted. Two thin pebble-rich beds, similar to those at 49690E, 67978N in the Deep Bay section, occur at 49267E, 68076N and 49221E, 68089N.

## PALAEONTOLOGY

Fossils are abundant in all parts of the formation but are less common in the sandy members. At Tobys Hill, the fossil content varies from 15% to 80% in the lower part and from 30% to 60% in the upper part. At Deep Bay the variation is 6-55%, 5-35% and 38-85% in the lower, middle and upper portions respectively. At Poverty Point fossils are few in the lower part of the section, but become common in the upper part.

Preservation of fossils is generally good at Deep Bay, Poverty Point and Glaziers Bay and moderate at Tobys Hill, suggesting variation in the conditions of deposition even over a short distance. A characteristic of the Grange Mudstone in all areas is the occurrence of strong laminations due to alignment of bryozoa and the presence of fossil-rich zones up to one foot thick.

A further common feature is the lateral as well as vertical variations in the fossils. In the Deep Bay section, fenestellids are common at the top and base and stenoporids in the middle part. In the Poverty Point region, bryozoa are dominant only in the upper parts. Brachiopods are generally less abundant. These are predominantly spiriferids, but some *Strophalosia* sp., *Schuchertella* and dielasmids are also present. In the Deep Bay section the brachiopods present include " *Spirifer* " *avicula*, " *S.*" *bilamellata*, " *S.*" *vespertillio*, *Notospirifer* cf. *darwini*, *Neospirifer*, *Grantonia hobartensis*, *Edmondia*, *Tomiopsis mantuanensis*, *T. ovata*(?), *T. parallela*, *T. subradiata* and *T. symmetrica*(?). *Strophalosia* is common on certain horizons, e.g., the upper part of the Deep Bay section where *S. typica* and *S. brittoni* occur. *S. preovalis* is prominent in the lower part of the Deep Bay section. *Schuchertella* occurs throughout, but has not been seen in the upper 75 feet of the Deep Bay section or above this horizon anywhere in this district. Gastropods, including *Peruvispira* and *Keeneia*, are also common. The pelecypods *Eurydesma* and *Deltopecten* are present on several horizons, particularly in the lower part of the Poverty Point section. Other rarer pelecypods include *Volsellina mytiliformis*, *Ptychomphalina* and *Aviculopecten sprenti*. Ostracodes and crinoid columns also occur in some zones.

Reasonable correlation may be made between the Deep Bay and Poverty Point sections but no overlap has been observed for the Tobys Hill and Deep Bay sections.

The Grange Mudstone is a marine formation, deposited in a relatively shallow cool temperate sea in which icebergs floated. The source rocks for the pebbles presumably lay to the W of this area.

### Malbina Formation

This formation consists of approximately 150 feet (45 metres, of conglomerate, sandstone and siltstone. In the Kangaroo Bay section, between 49740E, 67920N and 49695E, 67970N, the thickness is 163 feet (50 metres) and at Poverty Point, between 49365E, 67984N and 49380E, 67960N the thickness is only 94 feet (29 metres). The formation conformably overlies Grange Mudstone.

MALBINA FORMATION

KANGAROO BAY

POVERTY POINT

RISDON SANDSTONE

Calcareous sandstone

Siliceous and calcareous
siltstone  E = 4%  F = 30%

Siliceous siltstone E = 5% , F = 30%

E = 3%
E = 5%, F = 2%  MEMBER "E"
E = 15%

I. H. NAQVI
GEOLOGIST 1966

RISDON SANDSTONE

E = 30%

MEMBER "D"

Quartz sandstone
E = 7%

E = 3%

Fine sandstone  E = 15%
Gilledia          E = 8-10%
                  MEMBER "C"
F = 17%
E = 3%
                  MEMBER "B"

Siltstone  E = 5%

E = 5-10%

E = Pebbles (Erratics)
F = Fossils.

F = 5%, E = 1%
Feldspathic sandstone
F = 2-15%  E = 1-20%   MEMBER "A"
Conglomerate

Gilledia sandstone F = 30%, E = 1%
E = 1%
Conglomerate

GRANGE MUDSTONE

METRES    FEET
50 — 
      150
40 — 
      120
30 — 90
20 — 60
10 — 30
0 — 0

DEPT. OF MINES
2911 — 88

FIGURE 6.

Figure 6.

Outcrops of the formation are limited to areas S of Lymington, Cradoc and Deep Bay. It is Upper Artinskian or Kungurian in age and the formation in this district may be directly correlated with the type section as defined by Banks and Read (1962). Each of the two measured sections are described. (See fig. 6, pl. 7 and Appendix 1.)

## KANGAROO BAY SECTION

*Member " A "*

The basal member, " A ", overlies the Grange Mudstone with a thin basal conglomerate bed, and is composed of siliceous and feldspathic sandstone some 25 feet (7.5 metres) thick. The lowest 12 feet (3.5 metres) is dominantly medium to coarse grained, poorly sorted, feldspathic sandstone, very rich in quartz granules, pebbles (7-20%) and fossils (12%). The remaining thickness is made up of medium grained, poorly sorted sandstone with fewer granules and fossils. The rock is thickly bedded, cream or grey in colour, and the pebbles and fossils tend to occur together in zones up to 10 inches thick. No evidence of graded bedding has been seen.

The rock has disrupted framework with granules and pebbles in an abundant to predominant quartzose matrix. The main granule material is quartz, but low and high grade metamorphic rocks, granite, vein quartz and volcanic rocks are all represented. The pebbles are composed almost entirely of quartzite with subordinate acid to intermediate igneous rocks including granite. Angular fragments of slate and muscovite schist also appear in the upper parts of this member. The pebbles are about 1 cm in diameter, although granite boulders up to 6 inches in diameter are also present. The sphericity is generally low and the roundness high. The pebbles do not show any obvious preferred orientation.

Large poorly preserved casts and moulds of spiriferids are common; *Tomiopsis, Grantonia* and *" Spirifer "* avicula have been identified. Only a very few stenoporids are found. Big spiriferids tend to be concentrated in pebble-rich beds and are generally parallel to bedding. Fenestellids have been seen in this member and it is rare to find any brachiopods complete. These factors suggest turbulence in the depositional area.

*Member " B "*

Member " B " comprises approximately 24 feet (7.5 metres) of massive sandstone, dusky yellow in colour, with slightly more fossils and fewer pebbles than the underlying member. This member commences with an unfossiliferous sandstone 4 feet 3 inches thick with a few pebbles (3%), overlain by beds of medium to fine grained, well sorted, fossiliferous sandstone 1-2 feet in thickness.

In thin section (33645) quartz grains (50%) are subrounded to well rounded and have a mean diameter of 25 mm. Fresh plagioclase fragments are rare. The presence of a few bent fragments of feldspar, sheared muscovite laths and quartz showing undulose extinction indicates a metamorphic source. The matrix (45-50%) is composed of silt grade quartz, chlorite, limonite, muscovite, and some zircon and apatite. The texture tends to be mosaic.

Pebbles of quartzite, quartz porphyry, granite and slate as large as 4 inches in diameter are scattered sparsely throughout the unit. Quartz porphyry becomes particularly common toward the top.

Fossils tend to occur in zones of which at least 5 can be recognized. A dielasmid-rich zone occurs near the top. The fossils present are spiriferids, especially *Tomiopsis*, *Astartila intrepida* (Dana, 1849), *Vacunella*? sp. (Waterhouse, 1965).

### Member " C "

The basal 20 inches of this 10 feet (3 metres) thick member is a khaki coloured, very poorly sorted, fine grained sandstone containing quartz grains (60%), siliceous matrix (30%) and pebbles (5% at the base, 8-10% at the top). The remainder of the unit is a fine grained pebbly sandstone containing pebbles (20% at the top, 10% at the base) of quartzite, porphyry and granite. The pebbles are fairly well rounded and, with the exception of a granite block over 20 inches long, are generally 1 inch long. It is significant that no granite pebbles have been seen above this member. The matrix consists of particles of quartz, and a small amount of feldspar, of medium to fine sand grade.

### Member " D "

Member " D " consists of 58 feet (17.5 metres) of poorly sorted, medium-dark grey, well bedded, coarse siltstone. Fossils were not observed. In the basal 21 feet (6.5 metres), the siltstone contains quartz granules (7%) and pebbles (3%). Individual beds are about one foot thick. The next 28 feet (8.5 metres) are composed of coarse grained siltstone containing quartz granules (25%) and pebbles (30%). In the following 7 feet 6 inches (2.3 metres) quartz granules are only 10% and pebbles 15%.

A feature unique to this member is the abundance of pebbles, the pebble content being exceeded only in the basal tillite. The pebbles are dominantly quartzite, with subordinate acid and intermediate igneous porphyries and slate. Pebbles of porphyry and slate are more abundant in this member than in any other unit. Pebbles are generally 1-2 inches long, although many quartzite and slate blocks over 8 inches long are found. They are fairly well rounded but have low to moderate sphericity. There is also evidence of graded bedding. Some pebbles are faceted, indicating glacial origin.

### Member " E "

This member consists of about 45 feet (14 metres) of fossiliferous and unfossiliferous sandstone, siliceous siltstone, and carbonaceous siltstone and sandstone. Sorting is poor throughout the basal unit, a richly fossiliferous light grey sandstone, 4 feet (1.2 metres) thick. The fossils are predominantly brachiopods, especially *Strophalosia*, " *Spirifer* " *avicula* and *Tomiopsis*, although some pelecypods are present. There is then about 8 feet (2.3 metres) of unfossiliferous sandstone, in turn overlain by a poorly fossiliferous siliceous siltstone containing spiriferids, especially *Tomiopsis*.

The remainder of the member consists of a coarse, richly fossiliferous, carbonaceous siltstone and unfossiliferous carbonaceous sandstone. In thin section (33639), the siltstone contains subrounded quartz grains (70%) with a mean diameter of 0.25 mm with rare fresh plagioclase fragments. The presence of a bent fragment of feldspar and quartz showing undulose extinction indicates a metamorphic origin. The matrix (20%) is composed of silt grade quartz, chlorite, limonite, and a small amount of micaceous clay grade material. Fossils in this unit are dominantly *Terrakea brachythaera* and *Myonia corrugata* (Fletcher and Dun, 1929). Both are characteristic of this horizon in Tasmania and *M. corrugata* occurs in the Mantuan Productus Bed of Queensland.

The top of this member is marked by about 6 feet of carbonaceous sandstone which contains a highly carbonaceous lens about 1 foot below the top. The sandstone is fine grained, medium-dark grey and poorly sorted. It consists of quartz (50%), carbonaceous material (25%), siliceous cement (20%) and mica (5%). No pebbles were observed.

Pebbles (3-5%) scattered throughout the member are dominantly quartzite with subordinate acid and intermediate igneous rocks and quartz. They are well rounded with moderate sphericity and are generally 1 inch long.

## POVERTY POINT SECTION

The formation here is only 94 feet (29 metres) thick. A basal conglomerate is overlain by a fine grained, well sorted, unfossiliferous sandstone with very high porosity. It is rich in quartz granules, but pebbles are sparse and almost entirely of quartzite. This unit has been tentatively correlated with Member "A" of the Kangaroo Bay section. The succeeding sandstone is fossiliferous and contains a higher proportion of pebbles. A lens rich in dielasmids and pelecypods occurs near the top of this sandstone, similar to that in Member "B". The remainder of the formation is considerably more pebbly (4-15%) with pebbles of a type comparable with those of Member "D". Porphyry and siltstone pebbles are common in the lower parts with granite pebbles becoming more prominent toward the top. The size is generally 1 inch in diameter although some granite and slate blocks are over 9 inches long. The sphericity is generally low and the roundness high.

This section does not appear to contain Members "A", "C" and "E" of the Kangaroo Bay section and the reduction in thickness is noteworthy, suggesting a general thinning to the W.

In the Cradoc Hill area the thickness is about 100 feet (30 metres) and only members "A" and "D" are identifiable. To the N of Woodstock a very pebbly, siliceous fossiliferous sandstone overlies Grange Mudstone and is correlated with Member "A".

## CONDITIONS OF DEPOSITION

The formation was deposited in a marine environment subjected to intense iceberg activity. Some turbidity current action cannot be completely discounted. A high carbonaceous content near the top of the formation in the Kangaroo Bay section may suggest very shallow water deposition.

FIGURE 7.

Within the figure:

FERNTREE FORMATION
KANGAROO BAY

CYGNET COAL MEASURES
TOP FERNTREE FORM.
$\varepsilon = 3$-$10\%$   UNIT F

A

UNIT E
CONTINUED

Calcareous tubes 4%
Fissile & non fissile

Calcareous tubes
$\varepsilon = 15\%$
Fissile & non fissile

Calcareous tubes 8%
$\varepsilon = 8\%$

$\varepsilon = 10\%$ UNIT D

UNIT E

Fissile & non fissile.

Calcareous tubes 15%
$\varepsilon = 8\%$
Fissile & non fissile
$\varepsilon = 25\%$

$\varepsilon = 3\%$ UNIT C

$\varepsilon = 10\%$ UNIT B

$\varepsilon = 10\%$

$\varepsilon = 3\%$
A

UNIT A

$\varepsilon = 2\%$

$\varepsilon = $ Pebbles (Erratics)
$\mathfrak{I} = $ Fossils

Non fissile siltstone

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GEOLOGIST 1966

BASE FERNTREE FORM.
Feldspathic sandstone
$\varepsilon = 8\%$

RISDON
SANDSTONE

Conglomerate
$\varepsilon = 15\%$
MALBINA FORMATION

METRES / FEET scale:
110 — 360
100 — 330
90 — 300
— 270
80 — 240
70 — 210
60 — 180
50 — 150
40 — 120
30 — 90
20 — 60
10 — 30
0 — 0

DEPT. OF MINES
2909-88
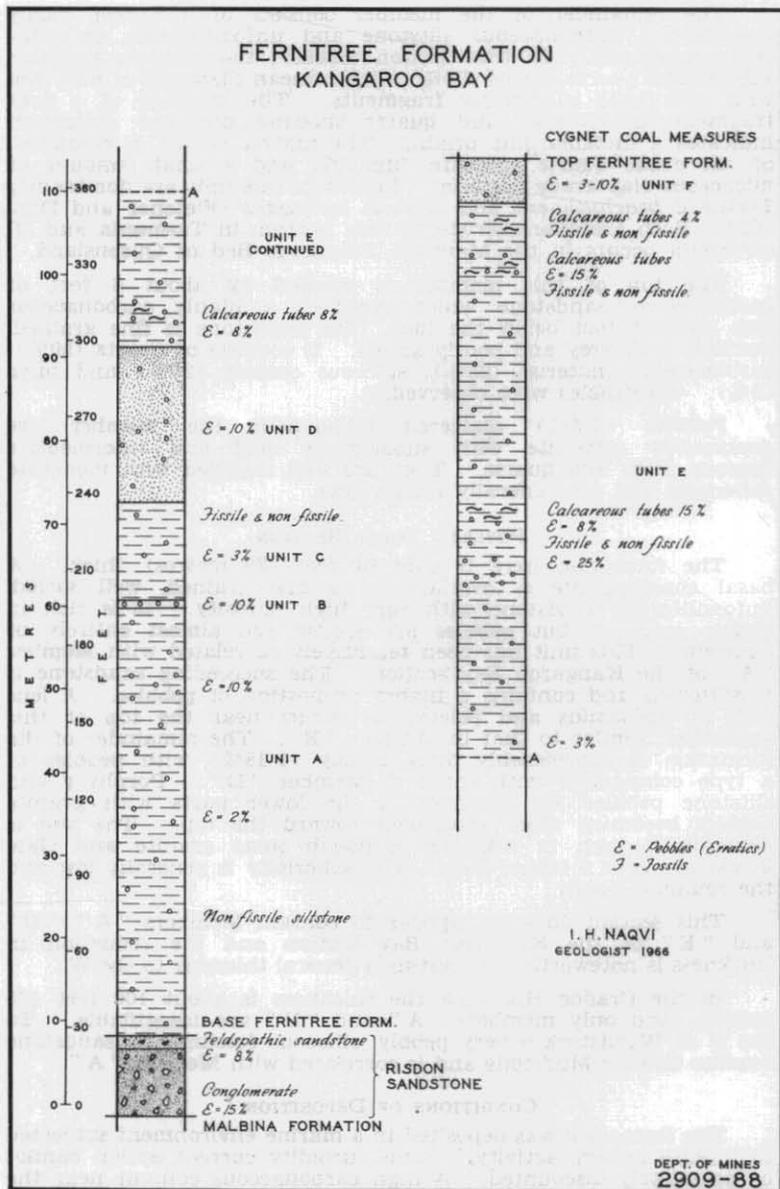
5 cm

The source of clastic material in this formation, as suggested particularly by the pebbles, must have been predominantly metamorphic rocks like the Precambrian rocks of Tasmania but some porphyry, granite, pegmatitic rock and older sediments were included. The abundance of quartz granules and feldspar suggests a richly granitic terrain.

### Risdon Sandstone

This formation of pebbly, feldspathic sandstone (Risdon Sandstone of Banks and Hale, 1957, p. 60) overlies the carbonaceous sandstone of the Malbina Formation with a slight disconformity. At Kangaroo Bay, as at other localities within the district, its thickness is 27 feet (8 metres). The rock is a distinctive marker of upper Artinskian to Lower Kungurian age. The section is shown in fig. 7.

It is very variable, showing all gradations from a conglomerate with quartz pebbles up to 1 inch in diameter in a matrix of angular quartz and feldspar, to a sandstone with feldspar. Pebbles of quartz and quartzite compose 6% of the rock.

The lower portions are massive, current bedded, poorly sorted, medium to coarse grained, resistant conglomerate (pl. 8). The conglomerate contains feldspar (10%), pebbles of round quartz and quartzite 1 inch in diameter (15%) and cloudy, subangular grains of quartz. Pebble-rich lenses up to 3 feet thick occur interfingered with quartz granule lenses. Quartz granules show moderate sphericity and low roundness but pebbles generally exhibit high roundness. The pebble lenses tend to be more plentiful near the base of the formation.

A thin section (33637) from the base of the formation contains well rounded quartz grains (90%), badly weathered feldspar (8%) and quartzite (2%). The average grainsize is 0.5-1 mm. A thin section (33636) from the top of the formation shows subrounded quartz (60%), plagioclase (5%), orthoclase (3%), iron oxide (5%) and a fine siliceous cement (27%). The matrix consists almost entirely of quartz and small rock fragments 0.5-1 mm in size. Some quartz grains show undulose extinction, while others show a secondary growth.

### CONDITIONS OF DEPOSITION

At Kangaroo Bay the cross bedding indicates a current direction from the NE but at Poverty Point it suggests a direction from the SW. The cross-stratification is found as solitary sets generally large in scale. Below each set is an essentially planar erosional surface. According to Allen (1963, p. 101) cross-stratification of this description would be constructed in shallow water by the building of solitary banks with straight or curving leading edges above the slip faces. Solitary banks are commonplace in braided modern rivers, in estuaries, on beaches and in the shallows just off beaches. The nature of the formation suggests a beach origin, and this is supported by the implied shallow water deposition of the upper Malbina Formation. The change from the Malbina to the Ferntree Formation has been postulated as being due to the Lower Kungurian Hunter-Bowen Orogeny of New South Wales which caused an epeirogenic rise of the Tasman area, shallowing of the sea and later freshwater conditions. There is also evidence in the Cygnet District that the Risdon Sandstone was perhaps deposited after the eustatic fall in sea level due to glaciation.

## Ferntree Formation

The Ferntree Formation (Ferntree Mudstone of Banks and Hale, 1957, p. 60) is 554 feet (169 metres) thick as exposed on the shore between Coal Mine Bay and Kangaroo Bay. It overlies the Risdon Sandstone conformably at Kangaroo Bay and is overlain by the Cygnet Coal Measures with a transitional boundary at Coal Mine Bay. The section is shown in fig. 7. It outcrops widely S of Deep Bay and Cradoc.

The formation consists predominantly of an alternation of fissile and non-fissile siltstone and mudstone, with two members of pebbly sandstone or conglomerate. About 140 feet from the top of the formation a bed, 1 foot thick, contains thick shelled broken brachiopods and pelecypods. Except for this, no distinguishable fossils have been found other than small calcareous tubes. Six distinct members can be recognized (fig. 7), differentiated on grain size, colour, pebble content and the nature of bedding. There are several minor poorly sorted beds rich in rounded pebbles. A siliceous cement is present in the coarser arenite, but in the lutite it is argillaceous. The lutite has an isotropic fabric and is bluish-grey and dark blue when fresh. The weathered rock is invariably cream coloured. Bedding is both shaly and flaggy. Fissile beds are generally about 6 inches thick and the non-fissile about 1 foot. The typical lutite is a dense, poorly sorted rock of fine to medium silt grade. Concretionary structures are common and the higher members of the formation have characteristic dark carbonaceous markings and other organic remains. Calcareous tubes up to 5 mm long and 0.5 mm in diameter are found in clusters, particularly in the upper half of the formation. All rocks are strongly jointed.

Examination of thin sections from the upper part of the formation (33628, 33629) shows that it contains subangular grains of clear quartz averaging 0.01 mm in diameter, with subordinate rock fragments, muscovite, magnetite and up to 6% feldspar. The matrix consists of clay, chlorite grains and rock flour. Ferruginous cement may make up 5% of the rock.

Pebbles are common throughout, varying rhythmically from 3% to 25%. They consist of rounded, dark and clear quartz, quartzite, chlorite schist and acid igneous rocks, particularly porphyries. Quartzite is most common. Porphyries in particular, and other igneous rocks, are common in the lower part of the formation. Pebbles generally have low sphericity and high roundness, and range in size up to 4 feet though the average size is only 1 inch.

At 203 feet (62 metres) above the base is a massive siliceous sandstone ("D"), 60 feet (18 metres) thick, which contains beds of ill-sorted round and discoidal pebbles, chiefly of quartz and quartzite. The sandstone contains angular quartz and is poorly sorted. Although it does not contain a high percentage of feldspar it is otherwise lithologically similar to the Risdon Sandstone. A much thinner siliceous sandstone bed also occurs 38 feet (12 metres) lower. A similar sandstone with conglomerate bands occurs near Cradoc at 49300E, 69460N, about 100 feet (30 metres) from the top of the formation.

The transitional unit at the top of the formation is well exposed on the shore platform at Coal Mine Bay. The rock is a pale brown, very fine grained, poorly sorted sandstone with mica (4%) and pebbles (3%).

A pyritic shale occurs in the faulted section of this formation at 49888E, 68048N on Deep Bay. Its stratigraphic position is unknown.

### CONDITIONS OF DEPOSITION

The environment of deposition of the Ferntree Formation is not clear. It was deposited under conditions unsuitable for marine life but where carbonaceous matter, which is responsible for the colour of the argillite, could accumulate. It is pyritic at Deep Bay and a few calcareous concretions occur. The formation is probably shallow water, possibly estuarine, littoral or sub-littoral bordering a low-lying land surface as suggested by Banks (1962, p. 210), and is probably Kungurian in age.

### Cygnet Coal Measures

The Cygnet Coal Measures is here defined as that formation of carbonaceous siltstone which disconformably underlies the basal grit of the Barnetts Member at 49753E, 67778N and disconformably overlies the Ferntree Formation with a transitional boundary at 49751E, and 67790N on the shore at Coal Mine Bay. It is here 20 feet (6 metres) thick. It is Kungurian to Upper Permian in age. Outcrops of the formation are to be found principally N of Randalls Bay. The section is shown in fig. 8. The precise definition of the Cygnet Coal Measures and its stratigraphic position are given by Banks and Naqvi (1967).

Disconformably underlying the grit is a thin bed of coarse, black, carbonaceous siltstone containing numerous graphite lenses 0.5 mm thick. Below this bed the rock consists of alternate carbonaceous, argillaceous and fine arenaceous laminae, 2 mm thick. Some convolute laminae occur. Argillaceous and arenaceous laminae may interfinger in some cases. At the base the carbonaceous siltstone is rich in arenaceous material, but this gradually decreases towards the top of the formation.

It is interesting to note that, although the name Coal Mine Bay suggests the presence of much coal, coal is virtually absent at this locality. However, according to Hills et al. (1922) coal was mined in the Devils Royals E of the Bay. The mine was not located by the authors.

### CONDITIONS OF DEPOSITION

No marine fossils have been found in this formation at Coal Mine Bay (Dr Conkin, pers. comm.). The presence of coal at various localities and the general abundance of carbonaceous material suggest it is of terrestrial origin. Banks (1962, p. 211) suggested a " sandy plain " across much of Tasmania, in which peat accumulated during the deposition of this formation.

CYGNET COAL MEASURES — SPRINGS SANDSTONE
COAL MINE BAY

*Massive sandstone* — MOUNTAIN LODGE MEMBER

*Transitional sandstone*

*Micaceous shaly sandstone*

SPRINGS SANDSTONE

*Feldspathic sandstone with siltstone pieces.*

BARNETTS MEMBER

*Feldspathic sandstone*

*Grit, coal fragments*

*Carbonaceous siltstone* — CYGNET COAL MEASURES

FERNTREE FORMATION

I. H. NAQVI
GEOLOGIST 1966

DEPT. OF MINES
2908—88

FIGURE 8.

5 cm

DISTRIBUTION OF PEBBLES

PERMIAN SYSTEM

I.H. NAQVI
GEOLOGIST 1966

Legend:
- QUARTZITE
- QUARTZ
- VOLCANIC IGNEOUS
- OTHER IGNEOUS
- SLATE, PHYLLITE, SCHIST
- SEDIMENTARY

Formations (top to bottom): CYGNET, FERNTREE, MALBINA, GRANGE, FAULKNER, BUNDELLA, QUAMBY, TILLITE

FORMATIONS

TOTAL PERCENTAGE OF PEBBLES

0    10    20    30

FIGURE 9.

DEPT. OF MINES
2906-88
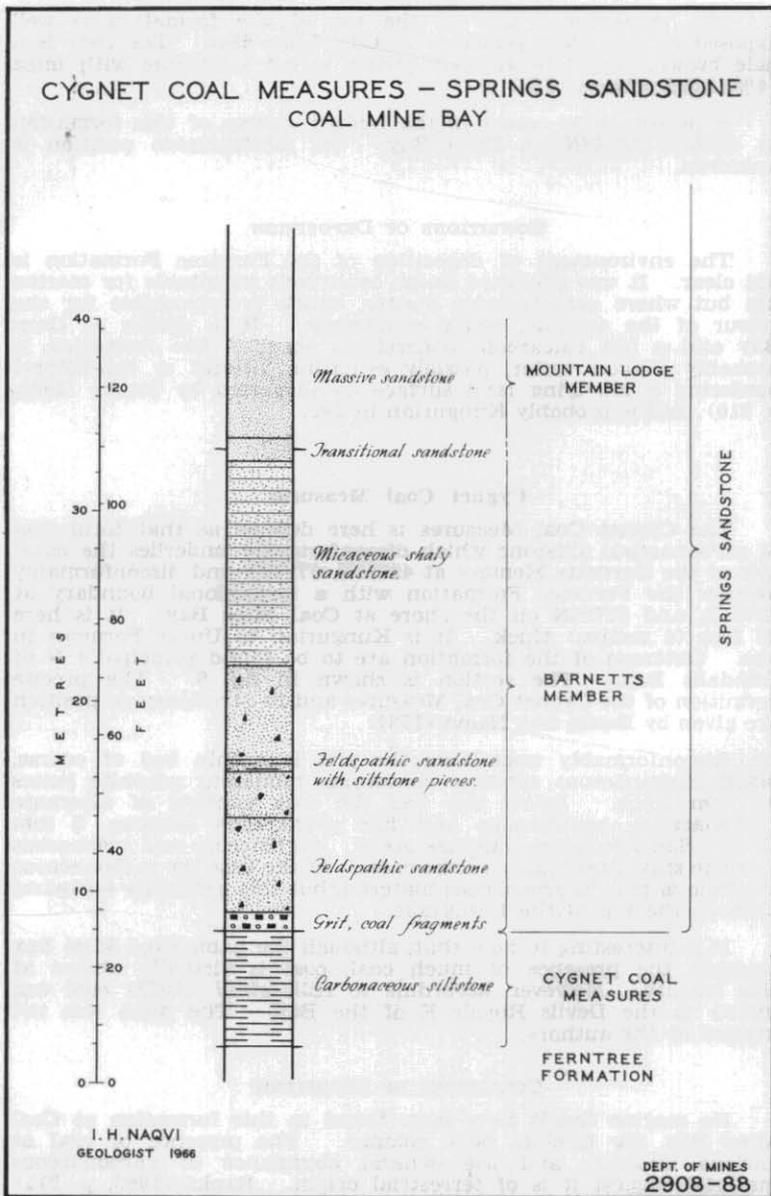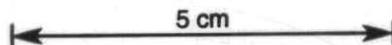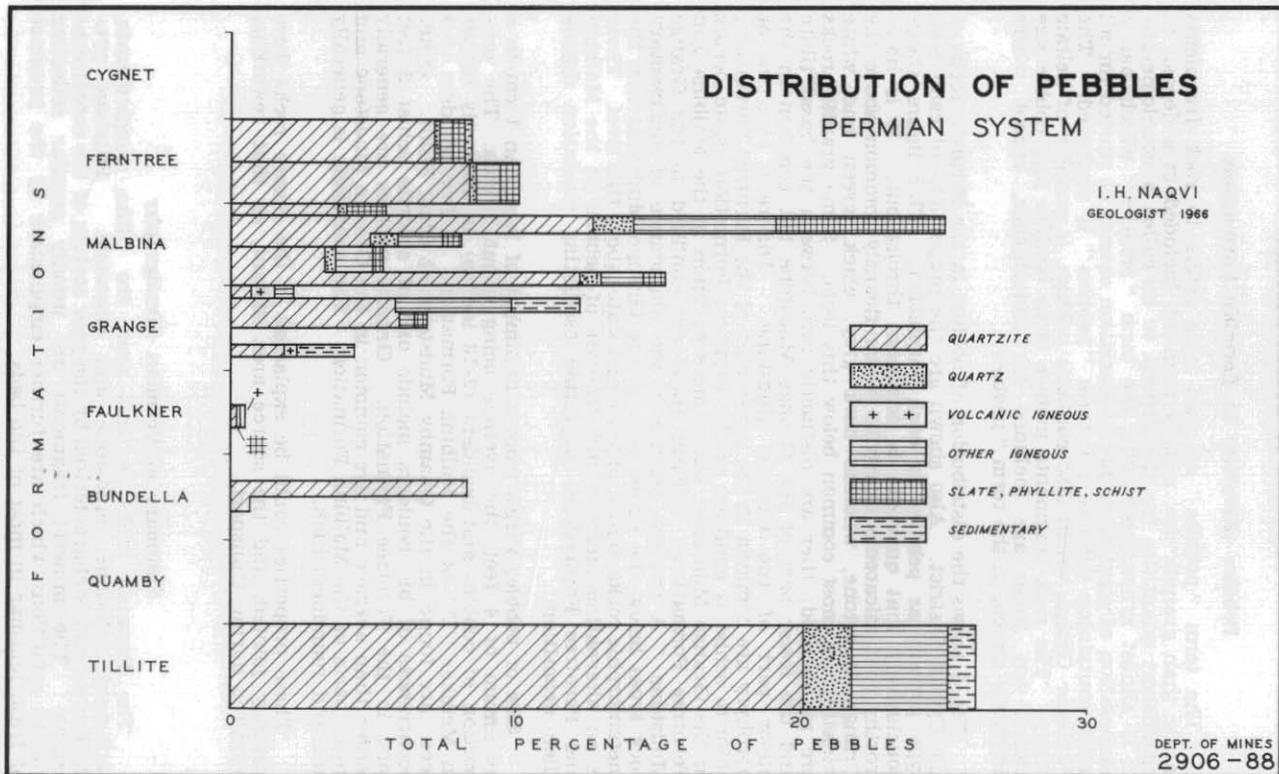
5 cm

### Pebbles (Erratics) in Permian Formations

The term "pebbles" as used here refers to rock fragments larger than granule size, usually rounded, included in a deposit in insufficient quantities for the deposit to be called a conglomerate. It is almost synonymous with the term "erratics" which has a connotation of glaciation, but as glaciation cannot be proved for all units containing pebbles, the term "pebbles" is preferred. The Faulkner Group, which also contains pebbles, is possibly of deltaic origin. The rock fragments include some boulder and cobble size pieces, but these are included for convenience, except where definitely stated, in the term "pebbles".

Fig. 9 shows the distribution of pebbles in the Permian rocks of the Cygnet District. Also shown are the proportions of each rock type present as pebbles in each formation. This figure shows conclusively that quartzite is dominant throughout. It is noteworthy that micaceous quartzite is significantly common above the Grange Mudstone, whereas dark grey, black, green and white varieties are most common below this level. Some granitic rocks are represented; they are distinctly rare between the basal tillite and the lower part of the Grange Mudstone but common in the upper part of the Grange Mudstone. Different varieties of porphyry are common in the upper part of the Ferntree Formation; chlorite schist is confined to the Ferntree Formation; slate occurs in the Grange Mudstone, but is more common in the Malbina and Ferntree Formations; volcanic rocks are confined to the Grange Mudstone. A marked feature is the abundance of sedimentary rock types below the upper part of the Grange Mudstone and the metamorphic rocks, schist, phyllite and slate, above this level. There is an alternating increase and decrease of pebbles in the Malbina and Ferntree Formations suggesting oscillating glaciation during their deposition.

Size of pebbles varies from a minimum of less than 1 cm to a maximum of 4 feet, the average being about 1 inch. The proportion of cobbles and boulders (2-18 inches) is distinctly higher in Member "D" of the Malbina Formation. A few boulders (1-4 feet) are found in the Quamby Mudstone at Shag Point. Other occurrences of big boulders include one of chlorite schist 2 feet long in the Ferntree Formation. Granite pebbles are generally larger than average and are common in the Grange Mudstone and lower parts of the Malbina Formation. The sphericity is generally low and roundness high.

These properties could be explained if the source rocks were strongly jointed, and the source area distant, so that reworking occurred during transport.

### Summary of Permian Stratigraphy

The Permian rocks in this area are tillite, conglomerate, sandstone, siltstone, mudstone and claystone. Siltstone predominates and is characterized by the poor sorting of the constituent grains. The mineral fragments are usually angular reflecting glacial conditions which are further emphasized by the presence of fresh feldspar in most of the beds.

The dominant mineral, in all grain sizes, is quartz. It is angular, often shows undulose extinction and is dominantly a clear vitreous variety. Feldspar reaches a maximum of 35% and is found both fresh and weathered. As far as can be determined there appears to be albite in the Faulkner Group, albite-oligoclase in the Malbina and Risdon Formations, and andesine in the Ferntree Formation. Mica, usually muscovite, was seen in most specimens. Tourmaline, zircon, pink garnet and pyrite are among the minor constituents.

The mineralogy and pebble content of the rocks indicates derivation from a low-lying terrain composed of acid and intermediate plutonic rocks, metamorphic rocks, quartz veins and Lower Palaeozoic sedimentary rocks. The abundance of Lower Palaeozoic sediments in older Permian and increasingly older rocks in the younger Permian is to be expected if the initial source area, presumably in western Tasmania, was composed of Lower Palaeozoic sedimentary rocks underlain by plutonic rocks, schist and phyllite.



PERMIAN  SEDIMENTATION  AND  GLACIATION

INTENSITY  OF  GLACIATION          DEPTH  OF  WATER

I.H. NAQVI
1965

INTENSITY  OF  GLACIATION ∝ NUMBER  OF  PEBBLES
DEPTH  OF  WATER ∝ LITHOLOGY & FAUNA
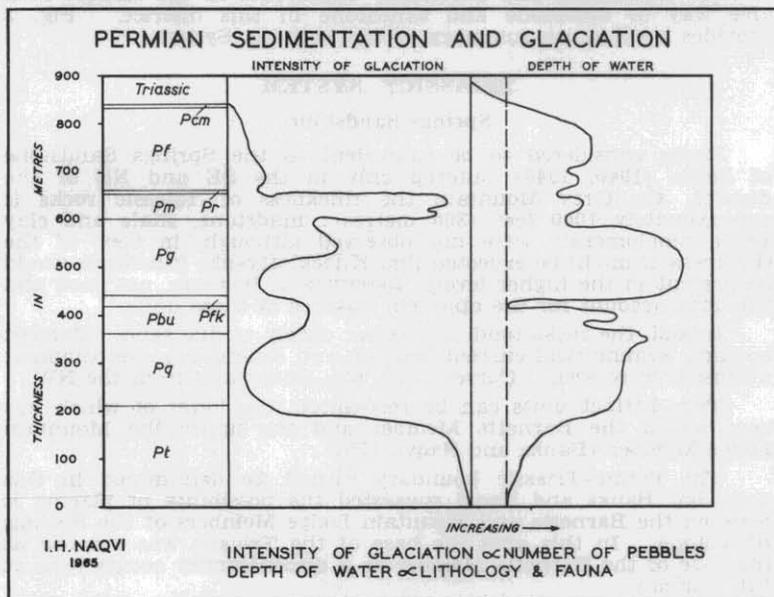
FIGURE 10.

The intensity of glaciation in relation to the thickness of the beds is indicated in fig. 10, and is based on the number of pebbles (erratics). It can be inferred that the intensity of glaciation reached a maximum during the deposition of the Malbina Formation, with minor peaks during Bundella, Grange and Ferntree times. It is possible that erratic-rich beds, such as those in the Malbina and Ferntree Formations, indicate a response to or an isostatic readjustment following removal of the ice load, rather than an increase in glacial intensity.

5 cm

There is considerable lensing of formations toward the W, examples being the Quamby Mudstone, and Malbina Formation. The Permian sediments were probably deposited nearly horizontally on a stable to mildly unstable shelf in shallow cold water conditions, the depth of the sea responding closely to changes in intensity of glaciation (figs. 9 and 10). Any deviation is thought to be due to tectonic activity. Apparently no vulcanism occurred during sedimentation. Deltaic conditions probably prevailed during the deposition of the Faulkner Group and the Risdon Sandstone. The Cygnet Coal Measures represent a rise in land level which is reflected in the increased coarseness of the upper Ferntree Formation, itself deposited in shallow water.

The correlation of individual formations with other Permian sections has been mentioned already, where possible. It is noteworthy that the Permian section above the tillite in the Cygnet District is the thickest yet found in Tasmania. The most noticeable feature is the marked facies change SW from Hobart, as both Darlington and Berriedale Limestones in the Hobart area give way to mudstone and sandstone in this district. Fig. 2 provides a columnar summary of the Permian System.

## TRIASSIC? SYSTEM

### Springs Sandstone

Rocks considered to be equivalent to the Springs Sandstone of Lewis (1940, 1946) outcrop only in the SE and NE of the district. On Grey Mountain the thickness of Triassic rocks is approximately 1000 feet (300 metres); mudstone, shale and clay pellet conglomerate were not observed although, in view of the thickness, it might be expected that Knocklofty-like lithologies would be present in the higher levels. Exposure is, however, not good and this may account for the apparent absence of these units.

Inland, the rocks tend to weather deeply to fine sand. Current bedding, symmetrical current bedding and concretions are common; no fossils were seen. Current flow was principally from the NW.

Two distinct units can be recognized, the lower of which has been called the Barnetts Member and the upper the Mountain Lodge Member (Banks and Naqvi, 1967).

The Permo-Triassic boundary cannot be determined in this area, but Banks and Naqvi suggested the possibility of placing it between the Barnetts and Mountain Lodge Members of the Springs Sandstone. In this area the base of the Triassic was mapped at the base of the Barnetts Member as a disconformity occurs here at this horizon.

### Barnetts Member

The Barnetts Member is that formation of feldspathic sandstone overlying Cygnet Coal Measures disconformably and underlying the quartz sandstone of Coal Mine Bay. It is considered to be a member of the Springs Sandstone. It is 89 feet (27 metres) thick at Coal Mine Bay, is Triassic in age and has been named for Barnetts trig. point (49820E, 67800N) near Coal Mine Bay. It shows a transitional boundary with the overlying quartz sediments of the Mountain Lodge Member. The section of this formation is shown in fig. 8.

The basal unit is a mixed zone, about 3 feet thick, consisting of grit lenses, feldspathic sandstone and stringers of coal. Evidence of disconformity is provided by the inclusion of pebbles of Ferntree Mudstone, the undulating contact with the underlying Cygnet Coal Measures, the increase in heavy minerals and coarseness and the inclusion of at least one conglomerate band and some broken allochthonous coal lenses, probably derived from the Cygnet Coal Measures.

This member has been more fully described by Banks and Naqvi (1967) from its type area at Coal Mine Bay, with particular reference to the Permo-Triassic boundary.

The thickness of the Barnetts Member is subject to minor variations. On the southern side of Cradoc Hill it is up to 80 feet (25 metres); at 49340E, 69455N it is approximately 100 feet (30 metres); near Woodstock the total thickness is unknown but the exposed thickness is nearly 100 feet (30 metres). In each place the member consists predominantly of feldspathic sandstone.

## Mountain Lodge Member

The quartz sandstone conformably overlying the feldspathic sandstone of the Barnetts Member with transitional boundary at Coal Mine Bay (49730E, 67742N) is correlated with the Mountain Lodge Member of the Springs Sandstone (Banks and Naqvi, 1967) on stratigraphical position and lithological similarity. Thickness in the Randalls Bay area is 65-90 feet (20-27 metres) and to the N of Woodstock over 325 feet (100 metres).

The rock is a medium-grained, well sorted, massively cross bedded, quartz sandstone, with some limonite concretions and occasional green and brown clay pellets. No fossils have been found. A sample of the sandstone contained 0.2% heavy minerals. These consist of tourmaline, ilmenite, melanite and rare zircon. Very little magnetite is present.

The overall conditions of deposition and source of material must have been similar to that of the Barnetts Member. The lack of feldspar could imply a change in provenance or increase in distance from the source. The cross-stratification is such that the cosets of group sets are individually large in scale. Each set of a coset is underlain by a planar non-erosional surface. The cross-strata are lithologically homogeneous. Allen (1963, p. 108) suggested that the structure results through sheets of local extent being thrown up so that they partly overlap.

## CAINOZOIC ERA

### Siliceous Conglomerate ('Silcrete')

A very hard, massive, highly siliceous, pebbly rock occurs on the shore of Port Cygnet at Elizabeth Point, Deep Bay and Drip Beach. It bears no particular relationship to other rocks nearby. In hand specimen it consists of quartzite and quartz pebbles (10%), vitreous quartz grains less than 2 mm (20%) and fine siliceous material (70%). The rock resembles an intensely metamorphosed sediment and weathers to rock flour and clay. Partially weathered, it appears as a sugary quartz sandstone.

In thin section (33750) the rock consists of quartz (38%), chalcedony (60%) and pebbles of quartz and quartzite (2%). Quartz grains vary in size up to 3mm across, averaging 0.5 mm. Sphericity is generally moderate to high but the roundness is low. Most quartz is clean and fresh although some shows undulose extinction. Some quartz appears to have been recrystallized.

The origin of silcrete is not yet properly understood (c.f. Woolnough, 1927; Waterhouse and Browne, 1929; Frankel, 1952; Williamson, 1957; Frankel and Kent, 1937; Jessup, 1960; Smith and Dury, 1965). Silicification may have occurred during humid Tertiary times or may have been related to basalt. The latter possibility cannot be dismissed although there is no evidence of Tertiary basalt in the area.

### Weathered Dolerite Deposits

Deposits up to 80 feet (25 metres) thick of deeply decomposed dolerite weathered *in situ* are to be seen at Wattle Grove, Gardners Bay and Mt Morrison. The original texture and jointing of the rock is preserved but the minerals have been converted to clay and limonite with kernels of less altered rock. The joints are kept open by chloritic material.

It has been suggested (Hale, 1958, p. 191) that this weathered material is a " C " horizon of laterite formed during the Tertiary or earlier. Possibly related deposits of weathered dolerite boulders occur S of Woodstock near the Huon River.

### Quaternary Gravel

Extensive deposits of gravel occur along the Huon River at Randalls Bay, Beaupre Point, Wheatley Bay and Cradoc.

At Randalls Bay they vary in thickness, 6-20 feet (2-6 metres) having been recorded by Keid (1947). The succession is soil, sand, gravel, clay and sandy clay but lensing complicates the succession. There are equal proportions of sand and gravel, with lesser amounts of clay. The gravel contains pebbles of quartz (chalcedony, agate) chert, quartzite, dolerite and mudstone in a sandy clay matrix and these range from sand grade to boulders 5 feet across. Quartz pebbles are most plentiful (83%) (including agate 8%), with smaller amounts of quartzite (10%), mudstone (2%) and dolerite (5%). Imbrication is developed locally suggesting a current from the N.

Gravel in other localities is similar. Most tends to occur along the bank of the estuary up to 100 feet above present sea level and it is thought it represents remnants of river mouth terraces associated with higher interglacial sea levels during the Pleistocene.

The agates could have been brought downstream by the Huon River from the Huon district where basalt flows and associated agates are known.

Quaternary gravel is associated with the present river systems, particularly Agnes, Sandfly and Nicholls Rivulets. Excellent exposures occur in cuts in the various flood plains. Such gravel, of unknown total thickness, is composed of quartzite, Permian and Triassic sediments, dolerite and quartz in a clay matrix. Above it lie the sandy clay and alluvium of the flood plain. Pebbles are mostly 1-3 cm across and have high sphericity and roundness.

# Igneous Geology

Igneous rocks within the Cygnet District fall within two distinct groups: the tholeiitic dolerite of Jurassic age and the Port Cygnet Alkaline Intrusives of Cretaceous age.

## DOLERITE

Dolerite outcrops over a third of the district, and the manner of intrusion and associated effects is discussed in the section on Structural Geology. The dolerite is emplaced as dykes at least 1000 feet wide and transgressive sheets more than 1500 feet thick. The contact effects of the intrusions are confined to baking of sediments and marginal chilling of dolerite. The contact zone is normally up to 50 feet wide. At Shag Point chalcedony has developed on the contact with Quamby Mudstone.

The general composition of the dolerite has been described by Edwards (1942, 1947) and McDougall (1962) (see Table 3, Nos. 6 and 7). The rock is bluish-grey or greenish, usually medium grained and contains some 35-40% pyroxene (augite and pigeonite) and plagioclase of composition $Ab_{45}-An_{55}$. Coarse grained dolerite occurs on Mt Morrison and Grey Mountain but no granophyres have been observed. The state of differentiation falls short of the granophyric stage, but is most extreme in the dolerite at Gardners Bay, Brabazon Point and Wattle Grove. The absence of granophyre suggests that these dyke bodies are too narrow and that rapid cooling prevented full differentiation.

The dolerite is regarded as Lower Jurassic in age on the basis of the following observations: it intrudes Triassic sediments and a series of K-Ar datings on the nearby Red Hill intrusion suggests an age between 143 and 167 million years (McDougall, 1961).

There appear to have been two intrusions of dolerite, one major and a second apparently minor. This has been implied by the composition of two dolerite dykes in the Regatta Point-Lymington area (Edwards, 1947). The second intrusion appears to be a differentiated form of the principal intrusion.

## PORT CYGNET ALKALINE INTRUSIVES

Alkaline rocks of extremely variable composition outcrop across the Cygnet Peninsula. The Port Cygnet Alkaline Intrusives occur as two distinct suites of rocks, as undersaturated and near-undersaturated shoshonitic rocks (Joplin, 1964). The form of intrusion is discussed under Structural Geology.

The near-undersaturated rocks have several noteworthy characteristics. They have a minimum of 7-8% alkalies and are very high in alumina, high in silica and barium, moderately high in lime, but low in magnesia. Further, a plagioclase feldspar, often andesine, and a potassic feldspar occur together. Melanite garnet is not uncommon in these rocks.

The undersaturated rocks contain very high potash, some nepheline, hauyne, other feldspathoids and zeolites.

TABLE 3: ANALYSES OF IGNEOUS ROCKS

| | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
|---|---|---|---|---|---|---|---|
| $SiO_2$ .... .... .... | 58.50 | 57.75 | 54.20 | 63.10 | 64.49 | 54.13 | 64.29 |
| $Al_2O_3$ .. .... .... | 19.81 | 18.80 | 20.48 | 17.11 | 17.48 | 15.31 | 11.82 |
| $Fe_2O_3$ .. .... .... | 1.71 | 6.05 | 4.90 | 1.04 | 1.64 | 0.73 | 6.31 |
| FeO .... .... .... | 1.66 | 0.84 | 1.26 | 3.02 | 1.69 | 8.23 | 4.46 |
| MgO .... .... .... | 0.47 | 1.01 | 0.40 | 1.15 | 0.66 | 6.66 | 0.44 |
| CaO .... .... .... | 5.65 | 2.35 | 2.85 | 3.65 | 3.28 | 10.72 | 3.43 |
| $Na_2O$ .... .... .... | 3.95 | 3.33 | 4.03 | 3.94 | 4.16 | 1.76 | 2.70 |
| $K_2O$ .... .... .... | 7.57 | 9.02 | 9.39 | 4.64 | 4.79 | 0.95 | 3.08 |
| $H_2O +$ .. .... .... | 0.11 | 0.28 | 0.42 | 0.42 | 0.52 | 0.50 | 1.22 |
| $H_2O -$ .. .... .... | 0.15 | 0.42 | 0.85 | 0.55 | 0.18 | 0.36 | 0.47 |
| $CO_2$ .... .... .... | Nil | Nil | Nil | 0.24 | 0.71 | .... | .... |
| $TiO_2$ .... .... .... | 0.32 | 0.10 | 0.20 | 0.82 | 0.46 | 0.70 | 1.28 |
| MnO .. .... .... | 0.12 | 0.25 | 0.12 | 0.12 | 0.11 | 0.16 | 0.13 |
| $P_2O_5$ .... .... .... | 0.30 | Tr | 0.50 | 0.30 | 0.22 | 0.09 | 0.31 |
| S .... .... .... | .... | .... | .... | | 0.06 | .... | .... |
| Total .... .... | 100.32 | 100.20 | 99.40 (sic) | 100.10 | 100.45 | 100.30 | 99.94 |

No. 1. Hauyne-sanidine-garnet porphyry—Edwards (1947)
No. 2. Sanidine tinguaite—Edwards (1947)
No. 3. Tinguaite—Edwards (1947)
No. 4. Syenite porphyry—Edwards (1947)
No. 5. Banatite (Joplin, 1964, p. 94, Mt Dromedary)
No. 6. Chilled dolerite, Red Hill—McDougall (1962)
No. 7. Typical granophyre, Red Hill—McDougall (1962)

## ORIGIN

The dolerite is a tholeiite and its differentiates are granophyres of the Red Hill type (McDougall, 1962). The alkaline rocks have been classed as shoshonitic rocks (Joplin, 1964). The two series of rocks are distinct in all stages of differentiation (see Table 3).

Analyses 1, 2 and 3 are for undersaturated rocks; 4 and 5 are typical of near-undersaturated rocks which are the most common in the district; 6 and 7 are of chilled dolerite and granophyre respectively. The Port Cygnet Alkaline Intrusives also contain much rubidium and strontium (R. J. Ford, pers. comm.) but these are probably associated with the potassium and barium respectively.

Comparison of the analyses of the alkaline rocks and the end members of the tholeiite differentiation series suggests that two distinct rock types are present. It will be observed that at no time does the alumina content of the tholeiitic series approach that of the alkaline rocks.

It was postulated by Carey (1958, p. 151) that these rocks are related and that differentiated dolerite assimilated limestone. At present, there is no evidence that assimilation could produce the required rocks from the tholeiitic series (Tilley, 1952, p. 540; Turner and Verhoogen, 1960, p. 153). In addition there is no evidence of desilication, as shown by the silica content of the banatitic rocks, the most abundant at Cygnet, and that of the typical granophyre, nor any marked presence of lime silicates as would be expected from such a reaction. Limestone could not be a source of potassium or aluminium.

The thermal conditions are relevant. All calculations have been made using transient state equations developed by Ingersoll *et al.* (1948). Dolerite sills 1800 feet thick are crystalline in 5000-6000 years, and at zero temperature in $10^5$-$10^6$ years. Jaeger (1961) showed that at the junction of sills and dykes a hot-spot remains. This means that when the material in the dyke and sill has crystallized, a portion of the material in the junction is still fluid. Allowing for this factor, such a system would be crystalline in 7000 years. These calculations do not allow for the distorted state of the isotherms in a dyke which has passed much dolerite. The rise in temperature of the wall rocks occurs long after the time of intrusion (Lovering, 1935) and thus the effect of crystallization following a single, rapid pulse of intrusion would be negligible. By contrast, the Red Hill dyke would have taken 20,000 years to become crystalline. All calculations are for the time for the temperature to fall to 700° C, and is clearly a maximum time in which reactions may occur. It is further noted that the existence of a second pulse of intrusion during cooling will not affect the time of cooling (Jaeger, 1958, p. 85). Two pulses of intrusion are indicated in this district but they are separated by a time interval greater than the cooling time for the primary intrusion. Since the second intrusion is probably minor it would have a negligible effect on the overall thermal conditions.

On thermal-time grounds it is unlikely that any truly acid phase is developed in any postulated dolerite system below Cygnet, and therefore the likelihood of limestone assimilation is considerably lessened.

The thermal requirements of the alkaline rocks are as follow: Edwards (1947) showed that some of the feldspars began to form at a temperature of 1000° C. If the alkaline rocks were produced by reaction from the dolerite, then reaction must have followed soon after the intrusion, and reaction is most unlikely on any scale at such an early stage. Since the overburden pressure at the

point of reaction would be at least 1000 bars, a temperature of 900°-1000° C would be required for production of the garnets (Deer *et al.*, 1962, pp. 89-93, 100).

Exothermic reactions must extend any reaction time but have not been considered here due to lack of thermo-dynamic information.

It has been noted that the thermal metamorphic effect of many dyke rocks and the large syenitic masses is limited. This does not necessarily imply low temperature emplacement, but rather a low heat capacity induced by small size. Many dykes are certainly low temperature and probably intruded as a crystal mush. Others, particularly in the region of Copper Alley, imply very high temperature emplacement by their effect on the country rock. The area of greatest metamorphism occurs W of Mt Mary and probably reflects the moistest part of the system. Sulphides also occur in this area.

## Age

Palaeomagnetic results (Robertson and Hastie, 1962) indicate that the alkaline rocks were contemporaneous with the dolerite. The average declination of the alkaline rocks, hybrids and contacts is 314° with an inclination of 85° (dolerite, $D = 325°$, $I = 85°$) (Irving, 1956, 1964). The similarity of the results does not necessarily imply similar ages since the pole position relative to Tasmania may not have varied in Jurassic-Cretaceous time. In addition, there is lack of systematic correlation of palaeomagnetic results from rocks of Lower Jurassic-Tertiary age in Australia generally (Robertson and Hastie, 1962, fig. 4, p. 267). Further, the results for the dolerite have been averaged from many intrusions in various parts of the State whereas those from the alkaline rocks represent only one instant in time and space. No great reliance is thus placed on the palaeomagnetic conclusion.

The stratigraphic evidence is limited and somewhat contradictory. Dykes of alkaline material intrude Permian rocks and dolerite, but have never been found in Triassic rocks. This may mean that there was insufficient head on the magma to intrude this level. The alkaline rocks are thus post-dolerite.

Five absolute age datings by the K-Ar method have been made. The results are tabulated in Table 4.

TABLE 4: K-Ar AGE DATINGS

| | | |
|---|---|---|
| Biotite .... .... .... .... .... .... | $99 \times 10^6$ years | |
| Sanidine .. .... .... .... .... .... | $99 \times 10^6$ years | Evernden and Richards (1962) |
| * {Hornblende .... .... .... .... | $109 \times 10^6$ years | |
| {Hornblende .... .... .... .... | $95 \times 10^6$ years | McDougall and Leggo (1965) |
| Hornblende .... .... .... .... | $98 \times 10^6$ years | |

\* The measurement of the hornblende by Evernden and Richards was apparently a bad run and was redone by McDougall and Leggo.

The excellent agreement of measurements, on different minerals from differing parts of the area (hornblendes), implies an age of approximately 100 million years. This is to be compared with 143-167 million years for the dolerite.

The Port Cygnet Alkaline Intrusives are therefore Cretaceous in age.

They bear no petrological relationship to the tholeiitic dolerite, but may form part of a differentiated series (Edwards, 1947) of which only part of the upper fraction has been injected. The differentiation process probably occurred at considerable depth.

## Thermal Metamorphism

The Port Cygnet Alkaline Intrusives occur as small bodies and as a consequence the contact effects are usually negligible. Considerable baking of tillite occurs at two localities, Forsters Rivulet and Wilsons shipyard. In thin section (33743) the baked tillite consists of quartz (50%), amphiboles (15%), epidote (8%), prehnite (6%), sphene (1%) and a matrix enriched with quartz, epidote and amphibole (20%).

Chilled margins to alkaline bodies are often non-existent, and where present are very thin. Only at Regatta Point, where the largest body of syenite porphyry occurs in contact with dolerite, has there been any significant alteration in the country rocks. Hydrothermal fluids from the alkaline rocks probably controlled the degree of thermal metamorphism. The hybridization of the dolerite has been mentioned on page 47, and fully discussed by Edwards (1947). The pyrrhotite nodules on the E side of Port Cygnet appear to have been produced from pyrite by the movement of hot liquors from the syenitic mass across the bay at Regatta Point. The temperature involved is about 550° in a sulphurous atmosphere as such liquors would have provided (Palache et al., 1944, v. 1., p.234). The tillite at Wilsons shipyard, 49730E, 68420N, shows reaction rings about the pebbles as in Forsters Rivulet. Reaction rings have also been seen about fossils in the Bundella Mudstone on the southern slopes of Mt Windsor, resulting in the conversion of calcite to wollastonite, prehnite and tremolite. Limited mineralization is associated with such zones.

## Rock Types

### (Detailed petrology has been given by Edwards (1947))

*Syenite Porphyry (Banatite)*

The dominant rock in the district, it occupies a considerable part of the peninsula and is usually deeply weathered to kaolinite bearing feldspar phenocrysts. The unweathered rock is light grey, hard, dense and porphyritic, containing abundant large phenocrysts of feldspar up to 2 cm across embedded in a groundmass containing small crystals of ferro-magnesian minerals. In a specimen from the top of Mt Windsor (33744) the main minerals are zoned plagioclase (12%) ($Ab_{70}An_{30}$-$Ab_{50}An_{50}$), zoned sanidine (8%) and hornblende (5%). Accessory minerals include magnetite, sphene, zircon and apatite. The groundmass consists of minute grains of feldspar, quartz and magnetite.

The rock occurs as dykes as well as in larger masses. Dykes of this composition are common about the peninsula. Examples are to be seen at 49816E, 68052N and 49564E, 68242N.

## Garnet Trachyte

Garnet trachytes have been described previously by Rosenbusch (Twelvetrees, 1901, p. 3) and analysed by Paul (1906) and MacLeod and White (1900). These occurrences were not precisely located and the following description, provided by G. Everard, refers to a dyke at 49660E, 68350N. The contact of this dyke with Grange Mudstone is shown in pl. 11.

The hand specimen is a faintly purplish, fine grained, grey rock with phenocrysts up to 4 mm long of honey-coloured garnet and colourless transparent feldspar. A little pyrite is widely disseminated in small crystalline aggregates often associated with the garnet. Crystals of epidote up to 3 mm long also occur.

In thin section (66187 of Department of Mines) the rock has a trachytic texture consisting of a mass of sanidine laths averaging about 0.3 mm long and showing flow, together with minute ragged flakes of biotite and granular epidote. There are occasional irregular scattered masses of magnetite, partly altered to hematite. Minute aggregates of pyrite also occur.

The garnet phenocrysts are almost colourless, irregular, incompletely isotropic and zoned. They have inclusions of epidote, feldspar, magnetite and a green biotite. The feldspar phenocrysts show zoning and are euhedral and lathlike; the edges are slightly rounded and irregular showing resorption or alteration. There are also larger irregular plates of biotite.

## Hauyne-Sanidine-Garnet Porphyry

A rather rare but striking rock which has large melanite garnet and sanidine crystals embedded in a dark green groundmass. Some aegirine, hornblende and oligoclase is also present. Accessory minerals include sphene and apatite. Dykes are to be found extending north from Tobys Hill (49771E, 68770N), near Harleys Jetty (49180E, 68102N) and Brabazon Point. A further fine example is found at 49345E, 68420N.

## Sanidine-Garnet Porphyry

This rock is very similar to the hauyne porphyry described above. It differs in lack of ferromagnesians, lack of feldspathoids and less plagioclase. Examples occur at 49750E, 69070N.

## Sanidine-Biotite Porphyry

This rock resembles the previous porphyries, but lacks garnet. An example was seen near the Mt Mary mine.

## Sanidine Porphyry

Narrow dykes that closely resemble trachytes occur intruding the metamorphosed dolerite at Regatta Point, and the mouth of Deep Bay.

### Sanidine Tinguaite

This consists principally of large phenocrysts of sanidine in a dense green groundmass. Also present, particularly as inclusions in the feldspar, are aegirine, melanite garnet and apatite. Immediately north of the jetty at the northern headland of Copper Alley, two coarsely porphyritic dykes outcrop on the beach. One dyke (pl. 12) contains swirls of crystalline sanidines. These dykes have distinctly chilled margins.

### Syenite Aplite and Syenite Pegmatite

Dykes, veins and schlieren of aplite and pegmatite are common at many points about the peninsula (e.g., Regatta Point, Petchey Bay). The aplitic rocks are variable in composition and contain various types of feldspars, a little biotite and some quartz. The pegmatites contain coarse tablets of sanidine in a groundmass of orthoclase, magnetite and some pyroxene with interstitial muscovite and sphene.

### Garnet Orthoclasite

This rock type closely resembles the syenite aplite but differs in the presence of much brown melanite garnet. Examples occur south of Regatta Point.

## Order of Intrusion

This appears to have been syenite porphyry, then the garnet trachyte and the various sanidine porphyries, the syenite aplites and pegmatites, and the garnet-orthoclasite.

## HYBRID ROCKS

Hybrid rocks were produced by thermal metamorphism and reaction of potassic fluids from the alkaline rocks on the tholeiitic dolerite. The belt of hybrid rocks and contact metamorphic rocks extends from the now disused Cygnet Jetty past the Judges Box at Regatta Point. The total exposure of affected rocks is about 500 yards on the shoreline. A full description of the mineralogical changes was given by Edwards (1947, pp. 98-105). Essentially, there was breakdown in the zone of thermal metamorphism of pyroxenes to hornblende, and magnetite to biotite and sphene. The hornblende is commonly choked with magnetite " dust ". In the transition zone the labradorite was converted to albite and simultaneously augite was re-developed from the hornblende. It appears that a little pyrite, apatite, orthoclase and perhaps quartz was introduced at this stage. The hybrid rocks consist mainly of orthoclase and lime pyroxene which is usually altered to biotite and melanite. Zeolites and feldspathoids are also developed in this zone. The texture changes from ophitic in the dolerite and thermal metamorphic zones to granular, which is usual for the alkaline rocks. The presence of sphene and apatite reflect the original composition of the dolerite.

# Structural  Geology

Geological structures within the Cygnet District fall into two distinct categories: major structures and minor structures.

## MAJOR STRUCTURES

The major structures within the area are believed to be inter-related, but may be listed briefly as the doming of the area, extensive faulting and form of the igneous intrusions.

### DOMING

An asymmetrical dome, centred on the Cygnet Peninsula, has dips of the order of 10°-15°, dips being steeper to the W. Possible causes of the doming are:

   (i) Tectonic doming in the late Permian.

   (ii) Tectonic doming during the early Mesozoic.

   (iii) Doming over an intrusive dolerite body—Jurassic.

   (iv) Doming over an intrusive alkaline body—Cretaceous.

   (v) Epeirogenic doming—Tertiary.

No substantial evidence is available to support a Permian doming although erosion of the Ferntree Formation and Cygnet Coal Measures can be shown at Coal Mine Bay.

Early Mesozoic doming cannot be distinguished from any Jurassic doming prior to high level intrusions of dolerite. Faults are predominantly pre-dolerite or concomitant with the dolerite. A small proportion are post-dolerite.

If the dome were Jurassic or older, most faults would be Jurassic or older. The doming cannot be Cretaceous or Tertiary since it would involve disruption of dolerite and no significant post-dolerite disturbances have been observed.

There could be a laccolithic body of dolerite, which at shallow depth is bowing up the sediments. This structure is unlikely in the crystalline basement and would be expected close to the base of the Permian. Considering the size of the dome it would require a laccolith with a central thickness of 2000 + feet. Such a structure is discussed on page 75 and found to be highly improbable geo-physically.

A further possibility is that a feeder or other body punched into the sedimentary pile. This should result in doming, conical fractures and a cone sheet, or even possibly a ring dyke, as by the mechanism of Anderson (1935). This is discussed in detail (p. 59).

While no definite age can be given for the doming, it must be prior to the high level dolerite intrusion. As the doming is not Cretaceous in age, no major doming or sedimentary disturbance can be ascribed to the alkaline intrusion. It is suggested that some arching of the sediments occurred above the banatite body (fig. 23) in the peninsula area, but this is a small secondary feature and must not be confused with the primary doming.

## FAULTING

Faults fall within two distinct age groups. Many faults can be shown to be pre-dolerite and many others can be inferred to be pre-dolerite by their association and manner of junction (e.g., Grey Mountain and Cradoc Faults; Tobys Hill and Port Cygnet Faults). Very few faults can be shown to have originated after the intrusion of the dolerite. Some dolerite has intruded the plane of the Mt Morrison Fault, implying at latest a Jurassic age for this fault.

The nature of the fault relationships implies that the faults are dynamically related to each other and to the formation of the dome. The whole pattern is complex and little definite sequence can be found in fault development. Fig. 11 shows the pattern and known throws.

The faults are both radial and tangential to the peninsula. Examples of tangential faults are the Glaziers Bay, Woodstock and Port Cygnet Faults. The greatest part of the Woodstock Fault is concealed by dolerite but a fault is indicated by the intrusion of dolerite into both Grange Mudstone and Triassic sandstone at the same level near Woodstock.

The variability of throws on the more lengthy faults and the complex interwoven pattern, as at Lymington, suggest continuous but individual block movement.

In the N and E of the district closed horst and graben blocks are present. In the Cradoc block, enclosed by the Woodstock, Grey Mountain and Cradoc Faults, there are smaller cross grabens and horsts, of which the Cradoc Hill Horst is one. East of Port Cygnet a further series of horsts and grabens can be seen. Here the trend is NE instead of NW.

In the peninsula area above the centre of the dome faults are transverse to the axis of the dome.

It is noteworthy that the faults with largest throws occur in the eastern parts of the district. Basal and middle Permian formations are matched across the Wheatley Bay, Gardners Bay, Port Cygnet and Cradoc Faults, and the area enclosed by them is the uplifted core of the dome. This gives the illusion that an igneous intrusion or a basement block has pushed up into the core of the dome, since normal doming should produce crestal grabens rather than a crestal horst (de Sitter, 1956, pp. 201-211).

The horst and graben structures about the margins of the dome are to be expected in such a tensional environment.

Most of the faults are normal and very steep. This may be implied from outcrop behaviour. The southern part of the Cradoc Hill Horst, bounded by the Slab Road, Port Cygnet, Mt Morrison and Grey Mountain Faults, has suffered separate differential movement.

The last type of Jurassic fault to develop is directly related to high level dolerite intrusion. It is the concomitant fault along which the dolerite dyke bodies intruded.

Post-dolerite faulting is limited, for example the fault near Brabazon Point (48895E, 68330N) and the disruption of some alkaline dykes S of Regatta Point. No large scale faulting of this type has been observed.
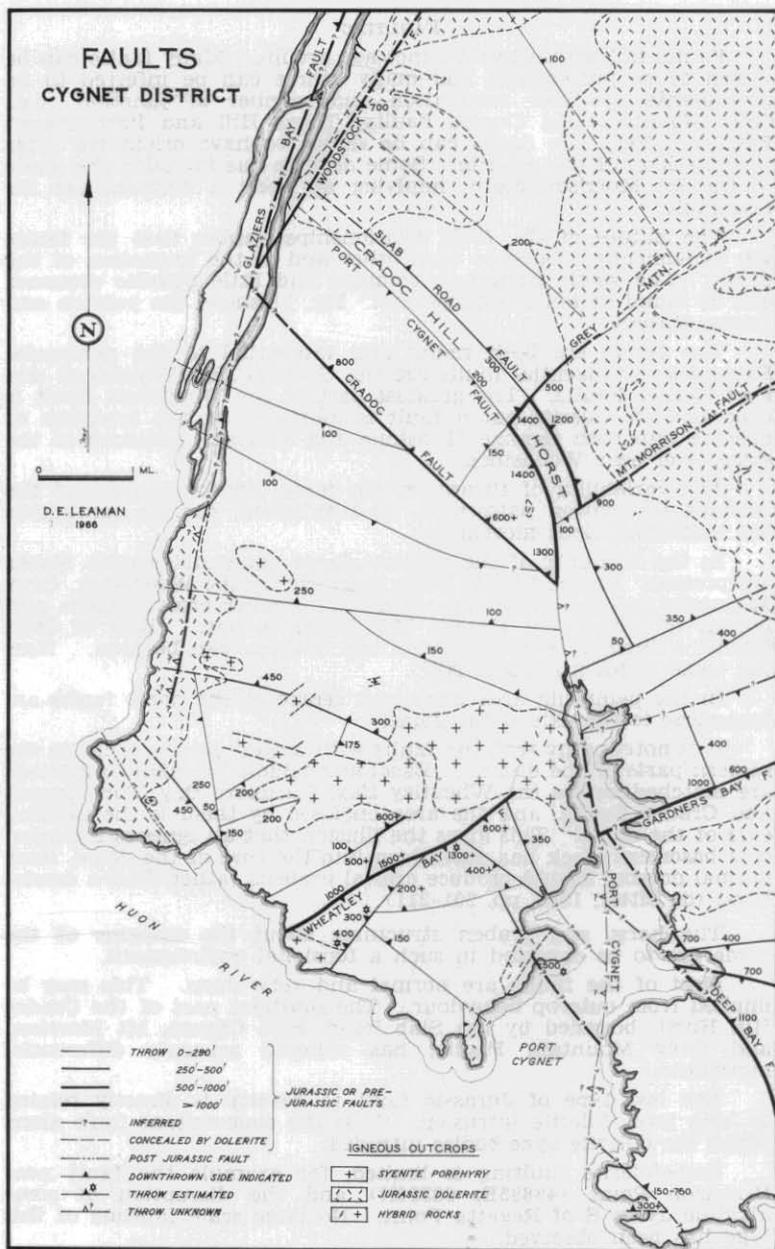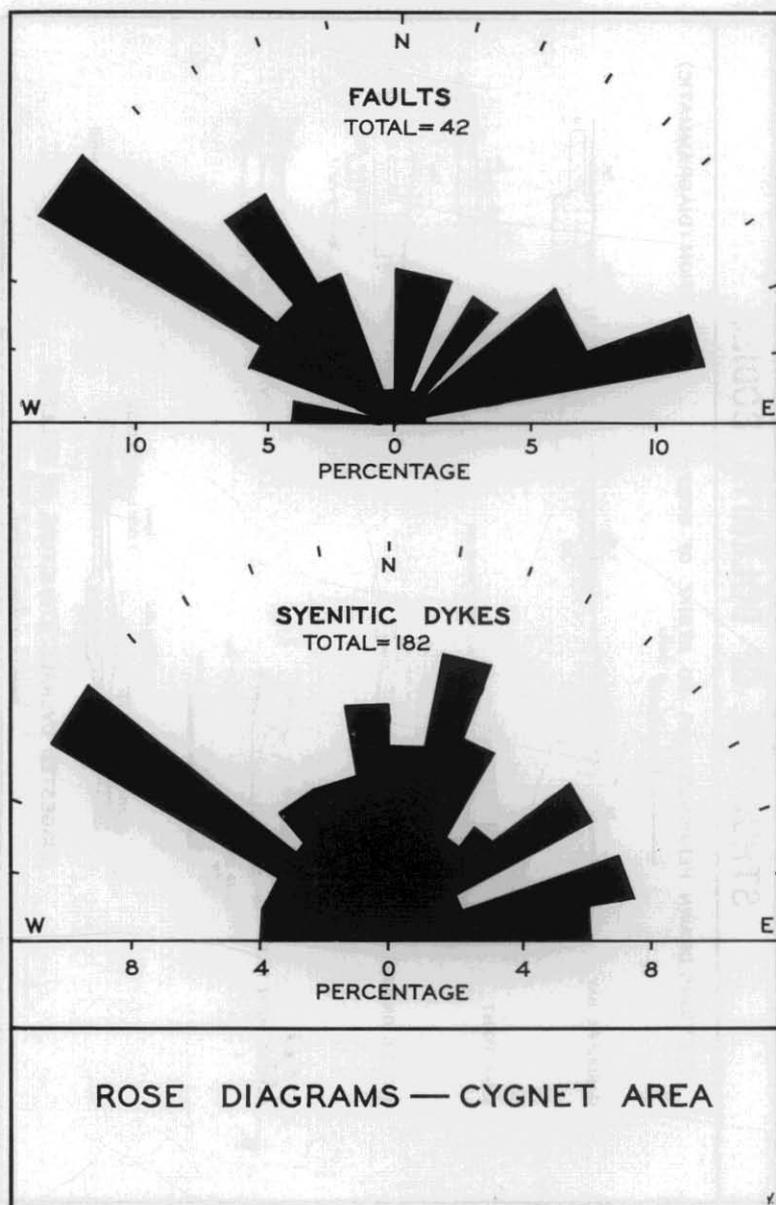
FIGURE 11.

FAULTS
TOTAL = 42

SYENITIC DYKES
TOTAL = 182
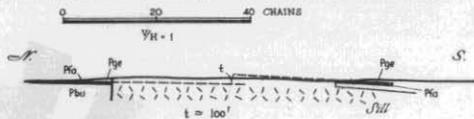
ROSE DIAGRAMS — CYGNET AREA

FIGURE 12.

5 cm

5 cm

## STRUCTURE OF DOLERITE BODIES

SECTIONS DRAWN PERPENDICULAR TO STRIKE OF BODY

SOLUTION (DIAGRAMMATIC)
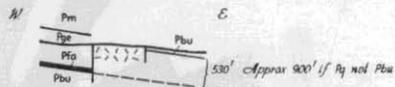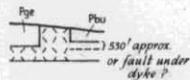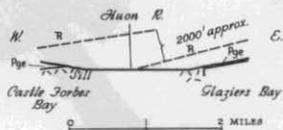
GARDNERS BAY (i)

SHAG POINT (ii)

WATTLE GROVE (iii)

ACROSS HUON RIVER (iv)

SUGGESTED OVERALL STRUCTURE OF DOLERITE

D. LEAMAN

A rose diagram (fig. 12) shows the trends of the Jurassic faulting. Since few SW trending faults from this area have been detected near Police Point, across the Huon River (Hale, 1953), it may be deduced that faults exist along the lower arm of the Huon River. Faults of Jurassic age thus enclose the peninsula.

## FORM OF THE DOLERITE INTRUSION

In this district, the dolerite intrusion may have taken various forms: e.g., multiple sheets, cone sheet, plugs or laccolith. Only a cone sheet (Carey, 1958) and a laccolith (Hills et al., 1922) have been suggested previously. The following is a summary of the observations on the dolerite occurrences.

### Shape

The major outcrop has a very imperfect annular shape.

### Character of Contacts

Most contacts are very steep.

(a) The dolerite extending from Glaziers Bay to Brabazon Point generally has near vertical contacts but in places the contact may be eastward dipping, judged on outcrop behaviour.

(b) The contacts at Shag Point are vertical.

(c) The southern contact of the Gardners Bay mass, near Port Cygnet only, is the upper boundary of a sheet which dips south-eastward. Elsewhere this contact is vertical, as is the northern contact of the same mass.

(d) Rafted blocks at Mt Morrison and Grey Mountain have horizontal contacts.

(e) The dolerite capping the southern part of Grey Mountain is a sheet.

(f) Part of the contact surrounding the Triassic sediments at Woodstock may be nearly horizontal, particularly near Sandfly Rivulet.

(g) The raft of Permian sediments near the Huon River at Woodstock is enclosed by dyke contacts.

(h) The dolerite at Regatta Point may have dyke contacts.

(i) There is a plug N of Cygnet.

### Some Details of Intrusive Bodies

Dolerite has been reported (Matthews, 1963; Longman, 1965) at approximately 60 feet depth in bores at Glaziers Bay. One such bore is well inside the main outcrop and more than 200 feet higher.

At Gardners Bay, the base of the Grange Mudstone occurs at a similar altitude on both sides of the dolerite body (fig. 13 (i)).

At Wattle Grove, the Malbina Formation on the coast is downthrown by about 600 feet, but this may be due to movement before the intrusion on the Glaziers Bay Fault. This could also reflect a change in thickness of the dolerite sheet across the dyke body (fig. 13 (iii)).

On the regional scale, as fig. 13 (iv) shows, the peninsula block is relatively downthrown but no fault of the required size can exist below the Huon River since no traces can be found to the N or S (Hale, 1953; Mather, 1955).

At Shag Point, the formations E of the dolerite have been upthrown by up to 900 feet (fig. 13 (ii)).

5 cm

FIGURE 14.

FLAT LYING STRATA VERTICAL DILATION ONLY

FLAT LYING STRATA OBLIQUE DILATION

VERTICAL DILATION ONLY

H = 2V

DIPPING STRATA VERTICAL DILATION

∝ = ⅓     H = 2V

VERTICAL DILATION ONLY

H = 2V

(iii)          (iv)

AFTER EROSION

AFTER EROSION OF DIPPING STRATA OBLIQUE DILATION

OBLIQUE DILATION IS V = H
∝ = ⅛

(ii)

∝ = REDUCTION BY OBLIQUITY

(i)

REFER ALSO WILLIAMS & GROVES 1967

DEPARTMENT OF MINES — TASMANIA

FORM OF DILATION ASSOCIATED WITH DOLERITE BODIES

DATE:— OCTOBER 1966

GEOLOGIST:— D.LEAMAN

DRAUGHTSMAN:— R.J.VOSS          MAP SHEET & Nº:- MECH.

REVISIONS:-          FILE Nº:— 2941

## Discussion of Dolerite Structures

### LACCOLITH

The dolerite may have the form of a large underlying laccolith with large dyke and sheet offshoots, but such a structure is most unlikely, particularly when the size of the body needed is considered. It will be shown (p. 75) to be geophysically improbable.

### CONE SHEET

Carey (1958) postulated the existence of a cone sheet, which he called the Huon Cone Sheet, with its centre below Cygnet.

*For:—*

(i) Isostrats can be constructed that are concentric about Cygnet and generally stratigraphically lower toward Cygnet (Carey, 1958) (see also p. 62).

(ii) Dolerite on the periphery of the area intrudes Triassic sediments. The topography in peripheral areas is generally high, but not always so (e.g., Woodstock).

(iii) This structure provides a coherent form of intrusion, explaining the source of the dolerite.

*Against:—*

(i) Isostrats do not reflect any particular dolerite structure and may be confused by dykes and parallel sheets, or invalidated by disregarding the actual character of the contact and considering only its location.

An example of such confusion may be shown S of Geeveston at 4835E, 685N (Ford, 1954). Isostrats are constructed so that only one formation is intruded between any two (Carey, 1958, p. 135). However, Carey (1958, pp. 133, 142) did not show that dolerite intrudes Ferntree Formation in the above locality. He then said (p. 145) "There is no overlapping of isostrat zones as would certainly be the case if the intrusions were random or if more than one sheet were involved"; yet the Ferntree Formation isostrat must here overlap the Grange Mudstone isostrat since Grange Mudstone is intruded on both sides of this locality. The presence of more than one sill or sheet in the Geeveston-Franklin area has been indicated by Ford (1954), and the topography and outcrop distribution supports only this hypothesis.

It must be noted that the dolerite in the Geeveston-Franklin area is barely one mile W of the Cygnet District and, by the cone sheet hypothesis, must be connected in the form of a massive inclined sheet to a dolerite centre below Cygnet.

(ii) That dolerite on the periphery of an area intrudes stratigraphically high sediments is inconclusive with respect to dolerite structure. That such an area may be topographically high is of little consequence. The effects of doming, Jurassic faulting and subsequent erosion must not be neglected. Further, a system of sheets in a domed area could give results similar to a cone sheet. If an upper sheet intruded in Triassic sediments was extensively eroded, as would be expected over the core of the dome, and the lower sheets partly exposed with large connecting dykes between both sets, then the dolerite distribution would be as at present with the topography bearing various relations to the structure.

(iii) Fig. 14 shows that where there is an inclined sheet, as in a cone sheet, there must be a vertical component of dilation equal to the thickness of the sheet when horizontal, which in Tasmania is usually of the order of 1000-1500 feet. The vertical dilation may be modified in magnitude by horizontal dilation and dipping sediments.

A requirement of any irregular cone sheet is that the enclosed funnel block be lifted by a given amount—depending on the magnitude of dilationary components (fig. 14) (also Carey, 1958, pp. 136-138).

Thus, if there is an irregular cone sheet centred at Cygnet, which breaks the surface as a dolerite ring at Shag Point, Gardners Bay, Wattle Grove, Pelverata and Grey Mountain, the enclosed block should be lifted by up to 1500 feet since this is the thickness of the main sheet present.

At Gardners Bay (fig. 13 (i)) basal Grange Mudstone occurs on both sides of the dolerite body. Since the component of dips in the section is so small, the horizontal component of dilation is of little effect (fig. 14 (iv)). If this dolerite were simply a vertical dyke there would be little or no dilation. If it is a vertical limb connected to a horizontal or inclined sheet, dilation must occur (fig. 14 (i), (iv)). Therefore, if the dolerite at Gardners Bay is one side of a cone sheet, dilation of considerable magnitude should occur across it. This has not been observed. The top of a sill or sheet may be seen on the southern side of the Gardners Bay mass. If this sheet has any significant thickness (greater than 100 feet) then it must be matched by a similar sheet on the northern side in order to maintain the dilationary balance (fig. 13 (i)). Thus, if a large sheet is present SE of the peninsula it must also be present beneath it.

At Shag Point (fig. 13 (ii)) sediments on the western side of the dyke are stratigraphically higher than those on the eastern side by up to 900 feet. This could imply a pre-dolerite fault along which the dyke was intruded. It can be seen immediately that no dilation has occurred, in the sense required by a cone sheet, which should be peninsula block up. Again if a sheet is present below the peninsula it must be present E of this dyke (fig. 13 (ii)). The spreading of the dolerite at Point Beaupre may imply a sheet to the E, passing beneath Port Cygnet (fig. 26).

At Wattle Grove (fig. 13 (iii)) the amount of dilation present is in the right amount and sense for a body dipping eastward. However, the Glaziers Bay Fault passes beneath this dolerite body, downthrowing toward the river. Since parts of the contact are near vertical or vertical it is unlikely that the difference in dilation reflects the shape of the dolerite body. A possible solution is indicated in fig. 13 (iii), if a sheet is present below the peninsula.

On the regional scale, across the Huon River (fig. 13 (iv)), the Cygnet District is stratigraphically some 2000 feet lower than the Geeveston-Castle Forbes Bay area (using dips of 10°; or 1500 feet at 6°). This difference could result from faulting or dilationary intrusions. There is no evidence in the Cygnet, Franklin-Geeveston (Ford, 1954), Police Point (Hale, 1953) or Huonville (Mather, 1955) Districts for faults of the magnitude required. It is concluded therefore that much of the difference has resulted from a dilationary effect.

If there is a sheet below the Cygnet Peninsula (as is required by the cone sheet hypothesis) which passes across the river, there will be no relative dilation in the roof block since it must have been lifted as a whole. If the sheet passed above the surface at Geeveston as required by the cone sheet of Carey (1958) then the peninsula block should be higher by some amount. However, neither of these conditions has been observed.

In the Castle Forbes Bay-Surges Bay region the top of a sill is exposed on the coast (Ford, 1954; P. J. Legge, pers. comm.). If this is the continuation of the sheet below Cygnet there would be no dilation between the Geeveston and Cygnet blocks. It is therefore concluded that an additional sheet exists below the Geeveston block (fig. 13 (iv)) which has increased the vertical dilation.

Another sill has been observed on Doodys Hill N of Geeveston. If, for example, this sill was 500 feet thick, it would increase the dilatancy in the Geeveston block by about that amount, thereby increasing the present estimate of 2000 feet to 2500 feet compared to the Cygnet block. This strengthens the contention that another large sheet is required beneath Geeveston (fig. 13 (iv)).

Since the supposed enclosed funnel block of the cone sheet has not been dilationally lifted, presumably it was downthrown prior to intrusion and later lifted. The ring fault required would be most irregular in shape and consistently downthrown toward Cygnet with a throw of at least 1500 feet if the vertical dilation was later of this order. The Glaziers Bay Fault, which presumably occupies the position of the ring fault beneath the dolerite at Wattle Grove, downthrows to the W, not E. The throw direction of this fault is known from its continuation up river and at Petchey Bay, and by drag dips at Glaziers Bay. A cauldron subsidence further requires a vertical or outward dipping ring fault. If the latter had occurred, a ring dyke and not a cone sheet would have resulted. The relative dilations for this structure are also not present. If the ring fault was vertical it is improbable that the dolerite as exposed at present conceals all traces of it, particularly if the dolerite breaking the surface formed part of a cone sheet which should be dipping inward.

The shape of the 'cone sheets' proposed by Carey (1958) is seen to be most peculiar when compared with cone sheets or basin-like intrusions elsewhere in the world. The classical cone sheets of Scotland (Anderson, 1935; Richey, et al., 1961) have persistently steep dips and are not particularly influenced by stratigraphic differences or the attitude of bedding.

Basin-like intrusions of various shapes have been noted in Pennsylvania (Hotz, 1952) and South Africa (du Toit, 1905, 1920). These usually have low dips at the centre, increasing either gently or steeply to the margins. No feeders are required beneath the centre of the basin.

Cone-like intrusions have also been noted in South Africa (Lombaard, 1952; Walker, 1959). These arise from a cupola in the roof of other sills or sheets and become steeper in dip away from the source cupola toward the land surface and higher stratigraphic levels.

However, the sheets of Carey (1958) were stated to dip at 45° in the Lower Permian, 25° in the Middle and Upper Permian and 10° in the Triassic.   This is the reverse of the South African examples.

## MULTIPLE SHEETS AND DYKE CONNECTIONS

The presence of more than one sill and large dykes in the lower Huon Valley was suggested by Ford (1954).

*For*:—

(i) Occurrence at Grey Mountain of a sheet capping the southern half of the mountain with a further sheet below; roof blocks on the lower sheet occur at Mt Morrison.

(ii) Occurrences of more than one sill in the Geeveston-Franklin District on both geological grounds (Ford, 1954) and isostrats (discussion, page 59).

(iii) The relationship of the eastern and western banks of the Huon River (e.g., fig. 13 (iv)) and the suggested conclusion (page 61).

(iv) The isostrat pattern obtained (Carey, 1958) can be explained by multiple sheets and dykes, if they are far enough apart and in a domed region as is the case here. The isostrats indicate more than one dolerite body only where the land surface and sheet separation permit (page 59).   The topography is such that in very few places can more than one sheet be seen clearly in a section, hence the relative simplicity of the isostrats.    Thus, if one sheet rarely breaks surface, the isostrat pattern will be formed mainly by any connecting dykes and the upper sheet.    Since erosion of the core of the dome has occurred, the upper sheet has been removed over most of the area. On a regional scale the result is dolerite in Triassic sediments on the periphery of the dome.

Concentric isostrats are no criterion of a cone sheet, as fig. 11 of Carey (1958) shows.   On each of the three structures isostrats will decrease in one direction.   If an area is domed and the core eroded, a concentric pattern could be obtained with both cone or multiple sheet structures.   Faulting adds minor complications.

(v) Multiple sheets of the configuration envisaged do not require relative dilations across dyke limbs (connections).

*Against*:—

(i) There is no information as to the source of dolerite.

(ii) There has been doubt that sheet-dyke junctions of the type indicated in figs. 13 (i), (ii), 14 (iv) could form and that large sheets could persist over large distances when the terrain above is extensively faulted.

McDougall (1962) and McDougall and Stott (1961) proposed such structures in the Red Hill region and somewhat smaller scale structures of dykes connecting two sheets have been observed at Hummocky Hills and the area NW of Campbell Town (W. L. Matthews, pers. comm.).    That large continuous sheets do occur in Tasmania is evidence that sheets are little affected by pre-existing faults.    The effect of such faults need not be important, depending on the surface area of the faulted blocks, the coefficient of friction, the frictional surface with adjacent blocks and the direction of intrusion stresses, i.e., across or along the fault plane.

On the basis of the above geological information it is concluded that the structure of the dolerite in this area takes the form of one main sheet which underlies the area and one or two other sheets which occur at a much higher stratigraphic level. These sheets are interconnected and fed by large N-S trending dykes (see also Ford, 1954). The detailed shape of the lower sheet, as indicated in figs. 21 and 26, has been deduced from the geophysical results.

### Forms of the Alkaline Intrusion

The Port Cygnet Alkaline Intrusives occur as dykes or large bodies.

The large bodies of material exposed W of Mt Mary and W of the mid-peninsula ridge between Silver Hill and Brabazon Point have been thought to be lava flows or sills (Twelvetrees, 1903a, 1907) or parts of a stock (Skeats, 1917; Edwards, 1947; Carey, 1958; Robertson and Hastie, 1962).

Along the western side of the peninsula ridge the syenite occurs as bodies of rock resting on the crests of spurs of the hill in a skin effect. The base of the material appears concordant. In each case the alkaline rock occurs as outliers on spurs, indicating that most of the material has been removed. At Mt Windsor the base of the material dips S, outcropping on the ridge N of Mt Windsor as well as on the lower slopes. Sill contacts have been observed for the material at Wheatley and Petchey Bays (pls. 13, 14).

## GEOPHYSICAL STUDY

The subsurface configuration of the dolerite and alkaline rocks can be studied geophysically by magnetic and gravity methods.

Magnetic methods may be used in any survey dealing with basic rocks since these normally have a greater magnetic susceptibility than the sediments they intrude and consequently show in magnetic relief. Gravity surveys are particularly valuable in areas where dense igneous rocks intrude lighter sediments. The anomalies may be directly interpreted in terms of geological structure (Steenland and Woollard, 1952; Romberg and Barnes, 1954; Greenwood and Lynch, 1959; McDougall and Stott, 1961).

No previous geophysical work has been undertaken in this district. The magnetic interpretation proved complicated, thus the gravity results have been interpreted as fully as possible, with control supplied from a simplified magnetic analysis.

### Magnetic Survey

The method of survey used was to run traverses from a base point and then at the end of each traverse recheck the base point. In this way the effects of drift, both of the instrument and the field, could be compensated. There was no magnetic disturbance on any of the days surveys were made. This was checked by reading certain tie points on each day of the survey. All stations were read until the results given by the instrument, an Elsec proton precession magnetometer, were consistent. For stations where the field exceeded 65,000 gammas, this meant that many readings were necessary due to the field being near the recording limit of the instrument used. All results were reduced graphically using a specially calibrated large scale graph. The accuracy of results is ± 5 gammas.

PORT CYGNET
MAGNETIC FIELD INTENSITY
FIELD IN GAMMAS

CONTOUR INTERVAL 250 GAMMAS (250 γ)

COMPILED BY
D.E.LEAMAN
JAN. 1965

FIGURE 15.

5 cm

KEY MAP SHOWING
AXES OF ANOMALIES
AND LOCATION OF PROFILES

2922-88

DEPARTMENT OF MINES—TASMANIA

SECTION LINES
AXES OF ANOMALIES : GRAVITY(RESIDUAL)
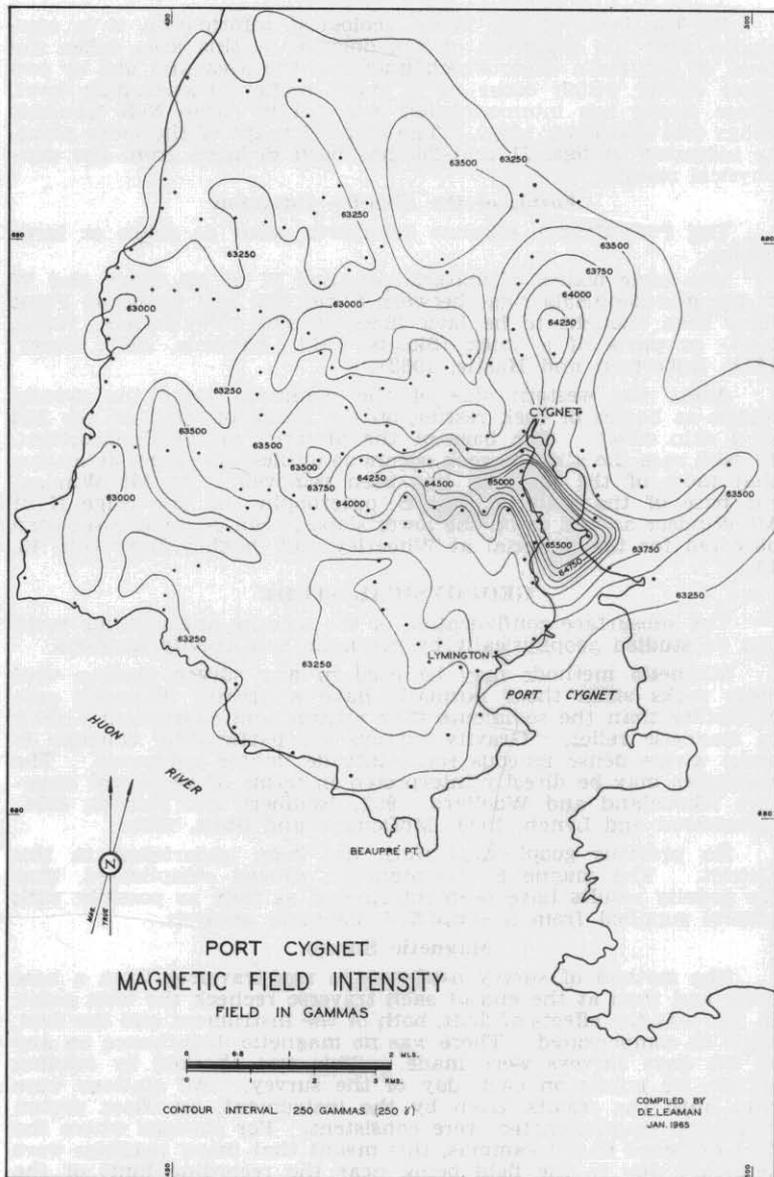MAGNETIC
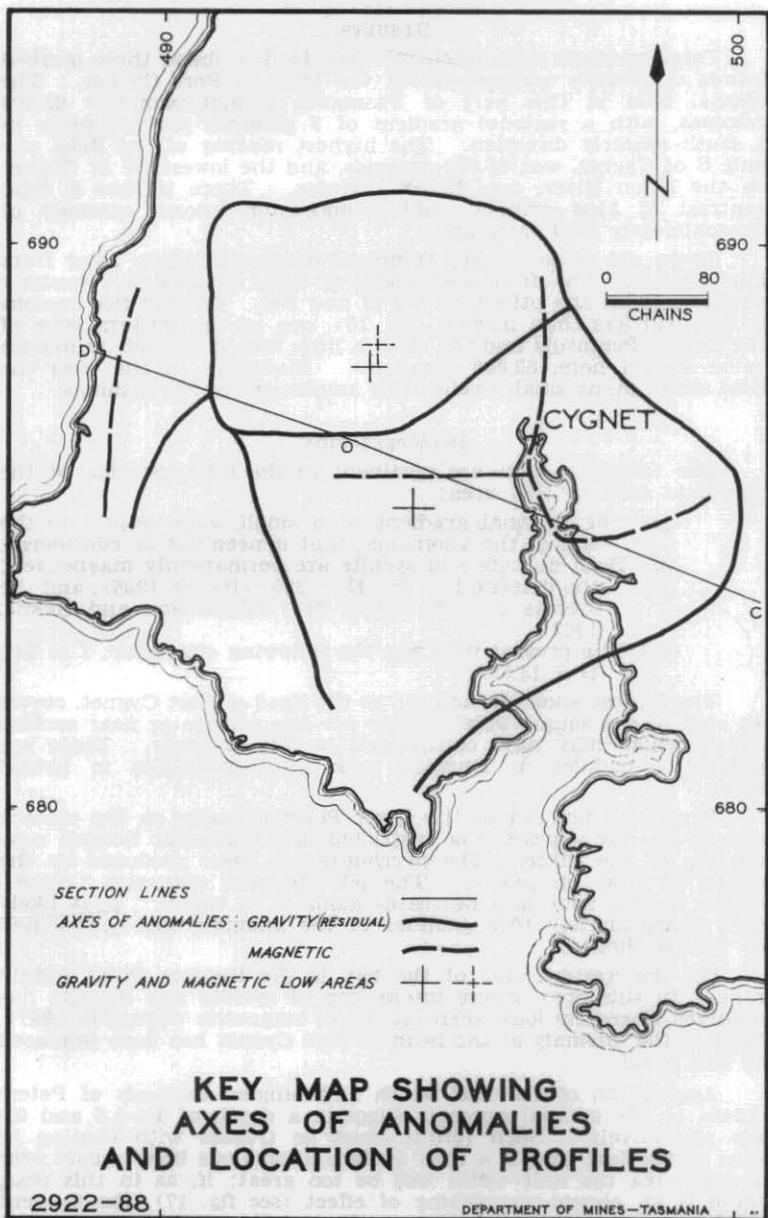GRAVITY AND MAGNETIC LOW AREAS

CYGNET

0        80
CHAINS

FIGURE 16.

5 cm

## Results

Total magnetic field intensity (figs. 15, 16) shows three marked trends of positive anomaly about the head of Port Cygnet. The normal field in this part of Tasmania is approximately 63,000 gammas, with a regional gradient of 9 gammas per kilometre in a south-westerly direction. The highest reading of the field, one mile S of Cygnet, was 65,830 gammas, and the lowest, W of Cygnet on the Huon River, was 62,718 gammas. There is thus a total contrast of 3100 gammas and a maximum known anomaly of approximately 2800 gammas.

There are three marked trends of positive anomaly away from Port Cygnet. The most pronounced of these extends in a westerly direction, with the others to the N and NE. In only two regions is the field less than normal (fig. 15), one at the western edge of the Cygnet Peninsula and the other a little NW of Cygnet (minimum value known here, 62,890 gammas). Elsewhere in the area the field shows many small swells, with amplitudes of 250 gammas.

## Interpretation

The following facts are pertinent to the interpretation of the magnetic field in this area:

    (i) The regional gradient is so small, with respect to the size of the anomalies, that it need not be considered.

    (ii) Both dolerite and syenite are permanently magnetized; the dolerite $I = 85°$, $D = 325°$ (Irving, 1956), and the syenite $I = 85°$, $D = 314°$ (Robertson and Hastie, 1962).

    (iii) The present field has the following character: $I = 73°$, $D = 13.5°$.

The largest anomaly, centred at the head of Port Cygnet, covers an area of one square mile. There are two surface or near surface effects which may have contributed to this anomaly. These are pyrrhotite nodules in Permian rocks and magnetite in hybrid rocks.

Pyrrhotite nodules in the lower Permian rocks on the eastern side of the bay appear to be restricted to a particular horizon near the top of the tillite. The pyrrhotite has been produced by the action of heat on pyrite. The NE trending magnetic "ridge" begins in this zone and decreases along it to the E. It is likely that approximately 1000 gammas of the anomaly was contributed by the pyrrhotite.

On the western side of the bay is the Regatta Point hybrid zone. In this area, where interaction of syenite and dolerite has occurred, there are local segregations of magnetite (Edwards, 1947). Most of the anomaly at the head of Port Cygnet has been produced by this effect.

Application of the half width and tangent methods of Peters (1949) to the general anomaly suggests a depth of 1.4-1.6 and 0.6 km respectively. Such results must be treated with caution in view of the fact that if a near surface anomalous body occurs over a wide area the half width will be too great; if, as in this case, there is an abrupt sharpening of effect (see fig. 17), the tangent method solution will be too low. The profiles (fig. 17) show that this anomaly is compounded of a deeper anomaly and a near

surface anomaly; consequently the half width result is thought to apply to the deeper features and the tangent method to the shallower effect. Even so the results can only be estimates since calculations on breadth or sharpness of anomaly often give unreliable answers.
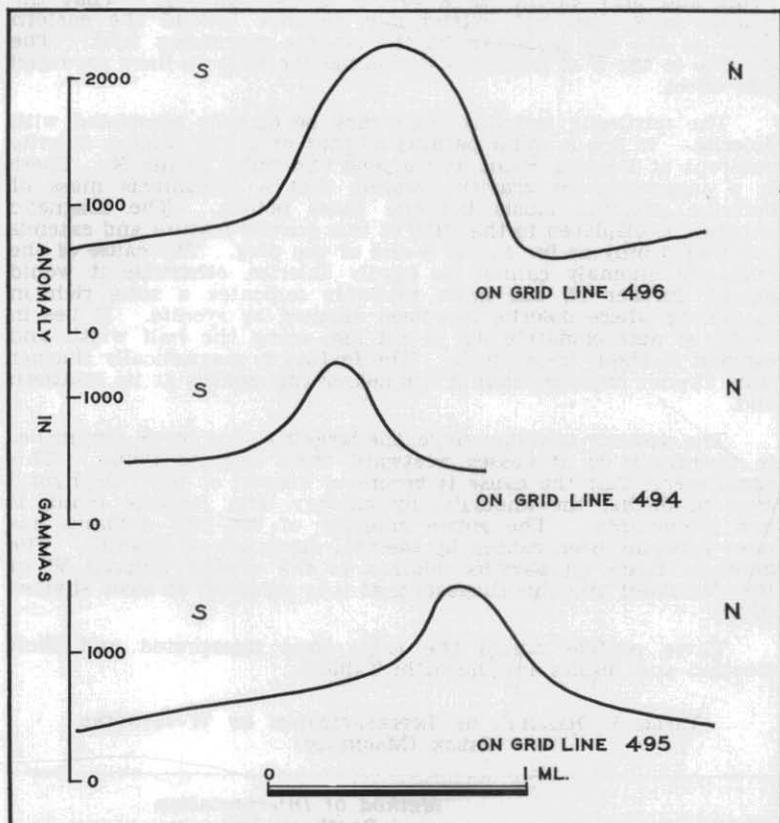


FIGURE 17.

In comparison with the causes of the primary anomaly the ridge features have probably also been produced as a result of thermal effects. This implies the presence of both dolerite and syenite below much of the area. It should be noted also that the pyrrhotite effect cannot contribute to the anomaly in the northern and western ridges since the exposed rocks contain no pyrrhotite horizon, are generally stratigraphically lower, and thermal metamorphism is so limited in this region that no conversion of pyrite to pyrrhotite would be possible were a pyrite horizon present.

5 cm

The ridge E of Port Cygnet begins by following the trend of the pyrite-pyrrhotite horizon. The anomaly falls off abruptly away from Port Cygnet implying that the heat source producing the pyrrhotite was more distant. Since a temperature of 600° C is required to convert pyrite into pyrrhotite there must be a nearby igneous body. The nearest exposed igneous material is at Regatta Point and may extend as a tongue under the bay. That the igneous rock does not extend any distance beyond the eastern shore of the bay is shown by the rapidly decreasing field. The dolerite to the S of Gardners Bay is too far away to have produced this effect.

The northerly trending ridge may be directly associated with dolerite. It has a trend parallel to that of a line joining dolerite outcrops at Regatta Point and a plug two miles to the N. There is a suggestion on gravity grounds that a continuous mass of doleritic material exists between these points. The magnetic anomaly is displaced to the NNE of this gravity feature and extends northward only as far as the S end of the plug. The cause of the magnetic anomaly cannot be purely dolerite, otherwise it would extend further N, but more probably indicates a zone rich in magnetite where dolerite has been affected by syenite. It lies in depth at approximately 0.8 or 0.4 km, using the half width and tangent methods respectively. The feature is magnetically sharper near Cygnet implying that it lies nearer the surface at its southern end.

The westerly trending ridge, the largest of the three, diminishes in magnitude as it passes westward from Regatta Point. This could mean that the cause is becoming deeper, or that the hybrid zone producing the anomaly, by analogy with Regatta Point, is less pronounced. The entire anomaly of 750-1500 gammas has most probably been caused by thermal alteration of dolerite. The anomaly bears no obvious relation to the syenite outcrop W of Regatta Point and this suggests that it is produced at some shallow depth.

Three profiles across the ridge were interpreted and their location and results are shown in Table 5.

TABLE 5: RESULTS OF INTERPRETATION OF W-TRENDING RIDGE (MAGNETIC)

| Location | Method of Interpretation (Depth in km) | | |
| --- | --- | --- | --- |
| | Smith Rules | Half Width | Tangent |
| Grid 494 ........ | .... | 0.8 | 0.2, 0.25 |
| Grid 495 ........ | <0.4-0.65 | 1.3 | 0.3, 0.25 |
| Grid 496 ........ | .... | ‥ 1.2 | 0.4, 0.4 |

Fig. 17 shows the broad regional base of the anomaly and a marked peak. It is likely that any feeders below this area produce the small broad scale anomaly with the sharper shallow-based anomaly superimposed. Thus for interpretation of the near surface effect the tangent method results are likely to be the best. Applying the Smith (1959, 1961) Rules to that profile for which two dimensional conditions are best satisfied, there is reasonable agreement with the tangent method results. The variation in Smith Rules result depends on the equation used.

It seems likely that the zone of thermal effects is nearly horizontal and just below sea level. The anomaly thus diminishes in amplitude westward due to increasing depth since the land rises westward away from Regatta Point. The basal anomalous feature appears to lie at 1 km at least.

The small magnetic low N of the western ridge may be correlated with the northern gravity low just to the SW. Presumably both these features have been produced by a column of sediments since these are lighter than igneous material and magnetically inert. From the displacement of the magnetic low to the N it has been possible to estimate the height of the sediment column it represents. Since the point of least field intensity is not precisely known, this figure can only be given as a range between two limits. The height of the sediment column is 1.2-2.5 km.

The swells of anomaly (250-500 gammas) are probably due to the underlying large masses of dolerite, and cannot be interpreted properly due to too little station control and uncertainty about field behaviour over these permanently magnetized bodies. This latter factor is the reason no detailed interpretation was undertaken, particularly since total field rather than vertical component was to be considered.

## Gravity Survey

Gravity observations were made with a Worden gravity meter (No. 273), scale factor 0.08962 mgal/div. Due to lack of any previous gravity work W of the divide from Mt Wellington to the Lower D'Entrecasteaux Channel, it was necessary to use a State Permanent Mark at Snug, which had previously been tied into Hobart, as base station. This was also the base station for the survey of McDougall and Stott (1961). The survey of the Cygnet area was tied in to this base station across the divide along the Oyster Cove-Nicholls Rivulet Road. The datum value of the Snug base is 980468.59 mgal.

Stations were placed on all available roads, with care to minimize terrain corrections on hillsides. The station separation is approximately one quarter mile. Since a number of roads are continuous across the area a small number of loops were possible. The misclosures in these loops were generally small and adjusted by the least squares method of Gibson (1941).

All stations were read twice with an interval of up to two hours between readings and were corrected for instrumental drift and, to some extent, tides although no special corrections have been made for tides. The location of all stations is known to an accuracy of better than 50-100 yards. All corrections made to the results have been calculated using an electronic computer. The

latitude correction was made using the equation of the theoretical earth ellipsoid (Heiskanen and Meinesz, 1958). The accuracy of the corrected results is approximately 0.1 mgal.

Measurement of the elevation of each station was made relative to high water level with an Askania microbarometer. As an additional control on height, stations were placed on all available bench marks. Each station was read twice within two hours and corrected for instrumental and atmospheric pressure variations. Since it was possible to end a large number of traverses at sea level, the control on height is excellent, better than one metre.

Free air and Bouguer corrections have been applied to all stations. The free air correction has been taken as 0.3086 mgal/m and the value of density adopted in the Bouguer correction was 2.6 gm/cm³ (see also p. 74). Terrain corrections have not been applied due to lack of contour maps. Stations needing most correction lie between 489491E and 493495E. Using the method of Sandberg (1958) the maximum correction would be 1.0-1.5 mgal. By the method of Hubbert (1948) most stations require less than 0.5 mgal.

### RESULTS

The results are presented in figs. 18 and 19 as maps of the free air and Bouguer anomalies. A regional gradient of 5 mgal/7 km decreasing to the NW is suggested.

The trends of the axes of the Bouguer anomalies are clearly shown in fig. 16 and it will be observed that there is an annular ridge with an E-W transverse ridge within the annulus. N and S of the transverse ridge are marked gravity lows. The anomalies decrease away from the concentric ridge in all directions.

The value of density selected for the Bouguer correction was 2.60 gm/cm³ on the basis of the following laboratory measurements (see Table 6). The number of samples reflects the proportion of the area composed of the various formations.

TABLE 6: DENSITIES OF VARIOUS FORMATIONS IN THE
CYGNET DISTRICT

| Rock | No. of Samples | Av. Density (gm/cm³) |
|---|---|---|
| Triassic undifferentiated .... .... .... .... | 4 | 2.43 |
| Barnetts Member .... .... .... .... .... .... | 3 | 2.42 |
| Ferntree Formation .... .... .... .... .... | 8 | 2.58 (2.58) |
| Malbina Formation .... .... .... .... .... | 5 | 2.54 (2.53) |
| Grange Mudstone .... .... .... .... .... .... | 4 | 2.54 (2.54) |
| Faulkner Group .... .... .... .... .... .... | 5 | 2.54 |
| Bundella Mudstone .... .... .... .... .... | 2 | 2.55 |
| Quamby Mudstone .... .. .... .... .... | 11 | 2.58 |
| Tillite .... ....... .... .... .... .... .... .... | 11 | 2.59* |

( ) Values of McDougall and Stott, 1961.
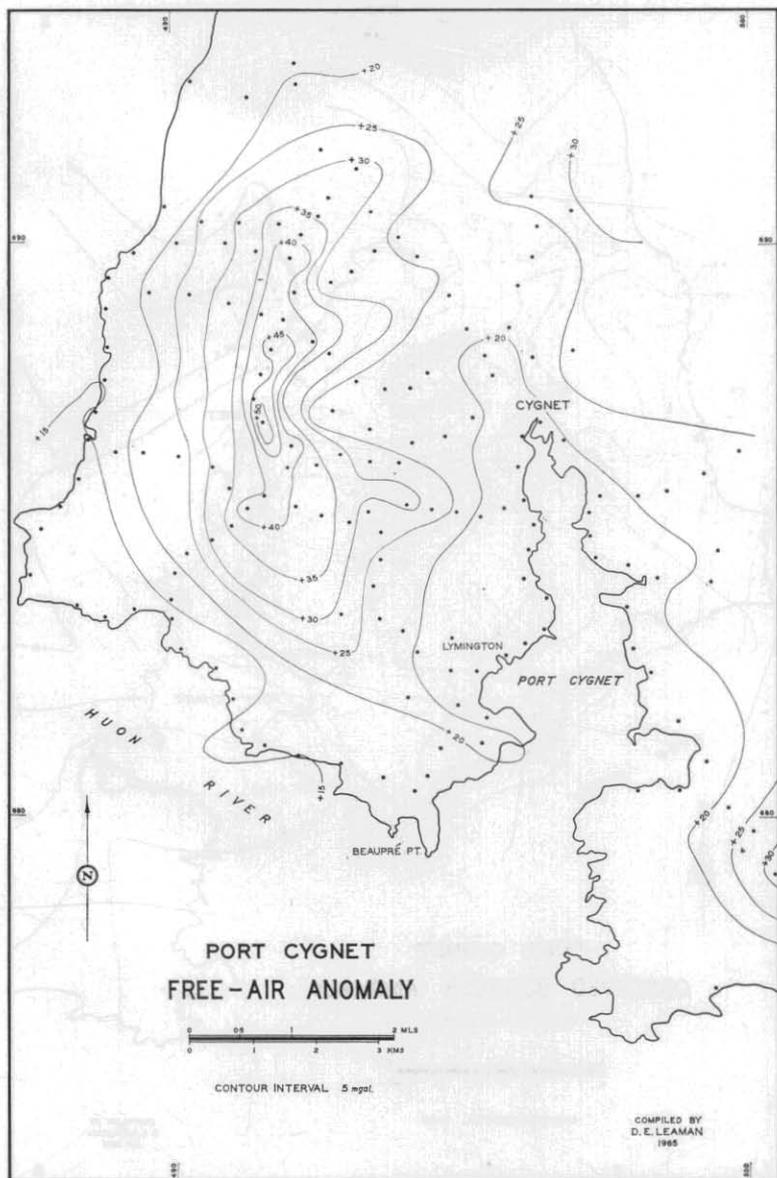* Matrix only measured. Density would be increased if pebbles were considered.

PORT CYGNET
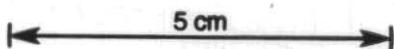
FREE-AIR ANOMALY

CONTOUR INTERVAL  5 mgal.

COMPILED BY
D. E. LEAMAN
1965

FIGURE 18.

PORT CYGNET
OBSERVED BOUGUER ANOMALY
DENSITY — 2·60 gm/cc

CONTOUR INTERVAL 1 mgal.

COMPILED BY
D. E. LEAMAN
JAN. 1965

FIGURE 19.

PORT CYGNET
RESIDUAL BOUGUER ANOMALY

CONTOUR INTERVAL 1 mgal.

○ BORE NOT STRIKING DOLERITE (DEPTH INDICATED)
● BORE STRIKING DOLERITE (DEPTH TO DOLERITE INDICATED)
+ SYENITE PORPHYRY        JURASSIC DOLERITE

COMPILED BY
D.E.LEAMAN
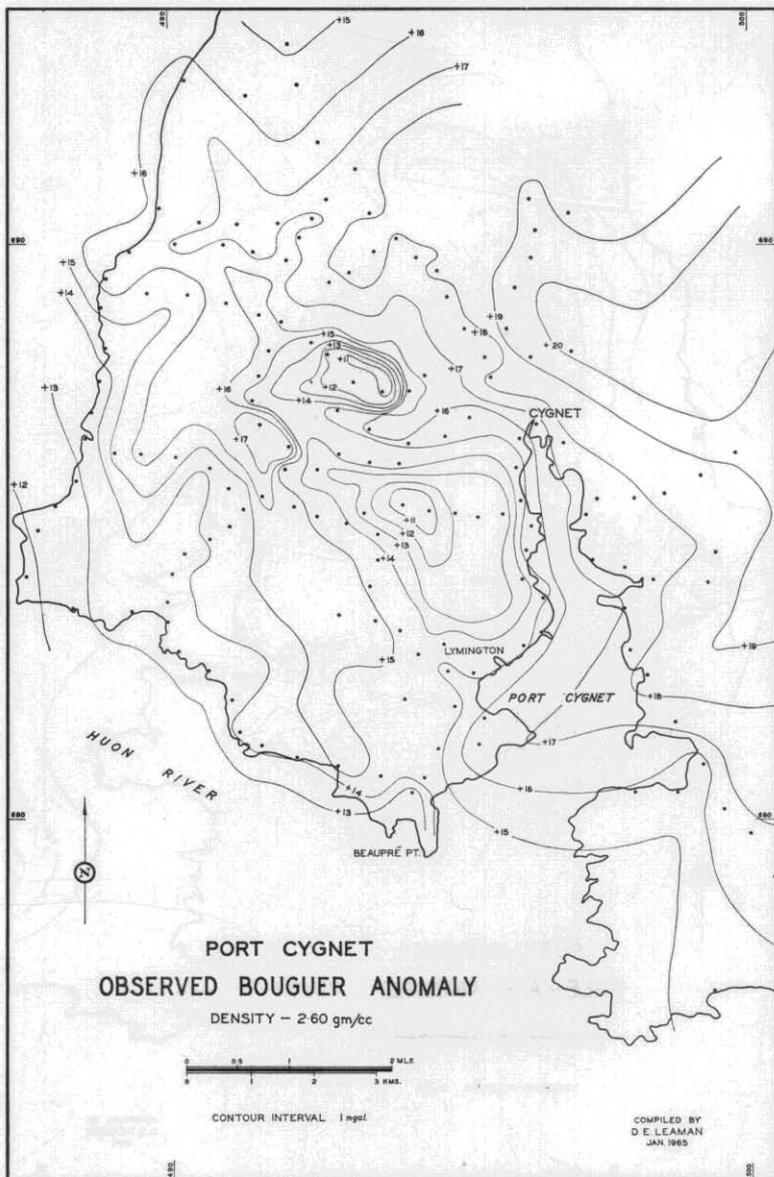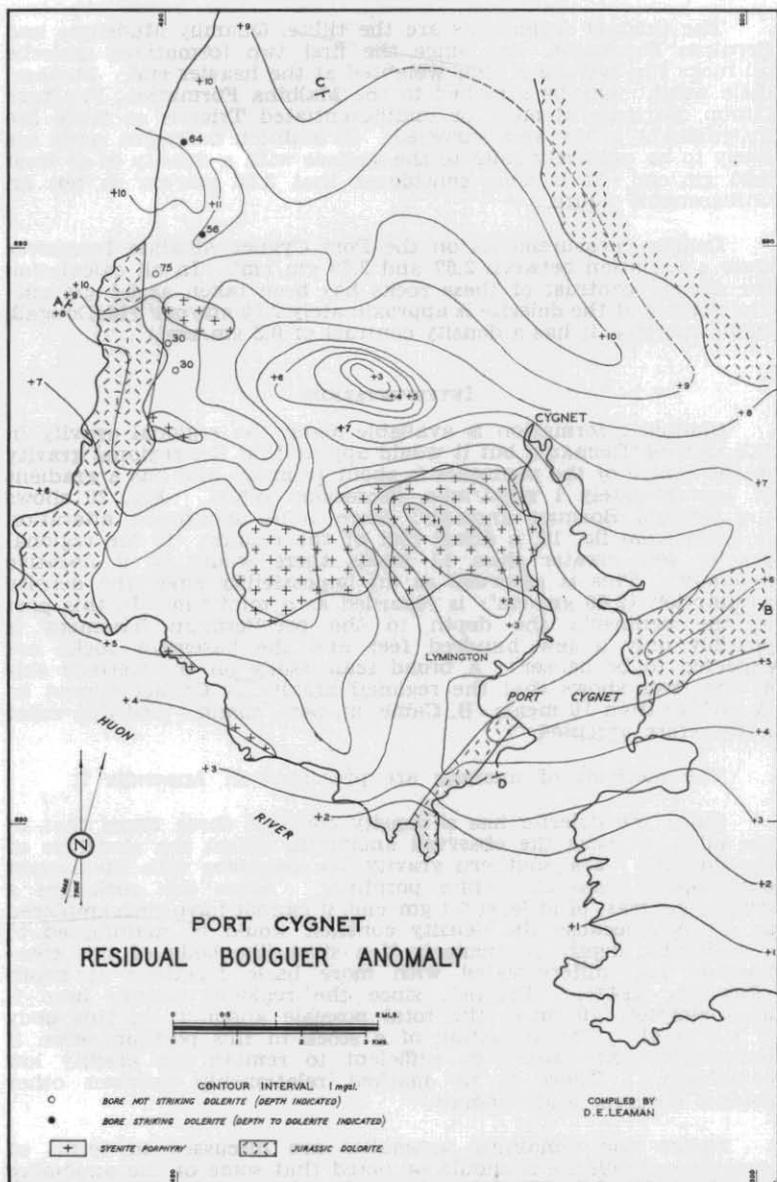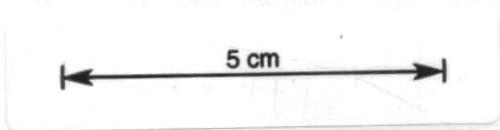
FIGURE 20.

The thickest formations are the tillite, Quamby Mudstone and Ferntree Formation, and since the first two formations underlie all rocks the average is thus weighted at the heavier end. Further, little weight may be attached to the Malbina Formation, Faulkner Group, Barnetts Member or undifferentiated Triassic as these are insignificant in the area surveyed. In addition basement rocks are likely to be relatively close to the surface with a density of at least 2.60 gm/cm$^3$. It is thus considered that 2.60 gm/cm$^3$ is not an unreasonable figure.

Density measurements on the Port Cygnet Alkaline Intrusives show a variation between 2.67 and 2.73 gm/cm$^3$. In all calculation the density contrast of these rocks has been taken as 0.1 gm/cm$^3$. The density of the dolerite is approximately 2.90 gm/cm$^3$ (McDougall, 1962) and thus it has a density contrast of 0.3 gm/cm$^3$.

## INTERPRETATION

Limited information is available about the regional gravity in this part of Tasmania but it would appear that the regional gravity in the centre of the peninsula is about 10 mgals and has a gradient of approximately 1 mgal/mile, decreasing WNW. Fig. 20 shows the residual Bouguer anomaly; there is no significant alteration in form from fig. 19, a direct plot of the results. If the regional gravity was greater than 11 mgals there would be a negative anomaly. This is regarded as an impossibility since the density assumption (2.60 gm/cm$^3$) is regarded as a minimum. In this part of the peninsula the depth to the pre-Permian basement is possibly only a few hundred feet and the basement rocks are expected to be denser. A broad scale study on the western side of the river shows that the regional gravity at Cygnet cannot be much less than 10 mgals (B. Cameron, pers. comm.) and this value is therefore accepted.

The methods of analysis are presented in Appendix 2.

Since the dolerite has a density contrast three times that of the alkaline rocks the observed anomalies reflect the structure of the dolerite. The southern gravity low coincides with the largest outcropping mass of syenite porphyry. Since this rock has a density contrast of at least 0.1 gm/cm$^3$, it cannot have been emplaced as a stock because the density contrast would be maintained to considerable depth, particularly if a stock-like body of this composition had differentiated with more basic fractions at depth (Edwards, 1947). Further, since the regional gravity here is approximately 10 mgal, the total possible anomaly on this body is 1-2 mgal. The attraction of a stock in this position (even if undifferentiated) would be sufficient to remove the gravity low completely. There is no marked relationship between other smaller outcrops and anomaly.

Before the remaining anomalies are discussed in terms of structure of dolerite it should be noted that some of the anomalies may be induced by the basement rocks which presumably occur at shallow depth. There is, however, no obvious pattern to these anomalies.

The ridge of anomaly running inside or over dolerite outcrops reflects the presence of dyke bodies of dolerite. The enclosed low represents a region with no dolerite or dolerite at depth. Since the geological observations and structural hypotheses require a sheet below the peninsula (p. 62, fig. 13), this was borne in mind during interpretation (fig. 21—section points A-B, C-D are indicated on fig. 20). To account for the general decrease in the gravity field below the peninsula this sheet must have a basin-like shape.

The laccolith suggested by Hills *et al.* (1922) to bow up the sedimentary rocks would need to be too large (p. 52) and no gravity low could exist over it.
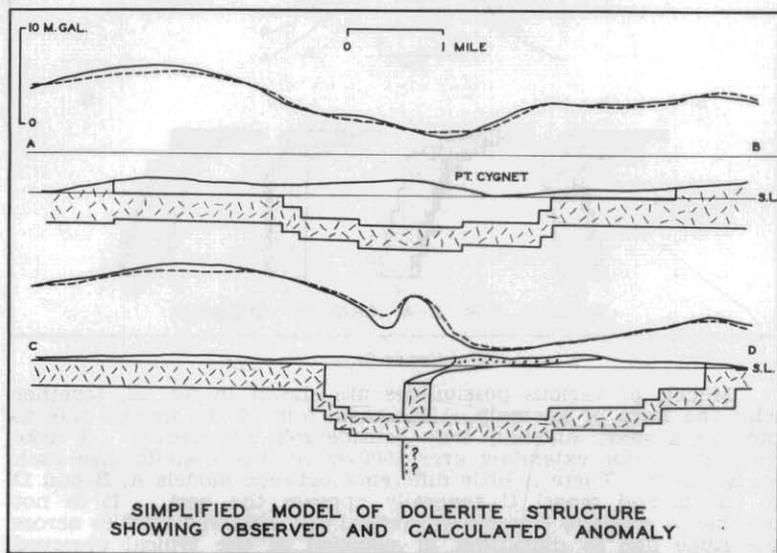


SIMPLIFIED MODEL OF DOLERITE STRUCTURE
SHOWING OBSERVED AND CALCULATED ANOMALY

FIGURE 21.

Within the basin-like structure, there exists a complexity, of which the following properties have been noted:—

(i) It is more than 2 miles long and is reflected in both magnetic and gravity surveys.

(ii) The magnetic anomaly is S of the gravity anomaly, suggesting that if they are related the mass occurs below the gravity anomaly and that the body inclines southward, the magnetic anomaly being due to hybridization of materials in the inclined arm where the syenite is more massively exposed.

(iii) The ridge feature is composed principally of dolerite with some hybrid rocks and syenite. There must be dolerite to account for its occurrence at Regatta Point and the hybrid zone to the W.
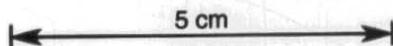
(iv) The gravity gradient from the ridge is steeper to the N, possibly due to (ii).

(v) It appears to merge with the sheet on either side, and the N-S magnetic anomaly reflects hybridization along part of the eastern section of the sheet.
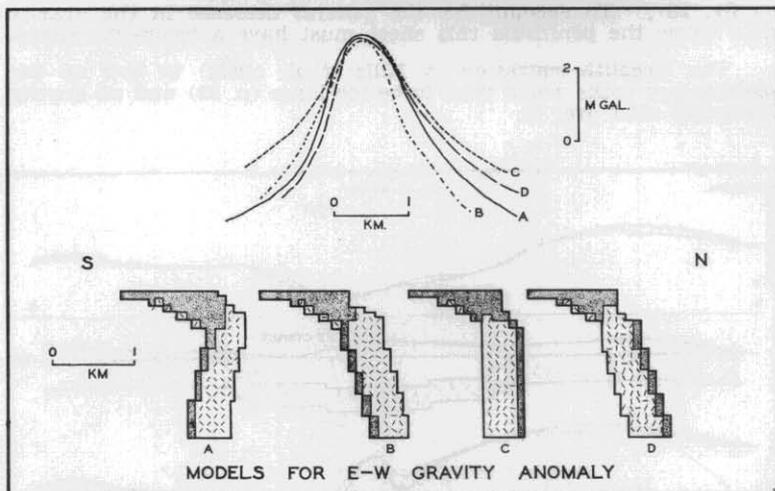


FIGURE 22.

Models of various possibilities are shown in fig. 22, together with the form of anomaly. The main aim of the models was to produce a sharp anomaly with considerable asymmetry. A dyke 500-600 m wide extending over 1000 m in depth would give such an anomaly. There is little difference between models A, B and D to the S and model C generally appears the best. It is not possible to compare directly theoretical and observed profiles across the ridge due to difficulties in selection of the typical observed profile. The following data describe, in some measure, the shape of the observed profile. The anomaly decreases 2-3 mgal in the first kilometre from the peak to the S and 3-5 mgal in the same distance to the N. In 1.5 km the fall is 2.6-4.5 mgal to the S and 4 mgal to the N. This dyke body cannot extend in depth at this size but a smaller feature may well do so. Little definite can be said about any feeders for either the dolerite or the Port Cygnet Alkaline Intrusives. A feeder extending in depth has been implied by the recent aeromagnetic survey of Tasmania (Finney and Shelley, 1966), but the aeromagnetic anomaly may simply reflect some basement influence. However, a feeder for the alkaline rocks at least must be present.

## Conclusions

(i) The magnetic anomalies are caused by the presence of dolerite thermally metamorphosed by syenite. The distribution of anomalies implies dolerite and alkaline rocks below much of the area.

|←          5 cm          →|
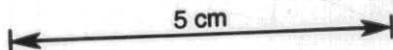
(ii) The gravity anomalies are predominantly related to dolerite structures.

(iii) The alkaline rocks do not appear to have been emplaced as a stock.

(iv) The dolerite appears to have the form of multiple sheets and large dykes. The main sheet has a distinctly undulating character. An E-W dyke which occurs below the peninsula consists mainly of dolerite in its upper zone and may be a feeder at depth for either rock type, although more probably for the syenite. It may be a combined feeder.

Alternatively, much of the E-W anomaly may be due to an ultrabasic or basic intrusive in the basement rocks which is in no way related to the Jurassic dolerite or Cretaceous alkaline suite. The present survey does not cover sufficient area to show if the anomaly is confined to the Cygnet District.

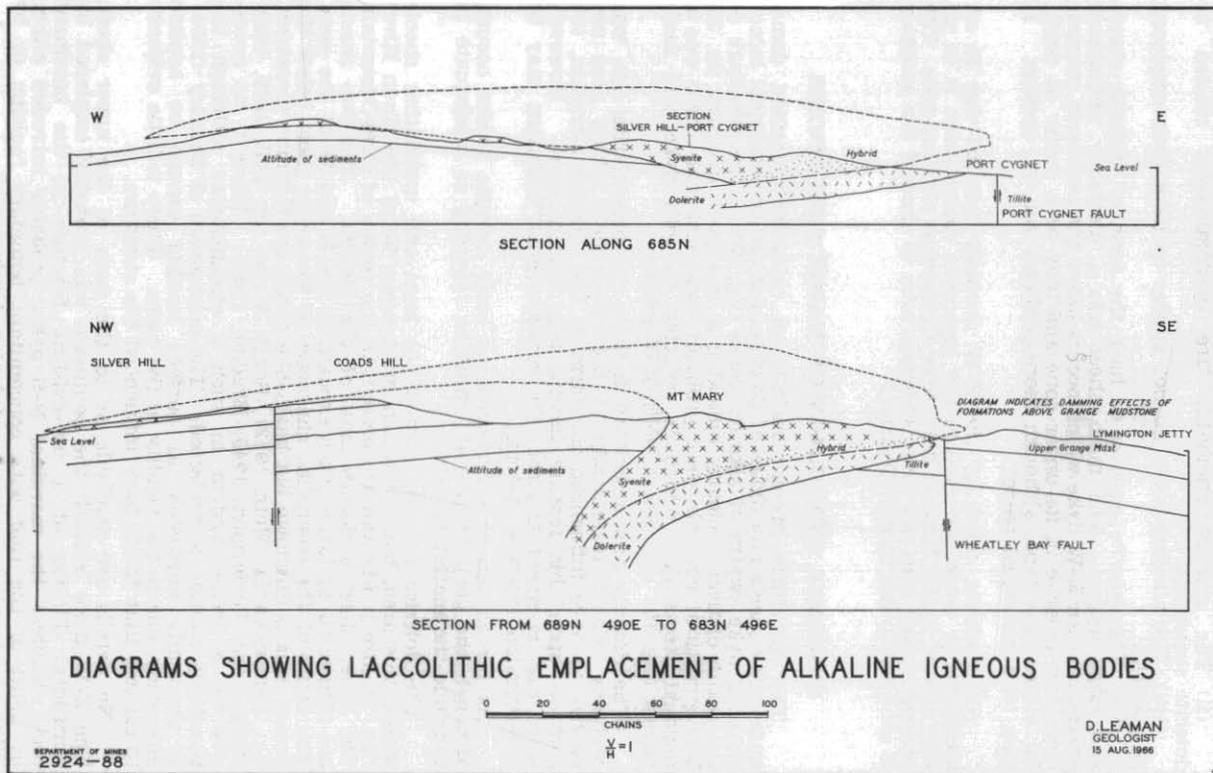## SUMMARY AND ORIGIN OF MAJOR STRUCTURES

The structures present include an extensively faulted dome, undulating sheets and dykes of dolerite and an asymmetrical laccolith and dyke swarm of alkaline rocks (fig. 23). The structure of the entire district is clearly indicated in the block diagram, fig. 26. The structural controls were probably local although there was a regional stress field which is reflected in both dyke and fault trends (fig. 12) and was a NNE-SSW tension.

The doming and associated faulting, of pre-dolerite age, was probably related tectonically to the stress field which does not appear to have influenced the form of the dolerite intrusion, the controls upon this feature having been purely local. However, since the basement is close, the controls upon intrusion may be pre-Permian fracture systems.

As far as can be ascertained no large dolerite feeder occurs, although the geophysical data must be regarded as inadequate to conclude the matter of feeders.

The dolerite has the form of at least two undulating sheets within this area, both of which must occur W of the Huon River (fig. 13, also p. 61) and are present in the region of Grey Mountain The lower sheet underlies most of the district. The two sheets are connected by large dykes exposed in the E and W of the area. The cause of the basin-like character of the lower sheet below the domed area is unknown but basin-like sheets are common elsewhere, e.g., Pennsylvania (Hotz, 1952), South Africa (du Toit, 1905, 1920; Walker and Poldevaart, 1949; Bradley, 1965). There is no necessity for a feeder system in such a circumstance although the possibility cannot be neglected. The mechanism of Bradley (1965) is physically impossible as surface loading cannot be applied effectively, due to the rigidity of the rocks. There is little evidence to suggest that faults have influenced the structure.

No details are available as to the form of the upper sheet. The E-W dyke beneath the peninsula was probably emplaced by horizontal dilation of a pre-existing fracture in the basement rocks, whereas the marginal N-S dykes probably intruded either by uplift of the roof with concomitant boundary faulting or by filling tensional spaces produced during doming.

5 cm

SECTION
SILVER HILL — PORT CYGNET

W

E

*Attitude of sediments*

Syenite

Hybrid

PORT CYGNET

Sea Level

Dolerite

Tillite

PORT CYGNET FAULT

SECTION ALONG 685N

FIGURE 28.

NW

SE

SILVER HILL

COADS HILL

MT MARY

DIAGRAM INDICATES DAMMING EFFECTS OF
FORMATIONS ABOVE GRANGE MUDSTONE

Sea Level

LYMINGTON JETTY

Upper Grange Mdst.

*Attitude of sediments*

Hybrid

Syenite

Tillite

WHEATLEY BAY FAULT

Dolerite

SECTION FROM 689N 490E TO 683N 496E

DIAGRAMS SHOWING LACCOLITHIC EMPLACEMENT OF ALKALINE IGNEOUS BODIES

0    20    40    60    80    100
CHAINS

$\frac{V}{H} = 1$

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GEOLOGIST
15 AUG. 1966

DEPARTMENT OF MINES
2924—88

In the higher levels the sheet-like intrusions were most probably controlled by particular formations, for example, the Grange Mudstone. A small sill protruding from the eastern dyke can be seen in this formation at Mt Morrison. The Grange Mudstone is very susceptible to such intrusions and the sheet below Cradoc is probably within it. Such an hypothesis of intrusion by multiple sheets presumes nothing about the source of dolerite. More than one pulse of intrusion is represented.

The structure of the dolerite deduced for this area is very similar to that in Guyana where there is one main sheet, a smaller high level sheet and occasionally a small low level sheet near the unconformity of flat-lying rocks and folded rocks. The sheets are interconnected by inclined dykes and fed by dykes, sometimes inclined, through the folded basement (Hawkes, 1966, fig. 2). The analogy with Tasmanian dolerite is remarkable.

The Port Cygnet Alkaline Intrusives have been intruded along the same fracture system at depth as the E-W dyke has occupied near the surface. There is a suggestion from the size of the anomaly that the cause may extend beyond the 1000 m calculated. However, at about this level the alkaline rocks broke through the lower dolerite sheet (note the deeper magnetic anomaly, p. 69) and then passed as a skin effect along the shrinkage fractures adjacent to the dolerite (fig. 23), until the flat-lying Permian sediments were reached. The bulk of the material lies W and slightly S of Regatta Point. From this level it has risen to the W and N, reversing the direction of intrusion, possibly forming a thin asymmetrical laccolith or tongue (fig. 23). The control on the intrusion in the higher levels has apparently been a function of the parting of various formations. Thus, concordant bodies of alkaline material occur in the Bundella and Grange Mudstones. Also the Wheatley Bay and Port Cygnet Faults appear to have had considerable influence in restricting the areas intruded by the banatitic body.

The roof sediment was also bowed up by the incoming material but the lift was restricted to the Regatta Point area and took place above the present surface on the two faults mentioned. No sediment roof to the syenite porphyry remains. The material passed as a thin sill in the area well away from Port Cygnet. The overall result of the intrusion was to produce an asymmetrical laccolith (fig. 23). Syenite porphyry also probably exists as a thin skin on part of the lower dolerite sheet NE of Cygnet. The contact zone is reflected in the northern magnetic ridge.

The intrusion of this material below Cygnet, even as a skin effect, would fracture the sediments and possibly revive old faults causing small movements. These fractures were occupied by dykes.

Edwards (1947) thought that the syenite porphyry occurred as a chilled margin to the "stocks". This effect is to be expected since the volume involved is small and the cooling rapid in this form of emplacement.

The dyke swarm is a different problem. Dykes occur principally in the sedimentary block of the peninsula and in the surrounding dolerite. Some also are found between Cygnet and Kettering. Dykes of all types have been shown to intrude the laccolith. They are rudely radial to the centre of the peninsula, probably due to the presence of radial fractures formed by the earlier doming.

POLES TO 150 MAJOR JOINTS IN GRANGE MUDSTONE
DEEP BAY—ABELS BAY AREA

N

JOINTS STRIKING AT 82°

JOINTS STRIKING AT 172°

W

E

S

(i)

> 5%
5%
4%
3%
2%
1%

POLES TO 150 MAJOR JOINTS IN FERNTREE FORMATION
ABELS BAY—EGGS & BACON BAY AREA

N

JOINTS STRIKING AT 244°

JOINTS STRIKING AT 159°

W

E

S

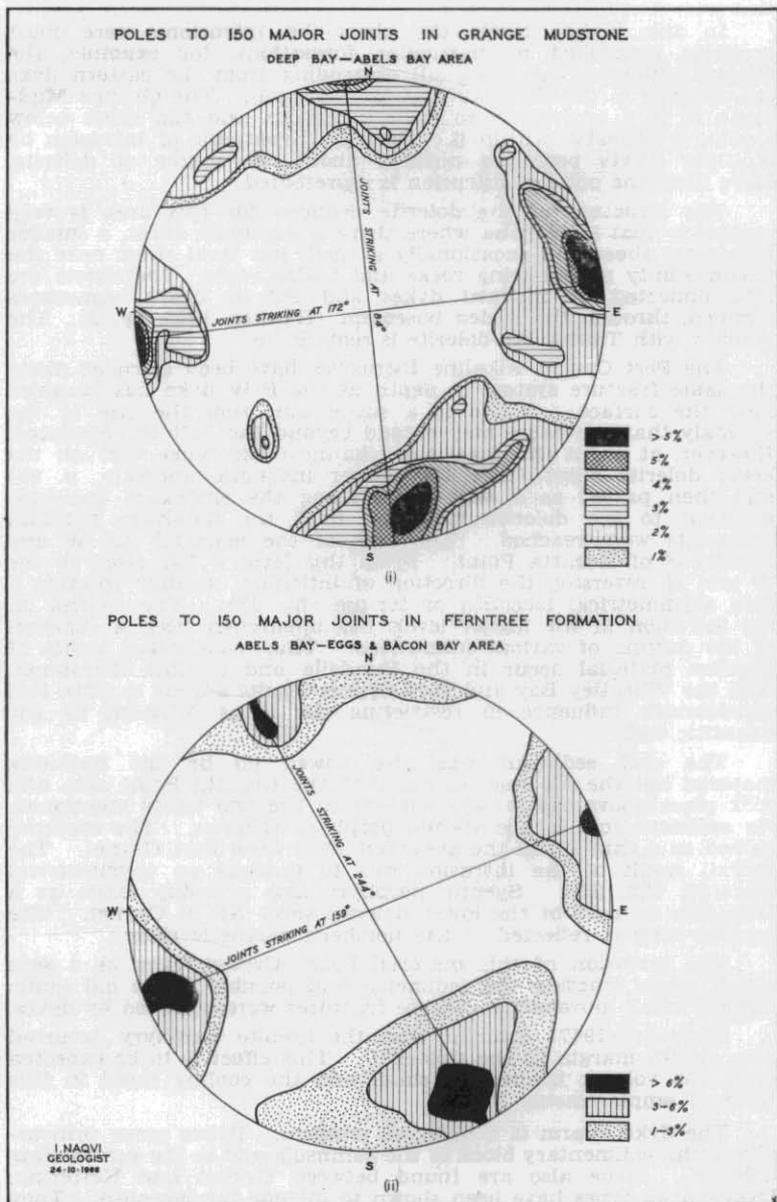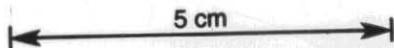(ii)

> 6%
3—6%
1—3%

I. NAQVI
GEOLOGIST
24-10-1966

FIGURE 24.

5 cm

Locally, however, dyke trends, as well as many fault trends, are related to major zones of weakness. Other dykes have a general N-S orientation and the control for this has been applied by the N-S orientation of large dyke bodies of dolerite. Many dykes have wavy contacts and this may suggest forcible intrusion of viscous magma as dyke "fingers" (Noble, 1952) which are to be seen in various stages of linear interconnection (pls. 13, 14). Indeed, many of the dyke "dilations" which are not post cooling may illustrate failure of the "fingers" to connect.

## MINOR STRUCTURES

### JOINTS

All rocks within the area are well jointed but detailed studies have been restricted to a very few formations.

In the Grange Mudstone, two joint directions (84°, 172°) are characteristic and this is clearly shown in fig. 24 (i) for 150 major joints on the shoreline in the Abels Bay-Deep Bay area.

The Ferntree Formation exhibits the strongest jointing of any Permian formation. The rock shows rectangular or polygonal jointing which has produced tessellated pavements on the shoreline. The blocks usually have sides less than a foot in length. A plot of 150 joints at Egg and Bacon Bay conclusively showed that the most pronounced directions are 64° and 159° (fig. 24 (ii)).

The dolerite is also extensively jointed, columnar jointing occurring in all large masses with platy and close columnar jointing near contacts. Joints are dominantly vertical or near vertical.

The syenite porphyry is also strongly jointed. Vertical and horizontal joints are most marked and although other directions may develop no conclusive system was observed (pl. 17).

### CROSS BEDDING

Cross bedding has been observed in the Triassic sandstone and the Risdon Sandstone. It is characterized in each case by the criteria of Allen (1963).

In the Risdon Sandstone the cross-stratification is found as solitary sets generally large in scale. Below each set is an essentially planar erosional surface. The cross strata in each set are discordantly related to the lower boundary of the set and may be straight or curved. Such stratification is thought (Allen, 1963) to have been formed in shallow water by the building of solitary banks, with straight or curved leading edges above slip-off faces, in rivers and shallows off beaches.

The feldspathic sandstone of the Barnetts Member exhibits large scale solitary sets of cross-stratification. Below each set there is usually a planar erosional surface; occasionally this surface is irregular. The cross strata are discordantly related to the lower boundary of the set and are lithologically homogeneous. Solitary banks or ripple trains were involved to produce this type (pl. 18). The current was from the NW (fig. 25).
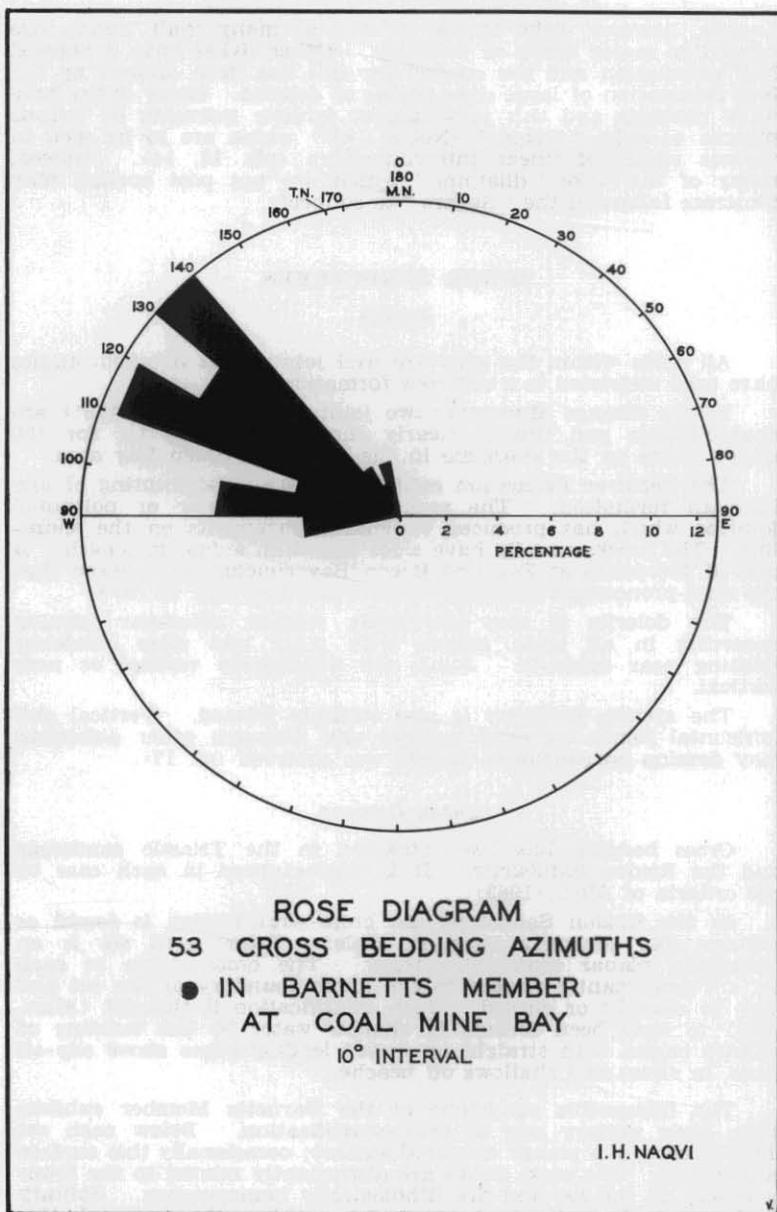
ROSE   DIAGRAM
53   CROSS   BEDDING   AZIMUTHS
● IN   BARNETTS   MEMBER
AT   COAL   MINE   BAY
10° INTERVAL

I. H. NAQVI

FIGURE 25.

The cross-stratifications of the massively bedded Mountain Lodge Member are grouped and individually large. Each set is underlain by a non-erosional planar surface. The cross strata in the sets are lithologically homogeneous and discordant to the lower bounding surfaces. Allen (1963, p. 108) suggested that this structure results through sheets of local extent being thrown up so that they partly overlap.

## LOAD CASTING

Load casting has been found in some places in the Ferntree Formation. It is developed due to the accentuation of pre-existing structures by loading.

## CONVOLUTE LAMINAE

Convolute laminae are found in the carbonaceous siltstone of the Cygnet Coal Measures at Coal Mine Bay. The contorted material is always arenaceous.

## OTHER MINOR STRUCTURES

Other structures such as sole markings and flame structures are found in the Ferntree Formation. Some tendency towards graded bedding has been observed in the Malbina Formation at some places, particularly in Members D and E.

# Economic Geology

Cygnet has long been known as a district in which minerals might be found, especially gold and coal.

## Gold

Alluvial gold-seeking has been carried on spasmodically for about a hundred years. Thureau (1881) reported that it had been first found in Agnes Rivulet. He was not impressed with prospects in the alluvium of the Lymington area. Attempts at lode mining were started in 1898. Smith (1899) reported fine specks of gold in a sample from Mt Mary which assayed 4 dwt 2 grn gold/ton but other samples assayed only a trace of gold or none at all. Neither of the present authors has found visible gold in any rocks of this area.

It is impossible to find out exactly how much gold the district has produced but Twelvetrees (1902, p. 260; 1907, p. 34) estimated 3000 ounces worth $32,000. Most came from the Lymington flats which are surrounded by steep hills from which the metal was derived. Reef gold was mined in a shaft near Kings Hill road.

### Petchey Bay-Lymington Area

Much of the higher ground in this region is capped with syenite porphyry. It appears that gold deposited at or near the contact with the sediments has been shed into either Lymington basin or the shore flats of the Huon River.

Riseleys Creek in the Wheatley Bay area, which drains the western side of the Port Cygnet Alkaline Intrusives, has always been considered to return the most gold, mostly honeycombed, heavy and coarse; one piece weighed 1 dwt 14 grn (Twelvetrees, 1907, p. 35). Gold has been traced up the valley, and a hole sunk to a depth of 20 feet in mixed porphyry and mudstone wash at the foot of the slopes showed colours of gold. It is not thought likely, in view of the rate of accumulation and gold content of the alluvial deposits, that any payable outcrop will be found.

Much gold has probably been removed from the shore flats by the action of tides.

The Lymington valley has been carved across the Port Cygnet Alkaline Intrusives mass and would appear to offer an ideal basin for the alluvial concentration of gold at the mouth of Forsters Rivulet. However, the gold is extremely patchy across the entire region.

### Mt Mary Mine

Situated W of Cygnet township, the Mt Mary mine consisted of several shafts which are now inaccessible. As a consequence no actual mineralization could be seen. The country rock is Permian tillite cut by many dykes of Port Cygnet Alkaline Intrusives. Scott (1927) reported pyrite mineralization in both tillite and intrusives in the form of disseminated grains. Examination of ferruginous quartz veins up to several feet thick showed them to be erratically gold bearing. Brecciation of the contacts has also been reported (Twelvetrees, 1907) and a reddish contact

rock bears visible gold. Assays of up to 5 oz gold per ton have been reported (Scott, 1927). The controls of gold emplacement cannot be deduced from old descriptions and re-opening of the shafts would be necessary to assess the reserves fully.

### Livingstone Mine

Situated on the slopes of Tobys Hill NE of Cygnet, the mine worked a quartz reef in syenite porphyry near the contact with Bundella Mudstone. A shaft was sunk for 60 feet following the parallel bands of quartz. Again initial assays were promising (Smith, 1899) but later results were disappointing. The rock also carries arsenopyrite, pyrite, chalcopyrite and galena. The lode here has been thought to be the most promising in the district and it is the only one found entirely in Port Cygnet Alkaline Intrusives.

### CONCLUSIONS

Any attempt to re-open these mines on present evidence would be highly speculative. While gold is certainly present, its distribution is too erratic, its source and rock relations too obscure and its overall quantity insufficient to permit economic working.

## Other Mineralization

Pyrite is the dominant mineral associated with igneous intrusion in this area. It is associated with all types of alkaline rocks, either as dykes or remnants of the laccolith, and is also to be found in the baked Permian sediments adjacent to most contact zones.

Galena and chalcopyrite mineralization occur at the Livingstone Mine and the quarry near Copper Alley Bridge at Lymington.

Pyrrhotite is also found in nodules in tillite and Quamby Mudstone on the eastern shore near Wilsons yard and Crooked Tree Point. It has been produced from the heating of sedimentary pyrite nodules by dolerite and/or alkaline magma.

Extensive pyrite and magnetite mineralization occurs in the hybrid zone at Regatta Point.

None of these minerals are of economic significance.

## Coal

Coal is present at Coal Mine Bay and at the Devils Royals. It generally occurs in the form of lenses and stringers which achieve lengths of 10 feet and a thickness of 10 cm. It is an allochthonous brown coal and was probably redeposited following erosion of the Cygnet Coal Measures. The coal resources are thus negligible in this district, although at Mt Cygnet, some miles to the E, two seams have been worked (Thureau, 1881; Hills, *et al.*, 1922).

## Road Making Materials

Quarries for the purpose of obtaining road surfacing and top dressing materials are common in the area. Ample dolerite is available for use on sealed roads and in many places jointing in fresh rock is close and irregular.

For use on unsealed roads a certain amount of incipient weathering is desirable so that the road dressing may bind with water. Deposits of weathered dolerite in a gravelly state occur at Wattle Grove, Glaziers Bay and Mt Morrison. Alkaline rocks have also been used as road surfacing since they readily weather under loading. Pleistocene gravels have also been used extensively for road surfacing and aggregate. Large deposits occur at Randalls Bay, Drip Beach and Cradoc, with estimated reserves of $10 \times 10^6$, $4 \times 10^6$, $5 \times 10^6$ cubic yards respectively. Tillite has also been used extensively.

## Oil (?)

Seepages of bituminous material or oil have been reported at Cradoc Hill. No traces of petroleum compounds have been seen, although ferruginous scums are common in seepages and springs.

# Appendix 1

## Systematic Description of Measured Sections

Specimen numbers refer to specimens in the collection of the University of Tasmania, Geology Department. Grain sizes were measured in the field by comparison under a hand lens of the rock with a standard chart (similar to that illustrated by Chilingar, 1956). Colours quoted refer to those listed in Goddard *et al.* (1948). The percentages were assessed in the field (Terry and Chilingar, 1955), and are only very rough guesses. These figures should be considered only as an indication of comparative variations of different kinds. The term " pebble " is taken as synonymous with " erratic " in its use here.

Numbers in the bracket next to the thickness correspond to the station numbers on aerial photographs of 1" = 500' scale (submitted to the Geology Department, University of Tasmania).

The following abbreviations have been used:

| | |
|---|---|
| Sandstone | sdst |
| Siltstone | sltst |
| Mudstone | mdst |
| Feldspathic sandstone | feldsp sdst |
| Quartz granule(s) | qtz gr |
| Fenestellids | fenestlld |
| Stenoporids | stenopd |
| Brachiopods | brachpd |
| Spiriferids | spfd |
| Gastropods | gastpd |
| Fossiliferous | fosfer |
| Grained | grd |
| Siliceous | sil |

## Section Along Shoreline from Coal Mine Bay (49730E, 67743N) to Deep Bay (49880E, 68052N)

| Unit | Thickness ft in (metres) | TRIASSIC |
|---|---|---|

**Mountain Lodge Member**

| | | |
|---|---|---|
| 1 | 49 3 (15.00) | (62) Medium grd, well sorted, cross bedded qtz sdst—qtz gr 77%, mica 10%, graphite 3%, sil matrix 10%—porosity poor—cross bedding suggests current from NW—specimen 33619 |

**Barnetts Member**

| | | |
|---|---|---|
| 7 | 4 7 (1.40) | (60-62) Dark yellowish-orange, thinly laminated, medium to fine grd, fairly well sorted sdst—qtz gr 60%, muscovite 20%, graphite 10%, iron 10%, laminations 3 mm thick—porosity high—specimen 33620 |
| 6 | 36 6 (11.12) | (51-56) Greyish-red purple, very fine grd, well sorted, fissile, micaceous shaly sdst—qtz gr 60%, muscovite 20%, feldspar 15%, graphite 5%—finely cross bedded—weathers to pieces 1 cm diam.—specimen 33621 |

| Unit | Thickness ft   in (metres) | |
|------|------|------|

**5**  23  9  (7.24)

(54-56) Pale reddish purple, fine grd, well sorted, strongly cross bedded sdst—qtz gr 60%, feldspar 20%, muscovite 5%, graphite 2%, clayey iron-rich matrix 10%, iron concretions 3%—porosity high—many clay pellet lenses present—specimen 33622

**4**  1  1  (0.33)

(54) Fine grd, feldsp sdst—qtz gr 72%, feldspar 20%, muscovite 6%, graphite 2%, some sltst pieces—top 17 cm bed contains pieces of sltst

**3**  8  0  (2.44)

(54) Very thinly laminated, fine to medium grd, light grey, fairly well sorted, feldsp sdst—qtz gr 55%, feldspar 35%, muscovite 8%, graphite 2%—laminae 2-4 mm thick—muscovite and graphite up to 40%—specimen 33623

**2**  12  0  (3.66)

(52-54) Fine to medium grd, light grey, fairly well sorted, cross bedded, feldsp sdst—composition similar to unit 3—iron concretions 2%—some coal in lenses 4 cm long and 1.8 cm thick and in stringers 1-2 mm thick and up to 7 cm long near the base parallel to cross bedding, and at an angle to it—specimen 33624

**1**  3  1  (0.94)

(4) Mixed zone—feldsp sdst—grit (conglomerate)—carbonaceous sltst and lenses of coal—(1) bottom 17 cm—qtz gr lenses contain coarse qtz gr 85%, fine to medium qtz gr 15%—(2) sandy lenses—(3) 64 cm zone of coarse grit and sdst lenses—qtz gr up to 3 cm, mostly 4-5 mm, subangular to subrounded, set in feldsp material which is 20% of the rock—southward this zone consists of carbonaceous lenses and occasional coal lenses 3-4 cm thick and extends for 18 feet—numerous coal stringers in feldsp sdst under coal lenses—specimen 33625

## PERMIAN

Cygnet Coal Measures

**1**  19  6  (5.94)

(5) Very fine grd, carbonaceous sltst with arenaceous laminae up to 4 mm thick—arenaceous material increasing toward base—some convolute laminae—specimen 33626

Ferntree Formation
" F "

**13**  6  6  (1.98)

(13) Transitional unit—very fine grd, pale brown, poorly sorted, fissile and non-fissile sdst—mica 4%, pebbles 3%,—fissile beds 27 cm, non-fissile beds 35 cm—porosity poor

| Unit | Thickness ft in (metres) | |
|------|------|------|

12 | 4 11 (1.50) | (6-7) Greyish-yellow green to light bluish-grey, very fine grd, poorly sorted sdst and sltst—pebbles 6-10%, increase upwards, tend to occur in clusters—porosity moderate—bedding poor to good—specimen 33627

"E"

11 | 5 8 (1.73) | (7-10) Pale brown to medium bluish-grey, poorly sorted mdst—calcareous tubes, 7 mm long and 1 mm diam. 4%, occur in clusters—pebbles 3%, one subrounded chlorite schist pebble measured 68 × 42 cm—bedding poor, individual beds 12 cm—porosity poor—specimen 33628

10 | 90 6 (27.58) | (10-13) Fissile and non-fissile, light olive grey and bluish-grey, very poorly sorted, coarse sil sltst—calcareous tubes 4 mm long oriented randomly—pebbles 15%, many schistose—excellent bedding planes, fissile beds 38 cm, non-fissile beds 25 cm—strongly jointed—weathers to creamy grey pieces 2.5 cm long parallel to bedding—specimen 33629

9 | 32 9 (9.98) | (13-15) Very light olive grey to dark grey, poorly sorted, sil sltst—qtz gr 1-2 mm 25%, calcareous tubes 15%, worm tubes 6%, pebbles 8%—change in types of pebbles, porphyry and quartzite becoming more common—hard massive 80 cm beds alternating with 60 cm fissile beds—porosity high—fossil zones with broken brachpds and pelecypods at base of unit—specimen 33630

8 | 60 9 (18.52) | (15-17) Medium grey, very poorly sorted, coarse, sil sltst—pebbles 25% (> 1 cm 8%, < 1 cm 17%)—fissile beds 15 cm, non-fissile beds 10-25 cm—fissility parallel to bedding or at a slight angle to it—weathers to light creamy angular pieces 1 cm diam. and 4 mm thick which cover the cliff sections—excavations due to weathering common—bedding planes good—specimen 33631

7 | 64 6 (19.66) | (17-18) Medium grey, fissile and non-fissile, coarse, sil, poorly sorted sltst—qtz gr 1-2 mm 20%, pebbles 3%—32 cm beds—porosity poor—weathering style different from others—specimen 33632

6 | 24 6 (7.47) | (18-19) Similar to unit 7 but beds 140 cm thick—pebbles 8%, qtz gr 10%, calcareous tubes 8%—fissility parallel to bedding

| Unit | Thickness ft in (metres) | |
|------|--------------------------|---|

**" D "**

5 — 60 9 (18.52) — (19-20) Very light grey, highly sil, poorly sorted, medium to fine grd, pebbly sdst—qtz gr < 1 mm 55%, pebbles 10%, sil matrix 20%, qtz gr > 1 mm 15%—bedding rather massive, individual beds 10 cm, 50 cm and 65 cm— porosity moderate—weathers to pale light grey pieces 5 mm diam.—small excavations due to weathering common—specimen 33633

**" C "**

4 — 37 9 (11.51) — (20-21) Light to medium grey, poorly sorted, medium to fine grd, weakly fissile sdst— pebbles 3%—fissile beds 10 cm and non-fissile beds 25 cm—porosity poor

**" B "**

3 — 1 3 (0.38) — (22) Highly sil, pebble-rich, very poorly sorted, medium to fine grd sdst—pebbles 10%—speci- men 33634

**" A "**

2 — 34 0 (10.36) — (22) Looks like unit 4—pebbles 10%—non-fissile beds 25 cm, fissile beds 15 cm—specimen 33635

1 — 130 0 (39.62) — (22-25) Fissile and non-fissile mdst—pebbles 2%—similar to unit 2

**Risdon Sandstone**

2 — 4 1 (1.25) — (26) Coarse to medium grd, light grey, poorly sorted, massively bedded, feldsp sdst—qtz gr 70%, feldspar 10%, sil matrix 12%, pebbles 8%—specimen 33636

1 — 22 6 (6.86) — (26-27) Very light grey, thickly cross bedded, highly sil, coarse grd, poorly sorted, pebbly sdst—angular qtz gr and feldspar—qtz gr 75%, feldspar (clay) 10%, qtz pebbles 15%— qtz gr 1-10 mm diam., mostly 3 mm, occur in lenses up to 4 cm thick with pebble-rich lenses—qtz gr moderate sphericity and low roundness, pebbles mostly moderate sphericity and high roundness—specimen 33637

**Malbina Formation**
*Member " E "*

22 — 5 5 (1.65) — (27-28) Carbonaceous sdst with a highly car- bonaceous (coal) lens 30 cm below top—sdst medium dark grey—poorly sorted—moderate porosity—qtz gr 45%, carbonaceous material 30%, sil cement 20%, mica 5%—specimen 33638

21 — 15 3 (4.64) — (28) Medium dark grey, sil, carbonaceous, coarse grd, poorly sorted sltst—qtz gr 40%, mica 4%, carbonaceous material 22%, pebbles 4%, fossils 30%—*Terrakea brachythaera*, spfd, and *Myonia corrugata*—specimen 33639

| Unit | Thickness<br>ft in<br>(metres) | |
|------|------|------|
| 20 | 13   0<br>(3.96) | (28-29) Light grey, poorly sorted, medium grd, sil sltst—qtz gr 72%, pebbles 5%, fossils 5%, sil cement 18%—specimen 33640 |
| 19 | 7   7<br>(2.31) | (29-30) Unfosfer, highly sil, very light grey, poorly sorted, fine grd sdst—glittering qtz gr 30% (up to 5 mm diam. but mostly 1 mm or less), very fine sand grade sil material 67%, pebbles 3%—specimen 33641 |
| 18 | 3   11<br>(1.20) | (30-31) Richly fosfer, very light grey, poorly sorted sdst—top 47 cm more richly fosfer, below this fossils only 3%—sil material 60%, qtz gr 15%, fossils 20%, pebbles 5% |

**Member " D "**

| | | |
|------|------|------|
| 17 | 7   7<br>(2.31) | (31) Medium dark grey when fresh but turns medium grey on weathering, poorly sorted, coarse sltst—sil material 75%, qtz gr 10%, pebbles 15%—porosity high—compact, with weak fissility |
| 16 | 28   6<br>(8.68) | (31-33) Medium dark grey to dark brown, poorly sorted, coarse sltst—silt grade sil material 45%, qtz gr 25%, pebbles 30%—bedding accentuated by weathering in cliff sections—individual beds 30 cm—weathers to light grey pieces 5 mm diam.—specimen 33642 |
| 15 | 21   6<br>(6.55) | (33-35) Medium light grey to medium grey, very sil, poorly sorted, very coarse sltst—coarse sil material 40%, sand grade sil material 50%, pebbles 3%, qtz gr 7%—bedding very good, individual beds 30 cm—weak fissility parallel to bedding or at a slight angle to it—specimen 33643 |

**Member " C "**

| | | |
|------|------|------|
| 14 | 8   7<br>(2.62) | (35-36) Very hard, compact, poorly sorted, very fine grd sdst—sand grade sil material 70%, qtz gr 15%, pebbles 15% (only 10% near base) |
| 13 | 1   8<br>(0.51) | (36-37) Very hard, sil, khaki, medium to fine grd, poorly sorted sdst—qtz gr 50% (up to 3 mm diam. but mostly 1 mm), very fine sand to silt grade material 40%, pebbles 8-10% (only 5% near base), one granite boulder measured 50 × 40 cm, no granite pebbles seen above this unit |

| Unit | Thickness ft in (metres) | |
|---|---|---|

**Member " B "**

| 12 | 21  0 (6.40) | (37-38) Similar to unit 13—qtz gr 70%, silt grade sil material 10%, fossils 17%, pebbles 3%—at least 5 fossil zones can be recognized—fossils 95% in top dielasmid beds and 7% in zone 3, some stenopd in zone 5—even grd, massively bedded—1 cm thick beds—porosity high—specimen 33644 |
|---|---|---|
| 11 | 4  3 (1.30) | (38-39) Khaki, medium to fine grd sdst, similar to unit 12 but unfosfer, contains more qtz gr—sorting poor—pebbles 3%—bedding good, individual beds 34 cm—specimen 33645 |

**Member " A "**

| 10 | 2  2 (0.66) | (3) Fosfer, light grey, fine grd, moderately sorted sdst—seems transitional from Member " A " to " B "—stenopd more common in bottom 4 cm—fine sand grade sil material 60%, qtz gr 34%, pebbles 1%, fossils 5%—top 15 cm and bottom 10 cm of the unit fosfer, fossil bands—bedding good, 10 cm thick beds—turns pale brown on weathering. |
|---|---|---|
| 9 | 3  7 (1.09) | (39-40) More sil and richer in pebbles, coarser grd, and more thickly bedded than unit 10—qtz gr 50%, sand grade sil material 45%, pebbles 5%—poor sorting—big spfd more common in pebble-rich horizons |
| 8 | 4  3 (1.30) | (40-41) Pebble-rich, fosfer, poorly sorted, light grey sdst—qtz gr 50%, fine grd sil material 15%, pebbles 20%, fossils 15%—4 zones—top (a) 15 cm: fosfer lens, fossils 15%, pebbles 2% —(b) 26 cm: pebble-rich zone, pebbles 40%, no fossils—(c) 22 cm: fossil zone—fossils 30%, pebbles 15%—(d) 67 cm: few fossils—fossils 10%, pebbles 5%—pebble-rich zones up to 26 cm thick |
| 7 | 2  8 (0.81) | (41-42) Coarse to fine grd, poorly sorted, qtz sdst—pebbles 10%, mostly in bottom 20 cm, fossils 4%, poorly preserved—specimen 33646 |
| 6 | 2  0 (0.61) | (42) Fine, even grd, light grey sdst—qtz gr 77%, feldspar 7%, sil matrix 15%, fossils 1%—loosely compact, friable rock—weathers to fine sand |
| 5 | 2  3 (0.69) | (42) Top 10 cm highly fosfer, pebbles 7%, fossils 15% for whole unit—specimen 33647 |
| 4 | 1  3 (0.38) | (42) Similar to unit 2 |

| Unit | *Thickness* ft   in *(metres)* | |
|------|--------------------|---|
| 3 | 2   8 (0.81) | (42-43) Highly sil, coarse, very poorly sorted, feldsp sdst—qtz gr 50%, feldspar 10%, pebbles 20%, sil matrix 10%, fossils 10%—fossils broken—10-20 cm beds—loosely compact and very friable—porosity poor—specimen 33648 |
| 2 | 1   10 (0.56) | (43) Coarse to fine grd, poorly sorted, light grey sdst—qtz gr 82%, feldspar 8%, sil matrix 10%—porosity high—friable |
| 1 | 2   0 (0.61) | (43) Highly pebble-rich bed—qtz gr 50%, pebbles 50%—sorting poor |
| Grange Mudstone | | |
| 39 | 10   6 (3.20) | (43-44) Greyish-orange fenestld sltst—fossils 55% (fenestld 70%), pebbles 1%—bedding excellent, 5-30 cm thick beds—porosity poor—fissility parallel to bedding—specimen 33650 |
| 38 | 8   6 (2.60) | (44-45) Highly fosfer, strongly fissile, greenish-grey sltst—fossils 70%—porosity high—no bedding—specimen 33651 |
| 37 | 2   5 (0.74) | (45) Greenish-red *Strophalosia*-rich sltst—pebbles 1%, fossils 20%—bedding good, 30 cm thick beds—porosity poor—specimen 33651 |
| 36 | 1   0 (0.30) | (45) Fenestlld-rich sltst—fossils 8%—specimen 33652 |
| 35 | 4   3 (1.31) | (45-46) Greyish-brown sltst—mica 2%, pebbles 1%, fossils 50%—bedding rather poor—specimen 33746 |
| 34 | 11   3 (3.43) | (46) Transitional unit—sltst, near top becomes sandy, richer in pebbles towards base—sand to silt grade sil material 63%, fossils 30%, pebbles 7%—sorting poor—specimen 33653 |
| 33 | 25   9 (7.85) | (46-47) Light brown, very poorly sorted, coarse to fine grd sdst—pebbles 12%, fossils 6%—bedding good, 10 cm thick beds—specimen 33654 |
| 32 | 15   3 (4.65) | (47-48) Pale brown, moderately sorted, fine grd, pebbly sdst—qtz gr 30%, very fine sand grade sil material 40%, pebbles 15-20%, fossils 10-15%—porosity moderate—specimen 33655 |
| 31 | 1   2 (0.36) | (48) Rather poorly sorted, light brown, fine grd sltst—pebbles 5%, fossils 25%, qtz gr 15%—bedding good, 8 cm thick beds—specimen 33656 |

| Unit | Thickness<br>ft  in<br>(metres) | |
|------|------|------|
| 30 | 1  2<br>(0.36) | (48) Pale yellowish-orange to very light grey, strongly fissile fenestlld slst—fossils 40% (fenestlld 85%), alignment of colonies make strong laminations—porosity high—specimen 33657 |
| 29 | 4  2<br>(1.27) | (48-49) Alternate light brown and yellowish-orange, non-fissile sltst, grey fissile sltst—fossils 25-30%, qtz gr 10%, pebbles 1%—fossils well preserved—bedding good, 20 cm thick fissile beds, 35 cm non-fissile beds—fissile beds richer in fenestlld—fissility parallel to bedding—specimen 33658 |
| 28 | 3  11<br>(1.19) | (49) Fissile and non-fissile sltst—qtz gr 25-30%, fossils 36% near top, 20% near base ((a) top 9 cm: fossils 30%, (b) 60 cm: fossils 25%, (c) 20 cm: fossils 18-20%, (d) bottom 30 cm: fossils 20%)—fossils well preserved—bedding good—fissile beds 15 cm, non-fissile beds 22 cm—porosity poor |
| 27 | 0  8<br>(0.20) | (49) Pebble-rich bed—qtz gr 30%, pale brown silt to clay grade material 33%, pebbles 27%, fossils 10%, fossils broken |
| 26 | 1  1<br>(0.33) | (49-50) Bed of light brown, medium to fine grd, poorly sorted sdst—qtz gr 20%, fossils 20%, pebbles 2%—specimen 33659 |
| 25 | 1  10<br>(0.56) | (50) Fissile sltst and non-fissile sdst—(a) Fissile sltst, dusky yellow—fossils 20%—laminations due to alignment of fossils—(b) Non-fissile sdst—pale yellowish-brown, poorly sorted, medium to fine grd—fossils 15-20%, qtz gr 20%, pebbles 4%—bedding very good, 18 cm thick beds—specimen 33660 |
| 24 | 42  9<br>(13.03) | (50-53) Fissile and non-fissile pale yellowish-brown mdst—qtz gr 5-15%, fossils 15-25% varying vertically and laterally—(a) Top 40 feet—fossils 15-25% in non-fissile beds, 25-40% in fissile beds—fissile beds with stenopd 40%, fenestlld 40%—non-fissile beds: stenopd 60%, fenestlld 15%—23 cm thick beds—specimen 33661—(b) Bottom 2 feet 9 inches—fossils 25-30% (stenopd 60%, fenestlld 20%)—32 cm thick beds—specimen 33662 |
| 23 | 2  10<br>(0.86) | (53-54) Medium light grey, strongly fissile sltst bed—fossils 3%, calcareous tubes 1 cm long and 2 mm diam. on bedding planes—porosity moderate—specimen 33663 |

| Unit | Thickness ft in (metres) | |
|------|------|------|
| 22 | 6   7 (2.00) | (54-55) Fissile and non-fissile mdst—fissile beds 10 cm, non-fissile beds 19-31 cm—fossils 30%, pebbles 7%—fossils vary vertically and laterally (fenestlld 45%, stenopd 30%) and form separate zones up to 4 cm thick—big spfd common—specimen 33664 |
| 21 | 43   6 (13.26) | (55-57) Fissile and non-fissile mdst—12-35 cm fissile beds, 21-37 cm non-fissile beds—light brown to yellowish-grey—pebbles 2%, fossils 25%, varying vertically and laterally, fenestlld colonies up to 18 cm across, well preserved bryozoa zones common—specimen 33665 |
| 20 | 4   0 (1.22) | (57-59) Yellowish-grey to light brown mdst, turns light grey on weathering—fossils 20-35% (Strophalosia 30%, stenopd 35%)—bedding good, 12 cm thick beds—specimen 33666 |
| 19 | 8   8 (2.64) | (59-60) Same rock as unit 20, less Strophalosia—10 cm fissile and non-fissile beds—fossils 20-36% (70% unidentifiable)—specimen 33667 |
| 18 | 3   2 (0.97) | (60-61) Fissile and non-fissile, yellowish-brown to light brown mdst—individual beds 21 cm—pebbles 4%, fossils 20% (fenestlld 50%)—specimen 33668 |
| 17 | 11   4 (3.45) | (61-62) Pebble-rich beds of fissile and non-fissile, yellowish-grey to light brown, poorly sorted mdst—pebbles 9%, fossils 8-25%, mostly broken and poorly preserved, pectens common—qtz gr 10% in zones extending up to 30 cm—individual beds 4-10 cm—porosity moderate—specimen 33669 |
| 16 | 19   0 (5.79) | (62-63) Pale yellowish-brown to light brown, hard non-fissile and soft fissile mdst beds—pebbles 3%, fossils 8-25% (Tomiopsis 40%), well preserved—specimen 33670 |
| 15 | 31   6 (9.60) | (63-64) Strongly fissile and non-fissile, pale yellowish-brown to light brown, highly fosfer mdst—individual beds 4-25 cm but 4-10 cm thick beds most common—fossils 5-40% but mostly 20-35% (70% broken), varying laterally and vertically, 2 cm thick zones with 75% fenestlld—specimen 33671 |
| 14 | 3   3 (1.00) | (80) Fissile and non-fissile mdst—fissile beds 7 cm, non-fissile beds 25 cm—olive grey to dark greenish-grey, poorly sorted—pebbles 1%, fossils 25-30% (brachpd 65%), 80% fossils broken—bedding good—specimen 33672 |

| Unit | Thickness ft in (metres) | |
|------|------|------|
| 13 | 2 5 (0.74) | (77-80) Medium bluish-grey sltst—fossils 20% (fenestlld 50%), fenestlld-rich (90%) zones— well preserved—fossils decrease and pebbles increase upwards—specimen 33673 |
| 12 | 1 0 (0.30) | (77) *Tomiopsis* bed—pale brown mdst—fossils 66% (*Tomiopsis* 90%), pebbles few—specimen 33674 |
| 11 | 4 8 (1.42) | (77-78) Light brown to medium grey sltst— fossils 50% (70% unidentifiable)—bedding poor—specimen 33675 |
| 10 | 6 3 (1.90) | (77) Light brown to pale yellowish-brown, thinly bedded mdst—pebbles 1%, fossils 25% (fenestlld 45%), well preserved, parallelism of colonies make laminations—porosity high— specimen 33676 |
| 9 | 6 0 (1.83) | (77) Medium grey to dark greenish-grey sltst— pebbles 1%, fossils 50% (*Strophalosia* 50%)— no bedding but lamination due to alignment of fossils—other features same as unit 8 |
| 8 | 5 6 (1.68) | (75) Medium grey to dark greenish-grey, poorly sorted, feldsp sdst—feldspar 9%, sand grade sil material 40%, pebbles 1%, fossils 50%— porosity high—specimen 33677 |
| 7 | 11 0 (3.35) | (75) Coarse greenish-grey, poorly sorted sltst— pebbles 6%, fossils 6%—a 20 cm thick feldsp sdst occurs at base—feldspar 30% |
| 6 | 9 6 (2.90) | (65-67) Pale yellowish-brown to pale brown, fissile and non-fissile mdst—fossils 40-60% (fenestlld 45%, stenopd 48%), strong laminations due to fossils, well preserved, stenopd show characteristically as holes on surface— weathers to angular and subrounded pieces 1 cm diam.—specimen 33678 |
| 5 | 9 9 (2.97) | (67-68) Pale yellowish-brown to pale brown, very hard, massive mdst—fossils 5% (pectens common)—poor fissility—bedding poor, individual beds 25-45 cm—specimen 33679 |
| 4 | 4 1 (1.24) | (68-69) Fissile and non-fissile, pale yellowish-brown mdst—pebbles 3%, fossils 6-8% (brachpd 60%)—fissile beds turn bluish-grey on weathering—fossils 3% in top part to 30% in lower part—stenopd 80% in top part— specimens 33680 (fissile), 33681 (non-fissile) |
| 3 | 0 10 (0.25) | (69) *Strophalosia*-rich bed |
| 2 | 0 9 (0.23) | (69) Stenopod-, gastpd-rich, fissile bed |

| Unit | *Thickness*<br>*ft   in*<br>*(metres)* | |
|------|----------------|---|

1     37   3<br>      (11.35)    (69-70) Pale yellowish-brown to light brown, fissile and non-fissile mdst—pebbles 3%, fossils 25% (brachpd 50%), 1-3 cm fossil-rich beds

## Section Along Shoreline from Poverty Point (49375E, 67944N) to Harleys Jetty (49175E, 68110N)

Risdon Sandstone

1     18   0<br>      (5.49)    (92) Very light grey, poorly sorted, medium to coarse grd, pebbly feldsp sdst—qtz gr 75%, feldspar 10%, pebbles 15%—pebbles mostly 2-3 cm diam., moderate sphericity, high roundness—qtz gr low sphericity, moderate roundness—thickly cross bedded—pebble-rich lenses up to 120 cm interfingered with qtz gr lenses of similar thickness—specimen 33682

Malbina Formation

*Member "E"*    Absent

*Member "D"*

6     1   2<br>      (0.36)    (92) Pale brown, moderately sorted, medium grd qtz sdst—qtz gr 84%, sill matrix 15%, pebbles 1%—specimen 33683

5     7   5<br>      (2.26)    (92-93) Moderately sorted, medium grey to medium light grey, coarse sltst—observable qtz gr 40%, sil material 55%, pebbles 5%—massively bedded—pebbles occur in lenses

4     73   3<br>      (22.33)    (93-95) Same rock as unit 5, with more qtz gr and pebbles—qtz gr 40-45%, silt grade sil material 50%, pebbles 5-10%—all constituents vary laterally and vertically—sorting poor—bedding poor, individual beds 45 cm—specimen 33684

*Member "C"*    Absent

*Member "B"*

3     4   2<br>      (1.27)    (95-96) Fosfer, highly sil, fine grd, well sorted, very light grey sdst—qtz gr 60%, sil matrix 9%, fossils 30%, pebbles 1%—fossil lenses 3-7 cm thick with 80% fossils (dielasmids 90%, pelecypods 7%, spfd 3%)—porosity high—bedding good, individual beds 30 cm—specimen 33685

2     4   11<br>      (1.50)    (96-97) Similar to unit 3—without fossils—qtz gr 80%, sil matrix 19%, pebbles 1%—tubular bodies like worm tubes on weathered surface—porosity very high—specimen 33686

| Unit | Thickness<br>ft   in<br>(metres) | |
|------|------|---|
| 1 | 3   5<br>(1.04) | (97-99)   Pebble-rich   bed   (conglomerate)—<br>pebbles 80%, sil matrix 20%—disrupted frame-<br>work |
| Member " A " | | Absent |
| Grange Mudstone | | |
| 16 | 28   0<br>(8.53) | (99-102) Medium to very light grey sltst—sil<br>silt grade material 65%, pebbles 2%, fossils<br>33% (fenestlld 40%, stenopds 40%)—strong<br>laminations due to alignment of fenestlld<br>fronds, unfosfer and fosfer zones—porosity<br>high—no actual bedding—specimen 33687 |
| 15 | 6   1<br>(1.85) | (102-104) Light to medium grey, poorly sorted,<br>coarse to fine grd sdst—very fine sand grade<br>sil bands up to 10 cm thick—fossils broken—<br>individual beds 10-45 cm—Fossils 5%—Pebbles<br>15% |
| Fault | | 95′ throw |
| 14 | 1   9<br>(0.53) | (104-105) Medium dark grey mdst—fossils 15%<br>(fenestlld   48%,   stenopd   48%),   massive<br>stenopd colonies—porosity poor |
| 13 | 47   6<br>(14.48 | (104-110) Very light grey, soft mdst and hard<br>sltst—fossils 20-30%, varying verticaly as well<br>as laterally—pebbles 4%—bedding good, indi-<br>vidual beds 7-60 cm—specimen 33688 |
| 12 | 2   0<br>(0.61) | (110) Medium grey mdst—pebbles 1%, fossils<br>10% (stenopds 60%, fenestlld 35%) |
| 11 | 29   3<br>(8.92) | (110-113) Medium to very light grey mdst—<br>fossils 4-35%, 20% on the whole (fenestlld<br>45%, stenopd 45%), strong lamination due to<br>alignment   of   fenestlld   fronds,   fenestlld<br>colonies up to 15 cm long well preserved—<br>10-60 cm thick beds—porosity high |
| 10 | 42   6<br>(12.95) | (113-122) Light brown massive mdst—pebbles<br>1%, fossils 15-20% (stenopd 50%, fenestlld<br>35%), vary in percentage and proportions of<br>associations, some fenestlld colonies up to<br>20 cm long, perhaps in growing position—<br>specimen 33689 |
| 9 | 25   0<br>(7.62) | (122-124) Pale to light brown mdst—pebbles<br>8% in top and 2% in lower part, qtz gr 10%,<br>fossils 25% (stenopd 40%, fenestlld 40%)—<br>bedding good—weak fissility—sorting poor<br>when qtz gr present—specimen 33690 |
| Break in Section | | (124-126) No outcrop |
| 8 | 2   0<br>(0.61) | (126-127) Mdst—specimen 33691 |

| Unit | Thickness<br>ft  in<br>(metres) | |
|---|---|---|
| 7 | 2  10<br>(0.86) | (127-128) Greenish-grey, moderately sorted, massive mdst—qtz gr 20%, fossils 1%, pebbles 1%, silt grade material 78%—pebbles occur in zones—specimen 33692 |
| 6 | 2  10<br>(0.86) | (128-129) Dark greenish-grey, poorly sorted, massive, mottled mdst—qtz gr 20%, pebbles 1%—porosity poor—strongly fissile—weathers to angular pieces 1 cm long parallel to fissility—looks like Quamby Mdst—specimen 33693 |
| 5 | 56  9<br>(17.30) | (129-136) Medium to light grey mdst—top 6 feet 9 inches: qtz gr 30%, pebbles 20%, fossils 2%—lower 50 feet: fossils 15%, pebbles 7%—most fossils small and broken—10-20 cm thick pebble zones—sorting moderate—60 cm thick beds—specimens 33694, 33695, 33696 |
| 4 | 1  9<br>(0.53) | (136-137) Same as unit 5—fossils 15%, pebbles 15%—specimen 33697 |
| 3 | 0  10.5<br>(0.27) | (137-138) Dusky brown pebbly sdst—pebbles 60%, sil matrix 40%—sorting poor—specimen 33698 |
| 2 | 5  3<br>(1.60) | (142-143) Very light grey, poorly sorted, medium grd sdst—very fine sand grade qtz 74%, qtz gr 20%, pebbles 5%, fossils 1%—bedding poor, individual beds 10-30 cm—specimen 33699 |
| 1 | 26  9<br>(8.15) | (143-144) Medium light to medium grey, moderate to poorly sorted sltst—fossils 6% (stenopds 50%, fenestlld 30%), well preserved—individual beds 4-20 cm |

### Section Along Shoreline from Drip Beach (49502E, 68065N) to (49550E, 68132N)

| | | |
|---|---|---|
| 12 | 14  6<br>(4.42) | (164-165) Pale yellowish-brown to greyish-orange baked mdst—fossils 10% (fenestlld 40%, stenopd 55%), 40-60 cm thick alternating fossil-rich (20%) and fossil-poor (3%) beds—specimen 33700 |
| 11 | 1  0<br>(0.30) | (165) Conglomerate—qtz pebbles 95%, qtz gr 5%, pebbles mostly 3-4 cm thick with low sphericity and moderate roundness—specimen 33701 |
| 10 | 38  6<br>(11.73) | (165-171) Unfosfer and fosfer mdst—individual beds 85 cm—very similar to unit 10 |
| 9 | 2  0<br>(0.61) | (171-174) Pale yellowish-brown, poorly sorted mdst—fossils 2%, pebbles 1%, qtz gr 20%—fenestlld 95% of fossils—qtz gr zones |

| Unit | Thickness ft in (metres) | |
|------|------|------|
| 8 | 1 6 (0.46) | (174) Dark olive brown, poorly sorted, pebbly sdst bed—qtz gr 70%, sil matrix 15%, pebbles 15%—transitional to unit 9—specimen 33702 |
| 7 | 24 0 (7.32) | (174-177) Pale olive to pale yellowish-brown mdst—fossils 15-20%, pebbles 1%, qtz gr 8%—massive stenopd colonies common—qtz gr in bands, good bedding—individual beds 30-50 cm—bottom 3 feet, fossils 30%—specimen 33703 |
| 6 | 39 9 (12.12) | (178-181) Light to medium grey, well sorted, Strophalosia-rich mdst—pebbles 1%, fossils 25-60% (Strophalosia 85%), alignment of Strophalosia causes lamination—specimen 33704 |
| 5 | 14 6 (4.42) | (181-182) Medium light grey mdst when fresh and light olive grey when weathered—qtz gr 15%—bedding good, individual beds 30 cm—specimen 33705 |
| 4 | 14 3 (4.34) | (182-183) Same as unit 5—fossils 2% (stenopd 90%) |
| 3 | 20 3 (6.17) | (183-184) Similar to unit 5—fossils 5% (stenopd 40%), 50% fossils broken—weak bedding planes—specimen 33706 |
| 2 | 20 3 (6.17) | (184-186) Very fine grd, greenish-grey mdst which turns light grey on weathering—fossils 3%—sorting good—porosity high—specimen 33707 |
| 1 | 12 3 (3.73) | (186-187) Massive, very fine grd, yellowish-grey to olive grey sdst—sorting good—porosity very high—specimen 33708 |

**Tobys Hill Road Section from 49920E, 68820N (Height 980 feet) to 49685E, 68809N (Height 210 feet)**

Figures in the first bracket next to the thickness are the approximate heights at which the units occur, and the figures in the bracket next to it are the station numbers on aerial photographs (4″ = 1 mile scale) corresponding to those points

(980′) (station 57/1985/run 7) Jurassic dolerite floats and soil

Grange Mudstone

| | | |
|---|---|---|
| 9 | 24 0 (7.32) | (962′) (49-50/1986/run 7) Dark grey, strongly baked mdst—fossils 10-25% (stenopd 75%), poorly preserved—bottom 76 cm stenopd 45%—individual beds 30 cm—specimen 33741 |

| Unit | *Thickness* ft  in (*metres*) | |
|------|------|------|
| 8 | 10   3 (3.12) | (958') (49) Baked mdst—top half, fossils 25-30%; bottom half, fossils 85% (stenopd 75%), strong lamination due to alignment of fossils—specimen 33740 |
| 7 | 67   6 (20.57) | (925') (48-49) Light brownish-grey, baked mdst—qtz gr 20%, fossils 15-40% (feneslld 50%, brachpd 40%)—outcrop broken—specimen 33739 |
| 6 | 42   6 (12.95) | (900') (47-48) Creamy to pale yellowish-brown, baked mdst—qtz gr 5%, fossils 15-30%, fossil-rich bands up to 2 cm—outcrop poor |
| 5 | 25   6 (7.77) | (890') (46-47) Very hard greenish-grey, baked, unfosfer mdst—specimen 33738 |
| 4 | 25   0 (7.62) | (878') (45-46) Outcrop good in lower part—light greenish-grey, calcareous sltst—calcareous material 2%, fossils 6% (brachpd 40%, fenestlld 10%), half unidentifiable—specimen 33737 |
| 3 | 1   10 (0.56) | (878') (45) Calcareous sltst—calcareous material 10%, occurs in patches, fossils 40% (fenestlld 90%, spfd 10%), spfd calcified—bedding good—porosity poor—specimen 33736 |
| 2 | 16   9 (5.11) | (870') (43-44) Richly fosfer, reddish-purple, baked mdst—fossils 40% (fenestlld 40%, stenopd 50%)—bedding good—porosity poor |
| 1 | 29   0 (8.84) | (850') (42-43) Light to olive grey mdst—fossils 4%, mainly spfd—porosity poor—specimen 33735 |

**Faulkner Group**

| | | |
|------|------|------|
| 5 | 28   6 (8.68) | (830') (41-42) Light grey, poorly sorted, fissile sltst—mica 8%—bedding poor—porosity moderate—many coarser bands consist of feldspar 5%, qtz gr 65%, pebbles 5%, clayey matrix 25%—sorting poor—weathers to light creamy square to rectangular pieces 2 cm diam.—outcrop very good—specimen 33730 |
| 4 | 4   8 (1.42) | (828') (40-41) Transitional unit—greenish-grey, fine grd, feldsp sdst—qtz gr 60%, sil matrix 30%, feldspar 10%—other features similar to unit 5—outcrop very poor—specimen 33731 |
| 3 | 13   7 (4.14) | (822') (39-40) Bottom 20 inches feldspar-rich soil, then outcrop begins—poorly sorted, medium to fine grd, very pale to light green, massively bedded, feldsp sdst—qtz gr 70%, feldspar 20%, sil matrix 10%—porosity very poor—bottom 8 feet coarser grd—specimen 33732 |

| Unit | Thickness ft in (metres) | |
|---|---|---|
| 2 | 11 9 (3.58) | (813') (39) Light greenish-grey when fresh, pale brown on weathering, fosfer mdst—fossils 20%—outcrop poor—could be a thin unfosfer band in this unit but it does not outcrop—specimen 33733 |
| 1 | 8 3 (2.52) | (810') (37-39) Very fine grd, light greenish-grey, massively bedded sltst—mica 2%—weathers to light brown rectangular pieces—outcrops best near the top—specimen 33734 |

Bundella Mudstone

| | | |
|---|---|---|
| 21 | 25 0 (7.62) | (790') (36) Light green-grey sltst—fossils 30% (stenopd 50%, 80% near top, fenestlld 30%)—bedding good, individual beds 8-15 cm—porosity poor—specimen 33712 |
| 20 | 8 10 (2.69) | (783') (35) Similar to unit 21—fossils 35% (stenopd 40%, fenestlld 35%)—bedding good—specimen 33713 |
| 19 | 24 3 (7.39) | (775') (34) Dark greenish-yellow sil mdst—fossils 40-50% (fenestlld 45%, stenopd 20%), lamination due to alignment of bryozoan fronds—bedding good, 15 cm thick beds—specimen 33714 |
| 18 | 17 6 (5.33) | (762') (34) Greywacke sdst—medium to coarse grd, poorly sorted—qtz gr 40%, feldspar 5%, sil cement 17%, pebbles 8%, fossils 30%—bedding poor—porosity poor—specimen 33715 |
| 17 | 0 9 (0.23) | (756') (33) Similar to unit 18—qtz gr 40%, feldspar 5%, sil cement 25%, pebbles 20%, fossils 10%—khaki—sorting poor—weathers to pale brown clay which blankets the outcrop—fossils very poorly preserved—specimen 33716 |
| 16 | 2 4 (0.71) | (755') (32) Best exposed in the quarry near station 31/1986/run 7 where 72 cm mdst overlies a 57 cm bed rich in fenestlld and *Strophalosia*—dark greenish-grey sil mdst—mica 2%, pebbles 2%, fossils 5%—weak fissility parallel to bedding—2 cm thick fossil lenses common—porosity poor—specimen 33717 |
| 15 | 52 6 (16.00) | (733') (31) Fissile and non-fissile mdst—sorting poor—quarry near station 31/1986/run 7, 8 feet fosfer, greywacke sdst, overlain by 3 feet 6 inches creamy greyish mdst; mdst with few fossils in 1 cm thick lenses; greywacke sdst, more fissile—richly fosfer—khaki—sorting poor—qtz gr 27%, mica 10%, matrix 20%, pebbles 3%, fossils 40% (stenopd 50%, spfd 35%), *Eurydesma* common—in upper part of greywacke sdst spfd and *Strophalosia* very common—specimen 33718 |
| 14 | 17 3 (5.26) | (727') (30) Richly fosfer, fissile and non-fissile, greyish-green mdst—fossils 60% (*Strophalosia* 40%)—specimen 33719 |

| Unit | Thickness ft in (metres) | |
|------|------|------|
| 13 | 1 5 (0.43) | (723') (29) Similar to unit 14—pebbles 5%, fossils 60% (bryozoans 60%)—porosity moderate |
| 12 | 3 10 (1.17) | (719') (28) Light brown to khaki, medium to fine grd, poorly sorted sdst—qtz gr 60%, sil cement 15%, mica 10%, pebbles 10%, feldspar 5%, fossils decrease in the lower part—specimen 33720 |
| 11 | 3 0 (0.91) | (715') (27) Similar to unit 12—pebbles 8%, fossils 5%—bedding apparent only by the alignment of fossils, individual beds 20-40 cm—turns pale green on weathering—specimen 33721 |
| 10 | 0 10 (0.26) | (712') (26) Khaki, fine grd sdst—sorting poor—pebbles 2%, fossils 50%, fenestlld, stenopd and spfd in equal proportion—specimen 33722 |
| 9 | 9 3 (2.82) | (705') (25) Similar to unit 10, but coarser grd—qtz gr 50%, mica 15%, feldspar 10%, sil cement 15%, pebbles 2%, fossils 10%—bedding massive—porosity high—specimen 33723 |
| 8 | 22 0 (6.43) | (695') (24) Pale brown, fine grd sdst—qtz gr 60%, mica 10%, fossils 30% (bryozoans 65%, well preserved fenestlld colonies 80% in some lenses)—lamination due to alignment of fronds—specimen 33724 |
| 7 | 10 3 (3.13) | (685') (23) Khaki, well sorted, fine grd sdst—qtz gr 65%, mica 5%, feldspar 10%, sil cement 20%—outcrops well—porosity high—bedding poor—specimen 33725 |
| 6 | 4 5 (1.35) | (680') (22) Greyish-orange, well sorted, micaceous sdst—fossils 20%—outcrop very poor |
| 5 | 7 3 (2.21) | (675') (21) Similar to unit 6—qtz gr 80%, mica 10%, sil cement 10%—bedding poor—specimen 33726 |
| 4 | 5 9 (1.75) | (665') (20) Highly fosfer, moderately sorted, fine grd, pale green mdst—mica 10%, fossils 40%—outcrop poor—bedding poor—weathers to subrounded 2 cm pieces—specimen 33727 |
| 3 | 20 3 (6.18) | (660') (19) Khaki, fine grd, feldsp sdst—feldspar 40%(?), qtz gr 40%, sil cement 20%—bedding very poor—specimen 33728 |
| 2 | 18 4 (5.59) | (648') (18) Pale green, fine grd, well sorted, micaceous sdst—qtz gr 60%, mica 10%, rare fossils — massive — porosity high — mica increases upwards |

| Unit | Thickness ft in (metres) | |
|---|---|---|
| 1 | 23 6 (7.16) | (640') (17) Poorly fosfer, pale green, micaceous, sil mdst—fossils 6%, stenopd most common—fossil bands 1-3 cm thick—non calcareous |

**Quamby Mudstone** Thickness: 500 feet (152 metres)

(630') (16) Sil mdst—compact—porosity poor—qtz gr and some concretions

(610') (15/2016/run 8) Greenish-grey mdst—some mica—weak fissility—specimen 33711

(595') (14) Dark grey mdst—some mica— massive—specimen 33710

(530') (12) Creamy greenish-grey sltst—some mica—light green on weathering

(495') (11) Compact, fairly hard, pale creamy mdst—some mica—massive—weathers to angular pieces 5 cm diam.

(455') (7) Dark grey sltst—some mica—hard—massive

(395') (5) Dark greenish-grey mdst—massive—weathers to angular pieces 3 cm diam. which tend to cover the outcrop—specimen 33709

(350') (4) Creamy light green, fine grd, clean sltst—fissile—porosity poor

(305') Pale brown mdst without pebbles

**Tillite**

(235'-305') Numerous qtzite pebbles and tillitic soil

(235') Outcrop of grey, fine grd, pebbly mdst of tillitic texture—granule size—erratics most abundant, some faceted—bedding massive—sorting poor—specimen 33742

(210') Pebbles common in the weathered outcrop

**Fault**

# Appendix 2

### Methods of Interpretation

The basic method has been to prepare models and then to compare the theoretical profiles produced with those observed. It should be realized that no model can correspond exactly to the actual structure due to the artificiality of the Bouguer anomaly, which was prepared from a density assumption presumed for homogeneous sediments, and the inherent ambiguity of the interpretation of a gravity field.

Due to the irregularities of shape in three dimensional structures such as were thought to be present, two dimensional formulae are not wholly applicable; no simple bodies can be equated with those regions where 3-D equations do not apply. To overcome this difficulty two distinct equations have been used, the results being calculated for equivalent points on the same profile and summed.

Calculations have been made on three dimensional bodies using the mass line method. This requires the model to be split into vertical prisms of such dimension that the mass contained could be said to be approximately that of a line through its centre. The method becomes inaccurate near the surface for profile points close to the block, particularly where the length of prism side is equal to, or less than, the distance from the centre of the block to the profile point. Centre refers to the intersection of the diagonals on the upper and lower faces of the vertical prisms, all of which have square sections. The mass line equation may be written as:

$$g = kG \; \sigma \; a^2 \; (1/_r - 1/_R)$$

where g = vertical component of attraction at required point

k = constant, depending on units used

G = gravitational constant

$\sigma$ = density contrast

a = length of prism side (prisms have square sections)

$_r$ = distance of point of calculation to top of prism

$_R$ = distance of point of calculation to base of prism

The effects of all prisms which form the body are summed for each point on the profile.

A two dimensional equation has been used in the peripheral parts of the structure, or where the body extends laterally for some miles. The equation used for submerged bodies is that of Nettleton (1942),

$$g = A\,\sigma\,t\left(\tan^{-1}\frac{d + t/_2}{x_1 - x} - \tan^{-1}\frac{d + t/_2}{x_1 + 1 - x}\right)$$

where $g$ = vertical attraction at required point
$l$ = length of block
$t$ = thickness of block
$d$ = distance of centre of block from surface
$x$ = distance of station from origin of traverse
$x_1$ = distance of block leading face from origin
$\sigma$ = density contrast
$A$ = constant, depends on units and incorporates gravitational constant

To use this equation the body is divided into thin horizontal slices of thickness t. The effect of each slice is then calculated for each point on the profile and summed for the total effect at each point. By choosing t very small, the effects of outcropping dykes may be approximated. Checks and calculation on outcropping dyke limbs have also been undertaken using an exact equation (Parasnis, 1962, p. 44). All calculation has been by automatic computer.

# Appendix 3

### Resolution of Dolerite Structures

Dolerite intrusions in Tasmania appear very random in many areas, and in other areas various interpretations are apparently possible. In the Cygnet area many structures at first appeared possible.

The following criteria and observations have been found helpful. Various pitfalls were found during the course of the study and are mentioned below.

1. The dolerite must be shown to be *in situ* before any conclusions are made.

2. Every contact must be inspected and its character observed or deduced in the field.

3. The association of faults and dilations to the dolerite body will suggest whether a sheet thickens, is discontinuous or has some distinct dip.

4. Thermal metamorphism is more extensive in roof rocks than in rocks beside or beneath the intrusive body.

5. A differentiation series has been shown to exist in Tasmanian dolerite bodies (Edwards, 1942; McDougall, 1962). This series develops according to the thermal and geometrical condition of the body.

    The geometrical conditions will determine whether any concentration of a particular phase is likely, as at Red Hill (McDougall, 1962), whereas the thermal condition will determine whether the phase forms at all. For example, the Gunnings Sugarloaf dyke (Edwards, 1942) which is larger than the Red Hill body has no extreme differentiate. This is probably due to the former body having been closer to the Jurassic surface and therefore more rapidly cooled.

    It is noted that the condition of convection, not yet observed in Tasmanian dolerite, may invalidate use of this criterion. Further developmental work must be undertaken in this field, since it cannot be applied to unknown bodies until data is available from many bodies of known shape.

6. Geophysical methods may be particularly useful. They should be applied with care and upon critical portions of the structure. Gravimetric methods are the most useful although magnetic and electrical methods may be applied. The results must be interpreted *with close attention to the geological observations*. It should be noted that geophysical interpretations are subject to some ambiguity.

Isostrats have been extensively employed since their introduction to Tasmania (Carey, 1958). The method need not give definitive results (e.g., p. 62) and should therefore be discontinued or very cautiously applied.

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PLATE 1—Shore platform, Ferntree Formation.

PLATE 2:—Shore platform, Malbina Formation.



PLATE 3:—Shore platform, Grange Mudstone.
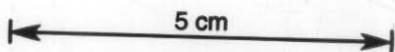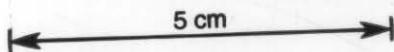
5 cm

PLATE 4:—Tillite.



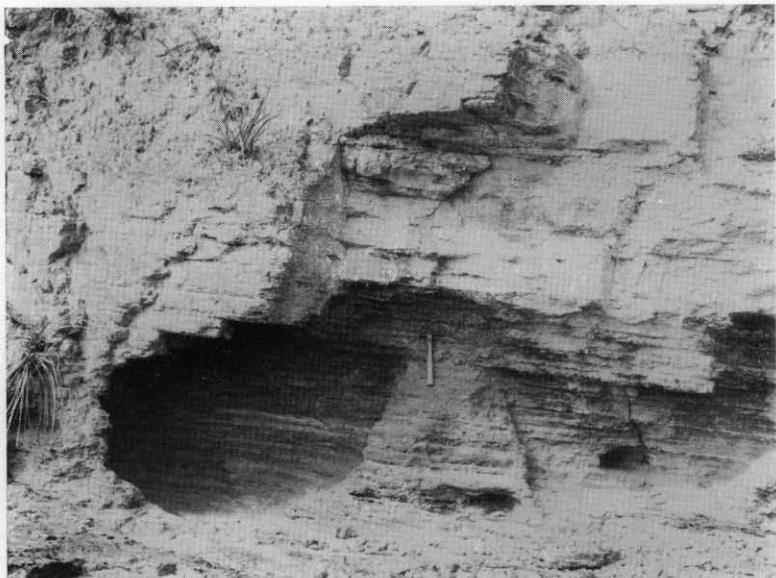PLATE 5:—Quamby Mudstone.

5 cm

PLATE 6:—Grange Mudstone.



PLATE 7:—Malbina Formation.

5 cm

PLATE 8:—Risdon Sandstone.



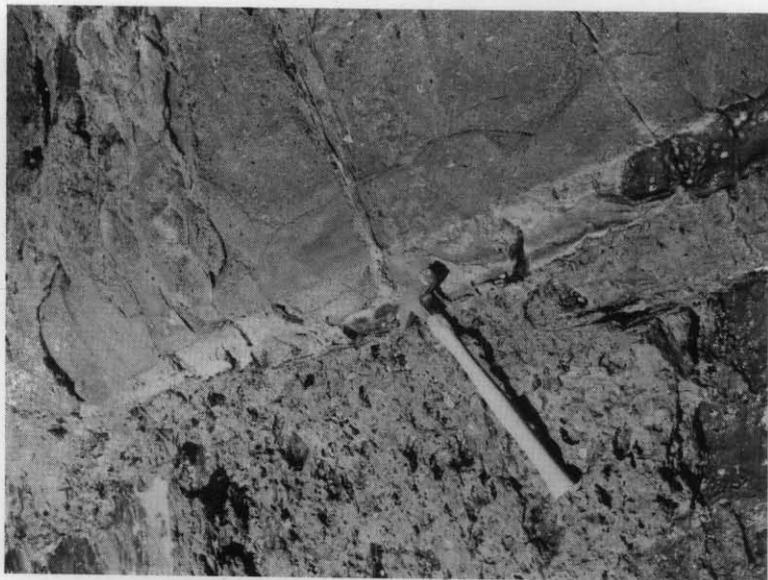PLATE 9:—Pleistocene gravel.

5 cm

PLATE 10:—Quaternary gravel.



PLATE 11:—Syenite trachyte showing contact zone.

5 cm

PLATE 12:—Tinguaite showing feldspar swirls.
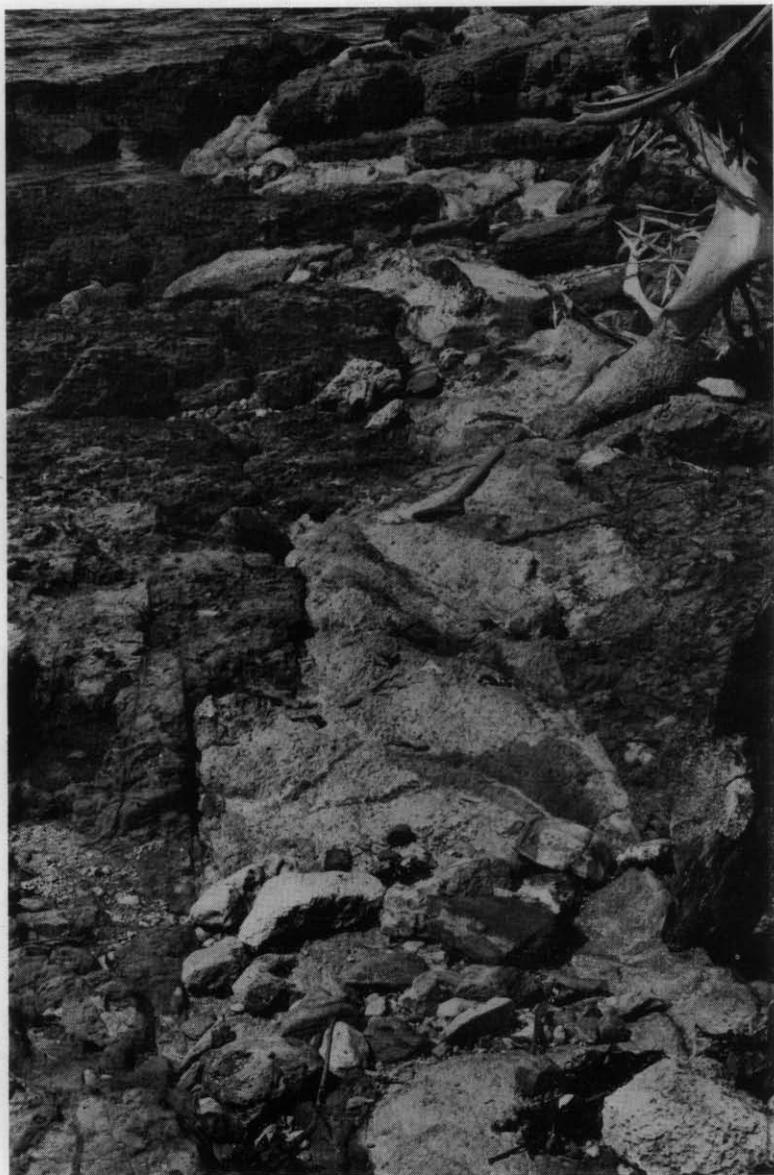


PLATE 13:—Dyke dilations.

5 cm

PLATE 14:—Dyke dilations.

5 cm

PLATE 15:—Syenite porphyry sill.



PLATE 16:—Syenite porphyry sill.
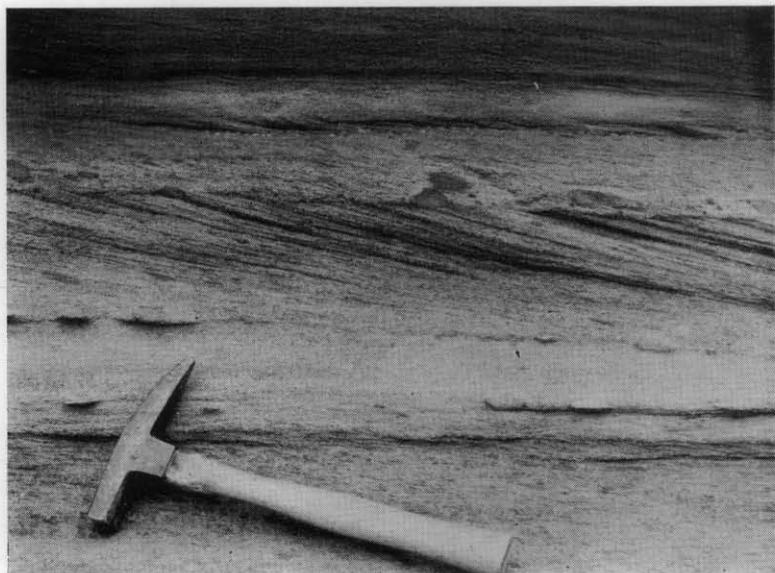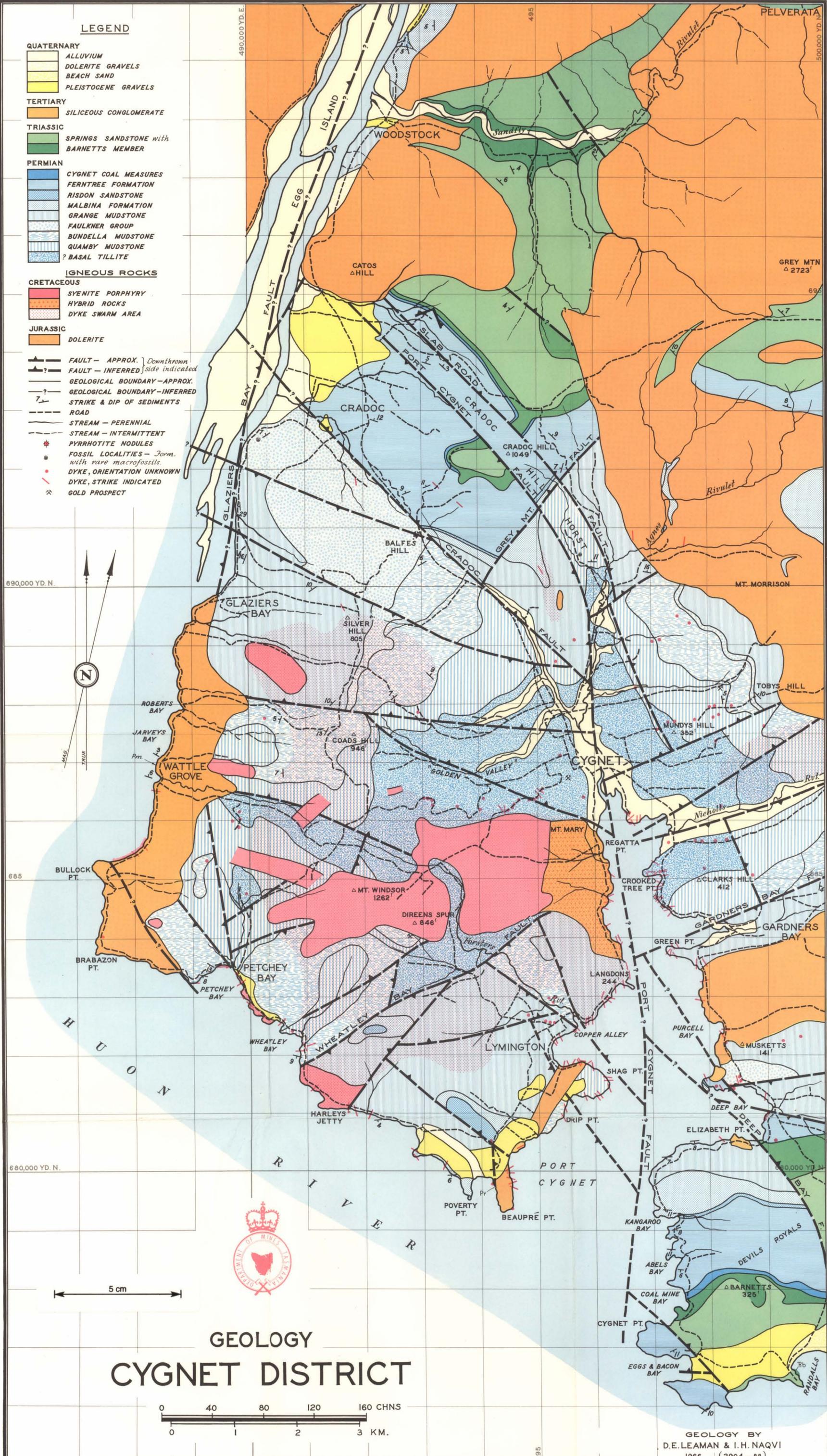
|← 5 cm →|

PLATE 17:—Joints in syenite.



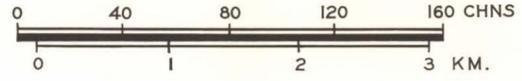PLATE 18: Cross bedding—Barnetts Member of Springs Sandstone.

|← ——— 5 cm ——— →|

## LEGEND

**QUATERNARY**
- ALLUVIUM
- DOLERITE GRAVELS
- BEACH SAND
- PLEISTOCENE GRAVELS

**TERTIARY**
- SILICEOUS CONGLOMERATE

**TRIASSIC**
- SPRINGS SANDSTONE with BARNETTS MEMBER

**PERMIAN**
- CYGNET COAL MEASURES
- FERNTREE FORMATION
- RISDON SANDSTONE
- MALBINA FORMATION
- GRANGE MUDSTONE
- FAULKNER GROUP
- BUNDELLA MUDSTONE
- QUAMBY MUDSTONE
- ? BASAL TILLITE

### IGNEOUS ROCKS

**CRETACEOUS**
- SYENITE PORPHYRY
- HYBRID ROCKS
- DYKE SWARM AREA

**JURASSIC**
- DOLERITE

- FAULT – APPROX. } Downthrown
- FAULT – INFERRED } side indicated
- GEOLOGICAL BOUNDARY – APPROX.
- GEOLOGICAL BOUNDARY – INFERRED
- STRIKE & DIP OF SEDIMENTS
- ROAD
- STREAM – PERENNIAL
- STREAM – INTERMITTENT
- PYRRHOTITE NODULES
- FOSSIL LOCALITIES – 7orm. with rare macrofossils
- DYKE, ORIENTATION UNKNOWN
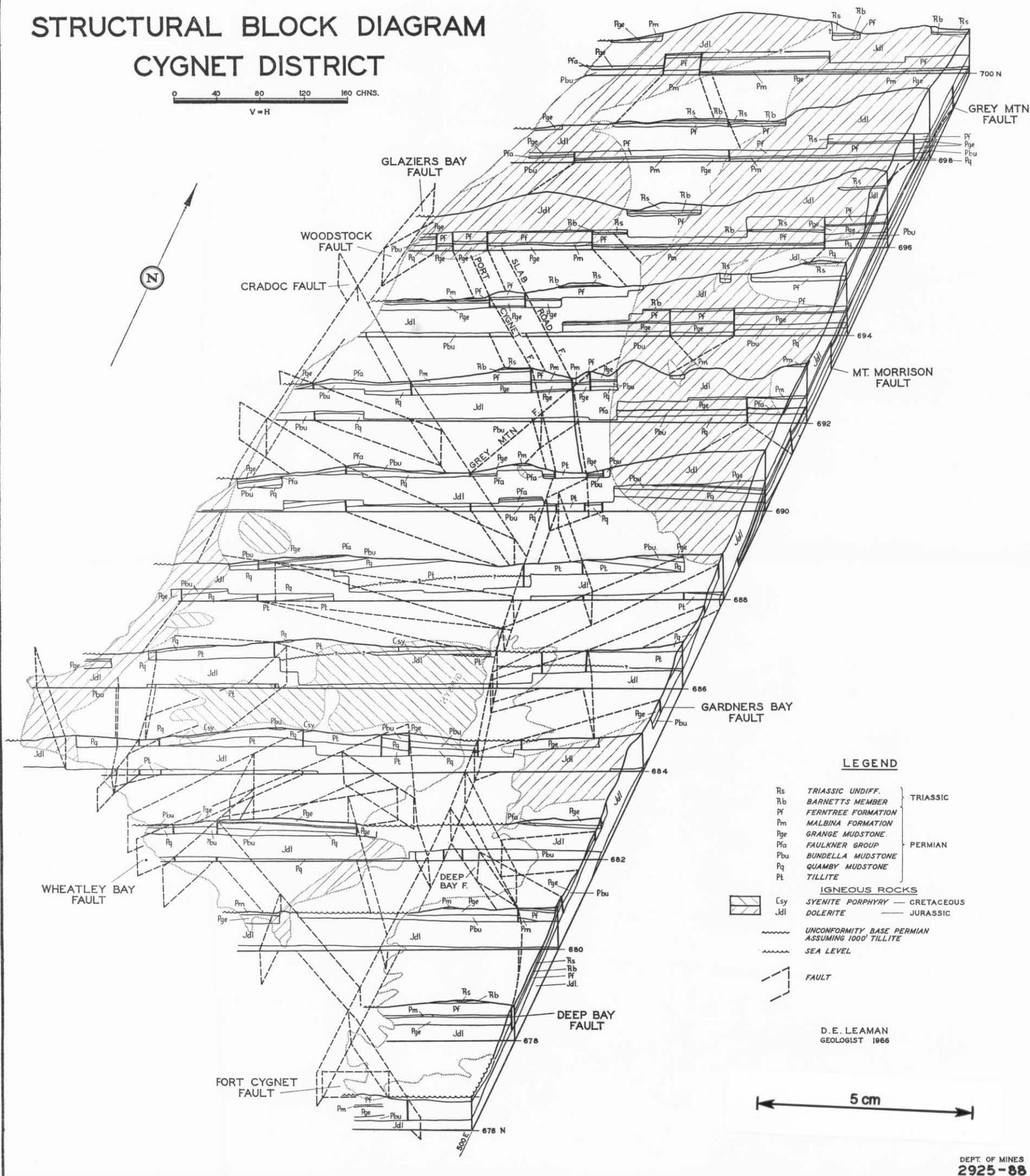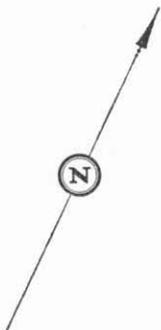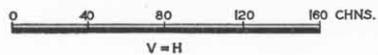- DYKE, STRIKE INDICATED
- GOLD PROSPECT

N

MAG.   TRUE

5 cm

## GEOLOGY
# CYGNET DISTRICT

0   40   80   120   160 CHNS
0      1       2      3 KM.

GEOLOGY BY
D.E. LEAMAN & I.H. NAQVI
1966   (2904–88)

GSB49

Mercury

PELVERATA
WOODSTOCK
CATOS HILL
GREY MTN △ 2723'
CRADOC
SLAB ROAD
PORT CYGNET
CRADOC HILL △ 1049'
GREY MT. HORST
CRADOC FAULT
BALFES HILL
GLAZIERS BAY
SILVER HILL 805
MT. MORRISON
ROBERTS BAY
JARVEYS BAY
TOBYS HILL
WATTLE GROVE
COADS HILL 946'
MUNDYS HILL 352
GOLDEN VALLEY
CYGNET
BULLOCK PT.
MT. WINDSOR 1262
MT. MARY
REGATTA PT.
CLARKS HILL 412
DIREENS SPUR △ 846'
CROOKED TREE PT.
GARDNERS BAY
BRABAZON PT.
PETCHEY BAY
GREEN PT.
PETCHEY BAY
Forshews FAULT
LANGDONS 244
PURCELL BAY
WHEATLEY BAY
WHEATLEY BAY
LYMINGTON
COPPER ALLEY
MUSKETTS 141
SHAG PT.
HARLEYS JETTY
DRIP PT.
DEEP BAY
ELIZABETH PT.
HUON RIVER
POVERTY PT.
BEAUPRÉ PT.
PORT CYGNET
KANGAROO BAY
ABELS BAY
COAL MINE BAY
DEVILS ROYALS
CYGNET PT.
BARNETTS 325'
EGGS & BACON BAY
RUNDALLS BAY
EGG ISLAND
BAY FAULT
690,000 YD. N.
685
680,000 YD. N.
490,000 YD. E.
495
500,000 YD. E.

# STRUCTURAL BLOCK DIAGRAM
# CYGNET DISTRICT

0  40  80  120  160 CHNS.

V = H

(N)

GLAZIERS BAY FAULT

WOODSTOCK FAULT

CRADOC FAULT

PORT CYGNET SLAB ROAD F.

GREY MTN. F.

GREY MTN FAULT

MT. MORRISON FAULT

GARDNERS BAY FAULT

WHEATLEY BAY FAULT

DEEP BAY F.

DEEP BAY FAULT

FORT CYGNET FAULT

700 N
698
696
694
692
690
688
686
684
682
680
678
676 N

500 E

## LEGEND

| | | |
|---|---|---|
| Rs | TRIASSIC UNDIFF. | TRIASSIC |
| Rb | BARNETTS MEMBER | |
| Pf | FERNTREE FORMATION | |
| Pm | MALBINA FORMATION | |
| Pge | GRANGE MUDSTONE | |
| Pfa | FAULKNER GROUP | PERMIAN |
| Pbu | BUNDELLA MUDSTONE | |
| Pq | QUAMBY MUDSTONE | |
| Pt | TILLITE | |

### IGNEOUS ROCKS

| | | |
|---|---|---|
| | Csy | SYENITE PORPHYRY — CRETACEOUS |
| | Jdl | DOLERITE — JURASSIC |

UNCONFORMITY BASE PERMIAN ASSUMING 1000' TILLITE

SEA LEVEL

FAULT

D. E. LEAMAN
GEOLOGIST 1966

5 cm

GSB 49

FIGURE 26.