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TASMANIA

DEPARTMENT OF MINES

GEOLOGICAL SURVEY EXPLANATORY REPORT

ONE MILE GEOLOGICAL MAP SERIES

K/55-6-29

DEVONPORT

by

K. L. BURNS

Issued under the authority of
The Honourable ERIC ELLIOTT REECE, M.H.A.,
Minister for Mines for Tasmania

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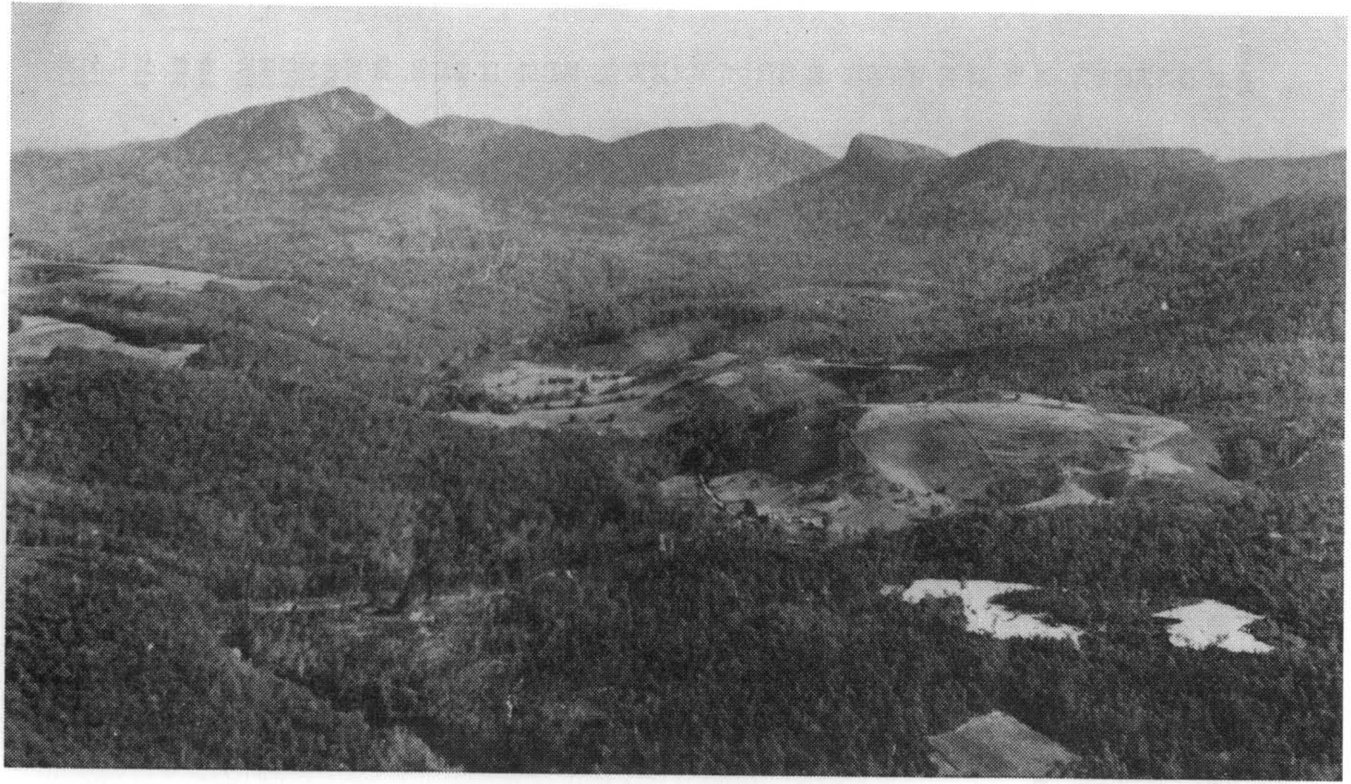
PREFACE

This report is primarily intended to cover the Devonport Quadrangle, but for the sake of clarification of tectonic problems, comments on areas extending across the southern and western boundaries are included. The original work published here was included in a thesis submitted to the University of Tasmania for the degree of Ph.D. and was done whilst Dr. Burns was on the staff of the Department of Mines.

As was the case in the previously published report on the Middlesex Quadrangle, the main geological problems are concerned with structures of the older rocks in the area, and it is for this reason that the chapters on this aspect are larger than is usual. The Mersey coalfield and the Dial Range mineral field have each attracted considerable economic attention in the past. While the Mersey coal field is of minor commercial importance, the Dial Range field may yet prove worthy of more detailed investigation, and it must be remembered that the Tertiary sedimentary deposits of the quadrangle extend out into the Bass Strait sedimentary basin.

Another point of geological interest, shared by this quadrangle with its neighbours, and the most important economically, is the presence of the Tertiary basalt, the weathering of which produced the rich soil of the North West Coast district of Tasmania. It was this rich soil that primarily attracted and held the population to what is fast becoming a well developed agricultural and industrial part of Tasmania.

J. G. SYMONS, Director of Mines.



The Dial Range from the North East

CONTENTS.

LIST OF FIGURES

* In folder at back of book.

PLATES

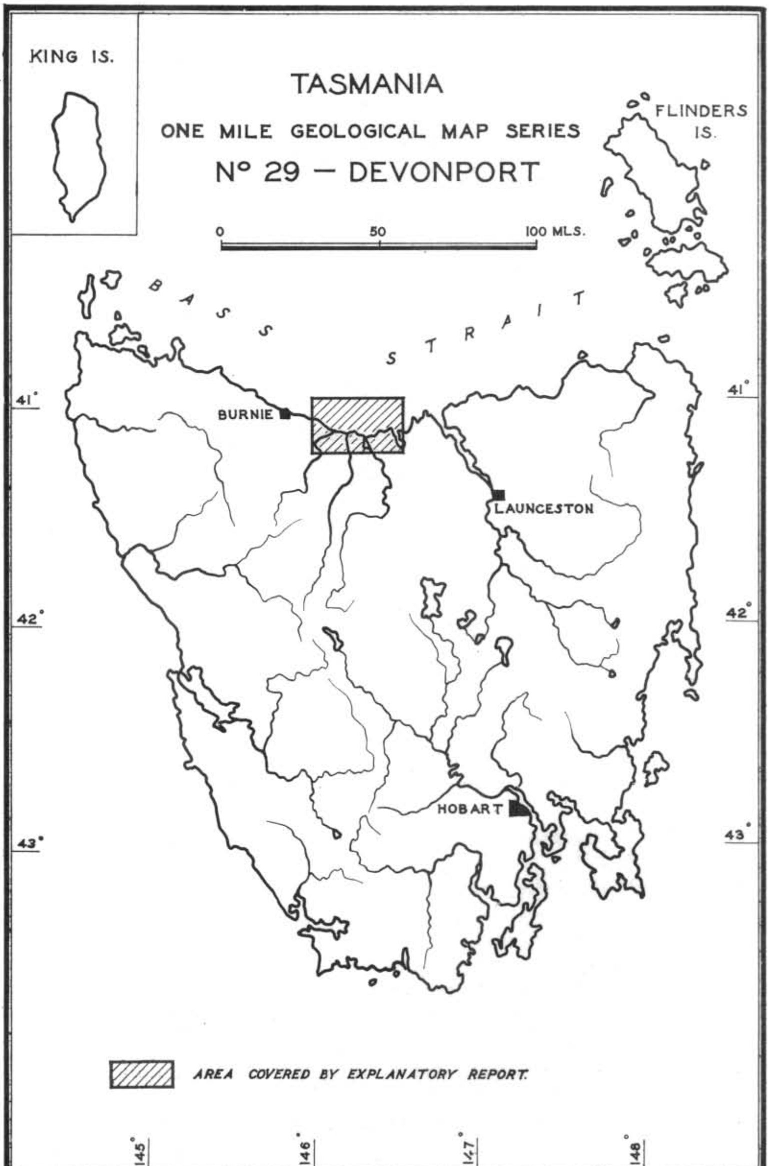

KING IS.
TASMANIA
ONE MILE GEOLOGICAL MAP SERIES
N° 29 — DEVONPORT
0
50
100 MLS.
FLINDERS IS.
BASS STRAIT
BURNIE
LAUNCESTON
HOBART
41°
42°
43°
AREA COVERED BY EXPLANATORY REPORT.
145°
146°
147°
148°

FIGURE 1.

5 cm

Explanatory Report of the Devonport Quadrangle

INTRODUCTION

The Devonport Quadrangle covers part of the coastal lowlands of the North West Coast district of Tasmania between longitudes 146°00′ and 146°30′E. and extends from Bass Strait south to latitude 41°15′S. (See Figure 1.)

Since Strzelecki (1845) reported on the general geology, the area has been visited by many geologists to report upon the mines of the Mersey Coalfield, metalliferous deposits of the Dial Range, oil prospects east of Latrobe, deposits of non-metallic and industrial minerals and engineering problems arising in development. A reconnaissance survey of the Dial Range Mineral Field by Hughes (1953) and a formation map of 33 square miles near Devonport by Rundle (1958) have been of great assistance in the present mapping.

Regional mapping was carried out between 1958 and 1962, mainly as a winter programme, on a scale of four inches to one mile. I am indebted to Messrs. R. D. Gee and G. McNamara for assistance in the field; to Messrs. G. Everard, W. St. C. Manson and C. J. Penman for data on mineralogical and chemical compositions of many of the rocks; to Mr. K. T. Kendall and staff of the drawing office for preparation of all the maps, plans and sections herein; to Messrs. B. Knight and J. New of the Mines Drawing Office, Department of Lands and Surveys, for title searches and assistance in locating early mining leases; and to Mr. D. Haig of the Nomenclature Board for his assistance in ensuring the historical accuracy of many topographic names which have been revived on this sheet. This work is a contribution to our understanding of the natural resources of the State and could not have proceeded without the co-operation and assistance of officers in all branches of the Department of Mines.

The author is indebted to Dr. E. Williams for helpful discussion and criticism, as a result of which the stratigraphic terminology of the map sheet has been revised for these notes. The principal alteration is in the status of several rock units of the Lower Palaeozoic succession. The names Junee and Dundas Groups were used on the map sheets, following some earlier practices. However, in the framework of the Australian Code of Stratigraphic Nomenclature the use of these terms for correlates of the West Coast units is not valid procedure. Accordingly the System names Ordovician and Cambrian are used here and the status of the Dial, Radfords Creek and Cateena units is revised to Group. It should also be noted that the Radfords Creek and Cateena units were intended to rank as Sub-Groups in the map index, but in giving these units lithological characterization the appropriate designations of rank were omitted.

5 cm

TOPOGRAPHIC UNITS – DEVONPORT QUADRANGLE

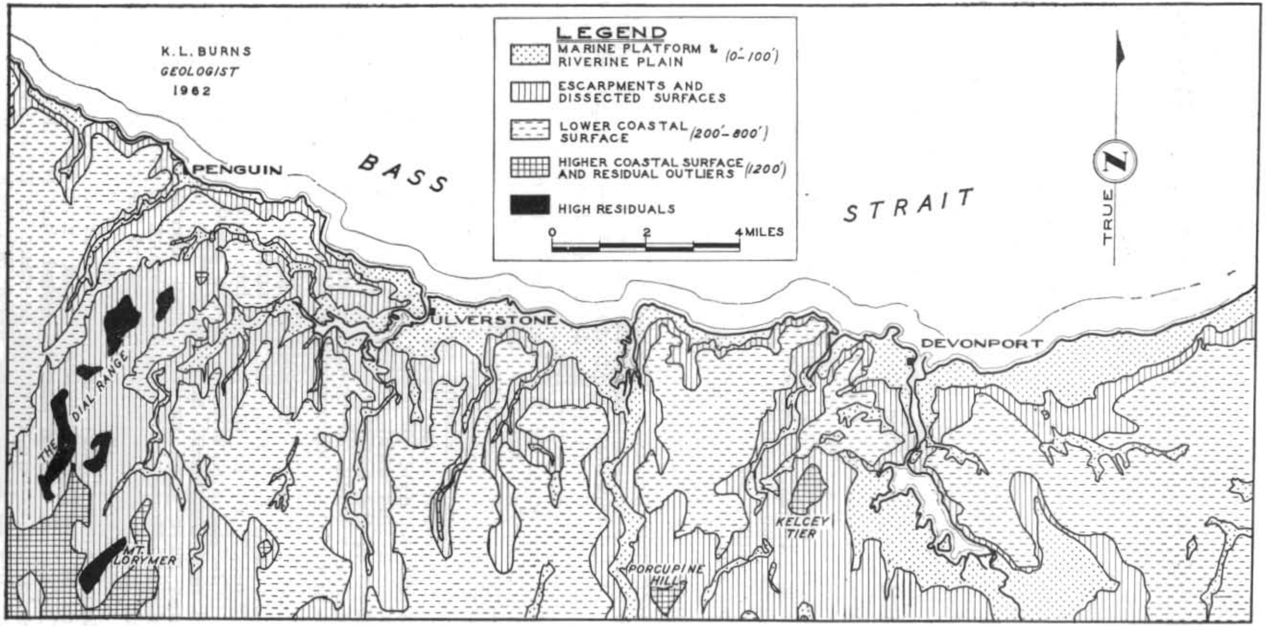


FIGURE 2.

PHYSIOGRAPHY

The Devonport Quadrangle covers part of the coastal lowlands of Northern Tasmania. Three topographic units comprise the greater part of the area—the coastal Marine Platform, the Lower Coastal Surface, and residuals rising above the latter. The distribution of these topographic units is shown in Figure 2, which was drawn on the basis of criteria by Davies (1959).

The Dial Range is a residual standing above the Lower Coastal Surface. The north end of the Range overlooks Penguin on the shores of Bass Strait. From Penguin the Range, with its companion Mt Lorymer, runs south of west for seven miles to terminate in the wide limestone valley of Gunns Plains in the NW part of Sheffield Quadrangle. The summits lie at a general elevation of 1800 feet, the highest peak being Mt Duncan at 2200 feet. The range is bounded on all sides by an escarpment up to 1500 feet high. The scarp is covered by talus except for occasional lines of cliffs up to 400 feet high.

Kelcey Tier is a low, mesaform residual with summit levels between 600 and 800 feet a.s.l. From close behind Devonport it runs east of south through Ellias Hill and Bonneys Tier to the Badger Hills west of Sheffield. The escarpments are marked by talus and by zones of deep deformational shear slides.

Between Kelcey Tier and the Dial Range there is a large tract of country dominated by the Lower Coastal Surface. East of Kelcey Tier, the Lower Coastal Surface is the dominant landform as far as the foothills of the Asbestos Range, in Beaconsfield Quadrangle. West of the Dial Range, the Lower Coastal Surface extends westwards to Wynyard and beyond. The Surface is a youthfully dissected, mature, largely erosional surface rising from an elevation of 300 feet or slightly less near the coast to about 900 feet ten miles inland. The surface is expressed by lateritization of volcanics, extremely deep weathering of cherts and acid lavas, and in places such as Nook, by a blanket of siliceous gravels. The age of this surface is probably Pliocene.

Cut into the seaward edge of the Lower Coastal Surface is a marine platform up to one mile wide, exposed by Quaternary strand line movement. The platform fringes the coast and extends inland as riverine plains. The scarp between the Lower Coastal Surface and the platform is mantled by talus and by zones of mass movement. Into the Lower Coastal Surface the rivers have cut meandrine V-shaped gorges which become progressively deeper upstream as the rivers are at or near grade. The level of the top of the valley fill is concordant with the level of the highest terraces on the Marine Platform. The Marine Platform is a surface of marine erosion with a thin layer, up to 25 feet thick, of beach shingle, sand dunes and coastal lagoon deposits. It is probably Pleistocene in age.

Quaternary uplift has moved the strand line some miles north of its Pleistocene location, exposing the deltas and entrenching the rivers into their fluvio-glacial gravel trains and into deposits on the Marine Platform.

DEVELOPMENT

The main townships and the principal highways are situated on the Marine Platform. From this coastal strip, secondary highways extend inland along the interfluves in a ladder pattern determined by the geology of the region. An early Tertiary youthful topography was blanketed with basalt, forming an extensive lava plain. The modern topography is superimposed discordantly, so that Tertiary and modern valleys rarely coincide. The modern interfluves are, therefore, frequently the site of Tertiary valleys and are occupied by basalt, the valleys being cut in older rocks. The basalt forms the bulk of the arable soil, so that agricultural development is largely confined to the modern interfluves. Along the interfluves run the major highways to the interior, through agricultural country with numbers of small townships.

In the early days of settlement, between 1850 and 1860, the principal access routes were probably along the river valleys. Tramways were constructed along the Don River from the coast to Barrington, along a route close to the present Don-Melrose railway; along the Wilmot River as far upstream as Upper Castra, a route now abandoned; and along the Leven River as far upstream as Gunns Plains, also now abandoned. These routes fell into disuse with depletion of timber resources and development of the agricultural country on the interfluves.

The area is well served by good highways. The developed country is mainly Tertiary basalt and this is cleared of timber, but the Palaeozoic and Precambrian rocks are largely waste-land carrying a secondary eucalyptus forest with a thick, scrubby understory of shrubs and bracken or, in many places, blackberry vines.

OUTCROP DISTRIBUTION

The distribution of outcrop is directly related to the physiography. There are excellent exposures in a narrow strip between low and high tide marks on the emergent marine platform, but elsewhere the platform and the floors of the river valleys are completely concealed by unconsolidated Quaternary deposits.

The bedrock on the Lower Coastal Surface is deeply weathered, as much as 90 feet in places on Forthside Hill, and is covered in other places with a veneer of gravel. In the Cambrian rocks, including chert and siliceous lavas, the bedrock is inaccessible and has to be identified from weathering products.

The escarpments between the Marine Platform and the Lower Coastal Surface, and around the residuals, are mantled with talus. Exposures are confined to discontinuous free faces on the higher parts of the escarpments.

Overall, the amount of rock exposed forms less than one percent of the total area.

HISTORY

Exploration and Development

Early maritime explorers of the North West Coast were Bass and Flinders, who circum-navigated Tasmania in 1798, Captain James Kelly in 1816, Lieutenant James Hobbs and Captain Rolland in 1824, Captain Hardwicke in 1824, and Captain Stokes of the *Beagle* in 1841. Captain Rolland travelled inland as far as " Rollands Repulse " or Mt Roland. Captain Hardwicke pronounced the country between the Mersey River and Rocky Cape as worthless and unfit for human habitation (Fenton, 1891, pp. 7, 13; Meston, 1958, p. 37).

The first inhabitants of the region were sealers (escaped convicts) of King and neighbouring islands who were settled there in 1802 and raided the mainland of Tasmania for aboriginal women (Fenton, 1884, pp. 100-101; Meston, 1958, pp. 37, 51).

Exploring from the settlement at York Town on the River Tamar, Dr Mountgarrett and Ensign Piper discovered the " First Western River " in 1805, which was later named Port Sorell.

In 1826 Edward Curr and a party from the Van Diemens Land Company travelled overland from Westbury to Northdown, and from there explored the North West Coast by whaleboat. They named the " Second Western River " the Mersey and explored the valley of the " Third Western River " (the Forth) as far upstream as Porcupine Hill (Meston 1958, p. 37). The V.D.L. Company established its headquarters at Circular Head and from this base teams of surveyors traversed most of the North West Coast in 1826-7, searching for open plains for pastoral development. In 1828 Hellyer began cutting a track south from Emu Bay through Surrey Hills and Hampshire while John Fossey began at the Chudleigh end. The two tracks met at the Mayday Plains in 1828, forming the first overland route to the North West Coast—the V.D.L. Track, or Great Western Road (von Stieglitz, 1947).

In 1827 Captain B. B. Thomas settled at Northdown, but after his murder by aborigines, the settlement was abandoned until the removal of the aborigines to Flinders Island in 1834, when B. W. Thomas re-settled Northdown and several paling splitters and settlers came to Port Sorell. A bridle track was cut across Badger Head to the Tamar in 1838. From Port Sorell, in 1839, James Fenton accompanied the geologist Count P. E. de Strzelecki on his survey of the Abestos Ranges.

In 1837 Frogmore Estate at Latrobe was taken up by Miss Moriarty, who was succeeded by Henry Bonney in 1837 and Thomas Johnson in 1840. Outcrops of " dysodile " or " yellow coal " were found a few miles to the south, but remained a scientific curiosity until the twentieth century.

In 1840 James Fenton settled at Forth and cut a track through to Frogmore. In 1842 N. L. Kentish cut and pegged a road from Kimberley through Sheffield, Barrington, Paloona and Clerkes Plains, to Emu Bay. This road reached the Leven River at Mannings Jetty in 1843, but was not used west of Barrington as the Leven was impassable, and the road gangs were withdrawn in 1845. The Leven Valley was first inhabited in 1848, at Lobster Creek, by paling splitters who were followed in 1851 by settlers at Ulverstone. In the land-rush of 1851 many blocks were taken out on the Dial Range by prospective settlers ignorant of the country, but were soon abandoned (Fenton, 1891, p. 117).

In April, 1850, Boswell Dean and David Cocker realized the value of coal discovered by Powell and Ayres on the Don River. Exploitation of the discovery led to rapid development of the area flanking the Mersey estuary some miles from the mouth of the river, a number of coal-mining and saw-milling settlements being established and ports developed. In 1853 Cummings, Raymond and Co. (later the Don River Trading Company) built a sawmill at the mouth of the Don River. A tramway was constructed up the river, reaching Barrington in 1878. In 1862 coal was discovered at Tugrah and the Company operated lime-works at Melrose from 1868. In 1859-60, R. C. Gunn and P. Lette visited gold mines at Lorinna and Calder. Using a map supplied by Dr J. Milligan (one-time V.D.L. surgeon at Hampshire), they explored the "Ring Plains" which had first been seen in 1827. A track was put through from Ulverstone via North Motton in 1860 to this new pastoral land, now known as Gunns Plains, which lies at the south end of the Dial Range.

The initial development of the region was pastoral. The V.D.L. Company, Fenton and Moriarty took up open, grassy plains as the cost of clearing the forest was prohibitive. A second stage of development consisted of timber-getting, occasioned by the demands of Melbourne after the gold rush of 1851. The introduction of ring barking and firing reduced clearing costs and opened the way for agricultural development. With development of agriculture, settlement spread slowly along the coast. A road was constructed from Deloraine to Latrobe in 1856, the Mersey and Forth Rivers were bridged in 1859, and the Leven was bridged in 1868. Mr Beecraft, the first settler at Penguin (1861), was reached by a road from Ulverstone in 1868.

Geological Exploration

The first geological exploration of the North West Coast of Tasmania was by Strzelecki. In an expedition supported by R. Murchison (Rawson, 1953, p. 147) he travelled down the eastern seaboard of Australia from Sydney to Wilsons Promontory, and then through Tasmania. He traversed the Asbestos Range near Port Sorell in 1839 and travelled along the V.D.L. track from Chudleigh to Circular Head. His map (1845) on a scale of 50 miles to one inch is the first geological map published for this region. Strzelecki included Tasmania in an orogenic belt, the Australian "Eastern Axis of Perturbation" which is the "Great Eastern Cordillera" of Murchison (Johnston, 1921, pp. 143, 155) and is now known as the Tasman Geosyncline after Schuchert (1916).

In April, 1850, coal was discovered at the mouth of the Bott Gorge on the Don River (Milligan, 1852). In 1855, A.R.C. Selwyn, the Government Geologist for Victoria, was commissioned to report upon the coal seams of Tasmania. His report on the Mersey Coalfield provoked a vigorous controversy. Selwyn considered that the fossiliferous marls of the district underlie the coal. Thomas Hainsworth (quoted by Johnston, 1888) found that marls occur, in places, overlying the coal, an observation confirmed by Gould in 1861. Hainsworth's discovery raised the possibility of more than one major seam and a bore was sunk in 1858 by private interests to a depth of 300 feet in search of additional seams, without success. On the recommendation of Thureau (1883), the newly-acquired Government Diamond Drill was used for further exploration and a hole was sunk to basement at 400 feet without success. Regional maps of the coalfield were drawn by Gould (1861), Thureau (1883), Twelvetrees (1911) and Reid (1922, 1924a). The last mine on the field closed in 1961.

James ("Philosopher") Smith visited Forth in 1849, and after a brief visit to the Victorian gold diggings, settled in 1853. He was the " . . . first to thoroughly explore the back country of West Devon. During the latter part of the fifties he made himself acquainted with the geological features of that inhospitable region in the vicinity of the Forth, Wilmot, Leven . . . " (Fenton, 1891, p. 172). Smith is credited (Fenton, 1884, pp. 360, 388; 1891, pp. 171-2) with the discovery of gold at Lorinna in 1858, copper at Barrington, copper in the Dial Range (Walloa Creek and possibly elsewhere), iron ore at Penguin, the first silver-lead in Tasmania at Penguin in 1860, and tin at Mt Bischoff in 1871, though Petterd (1896, p. 39) referred to an earlier discovery of silver-lead at Norfolk Plains in 1851.

Between 1850 and 1880 a discussion on the geology of the region was conducted at the Royal Society in Hobart by contributors such as Milligan, Gunn, Stephens, Smith, Gould and others, much of which was summarized by Johnston (1888). Stephens prepared a map of the North West Coast (Allport and Stephens, 1877; this map has been lost) which differentiated between two varieties of trap rock near Devonport.

The mineral discoveries at the Clayton River, Gawler River and Dial Range led to many geological investigations of particular mineral deposits. There were visits by Gould, Thureau, Smith, Montgomery, Twelvetrees and others. Numerous metallic deposits were found by prospectors but they all proved to be small and uneconomic. The only substantial production has been of iron ore from the low-grade deposits in Penguin Creek which are producing at the present time.

With the failure of attempts to exploit the shale oil south of Latrobe, a group of exploration companies drilled for natural oil in the period 1920 to 1930 in the country south and east of Devonport. The Permian rocks proved barren and Reid recommended that the companies explore the Tertiaries east of Latrobe in a combined, rationalized drilling programme. A deep trough was discovered by bores between Moriarty and Harford and prospecting of the seaward end of this trough was begun. The two holes sunk on the coast-line were apparently badly sited and missed the deep part of the trough and exploration was discontinued. A regional map of the area was prepared by Reid (1924a).

Since 1920 attention has been concentrated on the non-metallic deposits of the region, the possibilities of underground water and engineering problems arising in development. Officers of the Department of Mines have reported upon deposits of silica, clay, graphite, talc, sand, gravel and road metal. The Broken Hill Proprietary's quarries at Eugenana were substantial producers of limestone, the maximum rate of production being 300,000 tons per annum in 1939, and at the present time they are substantial producers of agricultural lime. Underground water has been investigated at Devonport, Spreyton, the Northdown-Sassafras area and the Northdown-Port Sorell area, and regional maps were produced by Elliston (1952) and Hughes (1954). The principal engineering problems are bridge foundations in the heavily-alluviated valleys, foundations for heavy structures in deeply-weathered basalt soil, and the protection of highways, pipelines and property as urban development expands to unstable parts of the coastal escarpment.

GEOLOGY

GENERAL

The major rock units in Devonport Quadrangle are shown in Figure 3. This map covers the land area of the Devonport Quadrangle and the northern part of Sheffield Quadrangle. It shows the inferred "bedrock" with Cainozoic deposits excluded.

There are four major structural or palaeogeographic units shown in Figure 3. West of the Dial Range, the Rocky Cape Group in the NW corner of the map is the extreme eastern edge of the Rocky Cape Geanticline of Carey (1953, fig. 3, p. 1115). Extending from the Dial Range to Ulverstone is a meridional belt of Cambrian rocks, occupying a basin here termed the Dial Range Trough, which expands at the southern end of the Dial Range into the Dundas Trough. Ordovician siliceous clastics are extremely thick in a narrow belt within the Dial Range Trough.

East of the Dial Range Trough is a small area of Precambrian metamorphic rocks, termed here the Forth Nucleus as it is a structure comparable in some respects to the Tyennan Block or Uplift of Carey (1953, pp. 1115, 1117). East of the Forth Nucleus is a belt of Permian and Mesozoic rocks occupying the Mersey Graben. The Graben is strongly faulted, the western margin being formed by a complex bundle of faults which are, in a large measure, Lower Palaeozoic structures re-activated in the early Tertiary. The overall structure is a set of horsts and graben, trending NNW, which are stepped down towards Bass Strait by faults trending WNW. The average dip of the sediments in this structure is about 350 feet per mile towards Bass Strait.

The geological history of the region is summarized in Table 1.

TABLE 1

Summary of Geological History

Quaternary	Sand dunes and coastal lagoons formed. Relative sea-level lowered six feet from Milford position.
Quaternary ? or Pleistocene	Internal deltas formed in the Forth, Mersey and Leven Rivers. Forest buried at Northdown Beach.
Pleistocene	Deposits on Marine Platform terraced by drop in relative sea-level. Deep deformational shear slides mantle coastal escarpment. Fluvio-glacially derived boulder trains from Central Highlands aggrade river valleys and are distributed along the coast by longshore currents.

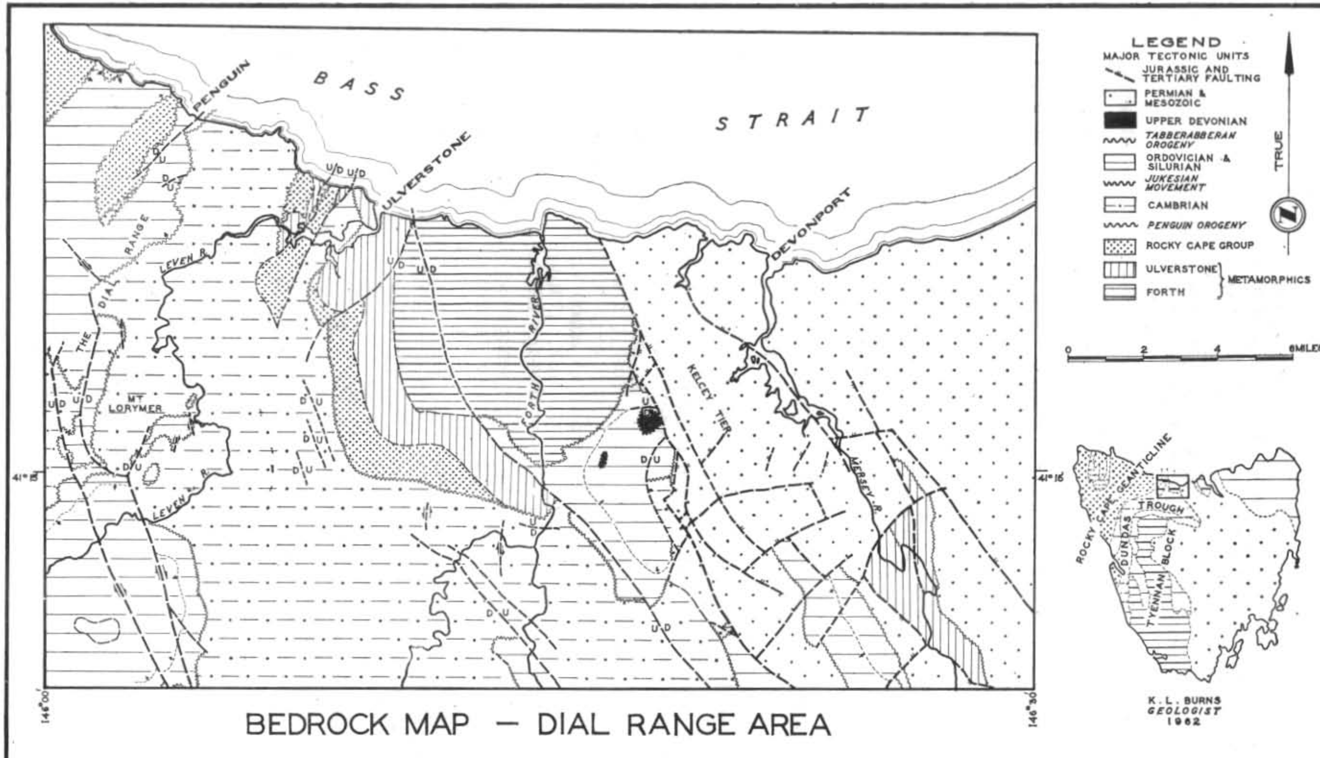

BASS STRAIT
PENGUIN
ULVERSTONE
DEVONPORT
THE DIAL RANGE
LEVEN R.
MT LORYMER
FORTH RIVER
KELCEY TIER
MERSEY R.
U/D
D/U
41°15'
146°00'
146°30'
LEGEND
MAJOR TECTONIC UNITS
JURASSIC AND TERTIARY FAULTING
PERMIAN & MESOZOIC
UPPER DEVONIAN
TABBERABBERAN OROGENY
ORDOVICIAN & SILURIAN
JUKESIAN MOVEMENT
CAMBRIAN
PENGUIN OROGENY
ROCKY CAPE GROUP
ULVERSTONE
FORTH
METAMORPHICS
TRUE
0 2 4 6 MILES
ROCKY CAPE GEANTICLINE
DUNDAS TROUGH
TYENNAN BLOCK
K. L. BURNS
GEOLOGIST
1962
BEDROCK MAP — DIAL RANGE AREA

FIGURE 3.

5 cm

Table 1—continued.

?	Pleistocene or Pliocene	Alluvial fans and talus mantle inland escarpments.
	Pliocene	Lateritization on the Lower Coastal Surface.
?	Pliocene to Miocene	Formation of the Lower Coastal Surface.
	Miocene	Moriarty Basalt, probably forming a lava plain.
	Middle Miocene to Upper Oligocene	Limestones in a marginal marine transgression. Wesley Vale Sand blanketing a fairly gentle topography.
	Oligocene	Thirlstane Basalt (valley-filling).
?	Oligocene or Eocene	Deposition of Harford Beds to a depth of 773 feet in erosional valleys.
?	Eocene to Paleocene	Erosion which reverses epeirogenic relief in places. Epeirogeny forming the Mersey Graben.
	Cretaceous	Erosion.
	Jurassic	Epeirogeny with intrusion of dolerite sills and dykes from sources near Dulverton and Port Sorell.
	Triassic	Continental sandstone deposited, about 1500 feet thick.
	Permian	Epi-glacial marine sediments and coal measures deposited on a subsiding shelf of considerable initial relief. Maximum thickness about 1500 feet, relief exceeded this.
	Carboniferous	Erosion.
	Upper Devonian	Spelean beds at Eugenana, continental deposits in Victoria.
	Middle Devonian	Tabberabberan Orogeny with mineralization, intrusion of quartz dolerite, intrusion of granite. Strong folding and faulting in two principal movements—the Loonganan (second) and Eugenanan (first).

Table 1—continued.

Lower Devonian to Silurian	Deposition of a maximum 5,000 feet of exogeosynclinal sediments.
Ordovician	Deposition of a maximum 3000 feet of Ordovician rocks. Miogeosynclinal limestones succeed terrestrial fanglomerates. Currents flowed generally south.
Cambrian	Deposition of a maximum (in any one place) of 5000 feet of eugeosynclinal Cambrian rocks in a linear trough (the Dial Range Trough) by currents flowing south. The Tyennan Orogeny accompanied deposition with two principal movements—the Jukesian Movement between Lower Upper Cambrian and Upper Upper Cambrian and the Hardstaff Movement in the Middle Middle Cambrian. The Jukesian Movement was accompanied by mineralization, keratophyric intrusions, and submarine mass movement. Both movements caused folding, erosion, and change in the type of sedimentation. Serpentine intruded into Precambrian is probably of Cambrian age.
Lower Cambrian	Erosion.
Precambrian	Intrusion of the Cooee Dolerite (700 m.y. B.P.). Penguin Orogeny caused two periods of folding in the Rocky Cape Group, the second phase accompanied by movement on the Singleton Thrust at the base of the Group. Rocky Cape Group deposited from turbidity currents flowing north. (?) Regional metamorphism of the Frenchman Orogeny. Forth and Ulverstone Metamorphics.

Stratigraphy

PRECAMBRIAN ROCKS

The Precambrian rocks of Devonport Quadrangle are assigned to three assemblages—the Rocky Cape Group, the Ulverstone Metamorphics and the Forth Metamorphics. The Rocky Cape Group is assigned to an "Upper Division" of the Precambrian, the Forth and Ulverstone Metamorphics to a "Lower Division". The Upper and Lower Divisions correspond in character to the "younger" and "older" divisions of Spry (1962a, pp. 107, 121-124). The terms Upper and Lower are preferred to younger and older, as they avoid an unproven implication of relative age and because they are descriptively accurate, the Upper Division everywhere overlying the Lower. The boundary between the divisions is a large thrust which is termed the "Singleton Thrust" as it is well-exposed in the country north of Singletons Point, about two miles west of Ulverstone. The terminology is tabulated below. It is emphasized that the three assemblages are distinguished on criteria of structure and metamorphic grade. Each assemblage may or may not have been deposited in a single period of sedimentation.

Upper Division: Rocky Cape Group.

———Singleton Thrust———

Lower Division:

Ulverstone Metamorphics

Forth Metamorphics.

Forth Metamorphics

The Forth Metamorphics is defined as the quartzite, schist and amphibolite which outcrop in the valley of the Forth River between the township of Forth, near 4225E 9280N, and an outcropping reef of Ordovician conglomerate about four miles to the south, near 4230E 9205N. Rocks of the Metamorphics extend from the Don River in the east, across the Forth and Clayton Rivers to Buttons Creek in the west. From Porcupine Hill in the south the outcrop extends northwards to be lost under Cainozoic deposits near Bass Strait. On Porcupine Hill, near 4242E 9205N, the quartzose clastics of the Ordovician Dial Group overlie quartzite of the Metamorphics with a pronounced structural and metamorphic hiatus. The Forth Metamorphics adjoins rocks of the Ulverstone Metamorphics at Buttons Creek, north of Abbotsham. The two assemblages are there structurally concordant in that the dominant foliations are parallel and were probably formed in the same period of deformation. The boundary between the assemblages is an arbitrary one, chosen as the first appearance of garnet in the schist. This corresponds approximately to the last appearance of conglomerate in the Ulverstone Metamorphics.

The Forth Metamorphics contains lithological repetitions on several scales—principally half a mile, 200 feet and 1-12 inches. The larger scales are probably due to tectonic repetition, while the smallest is sometimes tectonic, sometimes a metamorphic banding and often is probably bedding. The origin of the lithological striping is considered below (p. 132). For present purposes it is stated that the layering has no stratigraphic significance, the lithological units being mechanically emplaced to form a purely "tectonic succession".

The quartzite consists of coarse recrystallized quartz as undulose grains with interstitial muscovite. Some examples have a mosaic texture with patches of small, clear grains. Depending mainly on the proportion of mica, the field appearance varies from foliated "quartz schist" or micaceous quartzite, through layered flaggy quartzite with mica concentrated in layers, to coarse saccharoidal types free of mica. The schist is coarse, red or brown, foliated or pencilled rock, with porphyroblasts of almandine and sometimes albite, quartz as strings of small grains, and accessory sphene, opaque iron mineral, and probably rutile. Graphitic schist is recorded but the only outcrop located is a variety containing 5 per cent carbon, 200 yards north of Paloona Bridge, assigned to the Ulverstone Metamorphics. Amphibolite is of two kinds. One is a dark green, granoblastic rock with green hornblende, disjunctively folded quartz veins, porphyroblasts of garnet segregated into bands, and zoisite as grains and oriented prisms. Mineral segregation is sometimes striking, the rocks being called "hornblende gneiss" by Twelvetrees (1906b). The second kind is a greenschist, with chlorite, actinolite, and some tremolite, occurring as layers interbanded with mica schist in the schist belts. This is sometimes serpentinous (Spry, pers. comm.) or has thin layers rich in albite.

Ulverstone Metamorphics

The Ulverstone Metamorphics is defined as the quartzite, schist and conglomerate which outcrop on Picnic Point at Ulverstone between 41455E 9330N and 4148E 9327N. The name is a re-definition of the "Ulverstone Schist Series" of David (1932).

TABLE 2

Analyses of Precambrian Igneous Rocks

	(1)	(2)	(3)	(4)
SiO_2	48.48	41.16	36.32	52.47
Al_2O_3	15.68	15.94	5.39	16.07
Fe_2O_3	3.92	2.57	7.34	1.29
FeO	10.98	18.35	4.83	6.24
CaO	8.37	12.12	2.90	8.61
MgO	5.72	4.21	32.08	4.83
Na_2O	2.47	1.17	0.08	2.60
K_2O	1.17	0.21	0.03	2.23
MnO	0.21	0.32	0.15	0.15
TiO_2	0.80	2.00	0.10	1.36
P_2O_5	nil	0.18	nil	0.31
Cr_2O_3	nil	nil	0.45	nil
H_2O+	1.42	2.31	9.67	3.82
H_2O-	0.10	0.04	0.58	0.14
	99.32	100.58	99.92	100.12

(1) Granular amphibolite, hornblende rich, Forth Metamorphics.

(2) Granular amphibolite, garnet rich, Forth Metamorphics.

(3) Chlorite-tremolite greenschist, Forth Metamorphics.

(4) Average of three analyses of Cooee Dolerite.

Analyses from Spry (1962a, pp. 280-281).
Analyst C. J. Penman.

The *Goat Island Conglomerate* and the *Spalford Conglomerate* are two lithological units here correlated with the Ulverstone Metamorphics. The Goat Island Conglomerate is defined as the association of conglomerate and schist outcropping at 41265E 9337N at Goat Island. The Spalford Conglomerate is defined as that conglomerate exposed on the bank of Buttons Creek at Spalford, between the creek and the Castra Main Road at 41635E 92165N. These two belts of conglomerate may be stratigraphically equivalent to each other and to conglomerate exposed at Picnic Point.

Rocks assigned to the Ulverstone Metamorphics extend from Goat Island (2200 yards west of Picnic Point) SE as far as Spalford and probably as far as Paloona. Precambrian rocks south of Latrobe are similar in tectonic style and metamorphic grade to the Ulverstone Metamorphics.

The outcrop at Picnic Point is about 200 yards wide. The eastern half has alternating layers of schist and quartzite varying between 5 and 100 feet wide. The quartzite layers are white, flaggy rocks, folded into tight isoclinal folds with a small plunge to the north. Many bands are pinched out to the north and south by boudinage, so that some quartz bodies are large lenticular inclusions in schist. Muscovite-chlorite schist between the quartzite layers contains thin quartz layers about half an inch thick which are tectonically disrupted into lenticular inclusions. The western half of the outcrop is a repetition, due to transposition, of conglomerate and mica schist, and contains some layers of massive quartzite near the eastern edge.

At Goat Island, about 1½ miles west of Picnic Point, there is a repetition of conglomerate, mica schist, quartzose schist and some quartzite. The repetition is due mainly to transposition of an early lithological layering. Schist bodies occur as lenses with boundaries controlled by the transposition foliation and some thick layers preserve remnants of an earlier S-surface which may be bedding. The conglomerate consists of ellipsoidal quartzite pebbles varying in diameter from half an inch to over three feet with the great bulk of the pebbles having diameters between 6 and 12 inches. The pebbles are in contact except for a thin skin of schist in which they are enwrapped. At least 30 percent of the pebbles have convex surfaces, and for these the modal shape is ellipsoidal with axial ratios close to 4:2:1. They have a marked uniformity in orientation of their long axes. The size and shape of the pebbles in the conglomerate is of purely tectonic significance and is considered with other aspects of the deformation of the rock. The balance of probabilities is that the conglomerate is an original conglomerate (that is, was deposited as such) but there is some evidence that the conglomerate contains tectonic inclusions which now resemble pebbles, and that the original pebbles have not maintained their identity during deformation (many are pulled-apart into smaller bodies by boudinage, for instance).

West of Gawler a strike ridge of quartzite occupies the core of a broad, open Palaeozoic fold. The quartzite is in layers from one to three feet thick which alternate with thin layers of mica schist. Within the quartzite layers there is isoclinal folding of an early S-surface with development of mullions and a strong lineation at the intersection of this S-surface with the regional foliation. The quartzite belt is adjoined on the southern side by chlorite-muscovite schist which contains in one place (immediately west of the Gawler " talc " mines) a band of deformed conglomerate or perhaps tectonic inclusions of quartzite.

In outcrops on the Castra Main Road immediately north of the junction with Clerke Plains Road, there is a belt of massive, mullioned quartzite containing a few scattered quartzite pebbles which may have been tectonically emplaced along shear zones crossing the quartzite. About 100 yards west, schist contains the Spalford Conglomerate. This has pebbles of white, red, black and banded quartzite ranging from 2 to 12 inches diameter. The pebbles are rounded, sub-spherical and slightly flattened in the plane of the foliation. This rock is an original conglomerate, slightly deformed. West of Spalford there is a wide belt of pelitic rocks with bedding laminae marked by layers rich in quartz or chlorite. Secondary foliations are marked by growth of sericite or sometimes coarse muscovite. The outcrop is poor but pebbles scattered over a wide area suggest that conglomerate may occur in belts other than that shown on the map as the Spalford Conglomerate. The position of the boundary between the Ulverstone Metamorphics and Rocky Cape Group in the area SW of Spalford is inferred from deeply-weathered, widely-spaced outcrops.

Rocky Cape Group

Strzelecki (1845, pp. 117, 118) described clay slate and aluminous slate at Emu Bay and assigned them to his " first epoch " (i.e., the Precambrian). He differentiated between these and the Cambrian rocks of Penguin and Smithton. Quartzite at Rocky Cape was discussed by Twelvetrees (1903, 1906b) and purple slate at Penguin by Hughes (1953). Spry (1957a) defined the Rocky Cape Group as those sediments which outcrop on the North West Coast between Smithton and Penguin. From characters of structure and metamorphic grade it was suggested that mica schist in the Inglis River may unconformably underlie the Group, and an unconformable relationship with the Cambrian System was inferred at Penguin.

In Devonport Quadrangle, rocks correlated with the " Burnie Slate and Quartzite " form the basement on the western side of the Dial Range. On the eastern side of the Range, equivalent rocks occupy a narrow belt between the Cambrian of the Dial Range Trough and the Ulverstone Metamorphics of its eastern flank.

The base of the Rocky Cape Group is exposed at Goat Island, in road cuttings north of Singletons Point, and in the Gawler River near West Gawler, and is a large thrust, the Singleton Thrust.

The Rocky Cape Group underlies Cambrian rocks at the Iron Cliffs, near Penguin, where a 15° unconformity is exposed in Ellis's tunnel (Burns, 1961b). The unconformity has been traced north to an outcrop on the foreshore at the east end of Watcombe Beach, east of Penguin. The unconformity at the top of the Rocky Cape Group has been related to a tectonic movement, the Penguin Orogeny, by Spry (1962a, pp. 124-126). This hypothesis is confirmed but it has been found that the unconformity at Penguin is of rather a different time range from that envisaged by Spry, the time range embracing the Penguin Movement and much of the Tyennan Orogeny (Cambrian) as well.

The Rocky Cape Group consists of alternations of sandstone and mudstone. In places such as immediately west of Goat Island the quartzite occurs as units between 5 and 20 feet thick with intervening mudstone units up to 100 feet thick. In other places, such as Sulphur Creek and Blythe Heads, quartzite and mudstone are interbedded in layers from 3 to 12 inches thick while some areas appear to be largely mudstone, such as between Sulphur Creek and Howth Railway Station. The succession is monotonous and repetitive and is not readily subdivided. The only distinctive lithology is a sandstone which outcrops west of Goat Island (repeated three times by strike faulting) and contains a bed of conglomerate at its base. The thickness of the Group is unknown. Rocks of this lithology outcrop virtually without interruption from near Wynyard to Penguin, across the principal strike on the western side of the Dial Range, for a strike width of 15 miles, most of which has vertical or overturned bedding. As the Precambrian has an imbricate or schuppen structure, it is unnecessary to postulate enormous thicknesses. My impression from field work is that the thickness of the original sequence in Devonport Quadrangle is about 2000 feet, but this sequence has been "shuffled-up" by strike faulting so that in the rocks as now observed any part of the original sequence may be repeated many times. West of Goat Island the sandstone with a layer of conglomerate at its base is repeated three times by faults about 200 feet apart.

The sandstone is light cream or brown in colour and is usually in beds between one and four feet thick. Subangular, subspherical quartz forms between 40 and 50 percent of the rocks while rock fragments range from 0.1 to 0.5 mm diameter and form between 25 and 50 percent. The matrix is sericite and clay, sometimes carbonaceous. Grading from medium to fine sand occurs in beds four inches thick near Blythe Heads. The mudstone varies from yellow to dark grey or black according to carbon content and contains abundant clastic mica on bedding planes. In several places mudstone has been converted to phyllite by growth of sericite along foliations. In many places the laminations in the mudstone are obliterated by deformation although the major lithological boundaries, mudstone against sandstone, are invariably bedding.

SEDIMENTATION IN THE ROCKY CAPE GROUP

The sandstone of the Rocky Cape Group is fine to medium quartzose sub-greywacke with rare greywacke in the terminology of Pettijohn (1957). There is a monotonous repetition of lithologies wth alternations of sandstone and mudstone through some hundreds of feet. Bedding is strictly parallel, that is, there is no lensing or intertonguing. Although a single bed cannot be followed for more than about 500 feet, the succession and the lithologies are uniform in exposures over a wide area. Graded bedding from medium to fine sandstone has been found in some beds. Several types of bottom structures have been found, including flute casts, frondescent casts, and syndromous load casts. These characteristics, taken together, imply that the Rocky Cape Group was deposited from bottom-scouring density currents.

The flute casts are parallel ridges, up to two feet long and from one-half to two inches wide. They pitch 60° south in the bedding at Sulphur Creek with the bottom end broader and deeper, sometimes with small parasitic lobes. The northern ends flare and fade out to give an asymmetrical longitudinal profile. The surface of the casts is smooth. The flutes occur crowded together on the beds. Graded bedding shows that they are bottom structures. The flute casts are morphologically very similar to flute casts described by Rich (1950), Crowell (1955), Kuenen (1957), Wood and Smith (1958) and Williams (1959). However, it has not been verified that the casts have the internal structure described by these authors and due to the intensity of superimposed tectonic structures it cannot be shown whether or not the casts truncate the laminations in underlying beds. The flute casts have been found at the headland at Sulphur Creek, west of Howth Railway Station, and adjacent to Goat Island on the western side.

The frondescent casts occur crowded together on the bedding and overlap to give a sawtooth profile. The stems are about one inch wide, and the casts flare to about two inches wide at the "frond" or lobate end. A pattern of fine ridges and striations is parallel in the stems and diverging in the lobes. The striae end short of the lobe margin with slightly-expanded, tear-drop terminations. The stems in a group of lobate marks are approximately, but not strictly, aligned. There is no twisting of the lobate end. The marks are flat-topped with abrupt, convex margins at the lobe and along the sides of the stems but may merge into bedding at the stem root. In some marks there are small sedimentary cross-faults which offset the delicate structure of the mark but do not continue into the surrounding bed. Lobate markings have been recognized as bottom structures by Kuenen (1957, p. 239), Wood and Smith (1958) and Ten Haaf (1959). Those at Sulphur Creek are identified with the frondescent casts of Ten Haaf.

The syndromous load-casts appear as bottom structures on a graded bed at Blythe Heads. They are fine, rounded channels reaching 2 mm deep with flat-topped interfluves. They form dendritic patterns on the bed, converging to a bundle of parallel striae. The spreading branches of adjacent patterns are sometimes separated by a region of ovate pits. Dendritic bottom marks of this kind have been described by Kuenen (1957, plate 2A, fig. 22) and Ten Haaf (1959, p. 48). The structures at Blythe Heads are very similar, morphologically, to those described by Ten Haaf, so his terminology is adopted here.

In one structurally homogeneous area east of the headland at Sulphur Creek the mode of measurements of current directions from 11 localities is a pitch of 30° south in a mean bedding 75W180. Unwinding the bedding about the local fold axis and restoring the fold plunge to zero gives a vector directed to an azimuth of 014°. The lineations include flute casts and stems of lobate casts. Dendritic fans in the nose of a second-generation Precambrian fold at Blythe Heads, unwound in the same fashion, give a vector directed to an azimuth of 352°. Due to doubts about the kinematics of folding and magnitude of the first-generation Precambrian folds, these current directions are not to be regarded as accurate within a few degrees. However, a trial of several alternative methods of unwinding shows that the divergence of the primary current direction from those obtained amounts to less than 15°. The primary current direction was therefore from the south, towards the northern quadrant.

CAMBRIAN SYSTEM

In the Devonport Quadrangle sedimentary rocks correlated with the Dundas Group of Elliston (1954) occupy a meridional belt, termed the Dial Range Trough, extending from east of Gunns Plains northwards to Bass Strait. It is flanked by Precambrian rocks on the west side at Penguin Creek, and on the east side at the Gawler River. The trough widens rapidly near Gunns Plains to join the regional Dundas Trough of which it is a small off-shoot.

The succession in the Dial Range Trough is shown in Table 3. The general succession, greywacke (bottom), chert, spilite, greywacke (top) was known to Banks (1956, figure 2f) and Burns (1960a) and is based on palaeontological dating of fragmentary sequences. Regional mapping has now provided continuity within the Dial Range Trough and Table 3 confirms this general succession with a number of modifications.

The Cambrian rocks were deposited in an active tectonic environment. The form and character of the rock units strongly reflect movements accompanying deposition. Many of the form-(5870 feet) is only half the total of their maximum thicknesses

TABLE 3

CAMBRIAN SUCCESSION IN THE DIAL RANGE TROUGH

Succession	*Thickness feet*
— — — — — — Jukesian Unconformity — — —	
Beecraft Megabreccia and correlates (Teatree Point Megabreccia, Westbank Beds) equivalent to, or unconformably overlying, the Radfords Creek Group	<500
Radfords Creek Group	
Mudstone, sandstone and conglomerate	200++?
Applebee Volcanics	200
Mudstone, sandstone and conglomerate	400-500
— — — — — — Disconformity? — — — — — —	
Motton Spilite	0?-1500
Barrington Chert	250-2800+
— — — — — — Hardstaff Unconformity — — —	
Cateena Group	
Mudstone, sandstone and conglomerate	c.1050
Wilsonia Volcanics	0-350
Mudstone and sandstone	c.550
Kerrison Volcanics	120-400
Mudstone, sandstone, claystone and conglomerate	1000+
Isandula Conglomerate	600+
— — — — — — Disconformity? — — — — — —	
Lobster Creek Volcanics	1000+

(10650 feet). The lensing is due in part to hiatuses within the succession which increase in magnitude from the centre of the trough towards the flanks. Volcanics form about 30 percent of the succession.

Lobster Creek Volcanics

The Lobster Creek Volcanics is defined as the massive, intermediate to acid volcanics outcropping on the west bank of the Leven River between Lobster Creek, near 4080E 9320N, and Stanton Creek, at 4054E 9278N.

The formation outcrops in a belt four miles long from near Mt Montgomery to as far south as the north end of Mt Lorymer. Volcanics in the core of the Wilmot Anticline of Sheffield Quadrangle, eight miles further SE (4170E 9120N) are probably equivalent.

The rocks underlying the volcanics are not exposed. The overlying unit is the Cateena Group but this is missing in places and there the Lobster Creek Volcanics is succeeded directly by Barrington Chert.

The formation consists of massive, unstratified, medium-grained rocks of igneous derivation, with megacrysts of feldspar and chlorite, reaching a thickness close to 1000 feet in the type area.

The mineralogy has been described by Everard in Hughes (1953). At the mouth of Lobster Creek a porphyritic variety (29U8) consists almost entirely of sericitized, zoned plagioclase in a groundmass of fine-grained, largely euhedral, quartz and feldspar. The quartz has square outlines and rhombohedral twinning indicating β quartz. There are scattered clumps of chlorite and partially pseudomorphed hornblende. Disseminated cubes of pyrite are the principal accessory. In the Leven River, near Allisons Road (29U9, see analysis 1, Table 4) feldspar appears as large, sericitized phenocrysts and as smaller, clear, twinned laths of albite. Muscovite appears in clumps and large masses. Ilmenite occurs as rectangular, skeletal grains extensively altered to leucoxene. On the Leven River, 400 yards south of the mouth of Dial Creek, a white, porphyritic lava (29U6), outcropping in Davies Adit, has phenocrysts of zoned oligoclase and chloritized hornblende in a fine-grained groundmass of feldspar and β quartz. The same rock outcrops on the right bank of Dial Creek some hundreds of yards upstream from its mouth.

This formation was described as syenite by Smith (1899) who suggested it might be ". . . the root of the volcanoes from which the tuffs were ejected." Twelvetrees (1903, 1906b) suggested the formation was an intrusion related to the Devonian Housetop Granite. Hughes (1953) found the field evidence of the mode of emplacement to be inconclusive. In mineralogy and composition the formation resembles other Cambrian rocks of igneous origin and is quite different from the Devonian granite. The mudstone bounding the formation is altered in places but this is a hydrothermal effect post-dating Devonian cleavages and is not contact metamorphism. The emplacement of the Lobster Creek Volcanics occurred at an early time in the sedimentation of the Cambrian and was completed before the deposition of the Barrington Chert. The formation may be a laccolithic or diapiric igneous intrusion but the lack of alteration in the Cateena Group makes this un-

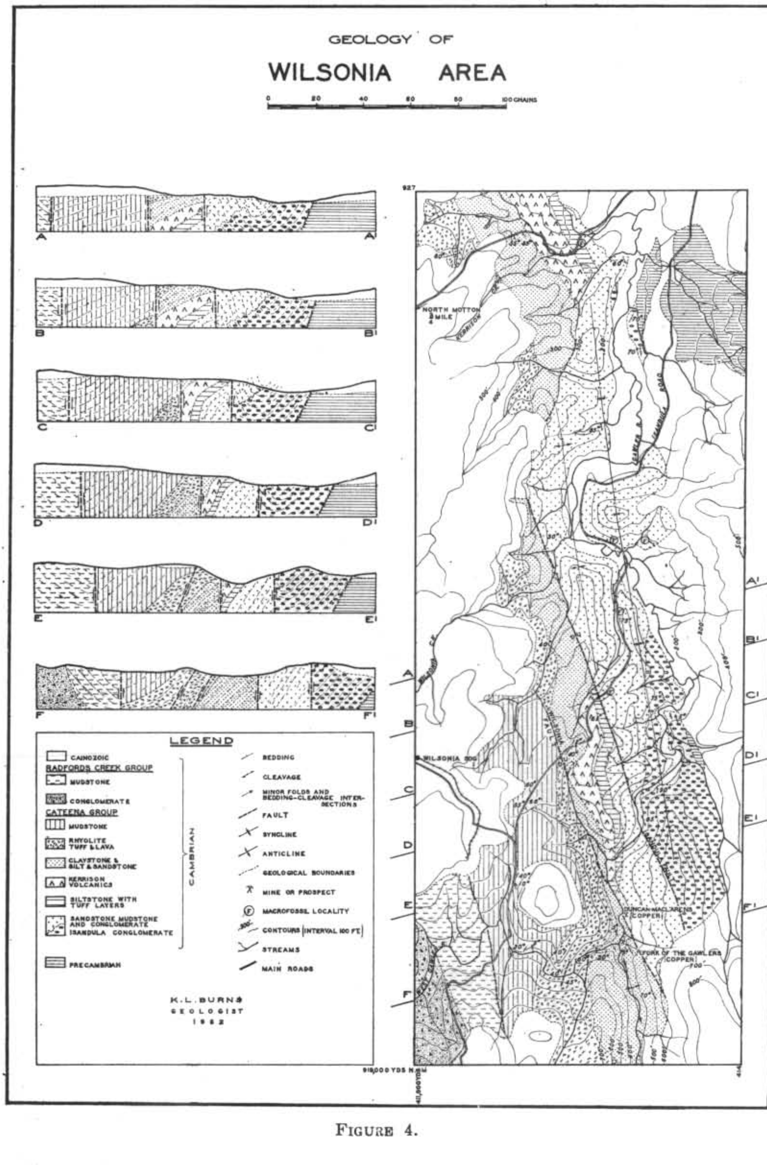


FIGURE 4.

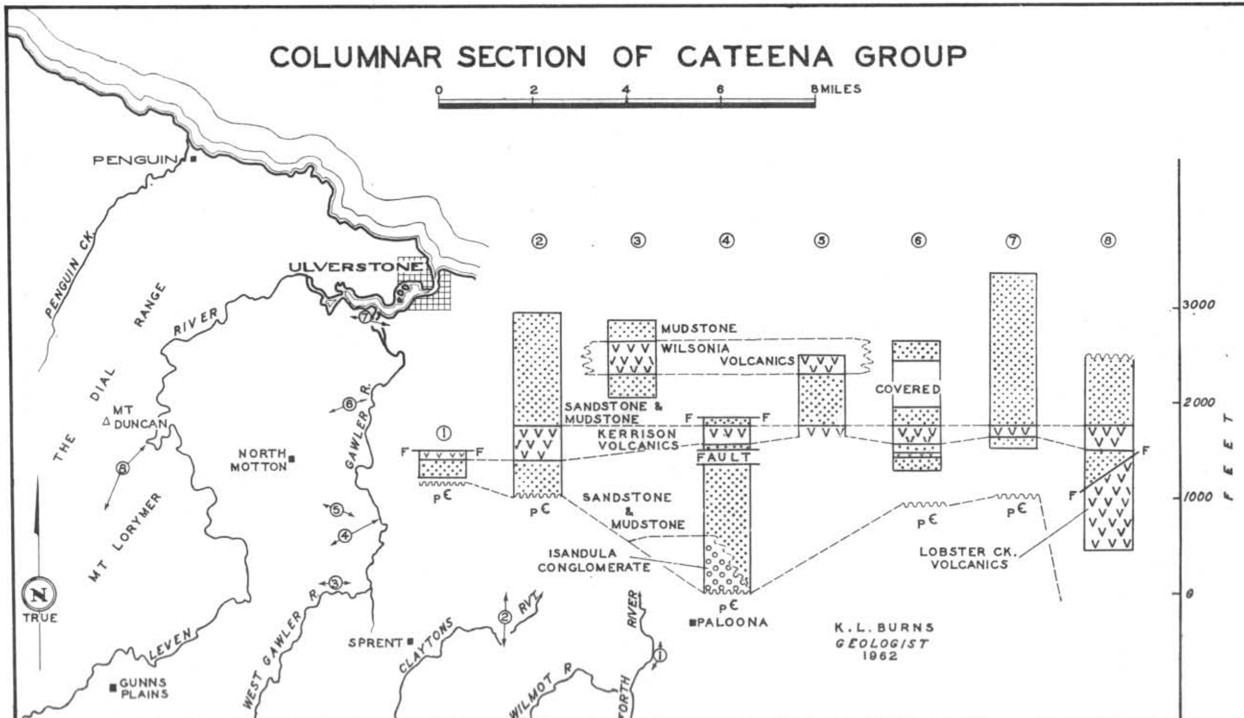

COLUMNAR SECTION OF CATEENA GROUP
0 2 4 6 8 MILES
PENGUIN
PENGUIN CK.
THE DIAL RANGE
MT DUNCAN
MT LORYMER
ULVERSTONE
RIVER
LEVEN
NORTH MOTTON
GAWLER R.
WEST GAWLER R.
SPRENT
CLAYTONS RVT.
WILMOT R.
FORTH RIVER
GUNNS PLAINS
PALOONA
N
TRUE
MUDSTONE
WILSONIA
VOLCANICS
SANDSTONE & MUDSTONE
KERRISON VOLCANICS
FAULT
COVERED
SANDSTONE & MUDSTONE
ISANDULA CONGLOMERATE
LOBSTER CK. VOLCANICS
pЄ
F
3000
2000
1000
0
FEET
K.L. BURNS
GEOLOGIST
1962

FIGURE 5.

likely. As the correlated rocks in Sheffield Quadrangle contain agglomerate and lapilli tuff (Burns, 1957a), the formation may be a submarine volcanic pile as suggested by Campana *et al.* (1958) and Solomon (1960) for a similar belt on the West Coast.

Cateena Group

The Cateena Group is defined as that group of rocks, predominantly mudstone, which overlies the Precambrian unconformably and the Lobster Creek Volcanics with an inferred disconformity and is overlain by the Barrington Chert in the Dial Range area. The succession within the Group is:

	Formation	*Thickness (feet)*
6	Un-named	c. 1050
5	Wilsonia Volcanics	0 to 350
4	Un-named	c. 550
3	Kerrison Volcanics	120 to 400
2	Un-named	1000 + ?
1	Isandula Conglomerate	c. 600

1. Isandula Conglomerate

The Isandula Conglomerate is defined as the conglomerate outcropping in the Gawler River near 4132E 9215N. It is at least 600 feet thick and consists of about 80 percent angular pebbles of purple mudstone averaging one-half inch diameter in a matrix of feldspathic sandstone.

At its eastern margin the conglomerate adjoins Precambrian rocks of the Rocky Cape Group and although the boundary is now nearly vertical it is probably an unconformity. On the western side the conglomerate is overlain conformably by mudstone of formation 2. The conglomerate forms a basal wedge and is overlapped to the north by overlying mudstone. There is probably interfingering with mudstone. The conglomerate is missing from the base of the Cambrian at Paloona and Sprent so it may have a restricted distribution. The conglomerate is monolithologic and strongly sheared and the field relationships (Figure 4) are not inconsistent with the possibility that it is a diataphral breccia, although there is no direct evidence in support of the hypothesis.

2. Un-named Formation

Overlying the Isandula Conglomerate near 4127E 9225N on the Isandula Road is an un-named formation consisting of at least 1000 feet of interbedded sandstone and mudstone, with some beds of conglomerate (see Figures 4 and 61). The formation is conformably overlain by the Kerrison Volcanics. The fresh rock is blue in colour, weathering green and then red. Mudstone and sandstone alternate in thin bands about one-half inch thick or as graded beds up to 18 inches thick. Fragmentary trilobites have been identified by A. A. Opik as of the *Ptychagnostus gibbus* zone which occurs (Banks, 1962a) in the Hodge Slate of the Dundas type section.

At Paloona Bridge volcanics correlated with the Kerrison Volcanics are underlain by:

		Feet
(Top)	Interbedded sandstone and siltstone	90
	Thin bedded, finely laminated chert	30
	Sandstone and siltstone	70

The succession is a composite one, computed from the field map of Figure 8.

At Moreton Road, Sprent, the formation is represented by 400 feet of massive green greywacke sandstone with ill-exposed layers of chert.

On the Preston Main Road, near 4125E 9265N, the succession underlying the Kerrison Volcanics is as tabulated below. The succession is faulted and is a composite one, computed from the field map of Figure 9.

	Feet
Kerrison Volcanics	
Fault	
Blue, laminated siltstone in beds averaging 8 inches thick, alternating with feldspathic sandstone in beds up to 18 inches thick, av. 1-2 inches. The siltstone contains sponge spicules recorded by Banks (1956, p. 184)	35
Fault	
Massive volcanics	40
Fault with a sliver of volcanics	
Grey siltstone in beds av. 12 inches thick interbedded with blue mudstone in beds 3-4 inches thick	10
Massive siltstone (containing one fault)	65
Coarse-grained tuff (containing one fault)	30
Covered interval	75
Weathered siltstone	75
Covered interval	1,200 (approx.)
Rocky Cape Group	

With allowance for faulting, the succession immediately beneath the Kerrison Volcanics is 35 feet (minimum) of mudstone and sandstone, overlying 65 feet (minimum) of massive siltstone, overlying about 30 feet of volcanics. Banks (1956, p. 184) gave these thicknesses as 110, 120 and more than 120 feet.

At Cateena Point the succession beneath the Kerrison Volcanics is as follows (Figure 42 covers the lower part of this succession):

Unit		Ft.	In.
	Kerrison Volcanics		
22	Finely laminated siltstone interbedded with fine sandstone. Fossils are trilobites, dendroids and brachiopods of the *Ptychagnostus gibbus* zone. (Identified by A. A. Opik)	11	0

Unit		Ft.	In.
21	Crudely laminated tuff of sand size with thin bands of chert and siltstone	21	0
	Break (traverse continued 100 feet south).		
	Tough coherent laminated green feldspathic sandstone	2	4
20	Coherent, yellow, fine-grained claystone, internally laminated with colour bands 4-10 mm thick. Structures include intrastratal folding, sedimentary dykes, cross-bedding and "flow-marks" on the upper surface. In thin section the rock consists (No. 9782) of layers 1-3 mm thick defined by alternations in grain size. Some layers contain 90 percent clay. The layers contain laminae about 0.5 mm thick, parallel in fine layers but foreset in coarse layers. Laminae in the coarse layers are marked by strings of chlorite. Chlorite forms about 60 percent of the rock as fine shreds about 0.005 mm long which tend to a reticulate pattern. Clay forms 40 per cent of the rock as irregular blobs 0.1-0.05 mm diam., av. 0.02 mm. A few scattered grains of quartz and probably opal av. 0.05 mm diam.	0	11
19	Soft, black, friable, fine siltstone, with white laminae av. 1 mm thick separated by an av. distance of 2 mm. This unit wedges out against greywacke conglomerate	3	11
18	As unit 20, with pronounced intrastratal contortions	1	1
17	Tough, black, coherent, very fine-grained siliceous mudstone with subdued laminae av. 1 mm thick. In thin section (No. 9780) the rock has laminae 0.05 mm thick marked by thin layers of opal and chalcedony. Opal forms 50 percent of the rock as equant grains 0.1 mm diam. Chalcedony forms 10 percent as length-slow fibres arranged radially and concentrically. Occasional grains of chlorite and quartz appear, av. 0.1 mm diam. Forty percent of the rock is an irresolvable groundmass of fine clay of which one-quarter part occurs as opaque masses about 0.02 mm diam. The chalcedony is the skeletal material of fossils which are radial spherulites 0.05-0.2 mm. diam. or star-shaped sponge spicules 0.05-0.1 mm diam.	1	5
16	As unit 20, with mud pellet bands and bands of black siltstone av. 3 mm thick	0	6
15	As unit 19, with a mud pellet band 7 mm thick at the base	0	3

Unit		Ft.	In.
14	Coarse, laminated sandstone. Pellets of yellow mudstone av. 3 mm diam. occur in layers up to one inch thick	0	5.5
13	As unit 19, with bands of coarse sandstone up to 7 mm thick, av. 4 mm and internally laminated	1	3
12	Greywacke conglomerate	1	5
11	As unit 19	0	8.5
10	As unit 17	0	5
9	As unit 19	0	2.5
8	As unit 17	0	3
7	As unit 19	0	3
6	As unit 17 with pull-apart structures in a matrix of greywacke conglomerate	0	3
5	As unit 19, containing sedimentary slides	7	6
	Low angle unconformity		
4	Consisting of up to 14 inches of black fine-grained siltstone with white laminae 1 mm thick showing compaction folding over boulders in the basal portion of the unit. The siltstone interfingers laterally with conglomerate. The conglomerate is up to 8.75 inches thick with pebbles of conglomerate and siltstone up to 8 mm diam., av. 4 mm, in a coarse sandstone matrix. The breccia contains one boulder of sandstone of diam. equal to the full thickness of the breccia. The breccia is an "autobreccia" formed from the siltstone and conglomerate. This unit has an irregular base on the underlying rocks. Sedimentary slides within the unit are truncated by unit 5	2	6
	High angle unconformity		
3	Gravitational slump zone with sedimentary rolls and slides developed in interbedded mudstone and conglomerate with accompanying autobrecciation	55	0
2	Yellow, massive mudstone with beds of graded conglomerate	12	0
1	Slide zone in interbedded mudstone and conglomerate	6	0
	Covered interval, containing an inferred unconformity	500	0
		(stratigraphic)	
	Ulverstone Metamorphics		

In Lobster Creek near 4084E 932N, rocks of the Cateena Group consist of nearly 200 feet of mudstone overlying Lobster Creek Volcanics. Interbedded feldspathic sandstone and mudstone form the upper part of the succession which is overlain by Barrington Chert. North of the creek the formation is less than 100 feet thick and may be absent.

In Hardstaff Creek between 4035E 9236N and 4045E 9253N, the Kerrison Volcanics is underlain by 400 feet of tough blue siltstone with interbedded sandstone in places, and coarse sandstone and conglomerate in others. In some outcrops the siltstone is thick-bedded and cross-bedded in two-foot sets but bedding is generally from 8-16 mm thick, with laminae showing intrastratal contortions. The conglomerates contain subangular chert and mudstone pebbles averaging two inches diameter in a matrix of angular rock fragments averaging 4 mm diameter. The succession is in faulted contact with the Lobster Creek Volcanics.

There is an assemblage of Cambrian rocks which probably belong to this formation on the footwall of the Ulverstone Fault 200 yards west of Picnic Point at 4141E 9330N (Figure 41). The western margin is a faulted boundary against Ulverstone Metamorphics. The eastern margin is an intricate boundary against schist and quartzite which appear to be disoriented blocks of Ulverstone Metamorphics and probably contain some blocks of Rocky Cape Group. It is probable that on the eastern side the Cambrian rocks were deposited on an erosional surface which was immediately underlain by the chaotic breccia of the Singleton Thrust.

Cambrian mudstone overlies mica schist at the eastern edge of the outcrop. The tectonic foliation in the schist is truncated at the boundary. At the north end of the outcrop Cambrian mudstone and Rocky Cape Group (?) sandstone are folded together. A lens of limestone about six inches thick is preserved at the base of the mudstone in several fold hinges. Away from the hinge zones the limestone occurs as contorted tectonic inclusions in foliated mudstone.

The beds in this assemblage are correlated with the Cambrian on lithological grounds and with the Cateena Group on the basis of continuity inferred from the regional mapping. Limestone has been recorded from this Group in one other locality, a bed about five feet thick outcropping at the Forth-Wilmot junction about 250 feet below the Barrington Chert (Burns, 1957a).

3. KERRISON VOLCANICS

The Kerrison Volcanics is defined as that formation of bedded tuff enclosed within mudstone at the northern tip of Cateena Point, west of Ulverstone, at 4133E 9302N. At the base, tuff is interbedded with mudstone, the base of the formation being the top of the highest mudstone bed. At Cateena Point the volcanics are represented by a bedded tuff which has bedding marked by alternations of very fine and medium-grained arenite. Feldspar is abundant as shreds and ragged patches. The thickness is 120 feet.

On the Preston Main Road near 4125E 9265N the volcanics are 195 feet thick and the rock is probably lava (analysis 3, Table 4). Half a mile to the north near the old "Kerrison Siding" of the

Nietta Railway the outcrop is predominantly porphyritic lava (analysis 4, Table 4). On the Isandula Road at 4127E 9225N there is a thickness of 200 feet of porphyritic lava. At 4185E 9180N on the Moreton Road east of Sprent there is 350 feet of porphyritic lava underlain by coarse agglomerate which has angular pebbles of lava up to two inches diameter in a chloritic matrix.

At Paloona Bridge there is, near the base of the Cambrian, a band of volcanics at least 100 feet thick which is correlated with the Kerrison Volcanics. On the south limb of a small anticline (Figure 8) the volcanics outcrop as layers of vesicular lava about two feet thick with a few inches of mudstone between the layers. Some of the beds are agglomerate with angular fragments of lava up to four inches diameter. On the north limb of the fold the volcanics contain boulders of mudstone up to two feet diameter. The lavas are porphyritic with phenocrysts of zoned, sericitized plagioclase and chlorite pseudomorphing hornblende in a fine-grained albite-sericite groundmass. From the analysis (No. 2, Table 4) Spry (1962b) has classified the rock as a sodic-potassic trachyte.

TABLE 4

Analyses of Cambrian Keratophyric Extrusive Rocks

	(1)	(2)	(3)	(4)	(5)	(6)
SiO_2	59.40	64.30	56.88	63.22	72.94	62.40
Al_2O_3	15.87	15.09	16.26	15.01	10.76	15.22
Fe_2O_3	3.28	1.61	2.76	1.85	3.83	2.42
FeO	4.11	3.24	4.88	3.69	1.67	2.76
CaO	5.14	1.78	3.36	3.74	0.78	2.86
MgO	2.93	3.16	3.96	2.47	1.23	1.78
Na_2O	3.17	3.66	5.35	4.66	4.22	4.85
K_2O	2.36	3.50	2.01	2.23	2.63	1.95
MnO	0.07	Trace	0.10	0.11	Trace	0.07
TiO_2	0.74	0.75	0.93	0.58	0.15	0.54
P_2O_5	0.17	0.05	0.22	0.12	0.12	0.19
H_2O+	3.07	1.90	2.60	1.86	1.47	1.64
H_2O-	0.25	0.45	0.12	0.16	0.15	0.06
CO_2	Nil	....	0.44	0.12	0.28	3.76
FeS_2	Nil	....	0.24	0.07	0.13	Trace
	100.56	99.49	100.11	99.89	100.36	100.50

(1) Lobster Creek Volcanics, Allisons Road Bridge, Leven River (4058E 9253N).

(2) Kerrison Volcanics: lava fragment in agglomerate, old pump-house, Paloona (4233E 91725N).

(3) Kerrison Volcanics: lava or lithic tuff, Preston Main Road, Gawler (4121E 9265N).

(4) Kerrison Volcanics: lava or crystal tuff, Kerrisons Siding, Nietta Railway (4116E 9277N).

(5) Kerrison Volcanics: water-laid fragmental, railway bridge, Cateena Point (4131E 9300N).

(6) Kerrison Volcanics: lava, mouth of Hardstaff Creek, Leven River (4049E 9255N).

In Hardstaff Creek the formation is represented by lava varying from 100 to 400 feet thick which has a well-marked flow texture at the base due to aligned phenocrysts. Near the mouth of Hardstaff Creek the rock has hypidiomorphic texture with heavily sericitized euhedral feldspar, clumps of chlorite (pseudomorphing hornblende) clotted with iron mineral, anhedral interstitial quartz and albite and accessory apatite and zircon (Everard, 29U7, in Hughes, 1953, and analysis 6, Table 4).

Analyst: C. J. Penman.

Although the lithology is bedded tuff at the north end of the Dial Range Trough, porphyritic lava with flow texture further south, and includes agglomerate along the northern edge of the Dundas Trough, the Kerrison Volcanics was deposited as one continuous layer. South east of Mt Duncan the formation can be traced by walking the outcrop for nearly two miles with no evidence of lensing. The outcrop is discontinuous along the eastern edge of the Dial Range Trough and the northern edge of the Dundas Trough but close mapping (as in figure 4) shows that the discontinuities are due to faults oblique to the strike. There is a close similarity in the successions immediately beneath the formation along the eastern side of the Dial Range Trough. Within the limits of resolution of the trilobite faunas, the volcanics are everywhere the same age. The formation has been traced for a distance of 14 miles along the margin of the Cambrian outcrop with no major changes in thickness or lithology, from Ulverstone to Paloona Bridge. It is probable that a lava and associated chloritic agglomerate in the angle between Aitken Creek and the Don River at Nook, 4.5 miles SE of Paloona Bridge, is the same formation. In terms of proportions of alkalies (cf. Spry, 1962b, p. 258) the lavas plot in the keratophyre field but the rock at Paloona is enriched in potash and the bedded tuff at Cateena Point has added potash and silica.

4 AND 6: UN-NAMED FORMATIONS

The Wilsonia Volcanics is lenticular and in places where it is missing the mudstones above and below cannot be distinguished from each other. At Cateena Point there is 1600 feet of interlaminated and interbanded sandstone and siltstone. Conglomerate is confined to the top 50 feet in a horizon which shows interstratal folding. The top of the succession is a reverse fault which upthrows Precambrian of the Rocky Cape Group and the base of the succession rests conformably on Kerrison Volcanics.

On the Preston Main Road the beds overlying the Kerrison Volcanics are (see field map, Figure 9):

		Feet
(Top)	Claystone and green feldspathic sandstone	200
	Covered interval	500
	Interlaminated siltstone and fine sandstone	95
	Sandstone and siltstone, the sandstone in beds about 18 inches thick with some beds cross-bedded and others containing layers of siltstone pellets	80

Interlaminated siltstone and sandstone with laminae from 1/4 to 1/16 inch thick	60
Pebbly, feldspathic sandstone with lenses and pellets of green mudstone and festoon cross-bedding pitching 25S in 45SW317	1.5
Green laminated greywacke siltstone overlying a few inches of chert or ashstone	1
Massive claystone	3
Covered interval	30

The total thickness is 900 feet with the top concealed.

In Wilsonia Creek near 4120E 9230N the succession is—

		Feet
(Top)	Wilsonia Volcanics.	
	Siltstone	100
	Coarse feldspathic sandstone with interbedded conglomerate and siltstone	100
	Claystone and siltstone, massive or interlaminated with sandstone	350
	Kerrison Volcanics.	

At Moreton Road, Sprent, these formations are about 1200 feet thick and consist dominantly of massive claystone with some chert beds which range up to 4 feet thick and some occasional beds of greywacke conglomerate and mudstone.

In Hardstaff Creek between 4025E 9230N and 4034E 9233N the formations total at least 700 feet in thickness and may be as much as 1500 feet thick. The rock consists of interlaminated, interbanded, interbedded, blue greywacke sandstone and siltstone. Laminae are 1-2 mm thick, bands from one to two inches thick, and beds up to two feet thick. The laminae in the sandstone are speckled with pyrite. Thick sandstone beds have sedimentary flowcasts at their base and contain trilobite and dendroid fragments. Conglomerate is interbedded in layers 2-4 feet thick. It contains more than 90 percent of subangular, subspherical, green, pyritiferous chert as pebbles averaging one inch diameter; less than 5 percent of laminated sandstone as pellets up to 12 inches long aligned parallel to bedding; and less than 5 percent of green and red, pyritiferous, keratophyre lava as rounded spherical boulders averaging 4 inches diameter. The matrix forms less than 5 percent of the rock and is a green chloritic pyritic sandstone. The conglomerate is sometimes cross-bedded near the top.

5. WILSONIA VOLCANICS

The Wilsonia Volcanics is here defined as the tuff and lava outcropping at, and for a distance of about 200 yards downstream from, the Ulverstone Water Supply intake on the Gawler River West near 4124E 9200N.

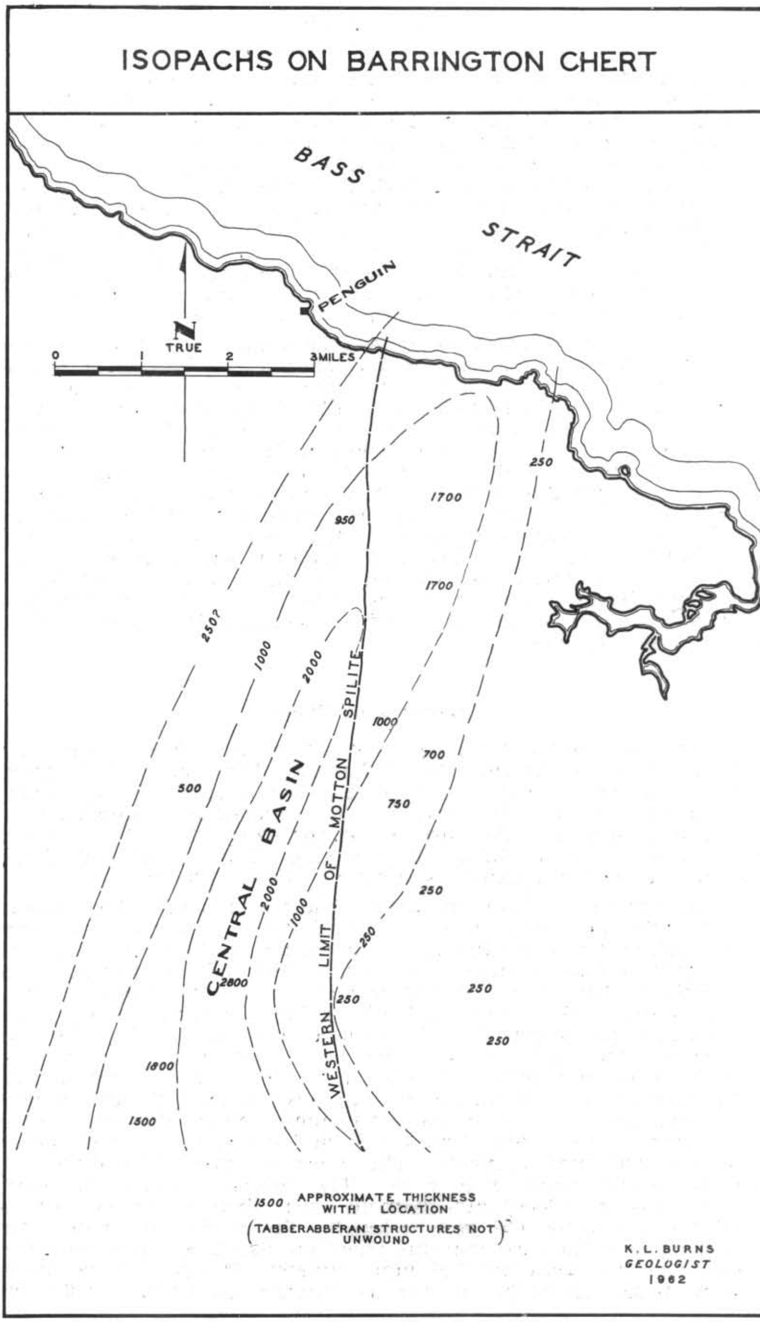
At the type locality the formation is overlain by at least 200 feet of blue, laminated calcareous mudstone. It consists of 5 feet of lava overlying 250 feet of thick-bedded tuff overlying about 100 feet of lava. The "breccia" referred to by Hughes (1961a) is a tuff with large fragments of cloudy orthoclase and plagioclase with some smaller megacrysts of fresh albite. There are bunches of a green mica, possibly fuchsite, and a few small spherules of muscovite with cores of quartz. A crude layering is marked by lines of small quartz grains. The lavas (No. 9095) are green, translucent thick-bedded rocks consisting of 30 percent albite as anhedral grains 0.1 mm diameter, 10 percent calcite as irregular spherical grains 0.2 mm diameter, 5 percent ilmenite, in a crypto-crystalline glass. About 30 percent of the groundmass is isotropic with minute polarizing dots within it; the remainder is composed of crystallites less than 0.001 mm diameter. There is abundant perlitic cracking. Another type (No. 9093) has anhedral micro-phenocrysts of albite up to 0.1 mm diameter scattered in the groundmass and a lamination marked by strings of cloudy, diffuse blobs of hematite. This variety is a very distinctive lithology with a milky white and orange banding when weathered.

In Wilsonia Creek near 4120E 9230N the formation is at least 200 feet thick but on the Preston Main Road, two miles further north, it is absent. The volcanics form a tongue in the mudstones which thickens to the south and SW. Rocks correlated with the Wilsonia Volcanics are over 500 feet thick in the East Gawler River and could be as much as 1000 feet thick (in the "East Gawler River Volcanics" of Burns (1957a)). Along the East Gawler River north of Upper Castra they form a belt of glassy and porphyritic lavas interbedded with tuff and bounded by massive claystone. The Wilsonia Volcanics of Devonport Quadrangle is thought to be a persistent tongue of a volcanic magnafacies which thickens to the SW. The formation is confined to the southern part of the "Eastern Basin" of Figure 43 and does not occur in the "Western Basin" nor along the margin of the Dundas Trough east of the Dial Range Trough.

Barrington Chert

The Barrington Chert of Jennings *et al.* (1959) occurs as a thick tongue in the Dial Range Trough. The maximum thickness shown on the isopach map of Figure 6 is a conservative estimate as in this region (Mt Lorymer) the succession is duplicated in part by a number of flat thrusts and the figure 2800 feet represents the thickness of the thickest thrust plate. Outside the central part of the tongue the thickness is fairly uniform at 250 feet.

The chert is thinly-laminated, black and white. The laminae show pull-apart structures of several kinds (usually tiny faults, the faulted zones passing into transformational breccia) and soft sediment slump structure including isoclinal recumbent folds. At Paloona the chert is thick-bedded with dark-coloured laminae and consists (Specimen No. 9092) of large, equant, angular clasts of chert about 5 mm diameter cemented by chert. The difference between clasts and matrix is the coarser grain size and presence of an opaque iron mineral in the clasts which have diffuse margins. The clasts consist of quartz in grains averaging 0.01 mm diameter with scattered large grains up to 0.05 mm diameter. Patches of angular hematite and diffuse limonite form 5 per cent of the clasts and average 0.05 mm diameter. The chert is crypto-crystalline with un-resolvable grain boundaries. The matrix consists of quartz grains less than 0.001 mm diameter with about 5 percent laths of chlorite averaging 0.01 mm in length. In cracks and seams, particularly near the clast margins, there are bands of coarse secondary quartz grains averaging 0.01 mm diameter. Portions of the matrix carry felted networks of fibrous chlorite as needles 0.001 mm



ISOPACHS ON BARRINGTON CHERT
BASS
STRAIT
PENGUIN
N
TRUE
0
1
2
3MILES
250
1700
950
1700
250?
1000
2000
SPILITE
1000
700
MOTTON
CENTRAL BASIN
500
750
OF
250
2000
1000
LIMIT
250
2800
250
250
250
WESTERN
1800
1500
1500 APPROXIMATE THICKNESS WITH LOCATION
(TABBERABBERAN STRUCTURES NOT UNWOUND)
K. L. BURNS
GEOLOGIST
1962

FIGURE 6.

diameter and 0.1 mm long. This autobrecciation occurs in mudstone interbedded with the chert and is very prominent in parts of the formation, especially the top 50 feet in Walloa Creek.

There are outcrops of chert in which a steeply-dipping black and white banding is truncated upwards by near-horizontal bedding. The best-exposed example is in the face of the lowest waterfall of Rogers Creek at the NW end of Mt Lorymer. The boundary between horizontal bedding above and nearly vertical banding below is a sharp line on the face of the waterfall. The boundary occurs in coherent, massive rock and is not marked by a layer of breccia or foreign material of any kind, the rocks above and below being "fused" together at the boundary. The rock above the boundary is horizontally-bedded black and white chert. The chert is laminated on a spacing of 3 mm and is bedded in layers 8-12 inches thick. The rock consists (No. 1818) of fibrous, radiating aggregates of chalcedony, tiny shreds and patches of quartz averaging 0.025 mm diameter, grains of iron mineral averaging 0.002 mm diameter but grouped in clumps ranging up to 0.2 mm diameter, brown clay and tiny laths of chlorite averaging 0.002 mm in length in a groundmass of crypto-crystalline quartz. The dark-coloured laminae contain an average of 40 percent iron mineral but some

TABLE 5

Analyses of Cambrian Cherts

	(1)	(2)	(3)	(4)	(5)
SiO_2	93.66	95.50	84.46	85.56	76.04
Al_2O_3	1.71	1.25	7.46	5.53	12.34
Fe_2O_3	2.27	0.50	1.25	2.92	1.89
FeO	0.38	0.26	0.61	0.90	0.35
CaO	0.03	1.28	0.26	0.38	0.36
MgO	0.45	0.29	1.19	1.01	1.33
Na_2O	0.07	0.14	0.26	0.20	0.36
K_2O	0.24	0.11	2.29	1.64	3.74
MnO	Nil	Nil	Trace	Trace	Trace
TiO_2	0.06	0.08	0.50	0.37	0.98
P_2O_5	0.02	0.52	0.15	0.18	0.20
H_2O+	1.00	0.75	1.89	1.50	2.36
H_2O-	0.20	Nil	0.18	0.15	0.34
CO_2	—	—	Nil	Nil	Nil
FeS_2	—	—	Trace	Trace	Trace
	100.09	100.68	100.50	100.34	100.29

(1), (2) Barrington Chert, Barrington.

(3) Granule chert conglomerate interbedded with siltstone in allochthonous slabs of the Beecraft Megabreccia (locality J, Figure 7) (4074E 93605N).

(4) Massive granule chert conglomerate occurring as slabs in the Beecraft Megabreccia (locality K, Figure 7) (4074E 93605N).

(5) Siltstone interbedded with granule chert conglomerate in allochthonous slabs of the Beecraft Megabreccia (locality I, Figure 7) (4074E 93605N).

Analyst: C. J. Penman.

laminae have as much as 70 percent. They contain about 20 percent granular quartz and about 40 percent clay. In this rock from above the boundary, the laminations are due to alternations of layers containing differing proportions of iron mineral. The laminae are themselves internally banded with streaks rich in iron. A few grains of chalcedony occur scattered along the contacts between laminae and a few thin seams of quartz about 0.05 mm wide cross the bedding.

The rock below the boundary has a vertical black and white banding. The black bands are sometimes lenticular. The white bands consist almost entirely of micro-crystalline quartz which contains less than 5 percent scattered tiny laths of chlorite and rare grains of limonite and calcite. The black bands (No. 1820) consist of up to 60 per cent fibrous chalcedony which usually occurs as spherulitic granules averaging 0.1 mm diameter and which is " dusted " with magnetite grains averaging 0.002 mm diameter. The black bands contain within them a few flakes of clear chert (clasts?) which range up to 0.5 mm long and have long axes parallel to the colour banding. Within the black bands occur long lenticular streaks of rock of high iron content. The boundaries between the dark-coloured and the light-coloured layers are sometimes sharp, sometimes gradational. Where the boundaries are gradational the proportion of iron mineral changes but grain size remains constant. In some places prominences of magnetite-rich chert protrude into clear chert like flame structures. The boundaries between the colour layers are simply changes in iron content which for the sharp boundaries are abrupt changes. One sharp boundary is offset on tiny faults which have the fault planes marked by thin seams of chalcedony.

The vertical banding in the rocks of the lower half of the waterfall is a primary compositional layering-bedding. This is truncated upwards by the base of the horizontally-bedded chert which forms the top of the waterfall. This structure is either an unconformity or a thrust. The fused nature of the structure suggests it was formed in sediment which was not highly indurated. It can be traced for about 200 yards northward from Rogers Creek, curving around the hillside parallel to the bedding in the upper beds. It was probably formed by large-scale slumping during deposition of the chert. Structures of this kind occur in other Cambrian rocks of the Dial Range Trough and are considered to be of great palaeogeographic significance. At Rogers Creek, it cannot be determined whether the structure is open-cast (an unconformity) or closed-cast (a gravitational slide).

In view of the anomalous relationship of the chert in some areas, particularly in an outcrop on the Leven River near Lobster Creek, Hughes (1953; see also Banks, 1956, p. 200) suggested that the chert might be in part a replacement deposit. The general stratigraphic relationships of the formation are here explained in terms of the Hardstaff Unconformity. The outcrop on the Leven River discussed by Hughes is the contact between mudstone of the Cateena Group and the Barrington Chert. The contact is vertical, with rotational joint boudinage in the chert and detached fold cores of chert in the mudstone. The contact is a zone of interpenetrative movement and not a transitional passage between the two lithologies. Chert boulders that occur within the Motton Spilite are xenoliths, not altered mudstone, as they occur in association with xenoliths of unaltered mudstone. In addition, beds of mudstone and conglomerate are interbedded with the chert, and greywacke immediately overlying the chert contains numerous chert pebbles. Thus, chertification would have needed to be highly selective and would have been completed immediately after deposition.

The beds near the top of the formation in Walloa Creek have angular chert pebbles forming 90 percent of the rock in a chert matrix and are interbedded with mudstone and sandstone. These beds are intraformational breccia formed shortly after deposition.

TABLE 6

Analyses of Cambrian Spilitic Rocks

	(1)	(2)	(3)	(4)	(5)	(6)
SiO_2	49.00	48.35	51.26	55.26	65.58	58.48
Al_2O_3	13.21	16.82	12.69	12.42	15.19	13.73
Fe_2O_3	1.57	2.85	0.80	4.06	0.82	2.11
FeO	12.07	10.21	3.47	5.33	2.15	5.65
CaO	10.00	9.55	12.60	7.40	2.92	1.00
MgO	7.10	4.46	3.76	7.13	4.06	8.60
Na_2O	1.77	3.78	4.74	4.40	5.86	3.12
K_2O	0.35	0.42	0.82	0.59	1.26	0.93
MnO	0.13	0.10	0.12	0.18	0.02	0.12
TiO_2	1.75	0.78	1.14	1.15	0.54	1.22
P_2O_5	—	—	0.18	0.19	0.14	0.17
H_2O+	3.25	2.32	1.43	2.12	1.70	3.75
H_2O-	0.40	0.32	0.20	0.13	0.23	0.37
CO_2	—	—	6.22	0.07	0.05	0.34
FeS_2	—	—	0.62	0.11	Trace	0.15
	100.60	99.96	100.05	100.54	100.52	99.74

(1) Pyroxene basalt, Motton Spilite, West Gawler River, Preston (4090E 9164N).

(2) Spilite, Motton Spilite, Penguin (Scott, 1952).

(3) Locality E (4080E 93605N)
(4) Locality F (4077E 9361N)
} Bedded vitreous tuff with chert granules occurring as allochthonous slabs in the Beecraft Megabreccia (localities refer to Figure 7).

(5), (6) Water-laid lithic tuff forming part of the autochthonous succession in the Beecraft Megabreccia (localities G, H, of Figure 7 respectively) (both close to 40755E 9361N).

Analyst: No. 2: B. Scott. Nos. 1, 3-6: C. J. Penman.

Motton Spilite

Nye (1931a, c) recorded what he considered to be Lower Palaeozoic dolerite at Penguin. Scott (1952) recognized this as a Cambrian spilite containing pillow lavas. Scott (1952) and Everard (29U14, 29U15, in Hughes, 1953) described the lavas at Penguin as consisting of laths of albite, $Ab_{98}An_2$, partly sericitized and chloritized. Augite is intergranular, fresh, and simply twinned. There are scattered grains of ilmenite, and patches of interstitial pale green chlorite containing granules of secondary sphene (analysis 2, Table 6).

Twelvetrees (1906b, p. 13) described the Motton Spilite of the Leven Gorge as a pyroxenic porphyroid containing plagioclase, augite, minor hornblende and biotite in a quartzo-feldspathic mesostasis which is largely granular quartz. Everard (29U10 in Hughes, 1953) described another variety from the same area having ophitic texture with laths and needles of plagioclase with weakly coloured augite in a matrix of devitrified glass.

The spilite contains contorted, broken shreds and patches of mudstone and chert as xenoliths. Pillows are well-exposed in the shoreline exposures at Penguin.

The Motton Spilite conformably overlies the Barrington Chert. The top of the formation is a spilite-conglomerate in the Leven River west of North Motton with large rounded boulders of spilite averaging two feet diameter in a matrix of greywacke mudstone. In the Leven River the spilite-conglomerate is about 50 feet thick. A similar conglomerate occurs at the base of the Teatree Point Megabreccia and is about 20 feet thick. The maximum exposed thickness of the Motton Spilite is nearly 1500 feet at North Motton. The formation thins rapidly at its contact with the Radfords Creek Group, along a line in the centre of the trough (Figure 6), and west of this line the Radfords Creek Group overlies Barrington Chert directly.

Radfords Creek Group

The Radfords Creek Group is defined as that group of rocks, predominantly mudstone, overlying the Barrington Chert and unconformably overlain by the Dial Group in the Dial Range area. The Group consists predominantly of mudstone and contains beds of tuff and lava, greywacke and quartzose conglomerate.

A number of fragmentary successions are available from the southern end of the Dial Range, in the Sugarloaf Gorge NE of Gunns Plains, in Walloa Creek SW of Mt Lorymer, and in the region on the southern, western, and NW sides of the Adam Creek Plains. This belt of sediment is recognized as being everywhere the Radfords Creek Group because the Applebee Volcanics can be traced through the belt and palaeontological evidence from widely separated localities shows that the sediments are everywhere much the same age.

At the south end of Mt Lorymer in Walloa and Applebee Creeks the succession is:

		Feet
(Top)	Mudstone and sandstone	200
	Applebee Volcanics	200
	Mudstone with chert conglomerate at the base (immediately west of the junction of Applebee and Walloa Creeks)	400
	Barrington Chert.	

The Applebee Volcanics is defined as that formation of keratophyric volcanics outcropping in Applebee Creek just upstream from its junction with Adit Creek. The formation has been traced from the type locality southwards, and it outcrops on the left bank of Walloa Creek just downstream from the mouth of Adit Creek. In this vicinity it is offset on the Duncan Fault but reappears on the other side of the fault, close to the base of the Dial Group, on the left bank of Pine Creek. It is there offset on the Kaines Creek Fault, and has been followed SW from there along the right bank of Pine Creek into the NE corner of Valentines Peak Quadrangle. The formation was not differentiated in earlier mapping (Jennings *et al.*, 1959) but it crosses the NW corner of Sheffield Quadrangle. Everard (29U11, in Hughes, 1953) described a rock which is probably the Applebee Volcanics. This is porphyritic with phenocrysts of plagioclase and irregular corroded grains of quartz in a quartzo-feldspathic groundmass in which the feldspar is heavily sericitized.

The mudstone, sandstone and conglomerate occurring in the country between the junction of Kaines and Milligans Creeks and Riana underlie the Applebee Volcanics and have a large areal extent due to low dips and gentle folding. Fragmentary trilobites have been obtained at 4016E 9198N; 4006E 9206N; and in a quarry near Riana at 4004E 9240N. Fossils have been observed at 4008E 9201N and 4000E 9250N. The Riana quarry fauna was identified by Dr. Palmer of the United States Geological Survey as equivalent in age to the *Leiopyge* horizon of the Leven Gorge.

In the Sugarloaf Gorge on the Leven River east of Gunns Plains a reconstruction (Figure 55) gives the following succession from west to east:

Unit		Feet
	Gordon Limestone.	
	Walloa Creek Fault	
1	"West conglomerate" (Ordovician)	120
	Inferred unconformity.	
2	Brecciated greywacke	84
	Major fault.	
3	"Middle conglomerate"	42
4	Mudstone	72
5	Tuff or greywacke	18
6	Mudstone	60
7	Greywacke	14
8	Mudstone	107
9	Greywacke sandstone and conglomerate with 3 feet of mudstone 20-23 feet above the base	45
	Major fault.	
10	"East conglomerate"	76
11	Mudstone	62
12	Tuff	62
13	Several hundred feet of mudstone.	

The succession is strongly faulted but the only faults with substantial throw are indicated above. Banks (1956, p. 184) measured the same section, obtaining:

Unit		Feet
	Ordovician conglomerate.	
	Unconformity.	
6	Argillite	58
7	Greywacke	17

8	Argillite	88
9	Greywacke	37
10	Conglomerate	67
11	Argillite	56
12	Tuff	56
13	Argillite with *Leiopyge*	270
14	Tuff and Lava	63
15	Argillite with *Clavagnostus*	300

The agreement between the two traverses is good considering the nature of the section and alterations to the cutting by road-works. Unit 13 is Middle Cambrian and is correlated with the Comet Formation of the Dundas Group type succession. The section measured by Banks excludes units 1 to 5 as listed above—Banks excluded that part which appears to be a tectonic repetition of portion of the succession which outcrops further west. The total thickness of the succession (units 2 to 15 above) is 1275 feet which is very large and the great thickness is considered to be due to repetition by thrusting. Units 3 to 9 and 10 to 12 are probably continuous sequences with only minor repetitions or omissions due to faulting.

South east of Mt Lorymer, Banks (1956, p. 185) observed the following succession:—

(Top) Quartz biotite keratophyre (Applebee Volcanics?).
Argillite.
Greywacke sandstone with *Pseudagnostus*.
Covered interval.
Argillite
Greywacke sandstone.
Covered interval, hundreds of feet.
Thin-bedded chert and argillite.
Argillite (40-50 feet).
Argillite with sandstone beds.

The fossiliferous sandstone is dated as basal Dresbachian which is younger than the *Leiopyge* horizon.

Further SE but in the same general vicinity the following generalized succession has been recognized:

		Feet
(Top)	Mudstone with volcanics	400+
	Mudstone (*Pseudagnostus* zone)	250
	Conglomerate (Sprent conglomerate)	300
	Motton Spilite.	

The conglomerate of the Sprent Formation has not been recognized away from the outcrops recorded by Jennings *et al.* (1959) and appears to be lenticular.

A generalized succession for the southern end of the Dial Range, based upon those listed above, is:

		Feet
(Top)	Mudstone	200
	Applebee Volcanics	200
	Mudstone with *Pseudagnostus* overlying mudstone, conglomerate, chert and tuffs with *Leiopyge*	400-550
	Barrington Chert in some places, Motton Spilite in others.	

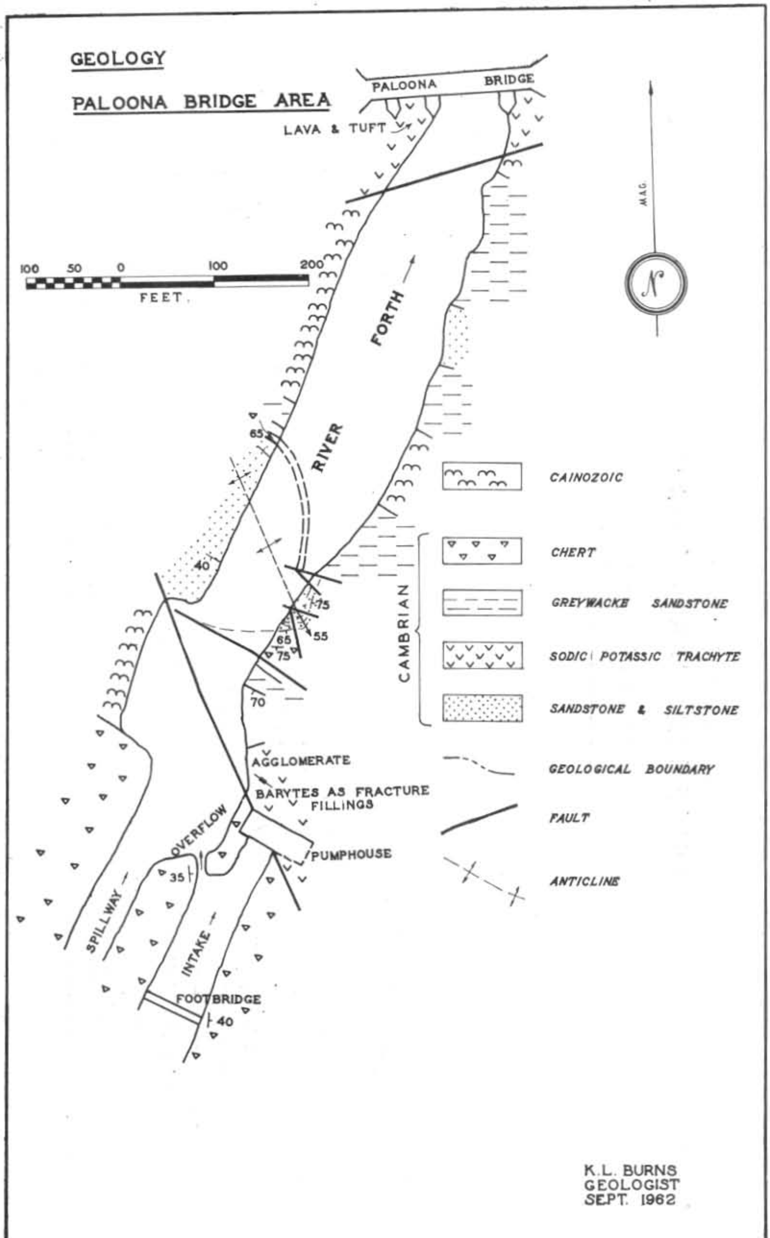

GEOLOGY
PALOONA BRIDGE AREA
PALOONA BRIDGE
LAVA & TUFT
100 50 0 100 200
FEET
MAG.
FORTH RIVER
CAINOZOIC
CHERT
GREYWACKE SANDSTONE
SODIC POTASSIC TRACHYTE
SANDSTONE & SILTSTONE
CAMBRIAN
GEOLOGICAL BOUNDARY
FAULT
ANTICLINE
AGGLOMERATE
BARYTES AS FRACTURE FILLINGS
OVERFLOW
PUMPHOUSE
SPILLWAY
INTAKE
FOOTBRIDGE
K.L. BURNS
GEOLOGIST
SEPT. 1962

FIGURE 8.

5 cm

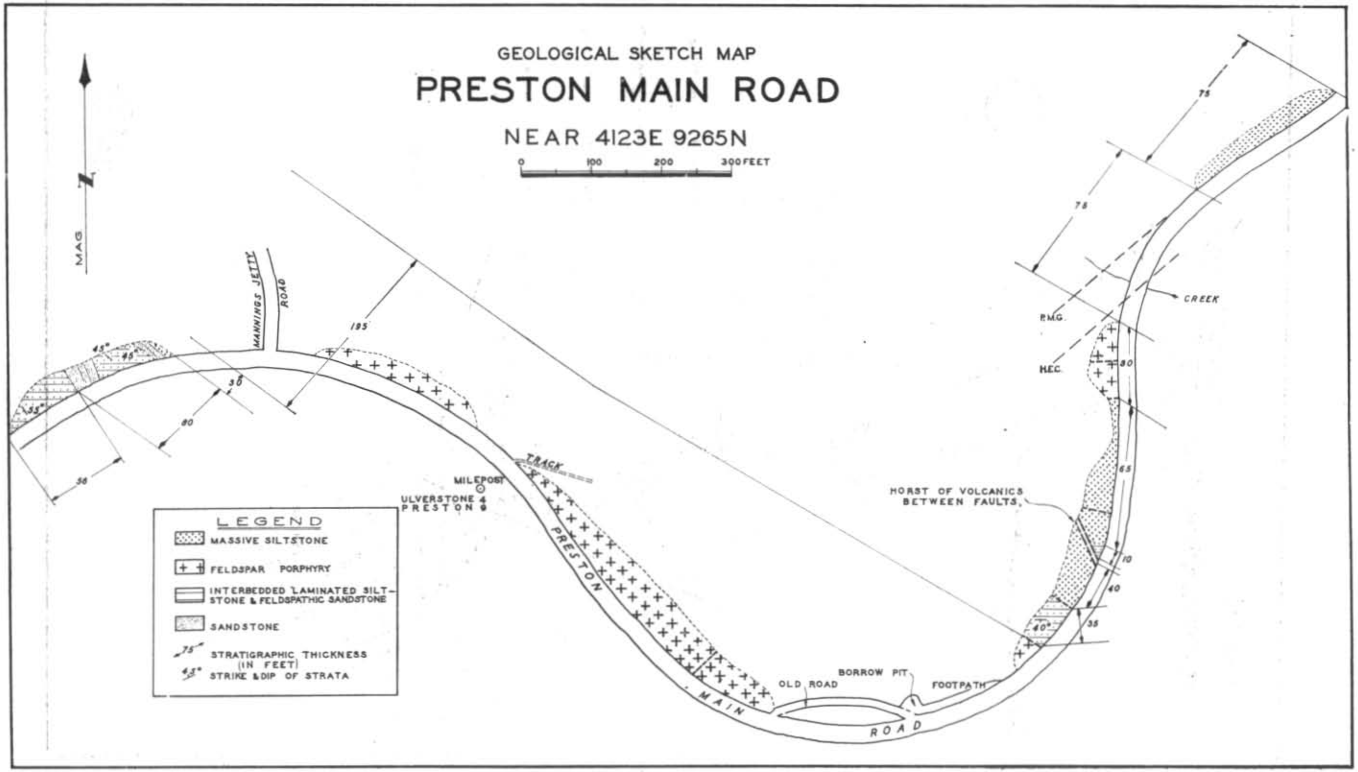

GEOLOGICAL SKETCH MAP
PRESTON MAIN ROAD
NEAR 4123E 9265N
0 100 200 300 FEET
MAG N
MANNINGS JETTY ROAD
PRESTON MAIN ROAD
TRACK
MILEPOST
ULVERSTONE 4
PRESTON 9
OLD ROAD
BORROW PIT
FOOTPATH
CREEK
HORST OF VOLCANICS
BETWEEN FAULTS
P.M.G.
H.E.C.
195
30
80
56
75
75
80
65
10
40
35
45°
45°
55°
40°
LEGEND
MASSIVE SILTSTONE
FELDSPAR PORPHYRY
INTERBEDDED LAMINATED SILT-STONE & FELDSPATHIC SANDSTONE
SANDSTONE
STRATIGRAPHIC THICKNESS (IN FEET)
STRIKE & DIP OF STRATA

FIGURE 9.

Beecraft Megabreccia

An almost continuous section across the Dial Range Trough is exposed on the foreshore of Bass Strait. The general dip is west with younger formations at the western end. A traverse along the coast-line from Penguin to Picnic Point crosses the following strata (see Figures 7, 27, 41):

Tectonic Unit	*Formation*
Western flank of the Dial Range Trough (Rocky Cape Geanticline)	Rocky Cape Group.
Dial Range Trough	Steeply-dipping unconformity, well-exposed. Beecraft Megabreccia, 2800 feet wide. Thrust (probable) (unconformity possible). Motton Spilite, 1950 feet wide. Thrust. Teatree Point Megabreccia, 700 feet wide. Stratigraphic contact (probably an unconformity). Motton Spilite, 8400 feet wide. Conformable stratigraphic contact. Barrington Chert, about 250 feet thick. Concealed, conformable stratigraphic contact. Mudstone of the Cateena Group, about 50 feet exposed. Concealed boundary, possibly an unconformity, more probably a Tabberabberan fault, down-throwing west by 1200 feet.
Goat Island Basement Wedge	Rocky Cape Group. Singleton Thrust. Ulverstone Metamorphics.
	Westbank Fault.
Ulverstone Basement Wedge	Rocks in the Westbank Chaos. Concealed boundary, probably an unconformity.
	Rocky Cape Group. Concealed boundary (the Singleton Thrust). Ulverstone Metamorphics.
	Ulverstone Fault.
Gawler Basement Wedge	Rocks correlated with the Cateena Group. Unconformity (well-exposed).
	Chaotic breccia probably on trace of Singleton Thrust. Ulverstone Metamorphics.

The foreshore east of Penguin was examined by Thureau (1882), Montgomery (1896), Smith (1899), Twelvetrees (1906b) and Scott (1952), and is mentioned by several other early writers.

Thureau (1882) described fine and coarse conglomerate containing red and yellow jasper and black hornstone. Near the Neptune Mine (Teatree Point) he observed dykes of basalt or andesite (trachyte) enclosed by friction breccia and a dyke of hornblendic porphyry (spilite?) which has transformed the mudstone to hornstone.

Montgomery (1896) recorded felsitic tuff and breccia of quartzite, hornstone and jasper. He found " . . . tufaceous indurated sandstones containing occasional waterworn pebbles but otherwise closely simulating a crystalline rock . . . " to contain feldspar and hornblende—probably the rock here termed welded tuff. He described the foreshore and wrote " . . . hard quartzites, slates, and in one place, limestone, and on a ragged surface of these, beds of breccia, tuff and felsitic ash, all somewhat mixed with ordinary sedimentary material, have been deposited. In several places there are dykes of Tertiary age bursting through the older rocks and lava flows covering them . . . " In this passage, Montgomery considered the structure (in mainly the Teatree Point Megabreccia) to be a dissected unconformity.

In 1867 Gould doubted whether "the whole series here developed is conformable, or whether some great break may not intervene between the breccias forming the summit of the Dial Range and the clay-slates and conglomerates occupying the country below." Montgomery considered that his "unconformity" at the Neptune Mine was the same one. However, Twelvetrees (1906b) in reproducing Montgomery's idea of a dissected unconformity on the foreshore, showed that it was not the same as that at the base of the Dial Group.

Scott (1952) determined a succession with volcanic breccia and tuff at the top (Beecraft Megabreccia?) overlying pillow and massive lavas (Motton Spilite) overlying shale and tillite (Teatree Point Megabreccia?). Banks (1956, p. 193) pointed out that the sediments are sub-greywacke breccia, not tillite.

The Beecraft Megabreccia is defined as the megabreccia outcropping on the foreshore at Penguin between 4073E 9361N and 4082E 9358N (Figure 7). The autochthonous, or matrix material is largely greywacke conglomerate and sandstone. Dips are rarely observed and are usually low so the total thickness probably does not exceed 500 feet. The beds are graded, usually simply, with pebbles of chert and have quartzite abundant at some places such as the NW extremity of the outcrop. The pebbles range from one quarter to two inches in diameter, the matrix from granule conglomerate to siltstone. Graded beds are 8-12 inches thick, usually grading from coarse sand to silt. Portions of the greywacke are rich in rock fragments, particularly lava, and are described here as tuff. The boundaries between the greywacke and the tuffaceous sandstone are not easy to define and are somewhat generalized on the map (Figure 7). According to Everard, a typical tuffaceous sandstone has pebbles of chert in a matrix of plagioclase, chert, fine-grained basalt and an isotropic green material which is probably volcanic glass and contains a little secondary chlorite (analysis 6, Table 6). In another sample, large corroded crystals of hornblende and sericitized plagioclase are set in a fine-grained quartzo-feldspathic matrix and the sedimentary origin is not obvious although chert pebbles occur in the outcrop (analysis 5, Table 6). Compositionally the tuff is higher in soda and silica that the spilite lava. The autochthonous beds may interfinger laterally with the Motton Spilite or may overlie that formation unconformably, but in either case are generally younger than the Motton Spilite.

Within the autochthonous rocks occur boulders, blocks and large slabs of lithologies contrasting with the autochthonous rocks. Hereafter these will be termed "slabs" to avoid confusion with clasts forming part of the autochthonous succession. The slabs comprise an "exotic" or allochthonous succession, and consist of siltstone, tuff, chert and chert breccia. Small slabs are monolithologic, large slabs consist of one or more lithologies interbedded.

Interbedded mudstone and chert breccia occur in slabs up to 400 feet long. The chert breccia itself contains slabs of chert up to 20 feet long. The 3 lithologies also occur separately as slabs 2-10 feet in length. For sizes smaller than about 6 inches the slabs of chert are difficult to differentiate from pebbles of chert included in the autochthonous beds although there are differences in rounding and sphericity which persist down to small sizes.

The following petrological descriptions are by Everard. The mudstone is white, fine-grained and consists mainly of sericite and quartz with a little clay (analysis 5, Table 5). The chert breccias are formed from close-packed cuneiform granules of chert and have less than 5 percent rounded pebbles of quartzite and a clay-sericite matrix (analyses 3 and 4, Table 5). The chert fragments are visible on chemically weathered (etched) surfaces, but in thin section the boundaries are not sharply defined, the fragments differing from the matrix in the slightly higher proportion of quartz to sericite. The slabs of interbedded mudstone and chert breccia are contorted, and in some of them (e.g. north of locality J, Figure 7) contain a transformational conglomerate (in the sense of Landes, 1945) composed of rounded boulders of chert averaging three inches diameter in a chert matrix.

There are some large slabs (midway between localities E and B, Figure 7) which consist of black chert. In section (Specimen No. 62-446) the chert consists of fine-grained quartz, sericite and carbon with aggregates of fine-grained crystalline calcite and disseminated very fine-grained pyrite. The rock is an autobreccia with the interstices between fragments filled with light-coloured chert (low in carbon) or pyrite. There is a group of small slabs of light-coloured chert (north of locality J, Figure 7) which consists (No. 62-441) of fine-grained quartz and sericite. There are some larger angular fragments of quartz and feldspar and disseminated grains of clay. There is abundant pyrite as disseminated grains and granular masses.

Two large slabs, each over 400 feet in length, are composed of welded spilitic tuff. The rock is tough, black and vitreous with rare "graded" beds of chert granule conglomerate and rounded boulders of diorite. The graded beds contain chert varying in amount from 50 percent at their bases to 10 percent at their tops. It is a compositional rather than a size grading. At the base of a graded bed the rock contains about equal amounts of chert and a very fine-grained, green, glassy lava as angular chips with interstitial magnetite. The lava fragments have no distinct boundaries, being distinct one from another only in relative grain size. Some coarse-grained fragments consist of albite needles and granules of pyroxene with clay, calcite and leucoxene in the groundmass (analysis 3, Table 6). Another sample consists of hornblende replacing pyroxene with some augite still remaining in sub-ophitic relationship with laths of plagioclase about 2 mm long. Disseminated magnetite and veins of clay material are present. The groundmass is a fine-grained aggregate of the same minerals (analysis 4, Table 6). Fine-grained glassy variants of the welded tuff superficially resemble black chert but can usually be distinguished from it by the use of a lens on fresh hand specimens. The proportions of alkalies in the welded tuffs are very similar to those in the spilite lava (cf. Spry, 1962b, p. 258). The compositions plot close to that of the "second-stage magma" of Spry (1962b, p. 262) but with an additional 3 percent silica derived from included detrital chert.

The general significance of the Beecraft Megabreccia is discussed elsewhere (p. 158). Discussion at this stage is confined to Montgomery's hypothesis that the structure is an erosionally dissected or perhaps tectonically disrupted unconformity. The general appearance of the outcrop is of many large slabs (allochthonous succession) of chert, welded tuff, chert breccia, and siltstone, embedded in a matrix (autochthonous succession) of greywacke mudstone, conglomerate and tuff. Montgomery's hypothesis stated that the slabs are an older sequence separated by an unconformity from the greywacke and tuff which are the younger sequence. Small rootless slabs would presumably be derived from erosion of pinnacles of the older sequence. Montgomery's hypothesis requires that the small slabs (rootless) would be essentially different from the large slabs which would have to be pinnacles rooting in depth. This is not the case. There is a complete gradation in sizes between small and large slabs. Some large slabs are twisted and are broken up at their ends into trains of aligned boulders. Slabs of all sizes are rootless masses.

Teatree Point Megabreccia

This is defined as that megabreccia west of, and adjacent to, Teatree Point at 4088E 9358N. The formation overlies Motton Spilite on the eastern side and is in faulted contact with the spilite on the western side.

The megabreccia contains autochthonous greywacke mudstone, conglomerate and sandstone. The conglomerate beds contain boulders up to two feet diameter of chert, mudstone, spilite, quartzite, and limestone. The basal beds of the succession are spilite boulder beds with large rounded spilite boulders averaging about two feet diameter. It is not known whether the formation overlies the spilite unconformably or not because the internal structure of the spilite is not known, but many of the boulders are not volcanic bombs and an erosional interval is probable. Much of the greywacke conglomerate has disrupted framework but there are beds of pebble and granule conglomerate with continuous framework which occur in beds up to 4 feet thick. The conglomerate is an unusual lithology in the Cambrian here, and Montgomery thought it was the unit now called the Duncan Conglomerate. The thickness of bedding is unusual and occurs elsewhere only in the *Leiopyge* zone near Riana (near the junction of Kaines and Milligans Creeks). The beds are composite with units which are poorly sorted but graded from pebbles at the base to usually granules towards the top. Some of the units of the composite beds have a thin layer of silt at their tops. The current ripples noted by Montgomery are asymmetrical current ripples on the top of a nearly horizontal bed and indicate currents from close to north.

The eastern part of the outcrop is highly contorted by interstratal folds, probably open-cast. One isoclinal recumbent fold near the Neptune Mine has an axis pitching steeply in an axial plane striking north. The closure floats in a large mass of autobreccia formed from the conglomerate. Transformational breccia ramifies through the outcrop as diffuse patches or as dyke-forms.

The allochthonous lithologies are chert, bedded limestone and massive calcareous dolomite in slabs up to 30 feet long. The bedded limestone is internally brecciated and crumpled by soft-sediment deformation. This may have occurred near the time of incorporation within the megabreccia as the bedding in one slab is deformed in conformity with the boundaries of the slab. Indeed, the slab has the form of a rolled-up pod.

Westbank Chaos

The term Westbank Chaos is a structural term and not a stratigraphic term, and refers to the assemblage of sheared Cambrian rocks on the footwall of the Westbank Fault, 200 yards east of Goat Island, near 4131E 9333N. On the western side the Chaos is in faulted contact with the Ulverstone Metamorphics, on the eastern side it overlies Rocky Cape Group with an inferred unconformity. The stratigraphic unit forming the Westbank Chaos was named the Westbank Beds in Banks (1962a) and is correlated with the Teatree Point Megabreccia as the lithologies in the Chaos are very similar to those at Teatree Point.

The autochthonous lithologies consist of coarse green and brown greywacke sandstone with mudstone and some conglomerate. Bedding is masked by a strong cleavage. In places this contains widely-separated boulders of mudstone up to six inches diameter.

The allochthonous lithologies occur within the chaos structure as slabs up to 200 feet long. Any particular lithology tends to occur in a train of slabs parallel to the Westbank Fault (Figure 68). The allochthonous succession can be determined from fragmentary successions preserved within the slabs and from the ordered arrangement of slabs of any one lithology. The units are:

(Top) Conglomerate.
Interbedded sandstone and mudstone.
Interbedded mudstone and calcareous mudstone.
Bedded limestone.
Massive calcareous dolomite.
Greywacke conglomerate with boulders of dolomite.

The conglomerate contains 90 per cent rounded to subrounded, discoidal to spherical pebbles ranging from one half to 12 inches diameter and averaging about two inches. The matrix is rock fragments varying from sand to granule size. The pebbles consist of greywacke sandstone (70 per cent), limestone and calcareous mudstone (20 per cent), and green and purple mudstone (10 per cent). There are rare boulders of chert, greywacke conglomerate and keratophyre. The conglomerate is well sorted with continuous framework. Beneath the conglomerate, mudstone, sandstone and calcareous mudstone alternate in beds about 8 inches thick. Brown subgreywacke sandstone dominates the top of the unit. The lowest 3 feet is almost entirely cross-bedded calcarenite (analysis 2, Table 7) with festoon cross-bedding in 8 inch sets indicating currents from the NNW in unrestored beds and originally from the NW. The bedded limestone is underlain by massive calcareous dolomite (analysis 3, Table 7) which is apparently structureless when fresh but which has a highly contorted crude banding of siliceous layers in deeply weathered rock. In one place the dolomite is underlain by greywacke mudstone containing boulders of dolomite from 4 inches to 4 feet in diameter. The outcrop in which this occurs appears to be part of the allochthonous succession. The conglomerate is about 20 feet thick, the bedded sandstone, mudstone and limestone is about 20 feet thick, the dolomite is about 20 feet thick, and the dolomite boulder bed about 5 feet thick. These thicknesses are of little meaning and the succession from which these slabs were derived could have been ten times as thick.

TABLE 7

Analyses of sedimentary rocks from the Westbank Chaos (4130E 9332N):

	(1)	(2)	(3)
SiO_2	59.86	20.70	11.00
Al_2O_3	15.78	5.67	0.94
Fe_2O_3	1.35	5.14	2.36
FeO	1.35	....	....
CaO	4.32	35.20	27.20
MgO	1.46	2.82	17.2
Na_2O	0.38	1.50	....
K_2O	4.09	0.16	
MnO	0.01	0.14	0.20
TiO_2	0.54	0.80	0.06
P_2O_5	3.16	0.13	0.52
H_2O+	3.45	....	....
H_2O-	0.70	....	....
CO_2	0.03	....	....
Ignition loss		28.08	40.43
C	1.48	....	...
FeS_2	2.26	....	....
	100.22	100.34	99.91

(1) Autochthonous mudstone.

(2) Allochthonous cross-bedded calcarenite.

(3) Allochthonous massive dolomite.

Analyst: C. J. Penman.

The rocks in the Westbank Chaos are assigned to the Cambrian on lithological grounds. The allochthonous lithologies are very similar to the allochthonous lithologies in the Teatree Point Megabreccia (particularly the cross-bedded calcarenite and the massive dolomite) which overlies the Motton Spilite.

Sedimentation during the Cambrian

There are several lines of evidence which show the system was deposited in a linear trough oriented north to south or NE to SW with an axial slope to the south. Observed current vectors are towards the south.

The Cateena Group is predominantly laminites of the first order (in the sense of Lombard, 1963). They interfinger southwards with massive claystone which outcrops near Sprent. The difference in facies could reflect difference in distance from a common source (cf. Hsu, 1960) but is thought to represent a cross-trough change, the laminites being deposited in the lowest part of the trough along the track of the currents and the claystone being deposited on the flanking high. The two facies could have the same or a different source.

Turbidites occur within the Cateena Group as two intercalations about 100 feet thick and about 1500 feet apart stratigraphically. In each intercalation the turbidites occur as groups of 20 to 30 beds. The beds at the base of the intercalation are thicker and coarser than beds at the top. The intercalations are thus " macro-graded units " in the terminology of Wood and Smith (1958). Each macro-graded unit is considered to be formed by re-deposition from a marine embankment of limited volume and the top of the units represents depletion of the source. Cyclic variations in grain size within the Dundas Group of the West Coast were noted by Carey and Banks (1954) and Banks (1956, p. 204) and termed " megacyclothems ". The megacyclothems were interpreted in terms of " tectonic instability and variations in height of the source area " (Banks, 1962a, p. 143). However, the macro-graded units of the Dial Range Trough are probably failures of an embankment type deposit which occurred whenever the front of the embankment reached a critical height or slope and do not necessarily represent tectonic changes. The beds immediately above the macro-graded unit at Cateena Point are predominantly laminites of the second order and pelagic deposits suggesting a diminution of the rate of supply and there is not alteration in the sediment corresponding to major tectonic or environmental change.

The Barrington Chert and Motton Spilite together form a large tongue which interrupts normal sedimentation and presumably is indirectly consequent upon the tectonic movement represented by the Hardstaff Unconformity at the base. The supply of normal sediment was not cut off as beds of mudstone and conglomerate occur within the chert and much of the chert is very impure; however, the environment was swamped by an influx of silica.

The Radfords Creek Group is mainly laminites of the first order in the southern part of the Dial Range, but with some thick turbidites near the top of the succession. The clasts are almost entirely derived from older units of the Cambrian succession. In the Sugarloaf Gorge the quartzite conglomerate was derived from the Rocky Cape Group on the western flank of the trough and represents a major change in provenance, presumbly due to the first emergence of the Rocky Cape Geanticline (of Carey, 1953). This conglomerate is well-exposed in the country between Loyotea and Loongana (in the Valentines Peak Quadrangle) where it is a continuous-framework deposit of well-rounded cobbles. It is there overlain by many hundreds of feet of mudstone so the environment of deposition was short-lived.

At the north end of the trough the autochthonous beds of the Beecraft Megabreccia are predominantly turbidites and the conglomerate in places contains a significant proportion of pebbles derived from the Rocky Cape Group. In the Teatree Point Megabreccia are very thick beds of granule chert conglomerate which are thought to represent a greatly-increased rate of supply. In the Beecraft Megabreccia and its correlates are enormous slabs of lithologies such as spilitic tuff, dolomite, cross-bedded calcarenite, chert granule conglomerate, and continuous-framework conglomerate, which are rare or unknown in the Cambrian. The megabreccias were formed by gravity down-sliding of large masses of semi-indurated material from the flanks of the trough. The deposits are the first products of the Jukesian Movement. At this time there was a significant difference between the sediments in the axis of the trough and the deposits of the flanking unstable shelves, due to the trough being very shallow and very narrow.

Igneous Intrusive Rocks

Serpentinite at the Forth and Clayton Rivers was recorded by Gould (1867), and Twelvetrees (1906b, pp. 11, 55, and sketch map p. 14). Twelvetrees (1909b, p. 15) described the rock as consisting of orthorhombic pyroxene and serpentine pseudomorphing olivine and named the original rock olivine-enstatite peridotite or harzburgite. Blake (1928c) and Taylor (1955) recorded the serpentine at the Clayton River as intrusive into the Precambrian rocks because " Around the serpentine bodies the planes of schistosity of the schist series are disturbed . . .". The serpentinite near Forth is an intrusion concordant with the foliation in the country rock and in one place has a foliation with pyroxene dimensionally oriented parallel to the boundary. The serpentinite at the Clayton River was considered by Taylor to be 4 or 5 physically distinct sill-like bodies. The serpentinite is a larger and more continuous body than Taylor supposed and is concordant in only its gross aspects. There is evidence of dilational emplacement in that, with removal of the largest mass shown on Devonport Map Sheet, the belts of quartzite on each side can be mated to form a single belt comparable in size and form with others in the Forth Metamorphics. Although concealed, the boundary must cut across the foliation in places. The " disturbance " of the foliation in schist occurs in this area due to Tabberabberan refolding of the foliation and has no necessary relation to the mechanics of intrusion. The serpentinite contains large aligned xenoliths of amphibolite, one with a strong lineation due to dimensionally oriented hornblende. The serpentinite is post-metamorphic and is correlated with Cambrian serpentinite occurrences in other parts of Tasmania.

There is a stock and a number of dykes which intrude Cambrian rocks on the foreshore east of Penguin (shown in Figure 7). These are identified as Cambrian in age because of their similarity to extrusive rocks interbedded with Cambrian sediments. A dyke in the Teatree Point Megabreccia appears to have been deformed in company with enclosing sediments at a time when the sediments were probably semi-indurated which dates the intrusion as Upper Cambrian. There are boulders of keratophyre in the Duncan Conglomerate (Ordovician) on the south bank of Myrtle Creek above the Myrtle Creek Falls which may have been derived from one of the intrusions. Intruding the Teatree Point Megabreccia are two thin dykes which consist according to Everard of phenocrysts of feldspar which average 2 mm diameter and are almost completely pseudomorphed by sericite in a fine-grained groundmass of mica, cloudy feldspar and fresh, untwinned anhedral albite averaging 0.05 mm diameter (analysis 1, Table 8). The rock has a well-marked flow texture. The dykes post-date the sedimentary folds, as they cut across them, but pre-date the shear zones being offset by them. The offset is not always a clean displacement. The age of the shear zones is uncertain, but as the dykes sometimes stop short of them, have rounded ends, and some small pieces are rotated and twisted, there appears to have been a pulling-apart of the dykes with mudstone flowing into the gap.

TABLE 8

Analyses of Cambrian Intrusive Rocks

	(1)	(2)	(3)	(4)
SiO_2	72.82	59.32	61.68	63.30
Al_2O_3	12.88	15.06	14.19	15.25
Fe_2O_3	0.86	2.74	0.29	0.86
FeO	3.08	4.46	1.38	2.28
CaO	0.24	4.64	7.68	4.04
MgO	1.01	3.53	1.70	5.00
Na_2O	2.28	3.51	3.79	4.19
K_2O	3.79	2.26	1.35	1.13
MnO	0.06	0.11	0.03	0.12
TiO_2	0.25	0.59	0.47	0.51
P_2O_5	0.06	0.10	0.03	0.08
H_2O+	2.00	2.93	2.02	2.32
H_2O-	0.40	0.16	0.15	0.13
CO_2	0.21	0.95	4.57	0.44
FeS_2	0.22	Trace	0.37	0.58
	100.16	100.36	99.70	100.23

(1) Trachyte dyke intruding Teatree Point Megabreccia, Neptune Mine (4090E 9358N).

(2) Dyke intruding Motton Spilite, Penguin (locality B, Figure 7 (4084E 9359N).

(3) Dyke intruding Beecraft Megabreccia (locality C, Figure 7) 40795E 93605N).

(4) Stock intruding Beecraft Megabreccia(locality D, Figure 7) (40775E 9361N).

Analyst: C. J. Penman.

A dyke intruding the Motton Spilite consists (Everard) of megacrysts of albite in a fine-grained matrix of clinozoisite, chlorite, albite and calcite. The texture is porphyritic and there is no free quartz (analysis 2, Table 8). This rock is very close to the keratophyric extrusives in composition (Table 4).

Intruding the Beecraft Megabreccia is a small stock (Figure 7) with a number of radial dykes. The rock is (Everard) medium-grained with an even, hypidiomorphic texture and subhedral, zoned, heavily sericitized plagioclase, irregular grains of quartz and laths

5 cm

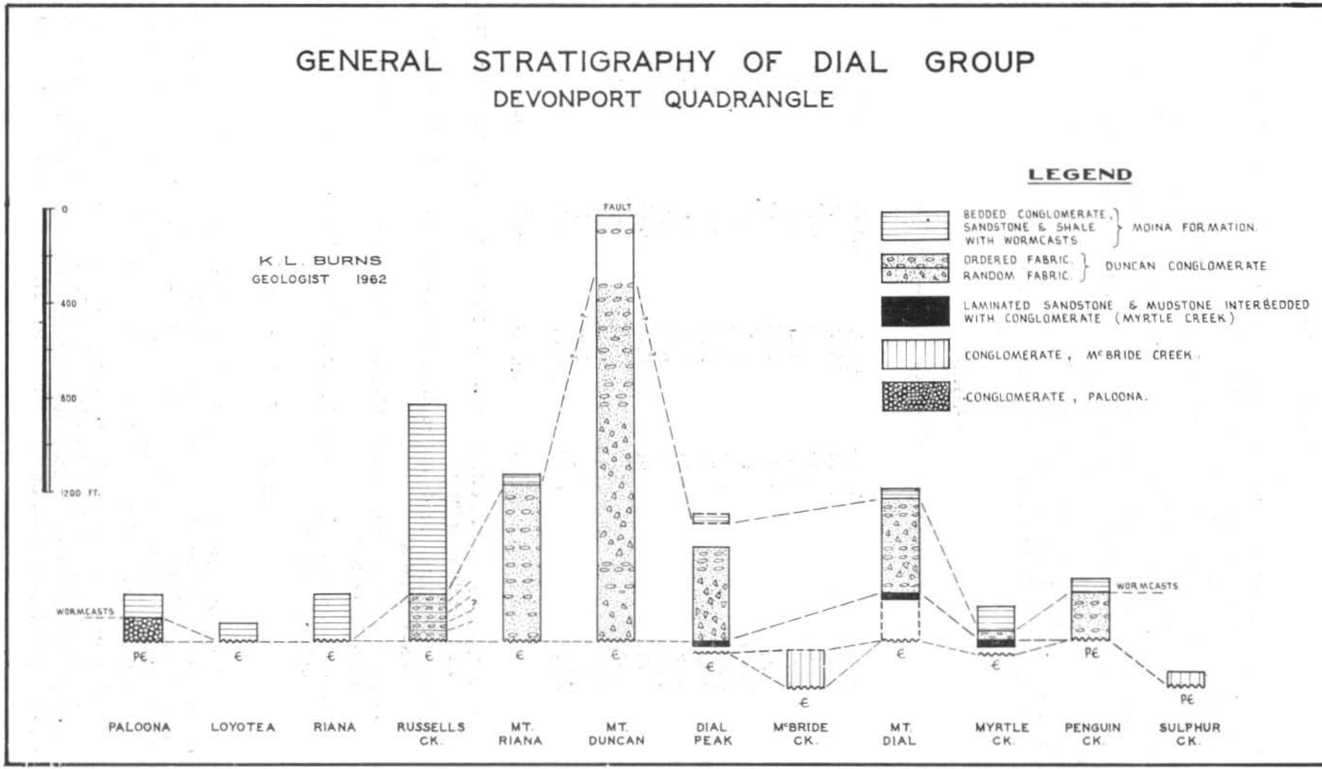


FIGURE 10.

and ragged crystals of tremolite. Sphene and pyrite occur as accessories (analysis 4, Table 8). The dykes are porphyritic with feldspar crystals 2 to 3 mm long completely altered to carbonate or sericite, anhedral albite with many inclusions, and irregular scattered ilmenite. The groundmass is an aggregate of the same minerals (analysis 3, Table 8). With respect to the stock, the dyke is lower in soda, much lower in magnesia, and contains a significant quantity of lime as the carbonate. The stock is crowded with xenoliths of the common adjacent rock types, including some of spilitic derivation, and has some large slabs as roof pendants. The eastern side is virtually a stock work. There is uniformity in the weathered appearance of these rocks which makes boundaries difficult to map but the distinction between stock and country rock is clear-cut in thin section. The compositional differences between the stock and the dyke appear to be due in part to contamination of the stock.

ORDOVICIAN SYSTEM

The Ordovician System in Devonport Quadrangle is represented by the Gordon Limestone overlying the Dial Group which consists of conglomerate, sandstone and shale. The succession, with youngest strata first, is:

Gordon Limestone

Dial Group	Moina Sandstone
	Duncan Conglomerate
	? Unconformity (not always present)
	Gnomon Mudstone

The Dial Group is defined as that group of predominantly siliceous clastics which overlies the Cambrian rocks unconformably and is overlain (conformably or perhaps disconformably) by the Gordon Limestone, in the Dial Range. In some places the group or its correlates rests on Precambrian. A succession has been established in the Dial Range and is listed in the table above, but there are several lithologically-distinct types of conglomerate which occur outside the Dial Range at Eugenana, Paloona and Sulphur Creek, the positions of which in relation to this succession are uncertain. (See Figures 10, 11).

The Magog Group has been defined (after Johnston, 1888, p. 39) as that group of sandstone and conglomerate units which unconformably overlies the Cambrian and is conformably overlain by the Gordon Limestone at Mt Magog near the junction of the Lobster Rivulet and the Mersey River. The Dial Group is strictly equivalent to the Magog Group in terms of stratigraphic position but is a " lithological *tout ensemble* " (Twelvetrees, 1909b, p. 9) which is different in many respects from the Magog Group. There is a marked lithological contrast between the Dial Group and the Magog Group which was recognized by Twelvetrees (1909b) and by Jennings *et al.* (1959) and the latter have, in fact, differentiated the two groups. A group is a lithogenetic entity and at this stage it is felt that the Magog Group and the Dial Group were, although deposited at the same time, probably deposited in different basins of sedimentation under different conditions of transport and may not together constitute a single lithological entity.

The conglomerate on the Dial Range was described by Gould (1867) who doubted whether all the strata in the district were

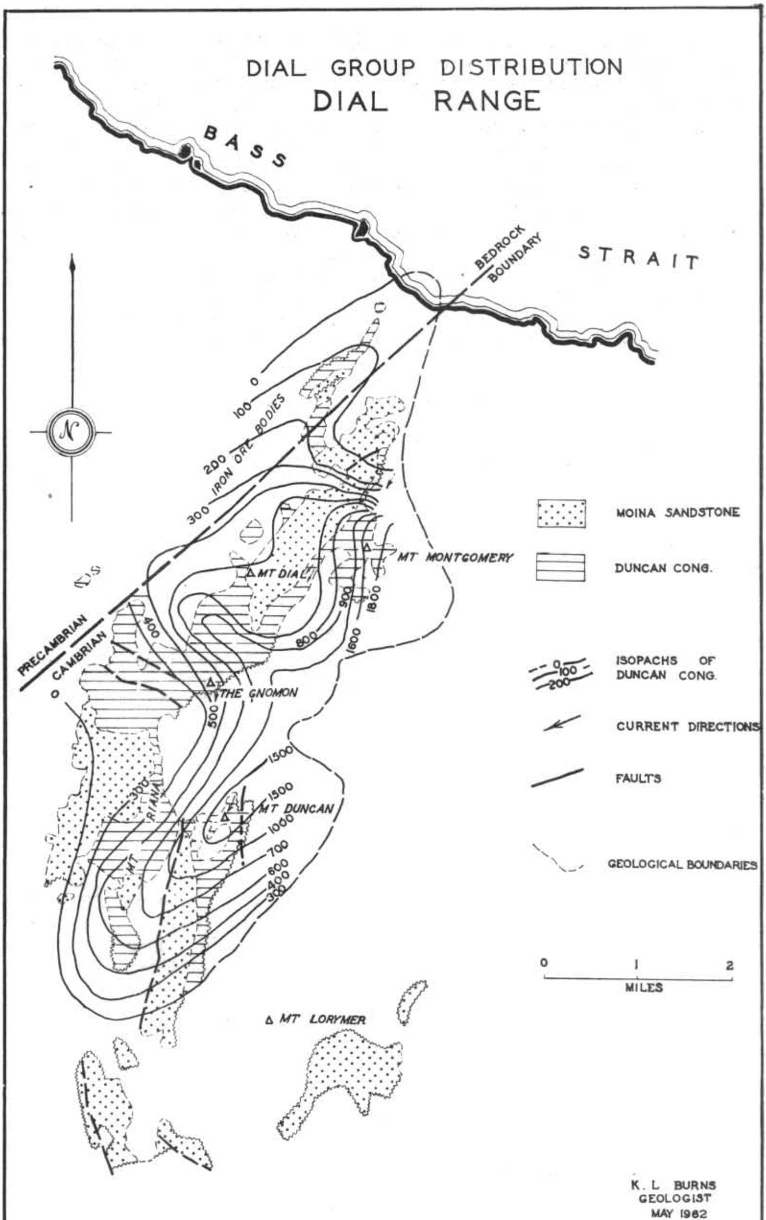
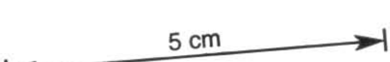

DIAL GROUP DISTRIBUTION
DIAL RANGE
BASS
STRAIT
BEDROCK BOUNDARY
PRECAMBRIAN
CAMBRIAN
IRON ORE BODIES
MT MONTGOMERY
MT DIAL
THE GNOMON
MT DUNCAN
MT RIANA
MT LORYMER
MOINA SANDSTONE
DUNCAN CONG.
ISOPACHS OF DUNCAN CONG.
CURRENT DIRECTIONS
FAULTS
GEOLOGICAL BOUNDARIES
0 1 2
MILES
K. L. BURNS
GEOLOGIST
MAY 1962

FIGURE 11.


5 cm

conformable, ". . . or whether some great break may not intervene between the breccias forming the summit of the Dial Range, and the clayslates and conglomerates forming the country below . . . ." Gould recognized that one unit of the Dial Group, the Penguin Creek beds, underlies the Gordon Limestone.

In 1896 Montgomery considered that what is here called the Dial Group extended down to sea-level at the Neptune Mine and thought the unconformity inferred by Gould was exposed there. Twelvetrees (1906b) considered that eruptive rocks (mainly Cambrian) preceded the "conglomerates of the Dial Range" (p. 11) and repeated Montgomery's view that the conglomerate descends to sea-level at the Neptune Mine, although he termed the Neptune Mine outcrop an "ill understood breccia". Twelvetrees (1909b) recorded that the conglomerate underlies Gordon Limestone at several places and overlies Cambrian slate. He also pointed out that it has a distinctive lithology which distinguishes it from what is now known as the Owen Conglomerate of Western Tasmania, but which is similar to that of the breccias at the Neptune Mine.

Johnston (1887; 1888) used the term "Dial Range and North West Coast Conglomerates" as a heading under which to discuss various conglomerates in many places, not necessarily all of the same age. Variations of the term were discussed in Smith (1957) and the term "Dial Conglomerate" was used by Jennings *et al.* (1959). The term "Dial Group" as used here is a redefinition of the term which follows the views of Gould (1867). Although the conglomerate of the Dial Group has been confused with other conglomerates by early authors, this re-instatement of the term is unlikely to lead to nomenclatural confusion.

Dial Group

GNOMON MUDSTONE

The Gnomon Mudstone is defined as the purple mudstone and fine sandstone which underlies the Duncan Conglomerate in Myrtle Creek at 4062E 9332N. It overlies the Cambrian System with an inferred (concealed) unconformity. The maximum exposed thickness is a little more than 30 feet, but in many places this formation is absent.

The succession on the face of the Gnomon, near 1,200 feet a.s.l., is as follows (youngest strata first):

	Inches
Duncan Conglomerate	
? Inferred unconformity	
Gnomon Mudstone	
Interbanded mudstone and sandstone	4
Conglomerate, with a wash-out at the base trending to 360°	7
Interbanded, interlaminated mudstone and sandstone	16
Conglomerate	3
Mudstone	1.5
Conglomerate	2-4
Interbanded mudstone, sandstone and conglomerate	6

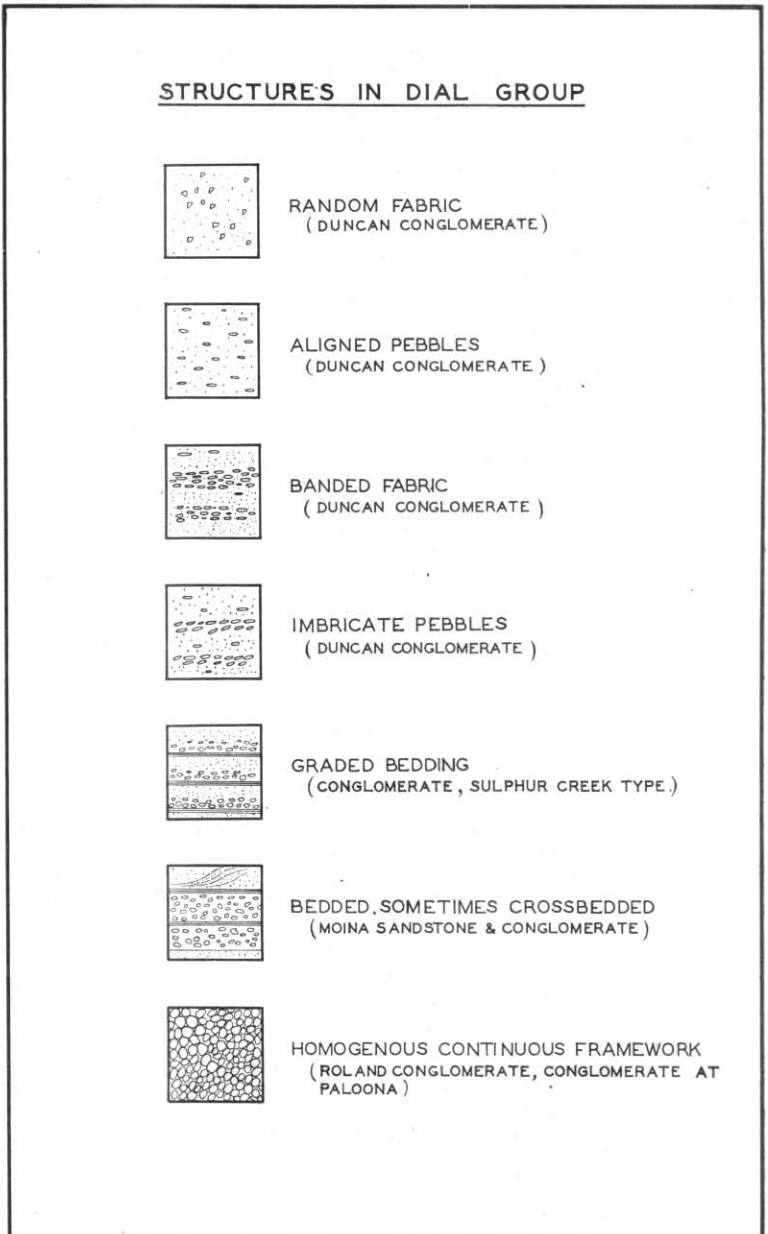

STRUCTURES IN DIAL GROUP
RANDOM FABRIC
(DUNCAN CONGLOMERATE)
ALIGNED PEBBLES
(DUNCAN CONGLOMERATE)
BANDED FABRIC
(DUNCAN CONGLOMERATE)
IMBRICATE PEBBLES
(DUNCAN CONGLOMERATE)
GRADED BEDDING
(CONGLOMERATE, SULPHUR CREEK TYPE.)
BEDDED, SOMETIMES CROSSBEDDED
(MOINA SANDSTONE & CONGLOMERATE)
HOMOGENOUS CONTINUOUS FRAMEWORK
(ROLAND CONGLOMERATE, CONGLOMERATE AT PALOONA)

FIGURE 12.

Followed downwards by:

	Feet
Covered interval	50
Inferred decollement	
Covered interval	800
Cambrian rocks	

The Duncan Conglomerate dips 15° to the SW, as determined from computations of apparent dips in the cliff face and direct measurements west of the summit. The Gnomon Mudstone, however, dips 45N290, implying an unconformity at the top of the formation. The contact is exposed, but in a face parallel to the strike of the mudstone and so shows no apparent discordance. The conglomerate bands in the succession are similar to each other as they consist of 80 to 90 percent chert as pebbles averaging two inches diameter with rare pebbles of mudstone in a matrix of granular chert. The chert pebbles are subangular.

At Myrtle Creek Falls (40613E 93325N) the succession on the south side of the creek is:

Duncan Conglomerate
Disconformity or thrust
Gnomon Mudstone: interbedded, interlaminated siltstone and sandstone, 30 feet thick with gaps.
Base concealed.

The Gnomon Mudstone has bands 1-6 inches thick of interlaminated siltstone and fine sandstone, of a dark red colour due to abundant hematite in the matrix. The contact with the Duncan Conglomerate may be a thrust as there are a number of thrusts exposed by the waterfall. There is a bed of laminated mudstone, 6 inches thick, near the base of the Duncan Conglomerate.

On the north side of the creek, the succession is:

	Inches
Duncan Conglomerate	
Gnomon Mudstone	
Laminated sandstone and siltstone, load-casted at the base	12
Conglomerate	12
Laminated sandstone and siltstone, containing a thrust fault	72
Base concealed.	

The top of the Gnomon Mudstone is put at the top of the highest mudstone band.

A composite section at Myrtle Creek is:

	Feet
Duncan Conglomerate	
Gnomon Mudstone	
Interbedded conglomerate and laminated mudstone	2 (approx.)
Laminated sandstone and siltstone (with gaps)	30
Covered interval	50 or less
Cambrian conglomerate	

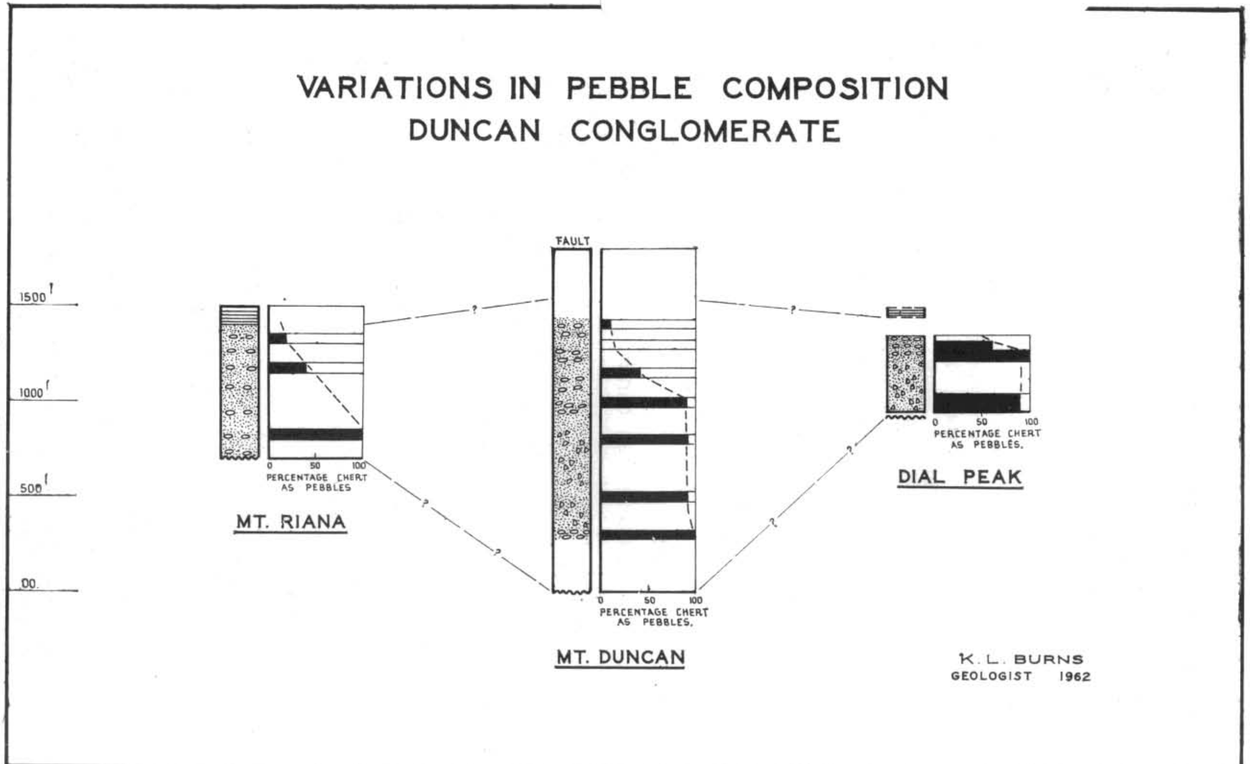

VARIATIONS IN PEBBLE COMPOSITION
DUNCAN CONGLOMERATE
1500'
1000'
500'
00.
MT. RIANA
PERCENTAGE CHERT AS PEBBLES
0
50
100
FAULT
MT. DUNCAN
DIAL PEAK
K. L. BURNS
GEOLOGIST 1962

FIGURE 13.

The formation is exposed north of Myrtle Creek at 40605E 93375N where it is 3 feet thick (base concealed) and consists of conglomerate interbedded with interlaminated sandstone and coarse siltstone, the beds being 3 inches thick. It is underlain by Cambrian mudstone which outcrops below a covered interval of about 30 feet.

The Gnomon Mudstone is assigned to the Dial Group because conglomerate bands within the Gnomon Mudstone are very similar to the Duncan Conglomerate; there is a transitional passage between the two formations expressed as lithological alternations; the formation is distinct from the mudstone of the Cambrian System in having a high proportion of detrital hematite; there is a pronounced structural hiatus inferred between the Gnomon Mudstone and the top of the Cambrian System.

DUNCAN CONGLOMERATE

The Duncan Conglomerate is defined as the conglomerate forming Mt Duncan, outcropping between the foot of the cliffs on the eastern face near 4038E 9268N and the headwaters of Hardstaff Creek near 4024E 9255N. The Duncan Conglomerate forms the lower parts of Mts Riana, Dial and Montgomery. The passage into the Moina Sandstone on Mt Riana and Mt Dial, where the conglomerate is about 650 feet thick, is by simple superposition. However, SW of Mt Duncan and immediately west of Mt Montgomery in areas where the conglomerate approaches maximum thickness, the field evidence suggests an interfingering relationship.

Isopachs on the Duncan Conglomerate are shown in Figure 11 The thicknesses were measured in the usual sense, that is, normal to bedding, but must be treated with some caution as the formation is a fanglomerate and thicknesses measured this way do not have the same significance that they have in other sediments.

The conglomerate is usually bimodal, sometimes trimodal, with the coarse fraction ranging from pebbles to boulders and the fine fraction from coarse sand to granules. The fabrics are termed " random ", " aligned " or " banded " as in Figure 12. Imbricate fabric is rare. These fabrics are characteristic of the Duncan Conglomerate and may be used to distinguish it from other formations of the group.

The pebbles consist of quartzite and vein quartz derived from the Precambrian Rocky Cape Group, hematite from a siliceous Precambrian orebody such as is now exposed in Penguin Creek, limonite from the hydrated Cambrian orebody of the Iron Cliffs, Cambrian chert largely derived from the Barrington Chert, and also rare boulders of Cambrian lava and mudstone. The proportion of chert decreases upwards in the formation as shown in Figure 13.

Penguin Area

On the western limb of the syncline at Penguin Creek, the Duncan Conglomerate is 100 feet thick, overlain by Moina Sandstone and resting unconformably on cleaved siltstone of the Rocky Cape Group.

Near the mouth of Penguin Creek, at 40610E 93604N, the pebbles consist of equal amounts of chert and Rocky Cape Group sandstone averaging one inch diameter. The matrix is angular chert averaging 2 mm and ranging up to 8 mm diameter. One boulder of siliceous hematite is 6 inches diameter.

Further south (4052E 9350N) the conglomerate contains 90 percent chert pebbles averaging half an inch, angular to rounded. Yet further south (4050E 9337N) rounded chert averaging a quarter inch forms 90 percent of the rock. From this variation, the conglomerate must have a banded fabric and this is visible in one outcrop on Marsdens Hill (at 40505E 93345N). A boulder bed within the conglomerate on Marsdens Hill has pebbles consisting largely of hematite.

On the eastern limb of the Penguin syncline, between 40595E 93370N and 40605E 93375N, the succession is:

	Ft.	In.
Duncan Conglomerate		
Bedded conglomerate	20	0
Banded conglomerate	1	8
Aligned conglomerate (min.)	25	0
Gnomon Mudstone		

In the uppermost unit, the beds average 6 inches thick and range up to 18 inches. The grain size varies between distinct beds, from coarse sandstone through granule conglomerate to pebble beds with pebbles averaging half an inch diameter. The grain size varies within narrow limits within beds, some of which are graded. Many beds, both coarse and fine, disappear by overlap to the NE.

The banded conglomerate has a layering defined by the segregation of pebbles into bands. The fine bands, with matrix dominant, are about one inch thick and occur at 4, 10, 15.5, 19, and 21 inches from the base. The bands have no clearcut boundaries. This bed is exposed for about 20 feet along the outcrop, then disappears by overlap to the NE.

The basal member contains 5 percent subrounded pebbles of Rocky Cape Group sandstone averaging 1.5 inches diameter, 10 percent subrounded chert averaging one inch and 10 percent siliceous hematite averaging one inch diameter. Boulders of ferruginous mudstone, rounded, and up to 12 inches diameter, are rare. Some of the chert pebbles show leached margins suggesting subaerial leaching before inclusion in the conglomerate. The matrix is angular chert, granule size, containing contorted shreds of micaceous hematite up to one inch long. The micaceous hematite is very friable and fragments this size are compatible with a source near the Penguin Creek iron field, one mile to the west. The conglomerate has a directed fabric with ellipsoidal pebbles having their long axes directed parallel to bedding.

Several hundred yards north, about 10 feet of this conglomerate is exposed, overlying the Gnomon Mudstone. The pebbles are still directed, but a further element of sorting has been introduced in that they are segregated into bands. The pebbles in the bands average 0.5 inch diameter, with some bands containing rounded cobbles up to 4 inches diameter. These bands are graded with larger pebbles at the base. A few bands show imbricate structure which indicates currents from the NE. There is a pronounced change in this bed in a short distance from a homogeneous texture and directed fabric to banded texture and directed, sometimes imbricate, fabric.

At the Devon Consols copper mine, near 40590E 93400N, is a bed of iron ore within the conglomerate, described by Montgomery (1896) as an interbedded syngenetic iron ore indicating lacustrine conditions of deposition. It is, however, a bed of boulders of hard hematite (with some chert boulders) which resemble the hard nodules of blue hematite found in the Penguin Creek orebody. This layer of bedded hematite conglomerate is probably the same as at Marsdens Hill which is about 50 feet above the base of the formation. It is found south of Myrtle Creek near 40625E 93290N and is probably continuous through the area north of Mt Montgomery.

At Myrtle Creek Falls, 40613E 93325N, the Duncan Conglomerate is 70 feet thick, overlain by Moina Sandstone and underlain by Gnomon Mudstone. The conglomerate has continuous size range from coarse to fine with no distinct modes or textural segregation of sizes. The range averaging 0.5 inch diameter forms about 20 percent, the range from 0.25 to 0.125 inch forms about 40 percent and is noticeably more angular, while coarse sand and finer sizes form about 40 percent of the rock. Ninety-five percent of the pebbles are chert, 5 percent are hematite, and one spilite pebble, 0.5 inch diameter, was noted. Pebbles of sandstone and rarely mudstone are found near the top of the unit.

If the conglomerate is traced south from Myrtle Creek Falls, it is found near 40625E 93290N to contain boulders up to two feet diameter of chert, greywacke mudstone and keratophyre. This is the only locality in the Dial Range where the Duncan Conglomerate contains Cambrian rocks other than chert. The keratophyre resembles intrusives in the Teatree Point Megabreccia suggesting a source NE of Sullocks Hill, NE of the conglomerate outcrop.

Mt Dial

On Mt Dial, 70 chains SW of Mt Montgomery, near 40475E 93085N, the Duncan Conglomerate underlies Moina Sandstone. The exposed thickness is 500 feet. The total thickness is near 700 feet, inferred from profiles. The bottom 200 feet is concealed by talus.

At 700 feet a.s.l. or 300 feet above the base, the conglomerate is banded, with bands averaging 7 inches thick. Coarse bands contain tabular to subspherical, angular pebbles of white quartz (rare), banded chert (55 percent), micaceous hematite (5 percent) averaging about one inch diameter. The matrix is granular chert. Some of the banded chert pebbles have leached margins. The fine bands are subspherical, subangular chert averaging very coarse sand or granule size, with rare rounded pebbles of chert and hematite up to two inches diameter.

For 100 feet above this the conglomerate is homogeneous, but at 850 feet there is another banded zone 5 feet thick which extends along the face for over 300 feet. The fine bands have weak, thin laminae due to variations in grain size from coarse to medium sand. The pebble bands have imbricate structure indicating currents from near 030°. The bands are not clear-cut but grade into each other.

At 1100 feet a.s.l. abundant boulders of hematite indicate a bed rich in iron. At the same altitude further north (40475E 93135N), stratigraphically immediately above, there are numerous boulders of wormcast sandstone assigned to the Moina Sandstone.

The Gnomon

The base of the Moina Sandstone, from projections, passes over the Gnomon about 100 feet above the peak. The conglomerate is 450 feet thick on the Gnomon and rests on the Gnomon Mudstone. The rock is fairly uniform in character, the principal variations being in the type and size of ferruginous fragments and the fabric of the rock.

At the base of the peak, at 1200 feet a.s.l., the lowest conglomerate bed consists of rounded, black, white and banded chert pebbles in a matrix of chert of very coarse sand to granule size. The matrix contains a few scattered granules of mudstone. The pebbles form 0-90 percent of the rock.

At the foot of the SE face, the lowest conglomerate bed contains boulders up to 8 inches diameter of limonite, forming 20 percent of the rock, with stalactitic, botryoidal, and radiating structures due to weathering. The limonite was derived from the orebody at the Iron Cliffs (Burns, 1961b) about one mile away.

At 4028E 9286N, 1200 feet SW of the Gnomon at 1050 feet a.s.l. and about 50 feet above the nearest exposed Cambrian rock, the conglomerate consists of rounded to subrounded, spherical boulders of laminated chert up to 12 inches diameter, averaging 4-6 inches, forming 10 percent of the rock. The fabric is random with a tendency to banding. The matrix is interbedded granule size and very coarse sand size, angular chert, in beds 6-24 inches thick.

At 1350 feet a.s.l. on the Gnomon, iron occurs as ferruginous pebbles up to two inches diameter. At 1400 feet, chert pebbles averaging two inches diameter are set in hematite cement. Except for a small area at Penguin Creek, this is the only place where iron is noticeable in the finer grade. At 1450 feet there is a ferruginous bed which has hematite pebbles averaging one inch diameter forming 60 percent of the rock.

At 1500 feet a.s.l. the conglomerate is strongly banded. The pebbles are subangular to subrounded, pink and white chert with 10 percent of them being solid red hematite. The matrix is chert of granule to coarse sand size. The banding is due to alternation of pebble-rich and pebble free layers averaging 6 inches thick.

At 1550 feet a.s.l., at 40287E 92892N, the pebble bands are about 3 inches thick, containing 60 percent rounded chert averaging 0.5 inch, 10 percent subrounded limonite averaging one inch and less than 5 percent sandstone and mudstone. The matrix is angular, granule-size chert. Within the pebble bands are occasional lenses of laminated, fine sandstone averaging one inch thick. Where iron is prominent among the pebbles a small proportion also appears in the matrix.

The rock at the summit of the Gnomon is massive and is composed of angular chert varying from granule to very coarse sand size.

In summary, the 450 feet of Duncan Conglomerate exposed on the Gnomon has a matrix of angular chert varying from very coarse sand to granule size. Hematite cement is exceedingly rare. The pebbles occur segregated into bands, except close to the base. The pebbles decrease in size upwards, from 8 inches diameter near the base to one inch near the top. Iron is prominent among the pebbles in the bottom 300 feet but is insignificant above this. At the top of the cliff, a new pebble type, sandstone (and rarely mudstone) of the Rocky Cape Group begins to appear, confined to the coarse fraction. Soft mudstone occurs as rare pebbles at the base; a little higher up it forms part of the matrix; higher still, it is absent. No pebbles of white secretion quartz were observed.

Mt Duncan

The lowest part of the succession on Mt Duncan is repeated by a steep fault across the eastern face. With allowance for this, the succession in an E-W line across the peak is 1800 feet thick, unconformably overlying the Cambrian and cut off in the west by the Duncan Fault. The passage into the Moina Sandstone occurs SW of the peak.

The lowest 300 feet is a chert granule conglomerate with pebble bands as on Mt Dial. The top of the cliff on the east face (40358E 92645N), 300 feet above the base, has rounded to angular pebbles of white chert 1-2 inches diameter, occurring in bands 6-8 inches thick. No other rocks occur as pebbles. The matrix is angular to subangular chert of granule size. The conglomerate here shows spheroidal weathering, resembling folding, but in a pattern which can be shown to be formed by concentric indurated bands about one inch wide inside joint blocks, forming closed loops and cross-cutting pebble bands. The conglomerate has a directed fabric.

At 40350E 92648N, 800 feet east of the summit, and stratigraphically 500 feet above the base, the rock is granule conglomerate with occasional chert pebbles averaging one inch. It contains beds about two feet thick of coarse sandstone. The conglomerate has a directed fabric.

At 500 feet east of the summit, 800 feet above the base, are found the first "exotic" pebbles, namely clear white rounded quartz averaging one inch diameter and forming 10 percent of the pebbles. The fabric in the conglomerate is random.

At 250 feet east of the summit, 1000 feet above the base, (40335E 92655N) the pebbles are predominantly chert, with some sandstone, averaging 4 inches diameter and arranged in bands, one of which is only 6 inches thick. The matrix is 90 percent chert, 10 percent sandstone, ranging from granules to pebbles in size, and averaging a quarter inch diameter. The bedding is here 55W010 with imbrication well-marked on faces striking near 070°, indicating currents from the NE.

At the summit of Mt Duncan, 1200 feet up in the succession, the conglomerate consists of subangular pebbles of sandstone, quartz schist, and pink and white chert, averaging one inch diameter but with one 4-inch chert boulder. Chert comprises 40 percent of the pebbles, schist and sandstone 30 percent apiece. The matrix is 60 percent white chert, 40 percent angular quartzite, 4-8 mm diameter. In places the conglomerate is very coarse sandstone with large rounded quartzite cobbles forming 60 percent of the rock.

At 1300 feet above the base (40315E 92650N) the pebbles are rounded to subrounded quartzite and micaceous quartzite averaging half an inch diameter, ranging from a quarter to one inch. The matrix varies from granules to very coarse sand. The pebbles are arranged in ill-defined bands about two inches apart, the pebbles comprising about 90 and 10 percent of the rock alternately. The fabric is directed, with the foliated rocks occurring as flattened discs with long axes in the bedding.

At 40310E 92655N, 250 feet west of the summit, 1400 feet above the base stratigraphically, the conglomerate is unsorted. There appear to be three modes at 0.1, 0.5, and one inch diameter. Rounded to subrounded white quartz forms 90 percent of the two larger sizes, foliated micaceous quartzite forms 40 percent of the smaller, with black and white chert the remainder.

The top 400 feet of the succession is not well exposed.

In summary, the conglomerate on Mt Duncan consists dominantly of chert for the lowest 500 feet, above which the amount of quartz and quartzite increases steadily to reach 60 percent at 1200 feet and 90 percent at 1300 feet and above. The matrix ranges from very coarse sand to granular chert. Textures are random or banded, the latter with directed, rarely imbricate, fabric. Rocks from a Precambrian source form 10 percent of the pebbles at 800 feet, enter the matrix at 1000 feet (10 percent) and are important matrix constituents higher (40 percent).

Hardstaff Creek

At Hardstaff Creek, SW of Mt Duncan, the Duncan Conglomerate unconformably overlies Cambrian greywacke conglomerate with interbedded sandstone and mudstone and is overlain by Moina Sandstone.

The conglomerate is about 300 feet thick, consisting generally of rounded to subrounded quartzite averaging two inches and chert 2-4 inches diameter in a very coarse sandstone matrix which comprises 40 percent of the rock The conglomerate near the base has the pebbles aligned in bands, and contains occasional beds of sandstone 18-30 inches thick. Chert is always the subordinate pebble type.

Mt Riana

At the south end of Mt Riana, the conglomerate is 650 feet thick, overlying Cambrian greywacke and conglomerate. At 100 feet above the base (40155E 92375N) the coarse fraction is subangular chert averaging one inch diameter, occurring in bands which sometimes contain only a single row of pebbles. The matrix is subangular chert ranging from 4 mm to very coarse sandstone size. The amount of chert as pebbles decreases upwards, so that at 500 feet pebbles of quartz and quartzite are predominant.

MOINA SANDSTONE

The Moina Sandstone of Twelvetrees (1913), as re-defined by Jennings (1958), is that formation of well-bedded sandstone, shale, and conglomerate which conformably overlies Roland Conglomerate in the Magog Group.

In the Dial Group, the name Moina Sandstone is used for that lithological assemblage consisting of well-bedded sandstone, shale and conglomerate, which has pebbles of largely Precambrian derivation, and which records marine organisms in the form of fossils, worm borings and painted markings.

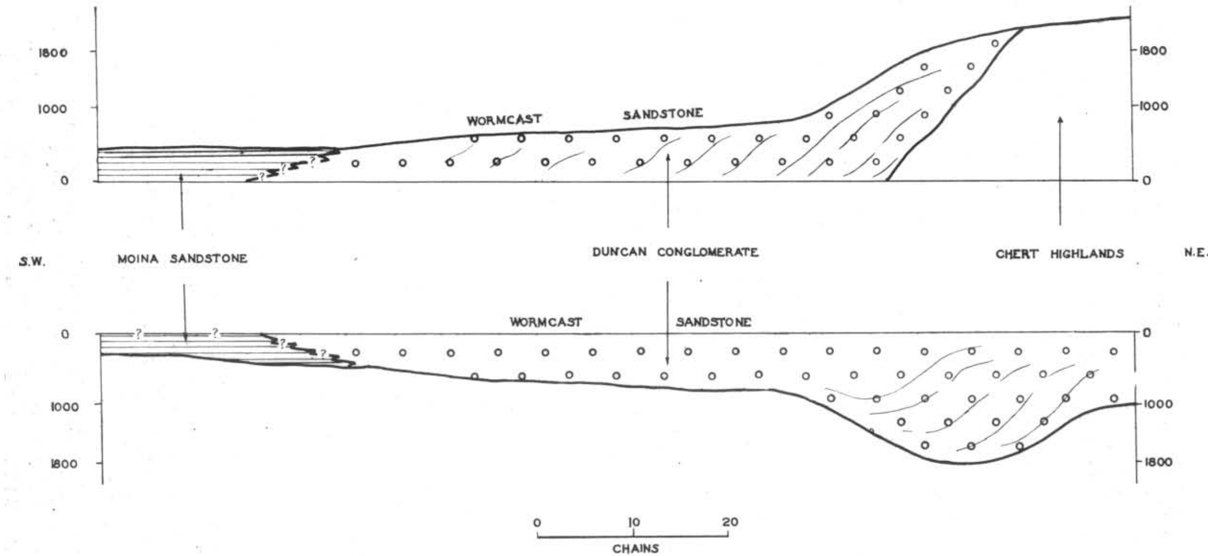
In the Magog Group the Moina Sandstone everywhere succeeds the Roland Conglomerate and overlaps it onto basement highs. In the Dial Group the Moina Sandstone is probably a marine magnafacies which underlies, overlies and interfingers with the terrestrial Duncan Conglomerate.

As interpreted here, the Moina Sandstone is a comprehensive unit. The lithology varies rapidly and many beds, particularly those of conglomerate, are discontinuous lenses so that the fragmentary successions from various areas are not readily correlated with each other. However, there are several distinctive lithologies within the formation which are (1) a wormcast sandstone, or collection of wormcast sandstone beds, termed the *Penguin Creek beds* after Gould (1867); (2) strongly graded conglomerate, sandstone and shale here termed the *Sulphur Creek conglomerate;* (3) fossiliferous shale near the top of the unit termed the *Florentine Valley beds* after Etheridge (1904). The relationships of these lithologies to each other and to the rest of the formation are uncertain.

On the west limb of the syncline at Penguin 50 feet of sandstone occurs, overlying the Duncan Conglomerate. This is the outcrop described by Gould (1867) as the "Penguin Creek beds". The outcrop is poor, with scattered boulders containing tubicolar casts at 40530E 93475N. From the casts, Gould recognized the sandstone as that which elsewhere underlies the Gordon Limestone. Following Gould, the Penguin Creek beds are here recognized as a lithology of the Moina Sandstone, consisting of flaggy-bedded, well-sorted, white quartz sandstone with tubicolar casts, which immediately overlies the Duncan Conglomerate. No upper limit has been seen.

The term "Florentine Valley beds" was used by Etheridge (1904) for fossiliferous mudstone immediately underlying the Gordon Limestone. Fossiliferous shale in this position occurs about half-a-mile north of Paloona (post office) and probably equivalent rocks occur in a fault-bounded outcrop at the mouth of Denny Gorge. The Florentine Valley beds, after Etheridge (1904) and Banks (1962b) is regarded as the coloured shale containing brachiopods and trilobites which directly underlies the Gordon Limestone. No lower limit is known, but the lower boundary of Banks (1962b) is probably applicable. There is similar, thick shale lower in the succession in some areas.

The term "Caroline Creek beds" was introduced by Stephens in Etheridge (1883, see Smith, 1957) for beds containing certain fossils at Caroline Creek, in Sheffield Quadrangle. The term was re-defined by Banks (1962b, p. 165) to mean that part of the



ALTERNATIVE RELATIONS WITHIN DIAL GROUP

K. L. BURNS
GEOLOGIST
MAY 1962

FIGURE 14.

Magog Group overlying the Roland Conglomerate and underlying the Florentine Valley Mudstone, and was applied to beds underlying the Florentine Valley beds near Melrose. The term is not used here.

In the Dial Range the Moina Sandstone may be recognized by its distinctive lithology and by its stratigraphic position. There are exposures in the syncline at Penguin, at Mt Dial, on Mt Riana, and in Hardstaff Creek south of Mt Duncan, in each case directly overlying Duncan Conglomerate.

On the eastern side of the Penguin Syncline at Myrtle Creek Falls (40613N 93325N) the Duncan Conglomerate is overlain by 50 feet of sandstone, in beds 6-12 inches thick, interbedded with mudstone one to two inches thick. This is a white quartz sandstone containing abundant wormcasts, particularly on top of the beds, and the outcrop is identified as equivalent to the Penguin Creek beds of the other limb of the syncline.

On Mt Dial, near 40475E 93085N, the Duncan Conglomerate is overlain by a minimum of 20 feet of wormcast sandstone. The casts are up to four inches long, average 0.1 inch diameter, and while most lie flat in the bedding plane there are a few short vertical stumps. This outcrop is identified with the Penguin Creek beds.

There is a stratigraphic uniformity at about this level in the Dial Group in the Penguin Syncline and on Mt Dial. There is a bed of hematite conglomerate just below the top of the Duncan Conglomerate and the wormcast sandstone just above, both of which are continuous throughout the area.

At the south end of Mt Riana the Duncan Conglomerate is 650 feet thick. The overlying Moina Sandstone is represented by conglomerate interbedded with pink quartzite, the latter in beds from 6 inches to 2 feet thick. The conglomerate consists of subrounded to rounded, spherical pebbles of pink quartzite averaging half an inch diameter, in a matrix of quartz sand. Chert pebbles are not entirely absent, forming, a little further north (40145E 92505N), 10-20 percent of the rock.

In Hardstaff Creek, south of Mt Duncan, the Moina Sandstone is 800 feet thick with the top of the succession cut off by faulting. The underlying Duncan Conglomerate is only 300 feet thick. The lowest bed of the Moina Sandstone is a mudstone, 10 feet thick, which is overlain by conglomerate, sandstone and shale in alternating beds about two feet thick. Pebbles of chert are rare in the conglomerate.

Mapping suggests that there is an interfingering contact between the Moina Sandstone of Hardstaff Creek and the Duncan Conglomerate of Mt Duncan. Although the Duncan Conglomerate thins rapidly southwards, in Hardstaff Creek it contains some beds of siltstone which were not found further north. Strike-lines drawn through the Moina Sandstone of Hardstaff Creek need to be sharply deflected if they are not to cross the traverse made across the summit of Mt Duncan, on which traverse line nothing but Duncan Conglomerate is exposed (see Figures 53 (bottom) and 54). The Duncan Conglomerate of Mt Duncan consists of chert-rich conglomerate at the base and Precambrian pebble conglomerate at the top (Figure 13), whereas in Hardstaff Creek the succession is chert-rich Duncan Conglomerate at the bottom, overlain by a bedded conglomerate rich in Precambrian pebbles, belonging to the Moina Sandstone. While it is not possible to exclude definitely the hypothesis that the Moina Sandstone here overlies the Duncan Conglomerate, the evidence suggests that the two formations interfinger in part (probably the lower part of the Moina Sandstone with the upper part of the Duncan Conglomerate). If this deduction is correct, it means that the Penguin Creek beds north of Mt Duncan is a transgressive member which occurs at about the middle of the Moina Sandstone, a viewpoint shown diagrammatically in Figure 14.

On the western side of the Dial Range, there is a narrow anticline west of Beecraft Point which separates the Penguin Syncline from the Camena Syncline to the west. The anticline coincides on the coastline with an abrupt lithological change in the Dial Group. The Penguin Syncline contains Duncan Conglomerate, fairly thin, overlain by Penguin Creek beds, and the conglomerate consists almost entirely of chert, with the unsorted fabric typical of the Duncan Conglomerate. On the west limb of the anticline, at Dial Point, the lowest exposed unit of the Dial Group is the Sulphur Creek conglomerate which is a well-bedded, strongly graded conglomerate with pebbles of Precambrian origin.

On the headland at Sulphur Creek, the lowest unit of the Sulphur Creek conglomerate is a coarse boulder bed which unconformably overlies Precambrian. This has boulders up to two feet long derived from the immediate bedrock. The unit is lenticular with a maximum thickness of five feet and is little more than brecciated, slightly disoriented, bedrock. This is overlain by a succession of conglomerate beds 6-13 inches thick. On the headland thick beds are graded from conglomerate, with pebbles of white quartz averaging one inch diameter, up into granule conglomerate or coarse sandstone. East of the headland coarse sandstone grades into mudstone. The sandstone contains edgewise conglomerate or casts of mudcracks in places. A mudstone band of restricted distribution contains painted markings similar to those described by Seilacher (1962).

There is a conglomerate outcropping in Penguin Creek, about half-a-mile upstream from its junction with McBrides Creek, which is probably equivalent to the Sulphur Creek conglomerate. It consists almost entirely of pebbles of quartzite and phyllite derived from the underlying Rocky Cape Group and contains sandstone bands. A conglomerate, presumably the same one, outcrops in McBrides Creek near 40295E 93120N where it consists of subrounded to rounded, subspherical pebbles of white quartz, blue quartzite and soft yellow phyllite ranging up to 6 inches but averaging two inches diameter. The pebbles form 60 percent of the rock in a matrix of granule size chips of phyllite and quartzite. The conglomerate is at least 20 feet thick and is underlain by flaggy-bedded siltstone at least 5 feet thick. This outcrop occurs at the western foot of Mt Dial at the foot of the mountainside which consists of Duncan Conglomerate, 700 feet thick. It is possible that the conglomerate overlies the Duncan Conglomerate, as shown in Figure 53 (top), but it is also possible that it underlies the Duncan Conglomerate and enters the Dial Range as a small tongue as shown in Figure 10. The fact that the wormcast sandstone is absent in McBrides Creek, and the Duncan Conglomerate has a tendency to a banded, graded fabric where thin at Myrtle Creek, suggests that the second possibility is the more likely.

The Sulphur Creek conglomerate is correlated with the Moina Sandstone, the lithological assemblage it resembles most, and is regarded as a member of that formation which occurs largely on the western flank of the Dial Range and which may not occur south of a line joining the Gnomon and the Blythe iron mines. On the foreshore it occurs at about the same level as the Duncan Conglomerate, but in McBrides Creek it may underlie Duncan Conglomerate. It almost certainly underlies the wormcast sandstone of the Penguin Creek beds.

At the southern end of the Dial Range, there are outcrops in Kaines Creek, Walloa Creek and east of Mt Lorymer which overlie the Cambrian directly, are well-bedded in places, and have large clasts of predominantly Precambrian origin. They are assigned to the Moina Sandstone and are probably stratigraphically beneath the Penguin Creek beds.

In Kaines Creek there are two outcrops of conglomerate, separated by a fault zone. The upstream outcrop, near 40105E 92155N, has 40 percent white quartz, 10 percent chert, and 50 percent sandstone as subangular to rounded pebbles up to 1.5 inches, average 0.5 inch, diameter. Downstream, at 40080E 92115N, chert is absent, and pebbles range from half an inch to 6 inches, average 3 inches, diameter.

In Walloa Creek, near 40250E 92050N, the Moina Sandstone is represented by conglomerate which contains blue micaceous quartzite pebbles as rounded, oblate ellipsoids up to 6 inches by 2 inches with 3 inches as the mean diameter. These comprise about 30 percent of the pebbles. Rounded, subspherical white quartz averaging one inch diameter forms 50 percent of the pebbles, and subrounded oblate ellipsoids of mean diameter two inches form 20 percent. The matrix is sand size rock fragments and constitutes up to 30 percent of the rock, but generally forms 5-10 percent.

Downstream, towards younger beds, the general succession is: (bottom) conglomerate, with grain size steadily decreasing to an average pebble size of one inch; red sandstone, as two beds 4 and 6 feet thick; conglomerate and sandstone in alternating beds, with some of the conglomerate containing up to 10 percent pebbles of white quartz averaging half an inch diameter.

Some miles further east, on the Leven River near 40670E 92270N, quartz pebbles averaging one inch diameter form 80 percent of the rock which has a matrix of quartz sandstone.

North-east of Walloa Creek, 40492E 92115N, the formation is represented by conglomerate containing rounded to subrounded quartz pebbles up to two inches diameter, average 0.5 inch, forming 20 percent of the rock. Angular to subangular pebbles of white, foliated sandstone averaging one inch but ranging up to 6 inches diameter form almost 80 percent of the rock. One solitary pebble of chert was noted. The rock has a continuous framework with the matrix being merely a few quartz granules among the pebbles.

The section in Kaines Creek where it crosses the northern rim of the Gunns Plains Basin is similar to that in Walloa Creek. In this area in general there appears to be a conglomerate of the order of 100 feet thick, fairly well sorted and with Precambrian clasts overlain by bedded sandstone and shale which are probably equivalent to those at Penguin Creek. The conglomerate is similar to that at McBrides Creek, which is correlated with that at Sulphur Creek. However, there is a tongue or fan of Duncan Conglomerate which trends SW from Mt Duncan and it appears unlikely that the conglomerates in McBrides and Walloa Creeks are physically connected underneath the fan, as at the south end of Mt Riana the Duncan Conglomerate of the fan rests directly on Cambrian, and the Moina Sandstone near Riana has chert pebbles predominating.

South-west of the Dial Range, at Loyotea on the road to Loongana in the Valentines Peak Quadrangle, the Moina Sandstone outcrops in a small gorge, overlying Cambrian mudstone.

Conglomerate in the outcrop consists of 40 percent subangular white quartz, 40 percent black chert, as pebbles in a chloritic matrix. Overlying the conglomerate is quartz sandstone which is cross-bedded in 4 to 6 inch sets, as festoons which, unwound, indicate currents from the NE.

East of the Dial Range, the Moina Sandstone is exposed at Eardley Tor, Kindred, Paloona, and Melrose.

At Eardley Tor, a composite section is (from the top):

	Feet
Ferruginous quartzite containing muscovite flakes	20
Conglomerate containing 90 percent of elongated, prismatic fragments of chlorite-schist, quartzite, and quartz-mica schist	10
White, thinly-bedded quartzite containing worm-casts	40-100
Poorly-sorted, thick-bedded conglomerate consisting of rounded quartz granules in a matrix of quartz sand	40
Flaggy-bedded, white quartzite	Several
Covered interval	c.40
Cambrian rocks.	

On the hill east of Kindred, on the left bank of the Forth River, the conglomerate at Paloona is overlain by a white wormcast sandstone, which is very poorly exposed. Wormcasts occur as branching types lying in the bedding and non-branching types perpendicular to bedding.

On the right bank of the creek, above the valley of Hoggs Creek east of Paloona Bridge, the Moina Sandstone overlies Cambrian mudstone. The basal bed is a white quartzite containing gastropod fossils.

In the Denny Gorge SE of the property " Sunder Pahr ", chert breccia at the base overlies Cambrian rocks. At the entrance to the gorge are two horizons of quartzite conglomerate, about 30 feet thick, separated by about 50 feet of flaggy quartzite containing gastropods. A laminated siltstone occurs in the middle of the gorge, and at the mouth is a laminated shale containing trilobites, brachiopods and pelecypods, which is probably the Florentine Valley beds. Similar shale occurs north of Paloona (post office), underlying the Gordon

Limestone. In Denny Gorge, and in the Don River north of Eugenana, the exposures are fairly good but the structure is not simple and a survey of the standard of Jennings (1958) is required to establish successions.

At the south end of Porcupine Hill the Paloona conglomerate is a lens of quartzite conglomerate underlying wormcast sandstone and is exposed on both banks of the Forth River. Well-rounded pebbles of spherical to ellipsoidal, recrystallized quartzite form nearly 90 percent of the rock which resembles the Roland Conglomerate in lithology but is not physically connected to it. This rock is shown as undifferentiated Dial Group on the map, but it may be equivalent to conglomerate at the base of the Moina Sandstone in adjacent areas.

Sedimentation in the Dial Group

The Duncan Conglomerate is poorly sorted, bimodal, with separated, subangular to rounded pebbles in a granular matrix. At the base the unit is coarse and unstratified, with large, scattered angular blocks. Higher in the unit there may be some evidence of sorting in the alignment of pebbles, crudely-defined pebble bands, or sometimes imbricated bands. There are occasional thin lenses of fine to medium sandstone but no claystone or siltstone. The conglomerate rests on a nearly horizontal base at Mt Duncan with a steep dip which is largely primary (Figure 53). The greater part of the conglomerate is a single resistant rock type, the Barrington Chert, from a source immediately to the east. The conglomerate has been transported, for the most part, less than a mile. It forms two thick fans centred on Mts Montgomery and Duncan (Figure 11). Currents are generally directed to the SW. The Duncan Conglomerate is a fanglomerate, mantling Cambrian hills which lay just east of Mts Duncan and Montgomery. There is no evidence of marine influence, and the occasional bleached borders are probably due to subaerial leaching as they occur on only occasional pebbles. The conglomerate was deposited in a topographic depression as there is a minor contribution from the western side, represented by ferruginous pebbles (from Cambrian and Precambrian orebodies) and pebbles from the Rocky Cape Group.

The marine Moina Sandstone is probably a transitional and littoral deposit formed in a shallow transgressing sea. The conglomerate pebbles are rounded to subrounded, averaging one inch diameter, and are mainly derived from Precambrian sources. At Loyotea currents were to the SW. Only fragmentary sections of the formation have been found, but it appears to consist of about 100 feet of conglomerate with some interbedded sandstone (the Sulphur Creek conglomerate in one area) overlain by interbedded sandstone and shale with minor conglomerate (the Penguin Creeks beds in some areas) overlain by brachiopod shale (the Florentine Valley beds).

The relationship of the Moina Sandstone and Duncan Conglomerate is not known precisely, but there is evidence that the part beneath the Penguin Creek beds interfingers with the Duncan Conglomerate, in one of the two alterative palaeogeographic reconstructions of Figure 14. The uppermost alternative of this figure is favoured as it fits better with structural data. This reconstruction

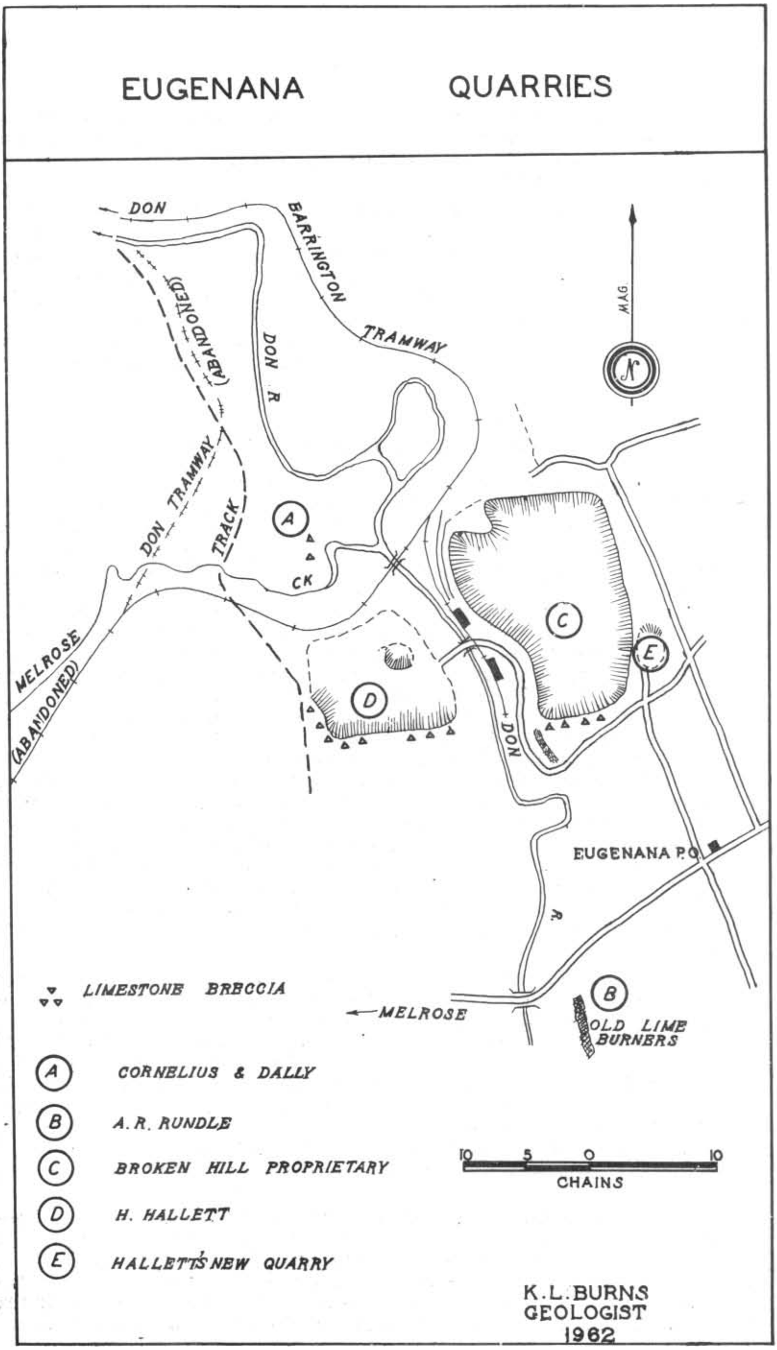


FIGURE 15.

5 cm

shows the Duncan Conglomerate as a thick fan, 1800 feet thick (measured normal to bedding) near its source, spreading out on the piedmont as a blanket about 650 feet thick. The Moina Sandstone probably obtained its chert component from reworking of the outer parts of the fans during the marine transgression.

Gordon Limestone

The Gordon Limestone is approximately 2000 feet thick at Gunns Plains. It is very pure, blue limestone, massive or thickly bedded, with abundant fossils at certain horizons. At Eugenana only the basal portion of the unit occurs and a B.H.P. borehole is reported to have penetrated 250 feet, all in limestone. The surface outcrops contain *Maclurites* which places them low in the formation.

Available information on the Gordon Limestone is summarized by Banks (1957, 1962b) and no new data are available for the present work. The formation ranges through Middle and Upper Ordovician and is succeeded in the Gunns Plains Basin of the Sheffield Quadrangle by Crotty Quartzite.

DEVONIAN SYSTEM

In the Devonport Quadrangle no rocks have been identified as belonging to the Silurian, but certain deposits at Eugenana have been referred to the Devonian. These are terrestrial spelean deposits preserved under conditions that are in some ways exceptional. Similar deposits may also occur at Railton in the Sheffield Quadrangle.

Eugenana Beds

The Eugenana Beds is defined as the unit containing the boulder bed, mudstone and sandstone which succeeds (overlies is not an accurate term) the Gordon Limestone at Eugenana and is exposed in the quarries there.

Thureau (1883) recognized fissure fillings in the limestone and observed folds in the beds. Henderson (1937) considered that sandstone overlying the Gordon Limestone east of Paloona was equivalent to the Crotty Sandstone; this sandstone is part of the Eugenana Beds. In 1953, K. G. Brill (pers. comm.) recognized the bedded deposits in Hallett's Quarry as cavern fillings. In 1960 samples from these beds were included with a collection of Permian material assembled by Banks, as the deposits were thought to be probably Permian. However, Balme (1960, see Banks and Burns, 1962) identified the flora as Upper Devonian.

The beds consist of a number of lithologies, all of spelean genesis. They are younger than the limestone as they include limestone fragments, and younger than the Tabberabberan Orogeny as they include disoriented blocks of foliated limestone. The sequence (order of formation, not order of superposition), is deduced as follows:—

5. Late limestone-boulder pipe fillings.
4. Sandstone fissure-fillings.
3. Sandstone and mudstone cavern-fillings.
2. Early limestone-boulder bed.
1. *Terra rossa* fissure-fillings.

The lithological character of each unit, and the mode of occurrence, is listed in Table 9.

TABLE 9

The Eugenana Beds

Name of Unit	*Boulder type*	*Matrix type*	*Mode of Occurrence*	*Stage of karst development*
5. Late limestone-boulder pipe fillings	Gordon Limestone from unit 2	Exotic	Pipes in unit 2 and bedrock	Collapse
4. Sandstone fissure-fillings	——————	Exotic	Fissure fillings in unit 1 and in bedrock	Vadose
3. Sandstone and mudstone cavern-fillings	Gordon Limestone from Unit 2	Exotic	Cavern fillings in unit 2	Vadose
				Rejuvenation
2. Early limestone-boulder bed	Gordon Limestone from bedrock via stage 1	Indigenous	Collapse trenches in bedrock	Collapse and clay filling
1. *Terra rossa* fissure fillings	——————	Indigenous	Fissure fillings in bedrock	Phreatic

TABLE 10.

Analyses of Carbonate rocks, Eugenana

	(1)	(2)	(3)	(4)
SiO_2	4.94	—	2.18	2.52
Al_2O_3	2.14	0.40	0.70	0.95
Fe_2O_3	1.50	0.86	0.59	2.01
CaO	—	49.92	53.40	37.50
$CaCO_3$	90.17	89.11	—	—
MgO	—	0.76	0.72	12.90
MnO	—	0.02	0.01	0.08
TiO_2	—	—	0.06	0.05
P_2O_5	—	0.01	0.02	0.04
S	—	0.09	—	—
Insolubles	—	9.01	—	—
Ign. Loss	—	39.54	42.58	44.15
	98.75	100.61	100.26	100.20

(1) Average of three analyses of Gordon Limestone (Reid, 1925b, Reg. No. 773).

(2) Average of fourteen analyses of Gordon Limestone (Henderson, 1937, Reg. Nos. 136-149).

(3) Gordon Limestone, east face of B.H.P. Quarry (4284E 9222N). (Analyst C. J. Penman, Reg. No. 2218).

(4) Dolomite lens, east face of B.H.P. Quarry (4284E 9222N) (Analyst C. J. Penman, Reg. No. 2216).

Terra rossa fissure fillings: The *terra rossa* is a tough, well-indurated red mudstone with shaly parting, smooth feel and conchoidal fracture. When occurring as fissure fillings it is massive, without bedding or laminations. In places it contains little chips of limestone averaging 8 mm diameter.

The analysis (No. 6, Table 11, and probably Nos. 1-5, Table 11) shows that it consists of insolubles from the Gordon Limestone (compare analyses 7 and 8, Table 11). This was recognized by Reid (1925b). A given weight of *terra rossa* was derived from solution of limestone of about 30 times the weight.

The fissure fillings have been observed only in the B.H.P. Quarry (Figure 15). They occur as a thin skin at the contact of limestone and dolomite, or occupying the space of a partly-dissolved dolomite lens. They also occur as narrow fissures in limestone, aligned along joints or schistosity, or as irregular bodies at the intersections of these structures. The largest fissures are over 2 feet wide, 10 feet high, and of unknown length or original height. There are large numbers of fissures filled with *terra rossa*, the proportion of *terra rossa* in the rock being sufficiently high to render quarrying for calcium carbonate content uneconomic in many places.

TABLE 11.

Analyses of Residuals, Eugenana

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
SiO_2	65.48	60.60	62.60	55.56	50.28	51.72	61.10	61.20
Al_2O_3	16.63	18.00	22.02	20.62	24.86	14.43	17.05	19.68
Fe_2O_3	8.87	11.30	5.36	8.46	13.82	12.87	15.19	16.59
FeO		0.39				0.74	0.87	
CaO						5.60		
MgO		1.30	1.60	1.40	1.42	2.04		
Na_2O						0.25	0.30	
K_2O						3.33	3.94	
MnO						Trace	Trace	0.28
TiO_2						0.86	1.17	1.69
P_2O_5						0.31	0.36	0.56
H_2O+						2.72		
H_2O-						0.73		
CO_2						4.11		
$CaCO_3$	0.93		Trace	2.84		—		
Ign. Loss			7.40	9.78	8.50	—		
FeS_2						0.09		
Na_2O+K_2O		3.63						
	91.91	95.22	98.98	98.66	98.88	99.80	99.98	100.00

(1), (2), (3), (4), (5) Clay (Reid, 1925b).

(6) *Terra rossa* fissure filling, eastern face, B.H.P. Quarry (4284E 9222N) (Analyst C. J. Penman, Reg. No. 2474).

(7) No. 6 recalculated on an anhydrous, carbonate-free basis.

(8) Gordon Limestone (Reg. No. 2218) from east face, B.H.P. Quarry, recalculated on an anhydrous, carbonate-free basis.

The *terra rossa* is of Devonian age as in places it grades insensibly into pollen-bearing mudstone. It is unlikely to be a Recent deposit as *terra rossa* is exceedingly rare in the modern Tasmanian karst. Thus Banks (1957, p. 44) said " . . . *terra rossa* is not the normal weathering product of the [Gordon] limestone under Tasmanian conditions except where the limestone is above local base-level . . . " and even then the occurrences are small and isolated.

Karren flutings occur in the limestone which bounds the fissures. They are not Recent, formed at the *terra rossa*-limestone contact, but are fossil structures as the lithified *terra rossa* is intimately plastered on the fluted surface of the limestone.

The fissure fillings of unit 1, probably in Cornelius and Dally's Quarry, is the formation recognized by Thureau (1883).

Early limestone-boulder bed: The western part of the B.H.P. quarry and all of Hallett's Quarry, except for a pillar of solid bedrock, is composed of a coarse boulder bed (for localities, see Figure 15). Outside the quarry area the boulder bed occupies trenches aligned in the direction of foliation in the limestone bedrock.

The boulders range in size from over twenty feet down to a few inches diameter, although blocks smaller than six inches are rare. The blocks are angular, the larger sizes being platy in shape reflecting a schistosity control of form. The small sizes are subspherical. The unit shows no sign of bedding or sorting although there is in places a crude orientation of boulders reflecting the structure of the adjacent bedrock. The rock is a megabreccia in the strict sense of Landes (1945).

The matrix is *terra rossa* forming less than 5 percent by volume which occurs as thin seams between boulders. The seams are usually less than one inch thick, although in one place a small lens is about 2 feet thick and over 5 feet long. In a small area at the centre of this lens, the *terra rossa* is laminated, everywhere else it is structureless.

Bedded cavern fillings: Within the boulder bed (unit 2) in Halletts Quarry are three lenses of interbedded green mudstone and yellow sandstone. These are the lenses recognized by Brill as cavern fillings in 1953. No. 1 lens, the easternmost, is several hundred feet long and about 25 feet thick. The beds overlie a bed of rounded limestone boulders which average 6 inches diameter, which in turn overlies the coarse boulder bed of unit 2. The structure of the lens is obscured by talus fans and Tertiary impregnations (often concretions) of limonite.

No. 2 lens, at the western end of the quarry (see Figure 16) is 6 feet long, 3 feet high, and consists of a core of green mudstone surrounded by weakly laminated *terra rossa*. The boundary between the two rock types is well-defined by colour, but in detail is gradational and contorted.

No. 3 lens is a large lens west of No. 2 and about 10 feet higher (in altitude). The bottom unit is a boulder bed with a green mudstone matrix, 0-10 feet in thickness. Over this is interbedded sandstone and mudstone. The mudstone is in beds of uniform thickness averaging 6 inches, but the sandstone beds decrease in thickness upwards from 12 to 6 to 5 inches to a group of upper beds which average 2 inches thick . This is a graded succession of the type of Wood and Smith (1958). The lens is bounded on all sides, including above and below, by unit 2. The contact of the mudstone of the lens with the *terra rossa* of unit 2 is an intricate boundary just inside the lens.

The material within the lens is almost entirely exotic and contrasts with the *terra rossa* which is almost entirely indigenous.

Unit 3 is of exotic derivation, originating from outside the limestone area, while the *terra rossa* of units 1 and 2 is indigenous. The differences between the exotic and indigenous mudstone are in colour, composition, mode of occurrence, and structure, the *terra rossa* not being bedded and showing lamination only where some introduced material is admixed with it.

The limestone boulders of unit 2 which overhang No. 3 lens carry vertical karren flutings. The boulders incorporated at the base of the lens are scalloped (with the green mudstone intimately plastered on the scalloped surface). The scallops plunge 10-060 in the east lens at Halletts Quarry and indicate an active underground stream in a vadose environment.

The thick sandstone in No. 3 lens is compositely graded. One simply-graded sandstone bed is a coarse sandstone from 0.7 to 0.9 inch thick at the bottom, containing angular fragments of claystone and laminated siltstone up to 0.5, averaging 0.2 inch,

5 cm

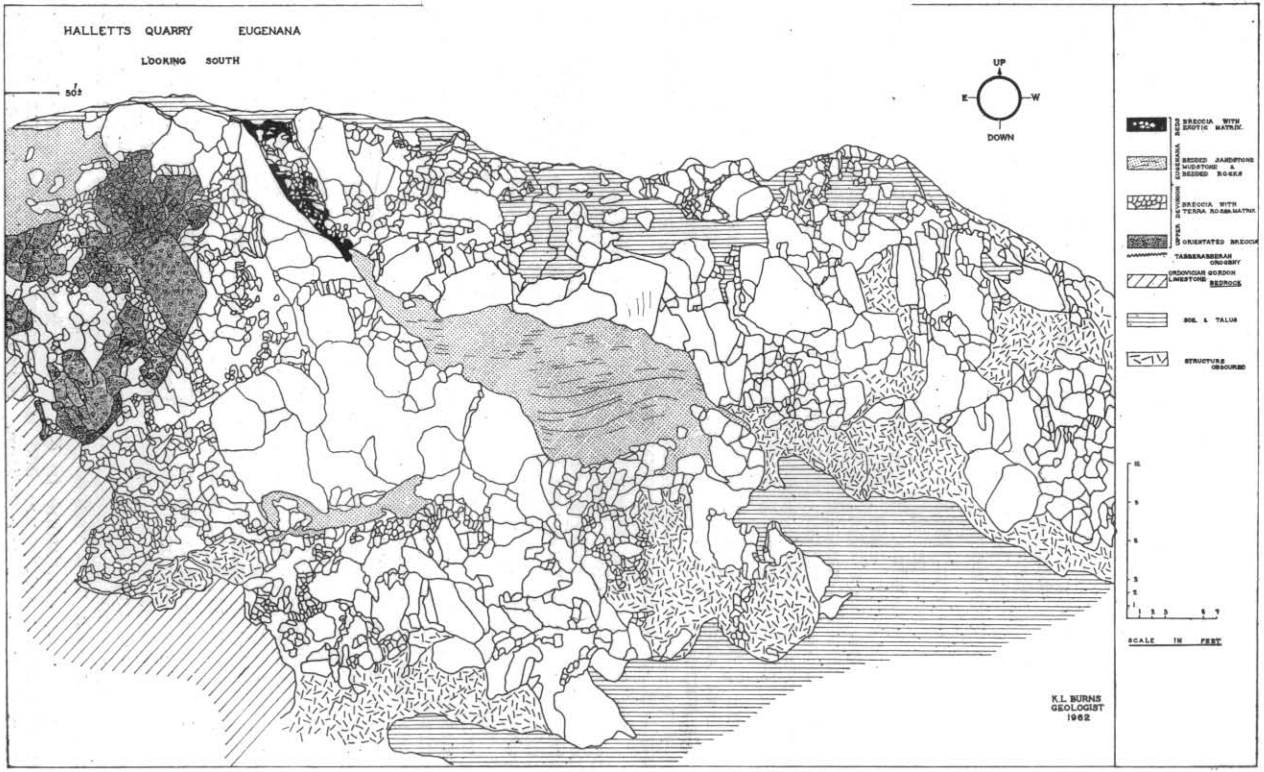


FIGURE 16.

diameter. Above this is 0.5 inch of medium-grained sandstone with plant fragments horizontally aligned. The top 0.2 inch is weakly laminated green mudstone, alternating laminae being rich in rock fragments.

The bottoms of some mudstone beds have casts of mud-cracks as cuspate ridges dividing the surface into polygonal cells averaging 0.5 inch diameter, and varying in shape from equi-radial to elongated. These are due to dessication, probably following draw-down.

The thick sandstone layers contain intrastratal closed cast folds accompanying sedimentary boudinage. Sometimes the boudinage is reflected in overlying beds by " wrinkles " resembling ripple marks. Flame structures are injected at the nodes of some boudins. In graded layers there are sometimes " periclinal undulations " of the bottom surface due to compaction over mud pellets in the base of the bed. These structures are due to soft-state deformation of the cave fill.

Sandstone fissure fillings: In the B.H.P. Quarry sandstone occurs as fissure fillings. It resembles the sandstone of unit 3 and carries plant fragments. The sandstone is usually surrounded by *terra rossa* in the lower parts of the fissures. The fillings are of exotic derivation introduced by flushing of *terra rossa* from the fissures of unit 1 and are probably coeval with unit 3.

Late limestone-boulder pipe fillings: Boulder pipes, of late origin, occur in several places. Across the top of the bedrock pillar in Halletts Quarry is a transverse band of boulders dipping west. In places within unit 1 are bands of finer-grained material in which the boulders are between 6 and 12 inches diameter. No. 3 lens (unit 3) in Halletts Quarry pinches upwards to a narrow pipe (Figure 16) which runs steeply up the face to the present land surface. It is filled with small limestone boulders in a mudstone matrix. The boulders are rounded and enwrapped in the matrix, the mudstone peeling like onion skins off a limestone core which may be due to the boulders tumbling into unconsolidated mudstone. In other places in No. 3 lens there is evidence of a late-stage collapse in that laminae are depressed under limestone blocks fallen from the cavern roof.

Sedimentation in the Eugenana Beds

All units of the Eugenana Beds were formed under spelean conditions and, as shown in Table 9, may be related to an evolving karst.

The lack of *terra rossa* inclusions in the exotic cave fill and the continuous gradation between massive *terra rossa*, laminated *terra rossa*, and strongly bedded cave fill indicates a change in provenance pre-dating the lithification of the *terra rossa* and spanning a short time interval. The change from bedded cave fillings to the late boulder pipes occurred before consolidation of the cave fillings. The Eugenana Beds were deposited in a short space of time.

The *terra rossa* fissure fillings occupy narrow fissures controlled by joints and schistosity in the bedrock, scallops are absent, karren flutings present, there is no flowstone, and the composition of the *terra rossa* is consistent with it having been formed practically *in situ* with very little transport. The environment was phreatic.

The boulder bed (unit 2) probably formed by collapse of the honey-combed rock consequent upon a draw-down due to external factors. The distribution of this unit is consistent with schistosity-controlled subsidence troughs.

The open cave system was developed at the water table by solution of unit 2. A similar rejuvenation of subsidence troughs has been described by Olive (1957). Turbulent, sand-laden water ran through the caves, scalloping boulders on the floor, while meteoric waters percolated through the roof. This vadose stage was short-lived, the stream rapidly aggrading and filling the cave before flowstone deposits could form. Eventually the stream transferred to higher levels or the surface, and at this stage the boulders forming the late boulder pipe fills either fell, or were washed, into the top of the caves.

Igneous Intrusive Rocks

The Housetop Granite is a coarse-grained, pink adamellite described in Hughes (1953, 1959) as consisting of plagioclase, orthoclase, quartz and biotite. It contains more plagioclase than the potassic Coles Bay Granite and the orthoclase is a little lighter in colour. Hughes (1959) also recorded porphyries formed from quartz and feldspar and black seams of quartz and biotite.

The granite is represented in the Devonport Quadrangle by a small area in the extreme SW corner, but this is only part of a large batholith which includes Mt Housetop in the Valentines Peak Quadrangle. The name follows Montgomery (1896, p. iv) and Twelvetrees (1909b, p. 15) and probably earlier authors, who used expressions such as "the Mount Housetop granite" and "the granite of the Hampshire Hills and Housetop area".

The Housetop Granite is post-Ordovician, as it displaces and metamorphoses Gordon Limestone at Loyotea and Hampshire. In Milligans Creek there is a wide contact aureole, and mudstone and conglomerate of the Radfords Creek Group are metamorphosed to coarse-grained amphibolite within the aureole. The alteration is selective and chert pebbles in the conglomerate can still be recognized within 20 yards of the granite boundary. A wide-spaced slaty cleavage in the mudstone appears to be obliterated in the aureole which would date the intrusion as post-Eugenanan.

Quartz dolerite intrudes the Dial Group along the surface of the Duncan Fault just east of the south summit of Mt Riana. The rock was described by Everard (29U5 in Hughes, 1953) as having hypidiomorphic texture with euhedral, sericitized feldspar, euhedral augite altered to hornblende and chlorite, with interstitial quartz. The principal accessory is ilmenite, largely converted to leucoxene.

PERMIAN SYSTEM

Principally for economic reasons, the Permian System of Devonport Quadrangle has attracted considerable attention. The main references are Milligan (1852), Selwyn (1855), Gould (1861), Thureau (1883, 1885), Fenton (1891), Twelvetrees (1911), Reid (1924a), and Nye (1928). There is discussion but little original information in Stephens (1870, 1874, 1885, 1886), Johnston (1888), Fenton (1884), Twelvetrees (1909a), Reid (1922), Voisey (1938), Banks (1958b, 1962d), Burns (1963a), and others.

Many authors reproduced earlier observations and the number of observed sections is quite small. Many of these sections have been mis-located in re-publishing, so the literature is very confused. It is felt to be desirable to reproduce those sections observed prior to 1910 and after 1928. For the intervening period, the papers by Twelvetrees (1911) and Reid (1924a) are readily available, and Nye (1928) was reproduced by Burns (1963a).

The general succession in the Permian System of Devonport Quadrangle is (from the top):—

	Feet
Kelcey Tier Beds (top missing)	600
Mersey Coal Measures	62-95+
Spreyton Beds	159-578+
Basal conglomerate	0-180+

The total thickness is more than 1500 feet. The physiographic relief at the base of the system is in excess of 500 feet in the area of the Great Bend, which is of the same order of magnitude as displacement of Mesozoic and Cainozoic faults. The geology is therefore fairly complicated, and the stratigraphy is heavily dependent upon subsurface information from boreholes. This drilling was reviewed by Burns (1963a) and the names used here for the bores follow his terminology.

The term Mersey Coal Measures is used in the sense of earlier authors. The terms Spreyton Beds and basal conglomerate are used for subdivisions of the "Basal Beds" of Jennings *et al.* (1959). Smith's Bore (Reid, 1924a, p. 110) is adopted as the type section for these formations on an interim basis, pending re-definition when the core from Ayers Bore is available.* Ayers Bore, planned for the location shown on the Devonport Map Sheet, was collared near 43195E 92230N at 100 feet a.s.l., about 450 yards SW of Smith's Bore, and there is not expected to be any difficulty in recognizing units erected on the basis of the Smith's Bore log.

Reid (1924a, pp. 14-15) and Burns (1963a) discussed the problems of identifying and locating some of the boreholes. Burns's (1963a) conclusions are modified a little here, particularly in that it is considered that the log on p. 113 of Reid (1924a) cannot apply to Watling's Bore. The log given on page 113 resembles that to be expected from Law's Bore. Law's Bore was collared in river gravels, and Twelvetrees (1911, p. 24) reported that it bottomed on limestone at 700 feet. Twelvetrees (ibid., footnote) was told the bore passed through tasmanite, while Reid (1924a, p. 70) was told it passed through coal measures, and presumably neither report is reliable.

There have been a number of controversies over the Permian succession in this district. Selwyn considered in 1855 that the fossiliferous marl he observed is stratigraphically underneath the coal. This is correct for marl in the Mersey Colliery shaft and in

* For the log of Ayers Bore, see Matthews (1964).

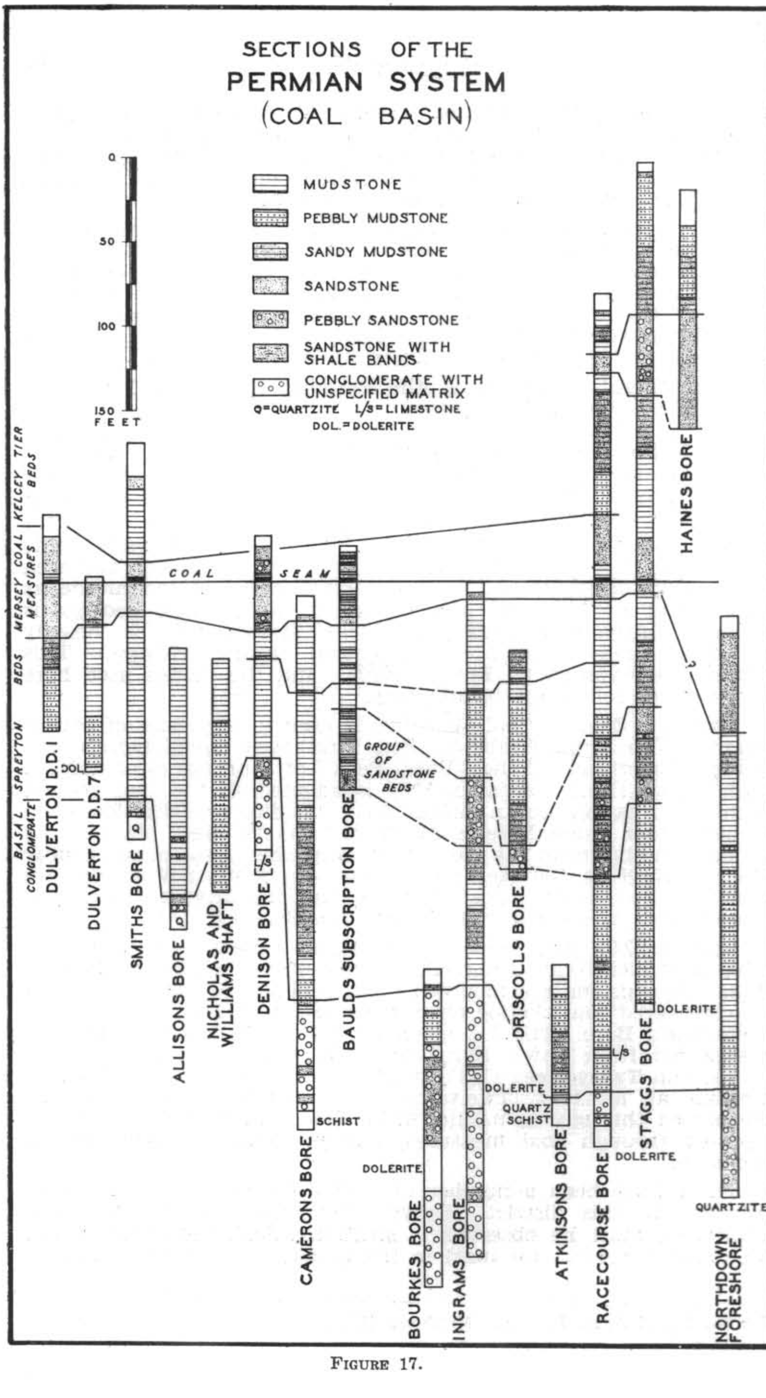

SECTIONS OF THE
PERMIAN SYSTEM
(COAL BASIN)
0
50
100
150
FEET
MUDSTONE
PEBBLY MUDSTONE
SANDY MUDSTONE
SANDSTONE
PEBBLY SANDSTONE
SANDSTONE WITH SHALE BANDS
CONGLOMERATE WITH UNSPECIFIED MATRIX
Q=QUARTZITE L/S=LIMESTONE
DOL.=DOLERITE
BASAL CONGLOMERATE
SPREYTON BEDS
MERSEY COAL MEASURES
KELCEY TIER BEDS
COAL SEAM
DULVERTON D.D.1
DULVERTON D.D.7
DOL
SMITHS BORE
ALLISONS BORE
NICHOLAS AND WILLIAMS SHAFT
DENISON BORE
L/S
CAMERONS BORE
SCHIST
BAULDS SUBSCRIPTION BORE
GROUP OF SANDSTONE BEDS
BOURKES BORE
DOLERITE
INGRAMS BORE
DRISCOLLS BORE
DOLERITE
QUARTZ SCHIST
ATKINSONS BORE
RACECOURSE BORE
L/S
DOLERITE
STAGGS BORE
DOLERITE
HAINES BORE
?
NORTHDOWN FORESHORE
QUARTZITE

FIGURE 17.

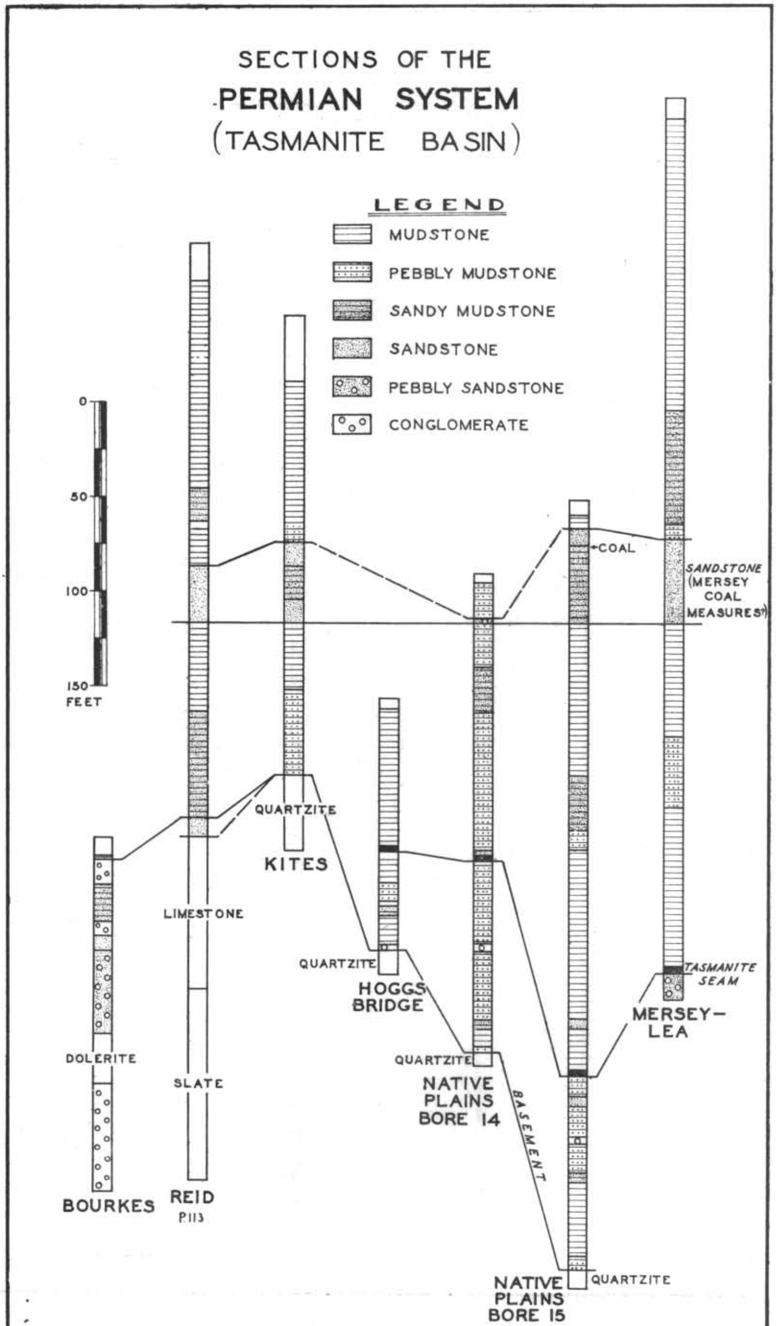


FIGURE 18.

5 cm

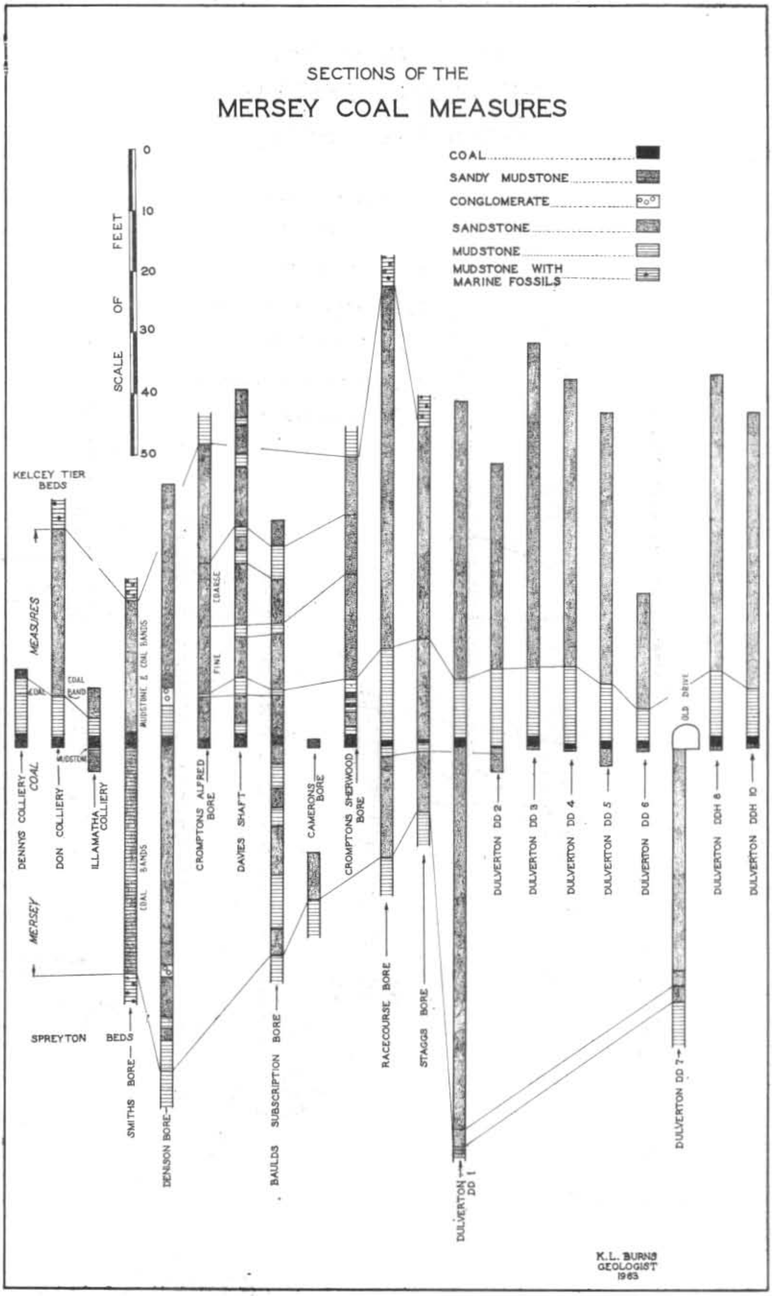


FIGURE 19.

5 cm

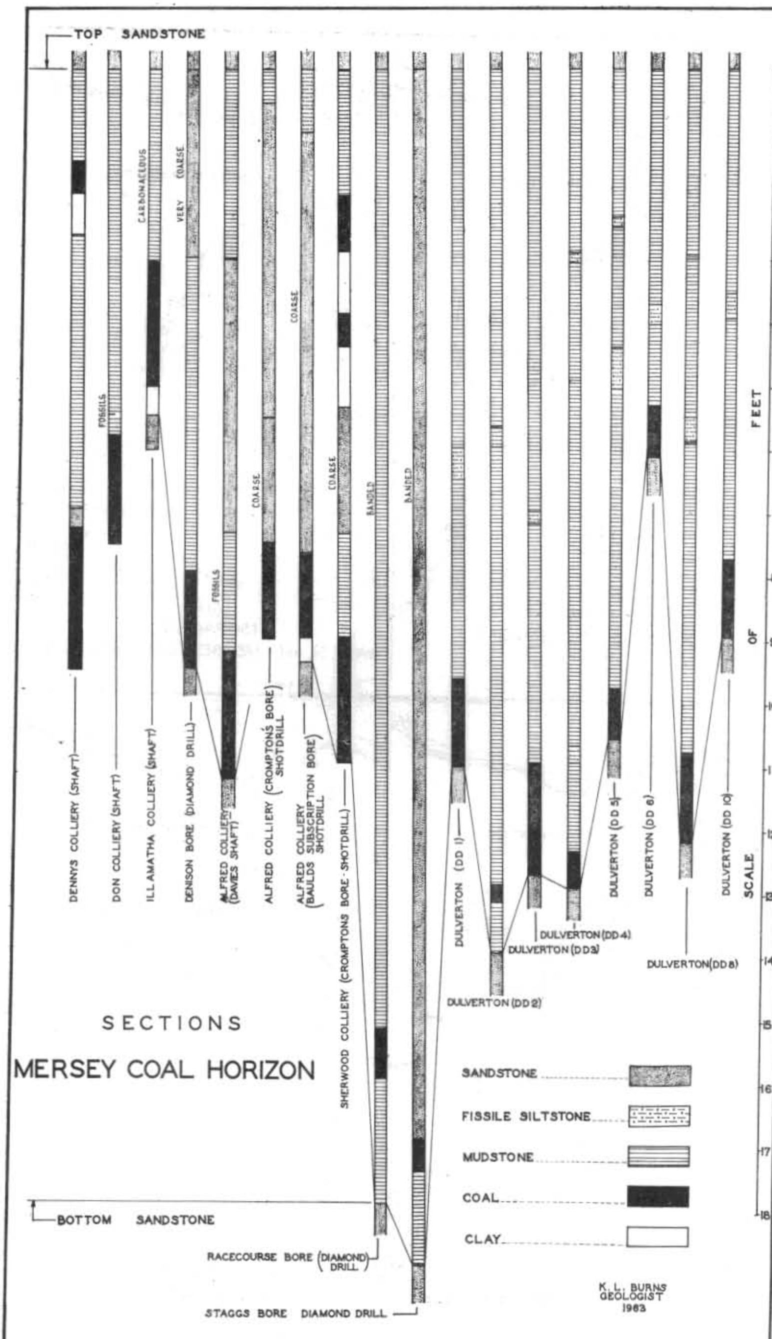


FIGURE 20.

5 cm

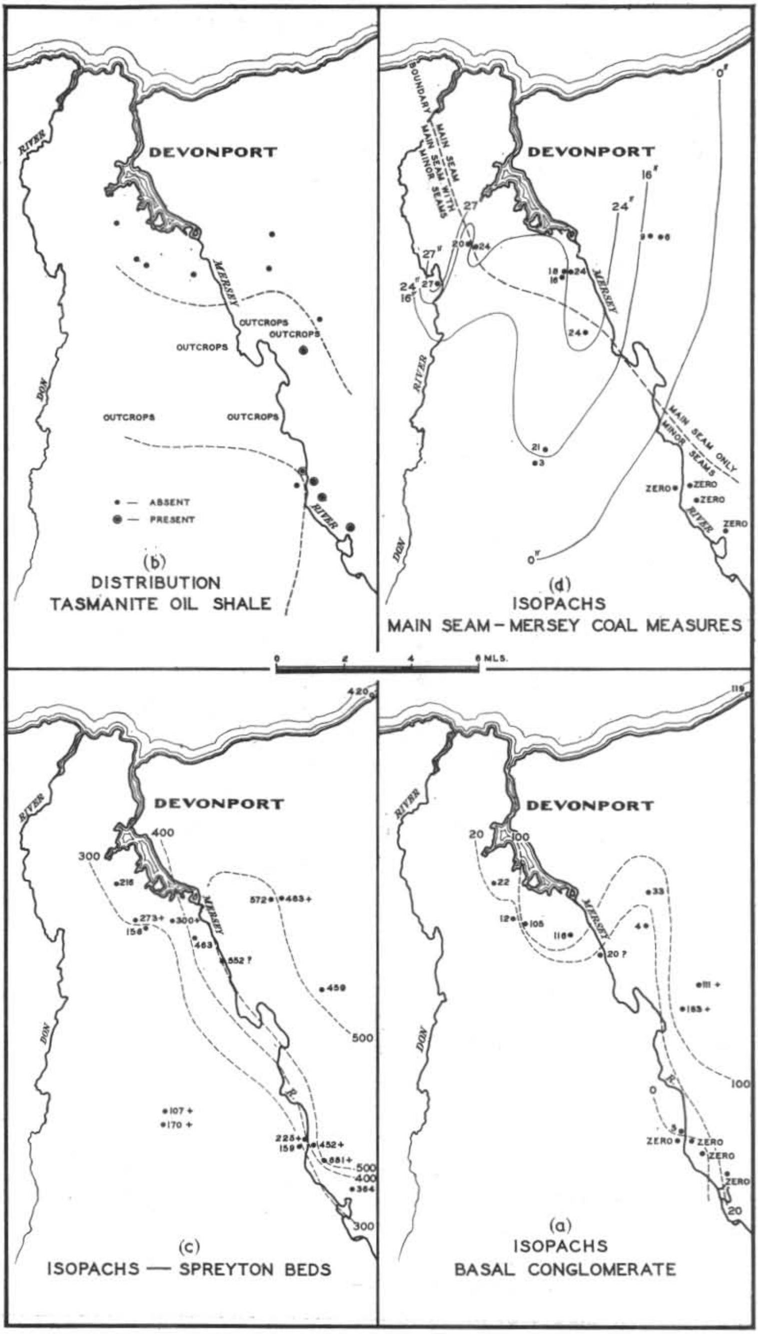


FIGURE 21.

5 cm

Nicholas and Williams's shaft (Figure 78) but not for the hill-top region at Aberdeen. A considerable expenditure of time and money was made in attempts to prove Selwyn wrong. A bore was sunk next to the Mersey Coal Company's shaft by miners working without pay and Williams attempted to sink his shaft deeper through the basal conglomerate. Eventually Thomas Hainsworth discovered that there are fossiliferous marls overlying the coal and Gould sunk a shaft on the site of one borehole (at the Don Colliery) in order to satisfy himself of this. Echoes of this controversy appeared in Johnston (1888).

As a result of the discovery that shelly marl both underlies and overlies the coal, the question arose as to whether there is more than one major seam. Bores were sunk in search of a second seam at the Alfred Colliery by Bauld, financed by subscription, and at the Denison Colliery by Thureau (1883, 1885) financed by the Government, in each case without success.

The third question was that of the equivalence of coal and tasmanite, a question reviewed by Banks (1958b, pp. 157-158). Twelvetrees (1911, pp. 21, 42, 51-52) argued this question and decided that, on the balance of probabilities, the coal and tasmanite are probably equivalent. The critical areas in this problem are Rays Creek at Nook and the mouth of Bott Gorge. Selwyn (1855) described tasmanite butting against coal at Nook, but the relationship is a faulted one (Twelvetrees, 1911, pp. 109-110). Reid (1924a, pp. 43, 98) claimed that the shale at the mouth of Bott Gorge is transitional between coal and tasmanite—this is the "Don Valley black shale" of Reid (1927). However, there are differences between the descriptions of this outcrop by Reid and by Milligan (1852), as well as large faults which juxtapose Mersey Coal Measures and basal conglomerate in the same way as at Nook, so that Reid's contentions are unacceptable without verification. The conclusions of Jennings *et al.* (1959) and Banks (1962d, p. 196) that the tasmanite is not a facies variant of the coal are supported here.

Banks (1962d) considered that oil shale other than tasmanite occurs in the Mersey Coal Measures. With Reid's Bott Gorge occurrence discounted, the evidence for this rests on "the presence of resinous looking particles in the coal" at Nook (Twelvetrees, 1911, p. 109) and on general considerations (Banks, 1962d, p. 204). It is difficult to obtain evidence on this question as the collieries are closed and sampling of mine dumps is unreliable due to the transport of specimens, which was considerable by 1911 (Twelvetrees, 1911, p. 42). However, oil shale is known at this horizon in other parts of Tasmania (Banks, 1962d, p. 204).

Most of the boreholes penetrated considerable thicknesses of strata and intersected recognizable lithological markers, so that in general the formations can be recognized without difficulty. However, there are two horizons of impersistent sandstone beds in the top part of the Spreyton Beds and in areas where the Mersey Coal Seam is absent, the identification of the Mersey Coal Measures is uncertain.

The upper horizon was intersected in the Denison, Baulds Subscription, Camerons, Ingrams, Driscolls, and Racecourse bores and usually consists of a single bed (Figure 17). The lower was intersected in the Baulds Subscription, Ingrams, Driscolls, Racecourse, and Staggs bores (Figure 17) and is calcareous without carbonaceous matter. These horizons underlie the Mersey Coal Measures.

A number of beds of carbonaceous sandstone are recorded from the Northdown Foreshore, Kites, Native Plain 14, Native Plain 15 and Merseylea bores, and the bore logged in Reid (1924a, p. 113) and there called Watlings. These sandstone beds (see Figure 18) were identified by Banks (1958b, Fig. 3) and Burns (1963a) as the Mersey Coal Measures. This identification is probable but it cannot be proven that the sandstone of Figure 18 is not equivalent to one of the horizons underlying the Mersey Coal Measures in Figure 17. However, there are strong arguments in favour of the sandstone of Figure 18 being the Mersey Coal Measures. First, there is no record of carbonaceous matter from the sandstone in the Spreyton Beds (Figure 17) but the sandstone of Figure 18 is carbonaceous. Second, rejection of this identification implies an excessive thickness of 945 feet of Spreyton Beds in the Merseylea Bore with neither top nor bottom (the writer disagrees with Reid's identification of basement) delimited. Third, although the one-inch thick coal seam in Native Plain 15 Bore is not in the usual position of the Mersey Coal Seam (Reid, 1924a, p. 84), coal occurs in or near this position in the Denny's Colliery Shaft, the Don Colliery shaft, and Crompton's Sherwood Bore (Figure 19). Fourth, the map of Jennings *et al.* (1959) indicates that at least the Merseylea Bore started above the coal measures. Fifth, the absence of the major coal seam in the sandstone of Figure 18 is consistent with the general distribution of coal in the Mersey Coal Measures (Figure 21d).

Basal Conglomerate

The basal conglomerate has been identified as follows:—

Bore	*Depth*		*Thickness*	
	From	*To*	*Feet*	*Inches*
Smiths	416′	438′	22	—
Allisons	290′	302′	12	—
Denison	263′ 9″	369′	105	3
Camerons	494′	610′	116	—
Bourkes	27′	210′		
	and 262′	378′	299	—
Ingrams	478′	589′		
	and 621′	795′	285	—
Atkinsons	151′	155′	4	—
Racecourse	935′	968′	33	—
Northdown Foreshore	555′	674′	119	—
Hoggs Bridge	263′	268′	5	—

For location of bores and identification of bore logs, see Table 12. At Kites, Native Plain 14, Native Plain 15, the basal conglomerate is absent. Isopachs on the formation are shown in Figure 21a. The sections in Bourkes and Ingrams Bores are interrupted by a dolerite sill.

TABLE 12

LIST OF THE PRINCIPAL PERMIAN SECTIONS

Reid's No. (1924)	*Date Approx.*	*Location*	*Drilling Company*	*Title of Bore*	*Reference to Bore Log*
1	....	....	....	....	....
2	1884	4338–9204–150	Tasmanian Government	Denison	Thureau (1885) Reid (1924a, p. 112)
3	1910	434– 914–800	Central D'Port	Bonneys Tier	Twelvetrees (1911, p. 91)
4	1900	4379–9188– 30	Henry Law and Co.	Law's	Twelvetrees (1911, p. 24)
5	1900	4384–9087–230	Henry Law and Co.	Law's Bore and shaft	Twelvetrees (1911, p. 24)
6	....	....	....	Native Plain No. 6	....
7	1910	....	....	Native Plain No. 7	Twelvetrees (1911, p. 85)
8	1910	....	....	Native Plain No. 8	Twelvetrees (1911, pp. 85-86)
9	1910	....	....	Native Plain No. 9	Twelvetrees (1911, p. 85)
10	1910	....	....	Native Plain No. 10	Twelvetrees (1911, p. 84)
11	....	....	....	Native Plain No. 11	....
12	1922	....	Adelaide Oil No. 1	Kites	Reid (1924a, p. 81)
13	1922	....	Adelaide Oil No. 2	Hoggs Bridge	Reid (1924a, p. 82)
14	1922	....	Adelaide Oil No. 3	Native Plain No. 14	Reid (1924a, p. 83)
15	1922	....	Adelaide Oil No. 4	Native Plain No. 15	Reid (1924a, p. 84)
16	1922	4365–9200– 30	Adelaide Oil No. 5	Camerons	Reid (1924a, p. 109)
17	1922	4322–9227– 40	Adelaide Oil No. 6	Smiths	Reid (1924a, p. 110)
18	1922	4333–9208–150	Adelaide Oil No. 7	Allisons	Reid (1924a, p. 111)
19	1910	....	F. Robinson	Rubicon No. 3	Twelvetrees (1911, p. 89)
20	1910	....	F. Robinson	Rubicon No. 4	Twelvetrees (1911, p. 89)
21	1922	4430–9183–350	Mersey Valley Oil No. 1	Driscolls	Reid (1924a, p. 71)
22	1922	4421–9159–300	Mersey Valley Oil No. 2	Bourkes	Reid (1924a, p. 72 not 73)
23	1922	4431–9172–350	Mersey Valley Oil No. 3	Ingrams	Reid (1924a, p. 73 not 72)
24	1922	4405–9219–100	Mersey Valley Oil No. 4	Racecourse (not No. 26)	Reid (1924a, p. 74)
25	1922	4405–9200–175	Mersey Valley Oil No. 5	Atkinsons	Reid (1924a, p. 75)
26	1922	4410–9219–175	Mersey Valley Oil No. 6	Staggs (not No. 24)	Reid (1924a, p. 76)

TABLE 12—*continued*

LIST OF THE PRINCIPAL PERMIAN SECTIONS

Reid's No. (1924)	*Date Approx.*	*Location*	*Drilling Company*	*Title of Bore*	*Reference to Bore Log*
27	1922	......	Adelaide Oil No. 10	Merseylea	Reid (1924a, p. 85)
28	1923	4466–9227–150	Mersey Valley Oil No. 8	Hermitage	Reid (1924a, p. 104)
29	1923	4489–9227–140	Adelaide Oil No. 8	Iles	Reid (1924a, p. 102)
30	1923	4489–9209–300	Adelaide Oil No. 9	Burgess	Reid (1924a, p. 103)
31	1923	4489–9225–220	Mersey Valley Oil No. 9	Parsons	Reid (1924a, p. 105)
32	1923	4324–9253– 10	......	Watlings	Not Reid (1924a, p. 113)
33	1923	4373–9259–180	Mersey Valley Oil No. 7	Haines	Reid (1924a, p. 77)
34	1924	4436–9303– 50	......	Northdown Beacon	......
......	1923	4448–9237–140	......	Windy Ridge	......
......	1928	4460–9322– 10	Adelaide Oil	Northdown Foreshore	Nye (1928) Burns (1963a)
......	1922	......	Adelaide Oil No. 11	......	Reid (1924a, p. 113)
......	1858	4361-9199–100	Subscription	Bauld's Subscription	Gould (1861, pp. 5–6) and herein
......	1861	4315–9235– 50	......	Crompton's Spreyton Bore	Gould (1861, p. 8) and herein
......	1860	4370–9170– 50	......	Crompton's Sherwood Bore	Gould (1861, p. 6) and herein
......	1855	4295–9196–175	Dean, Fawns and Hurst	Denny's Colliery Shaft	Selwyn (1855, pp. 138-9) and herein
......	1861	4310–9217–125	Zephaniah Williams	Don Colliery Shaft	Johnston (1888, p. 132) and herein
......	1860	4363–9199– 80	Johnson?	Crompton's Alfred Bore	Gould (1861, pp. 4–5) and herein
......	1870	4362–9199– 90	Wm. Davies?	Bauld's Alfred Shaft	Thureau (1883, sketch 1) and herein
......	1854	4353–9208– 60	Williams' Hobart Syndicate	Nicholas' and Williams' Shaft	Selwyn (1855), Thureau (1883) and herein

TABLE 12—*continued*

LIST OF THE PRINCIPAL PERMIAN SECTIONS

Reid's No. (1924)	*Date Approx.*	*Location*	*Drilling Company*	*Title of Bore*	*Reference to Bore Log*
......	1943	4313–9214–150	Bound Brothers	Illamatha Colliery Shaft	Herein
......	1934	....	Tasmanian Government	Dulverton No. 1 Bore	Herein
......	1934	....	Tasmanian Government	Dulverton No. 2 Bore	Herein
......	1934	....	Tasmanian Government	Dulverton No. 3 Bore	Herein
......	1934	....	Tasmanian Government	Dulverton No. 4 Bore	Herein
......	1934	....	Tasmanian Government	Dulverton No. 5 Bore	Herein
......	1934	....	Tasmanian Government	Dulverton No. 6 Bore	Herein
......	1934	....	Tasmanian Government	Dulverton No. 7 Bore	Herein
......	1935	....	Tasmanian Government	Dulverton No. 8 Bore	Herein
......	1935	....	Tasmanian Government	Dulverton No. 9 Bore	Herein
......	1935	....	Tasmanian Government	Dulverton No. 10 Bore	Herein
......	1963	43195E 92230N	Tasmanian Government	Ayers Bore	In progress*

*See Matthews (1964)

The basal conglomerate is exposed at the Great Bend of the Mersey River and below Bott Gorge in the Don River (4289E 9185N, altitude 400 feet). It is absent from the base of the Permian System on the hill SE of Latrobe (4400E 9198N, altitude 170 feet). It may be distinguished from the pebbly mudstone of the Spreyton Beds by the composition of the matrix which is usually sand, sometimes possibly rock flour, rather than mudstone. A quartz sand matrix and basal position is definitive of the basal conglomerate. There may be thin beds of pebbly sandstone in the lower part of the Spreyton Beds in some areas which are lithologically similar to the basal conglomerate, but these are underlain by mudstone.

Near Buster Road (Burns, 1957a, near 4289E 9185N) the basal conglomerate consists of subangular pebbles averaging one inch diameter but ranging up to two inches diameter, of white quartzite, schist, and conglomerate. The matrix is feldspathic sandstone. Beds of highly conglomeratic rock with basal diastems alternate with banded sandstone, pebbly sandstone and occasional rare lenses of fossiliferous sandstone. G. Lane (pers. comm.) identified the following fossils:

Eurydesma cf. *hobartense* (Johnston) 1888.
Platyschisma cf. *rotundum* (Etheridge) 1872

and wood stems. Marine fossils also occur in the Denison Bore (163′ 9″ to 351′ 3″).

Nye (1928) recorded quartzite pebbles and boulders in sandy sediment from this formation. The logs recorded by Reid (1924a) list boulders of quartzite, quartz, quartz schist, and quartzite conglomerate. Occasional records of limestone may be pebbles but could be interbedded lenses.

This formation is not a tillite (Banks, 1958b, pp. 165-166). Banks discussed the tasmanite in connection with this formation but the tasmanite occurs in the lower part of the Spreyton Beds (Banks, 1962d, p. 196).

Spreyton Beds

The Spreyton Beds has been identified as follows (see Table 12, for location of bores and identification of bore logs):—

Bore	*Depth*		*Thickness*	
	From	*To*	*Feet*	*Inches*
Smiths	200′	416′	216	—
Allisons	17′	290′	273	(top missing)
Denison	106′ 3″	263′ 9″	157	6
Camerons	26′	494′	468	—
Ingrams	19′	478′	459	—
Racecourse	357′	935′	578	—
Staggs	506′	989′	483	(bottom missing)
Northdown Foreshore	135′	555′	420	—
Dulverton No. 1	147′	254′	107	(bottom missing)
Dulverton No. 7	60′	230′	170	(bottom missing)

In the Railton-Merseylea area, there is some question of identification with regard to the Mersey Coal Measures. With the identification made as discussed above (p. 96), the Spreyton Beds occurs as follows:—

Bore	*Depth*		*Thickness*
	From	*To.*	*Feet*
Kites (12)	326′	485′	159
Hoggs Bridge (13)	8′	263′	255 (top missing)
Native Plain 14	56′	508′	452 (top missing)
Native Plain 15	128′	809′	681
Merseylea (27)	552′	916′	364

Isopachs on the formation are shown in Figure 21c.

The Spreyton Beds outcrops on the western side of the Don River near Tugrah at 4274E 9262N. The outcrop contains bands of siltstone averaging 16 inches thick and alternating with pebbly bands about 12 inches thick. The siltstone is white, feldspathic, with cross-bedded laminae about 1 mm thick, occasional small shell fragments averaging 5 mm diameter, and rare rounded ellipsoidal quartzite pebbles averaging 0.5 inch diameter. The pebble bands have a coarse sandstone matrix of quartz, feldspar and rock fragments. The pebbles are rounded, ellipsoidal or quadrate, are of quartzite, and range up to 4 inches diameter. The proportion of pebbles to matrix is variable. Fossils are gastropods and brachiopods.

At Dulverton, Spreyton and Northdown the Spreyton Beds is mudstone with bands of pebbly sandstone and layers rich in shells. In the Tarleton-Latrobe area, there are a number of beds of calcareous pebbly sandstone (Denison, Camerons, Ingrams, Driscolls, Racecourse, Staggs Bores) (Figure 17). Further south in the "tasmanite basin" there is a seam of tasmanite oil shale at varying heights above the base of the unit, and some impersistent beds of pebbly sandstone near the base (Figure 18). The tasmanite basin is delimited by a buried bar struck in Kites Bore. In all three areas, carbonaceous matter occurs in the Spreyton Beds.

The Spreyton Beds is equivalent to the Quamby Group plus the Golden Valley Group of Banks (1962d, p. 193).

Mersey Coal Measures

The Mersey Coal Measures has been identified as follows:—

Bore	*Depth*		*Thickness*
	From	*To*	*Feet*
Smiths	138′	200′	62
Racecourse	262′	357′	95
Staggs	442′	506′	64

Incomplete sections were obtained in the Dulverton 1, Dulverton 7, Denison, Camerons, Baulds Subscription, and Ingrams Bores, as shown in Figure 17.

As discussed above (p. 96) there is evidence in favour of the sandstone in Northdown Foreshore, Kites, Hoggs, Native Plain 14, Native Plain 15, and Merseylea Bores being the Mersey Coal Measures (Figure 18).

The Mersey Coal Measures is exposed on the eastern side of the Don River at Tugrah, near 4275E 9248N. The section probably ranges from the base of the Kelcey Tier Beds down to fairly close to the top of the "bottom sandstone" (see below). There is another natural exposure on the left bank of Ballahoo Creek near the old Mersey Colliery, but only part of the "top sandstone" and the "coal horizon" is exposed. At the Southern Star Colliery the base of the Mersey Coal Measures may occur on the hillside but is not exposed.

The natural sections being incomplete, knowledge of the stratigraphy is based on bores and colliery openings, of which there are a considerable number. In Figure 19 are shown columnar sections from twenty artificial openings that expose fairly complete sections through the formation. The formation may be divided into three members, a "top sandstone" overlying a "coal horizon" overlying a "bottom sandstone".

"Top sandstone"

This is exposed in the natural section at Tugrah (4275E 9248N) which probably affords a complete section through the member. It consists of thick and flaggy-bedded sandstone varying in grain size from fine to very coarse sand and contains lenticular beds of mudstone. The thickness varies from a maximum of 60 feet in the Racecourse Bore to a minimum of 22 feet in Smiths Bore.

"Coal horizon"

Predominantly mudstone, this member is 18 feet thick in the Racecourse Bore, and probably only 5 feet 6 inches in the Illamatha Colliery Shaft. Detailed sections through the member, from 18 localities, are shown in Figure 20. Thicknesses of the main coal seam are shown in Figure 21d. The seam averages about 2 feet thick and appears to be confined to a "coal basin" which lies NW of the Great Bend, and to be absent outside this area. The seam may rest on mudstone as in the Racecourse and Staggs Bores, on a thin bed of fireclay as at the Alfred Colliery or as at Tugrah, or may occur at the bottom of the member directly overlying the bottom sandstone as at Dulverton (Figure 20). In places this member contains thin, minor seams of coal which overlie the main seam, as at the Don, Denny's, and the Sherwood Colliery. These minor seams were also reported by Milligan (1852) from Bott Gorge. There appear to be 3 fairly well defined areas, one containing the major seam only, another containing the major seam with minor seams and the third containing minor seams only. The boundary between these areas is shown in Figure 21d.

At the top of the member are some lenticular beds of sandstone, as shown in Figures 19 and 20. At the Illamatha Colliery one such bed, reaching a maximum of 18 inches thick, can be traced through the mine as a large lens immediately beneath the top sandstone. It thins eastward towards the main shaft and is absent in the eastern part of the workings. A sandstone in this position is well-developed at the Alfred Colliery and may pass into the conglomerate of the Denison Bore. This member is exposed in natural sections along the railway line at Tugrah, and at the mouth of Bott Gorge.

" Bottom sandstone "

This is predominantly sandstone but with a bed of conglomerate in the Denison Bore and with bands of mudstone in Baulds Subscription Bore at the Alfred Colliery. The sandstone contains coal bands as in Smiths Bore. No natural exposure of this member is known within Devonport Quadrangle but there may be one at the mouth of Bott Gorge, poorly exposed, if the mudstone at river level belongs to the Spreyton Beds as seems likely.

This three-fold division of the Mersey Coal Measures suggests correlation with the subdivisions of the Liffey Group of McKellar (1957) into Creekton plus Woodside, Kopanica, and Flat-top formations.

Kelcey Tier Beds

The Kelcey Tier Beds is that formation of mudstone and pebbly mudstone with bands of siltstone and sandstone which forms Kelcey Tier and Ellias Hill. The best section is on the west side of Ellias Hill between 4290E 9220N and 4301E 9218N and contains 3 sandstone horizons. The formation conformably overlies the Mersey Coal Measures at the Don Colliery.

The Kelcey Tier Beds is probably equivalent to the Cascades Group plus Malbina Formation plus Ferntree Group of Banks (1962d). The new name is introduced as these units cannot be distinguished here. Identification of the sandstone " marker horizons " will probably permit subdivision into these units. There is some evidence (Twelvetrees, 1911, pl. 2) that the Kelcey Tier Beds is overlain on Bonneys Tier by the Cygnet Coal Measures.

A fossiliferous shelly marl at the base of this unit was encountered in a number of colliery openings, and the initial controversy over its stratigraphic position has been discussed previously (p. 89). The only records of higher beds are Twelvetrees (1911, pp. 91-92) who described a bore sunk 447 feet through dark, sandy, micaceous mud shale containing *Fenestella*; and Gould (1861, p. 7) who described a natural succession near the Russell Colliery of (top) dark blue marl, overlying sandstone, conglomerate, clay, marl, conglomerate, sandstone, sandy clay, overlying fossiliferous sandy clay (bottom). Gould's section is unlikely to be much more than 50 feet thick.

In the Devonport Quadrangle a number of " marker horizons " of pebbly sandstone have been recognized and mapped. The markers are numbered in order as they occur on Ellias Hill, and the probable identity of the markers in other areas is indicated by the numbers.

Marker 1 is a conglomeratic sandstone at Tugrah Siding. East of Eugenana Quarries it is sandstone, and at Buster Road it is pebbly sandstone. At Aberdeen, Bore 1 of Figure 78 started on or just below this marker, and met coal at 134 feet (Selwyn, 1855, Fig. 1—note that his fault may be disregarded). The sandstone at Latrobe which is correlated with Marker 1 occurs in the Racecourse, Staggs and Haines Bores (Figure 17) at about 200 feet above the coal. The marker is 107 feet thick in Staggs Bore, and more than 135 feet in Haines Bore. The thickness at Tugrah and Aberdeen is only a few feet.

Marker 2 is a coarse siltstone where it crosses the Stony Rise Main Road. Along the right bank of the Don River to the south, the matrix is 80 percent quartz, 20 percent feldspar, with the size of fine sand, and the pebbles consist of angular quartz and rock fragments averaging 8 mm diameter. East of Tugrah, this marker is identifiable from the rock fragments, and is conglomeratic near Tugrah Siding. On Ellias Hill Marker 2 is recognizable in some outcrops by the quartz and rock fragments occurring in a coarse siltstone matrix, in other outcrops it is a pebbly sandstone. On the Bass Highway at Don, in the Devonport Water Supply Tunnel in the Kelcey Tier-Ellias Hill saddle, and on the Moriarty Road at Staggs Hill, it is a thin or flaggy-bedded feldspathic sandstone.

Marker 3 was described by Burns (1957c, pp. 44-45) as a fine-grained carbonaceous sandstone with plant remains, pebbly bands and some large erratics. The best exposure is just NW of the top of Ellias Hill, in other areas the marker is obscured by talus.

The Kelcey Tier Beds is generally badly exposed and it is possible that the marker horizons are resistant beds in sandstone units that may be quite thick in places.

Sedimentation in the Permian System

The Permian System is badly exposed in Devonport Quadrangle and no worth-while information on processes of sedimentation has been collected. However, the bore data provide information on the general distribution of formations and permit of some palaeogeographic deductions.

The isopachs on the basal conglomerate (Figure 21a) probably reflect basement topography. At this general period of time, there was a seaway crossing Tasmania from Hobart to Devonport (Banks, 1962d, p. 195). On the western side of this seaway, the basal conglomerate occurs as a fairly thin blanket, of the order of ten feet thick (Banks, 1962d, fig. 30b). In Figure 21a, this thin blanket occurs SW of the Mersey River with a small high (conglomerate thickness zero) near Hoggs Bridge. The edge of the seaway trends NW approximately along the present route of the Mersey River. North-east of this edge, the basal conglomerate rapidly increases in thickness from 20 feet to probably more than 200 feet. This increase in thickness probably reflects basement topography and is unlikely to be of tectonic origin. The fact that the edge of the seaway corresponds approximately with the edge of the Mersey Graben shows that the structural relief of the Graben is not reliably measured at the base of the Permian System. It is possible that the other side of this seaway is at the Northdown Foreshore Bore where the basal conglomerate is thinner than in the bores SE of Sassafras.

Isopachs on the Spreyton Beds (Figure 21c) have generally the same pattern as those on the basal conglomerate, but the topography indicated is more subdued. The seaway appears to be a fairly narrow trough extending SE from Latrobe. The distribution of tasmanite oil shale (Figure 21b) is marginal to this trough. As shown in the columnar sections of Figure 18, the oil shale is probably overlapped against rising basement at the edge of the trough, a behaviour which has been observed at Dairy

Plains some 20 miles further south. The isopachs on the Spreyton Beds have a pattern similar to those on the Quamby and Golden Valley Groups (Banks, 1962d, fig. 30c, d) as would be expected since the Spreyton Beds is compounded of these groups.

Thickness variations in the higher formations are unknown. Information is available for only the main Mersey coal seam (Figure 21d). This pattern, and the Tasmania-wide pattern for the Mersey Coal Measures (Banks, 1962d, fig. 31b) suggests a palaeogeography quite different from that of older formations. The patterns suggest a shallow basin trending north, and deepening northwards, and minor seams occur only in the southern (higher) parts of the basin.

Bore Logs in the Mersey Basin

BAULD'S SUBSCRIPTION BORE

Bore No. 4 of Figure 78, at 4361E 9199N (collar altitude 100 feet), was put down by subscription to nearly 500 feet (Gould, 1861, No. D). According to Thureau (1883) it was sunk by Bauld at the Alfred Colliery in 1858, passing through marine beds to coal at a depth of 53 feet 6 inches and thence to a further depth of 246 feet 7½ inches, total depth being 300 feet 1½ inches. Gould said the bore was sunk in search of a second seam. The bore log was published by Gould (1861, pp. 5-6) and an amended version by Reid (1922, p. 225). Gould's original log is reproduced here with stratigraphic interpretation added. Note that " faikes " is a fissile sandy shale, and " blaze " is shale.

Unit No.		*feet*	*inches*
	Quaternary		
1	Surface	3	0
2	Sand and stones	9	0
3	Gravel	5	0
	Mersey Coal Measures		
4	Brown sandstone	4	2
5	Grey faikes	2	6
6	Dark faikes	1	4
7	Grey faikes	2	0
8	Grey sandstone	7	3
9	Grey faikes	1	6
10	Grey sandstone	9	6
11	Grey faikes	1	0
12	Coarse grey sandstone	6	8
13	Dark clod faike or parting	0	1
14	Coal, first seam	1	4
1	Fire clay or damp	0	5
2	Sandstone in beds	3	10
3	Dark grey faikes	4	0

4	Grey sandstone	3	3
5	Dark faikes	1	9
6	Grey faikes	1	6
7	Dark grey sandstone	8	0
8	Dark faikes	3	9
9	Dark faikes and blaze	5	3
10	Dark grey sandstone	4	3
	Spreyton Beds		
11	Grey faikes	8	5
12	Black blaze	1	4
13	Grey faikes	1	0
14	Dark blaze	10	3
15	Dark grey faikes	2	0
16	Dark faikes and blaze	12	6
17	Grey sandstone	1	0
18	Dark faikes and blaze	13	9
19	Dark grey sandstone	1	10
20	Grey faikes and blaze	16	8
21	Grey sandstone	0	6
22	Dark blaze	12	0
23	Grey faikes	3	0
24	Strong dark grey faikes	5	9
25	Dark blaze	5	0
26	Dark faikes and blaze	5	0
27	Strong dark grey faikes	16	6
28	Sandstone in beds	3	9
29	Dark grey faikes	3	10
30	Extra hard sandstone	0	10½
31	Strong dark grey faikes	12	5
32	Strong grey faikes	6	3
33	Dark sandstone	2	9
34	Dark grey faikes	1	6
35	Light grey sandstone	6	5
36	Dark grey faikes	4	4
37	Light grey sandstone	7	0
38	Light grey sandstone	0	10
39	Dark grey faikes	1	6
40	Grey sandstone	1	11
41	Grey faikes	0	9
42	Grey sandstone	34	1
		295	0½

CROMPTON'S SPREYTON BORE

A bore was sunk by Crompton near the Spreyton Racecourse about 1861, at very approximately 4315E 9235N (collar altitude 50 feet). The log was reproduced by Reid (1922, p. 226) who called the bore location Tarleton. The log below is after Gould (1861, p. 8).

	feet	*inches*
Quaternary		
Gravel	2	0
Clay, of a superior quality	4	0

Indurated clay, strongly resembling sandstone	12	0
Kelcey Tier Beds		
Fine sandy marl, or blue binds	14	0
Mersey Coal Measures		
Fine grey sandstone	18	0
Bed or parting, darkish cream colour	0	6
Fine dark coloured sandstone	10	6
Fine light coloured and rather strong (*sic*)	5	6
Very fine ditto, and very strong	3	0
Very coarse grey sandstone, soft	2	0
White soapstone	4	3
Very coarse grey sandstone, rather soft and free cutting	16	7
Very strong sandstone rock	1	8
Coarse sandstone, soft	4	0
Light coloured clod or soapstone	2	0
Coarse grey sandstone, in thin layers, good stone to cut	31	6
" At this point all our water left the hole. In 5 minutes' time the water in the hole dropped 130 feet."		
Strong dark grey sandstone, almost as heavy as lead, very difficult to collect the borings in consequence	3	6
	135	0

CROMPTON'S SHERWOOD BORE

Crompton's bore at Sherwood (or Dawson's Pits) was sunk on the bank of Caroline Creek at (very approximately) 4370E 9170N (collar altitude 50 feet). The log below is after Gould (1861, p. 6) but note also Johnston (1888, pp. 132-133) and Reid (1922, p. 227).

	feet	*inches*
Quaternary		
Surface soil and clay	7	0
Gravel	1	0
Indurated clay	6	0
Kelcey Tier Beds		
Marl or blue binds	32	0
Mersey Coal Measures		
Strong grey sandstone	10	0
Soft grey sandstone	10	0
Soft grey sandstone with thin shaly bands and streaks of carbonaceous matter	17	0
Light coloured shale	2	0
Coal	0	10½

Fireclay	1	0
Coal	0	6
Fireclay	1	0
Soft grey sandstone, very coarse and gritty	2	0
Black shale or clod	1	7½
Coal	2	0
	94	0

DENNY'S COLLIERY SHAFT

Shaft No. 4 of Figure 78 (Gould, 1861, No. M) was sunk at Denny's Colliery in 1855, near 4295E 9196N (collar altitude 175 feet). The section was (after Selwyn, 1855, pp. 137-8):

	feet	*inches*
Quaternary		
Mould	3	6
Yellow clay	2	6
Mersey Coal Measures		
Grey sandstone	1	6
Blue bind or shale	2	5
Coal	0	6
Blue fireclay	0	8
Clod	4	4
White sandstone	0	4
Coal	2	3
	18	0

DON COLLIERY SHAFT

Shaft No. 9 of Figure 78 (Gould, 1861, No. I) was sunk by Williams at the Don Colliery about 1861 at 4310E 9217N (collar altitude 125 feet). The section below is after Johnston (1888, p. 132) and was reproduced by Reid (1924a, p. 108):

	feet	*inches*
Quaternary		
Surface clay	30	0
Gravel	3	0
Kelcey Tier Beds		
Sandstone with yellow streaks	3	0
Blue marl, with abundant remains of marine fossils, viz. *Spirifera, Aviculopecten, Pachydomus, Pterina, Cardiomorpha,* &c.	21	0
Mersy Coal Measures		
Grey sandstone with streaks of carbon	27	6
Black clod	....	....
Streak of coal	....	....
Shale (charged with alum)	5	0
Shale full of impressions of *Glos-*		

sopteris, Gangamopteris and *Noeggerathiopsis*	0	6
Shale	0	4
Coal	1	8
	92	0

CROMPTON'S ALFRED BORE

Bore No. 3, Figure 78 (Gould, 1861, No. C) was Johnson's borehole. This may be the same as Crompton's bore which was recorded by Gould (1861, pp. 4-5), Reid (1922, p. 224) and Johnston (1888, p. 132). The location is 4363E 9199N (altitude of collar 80 feet).

Gould's log was:

	feet	*inches*
Quaternary		
Surface soil and clay	6	0
Indurated clay	6	0
Gravel	6	0
Kelcey Tier Beds		
Blue marl	14	0
Mersey Coal Measures		
Sandstone, streaked yellow and white	20	0
Coarse grey sandstone	10	0
Fine grey sandstone	11	0
Parting	0	6
Grey sandstone streaked with black	5	0
Very coarse sandstone	2	0
Coal	1	6
	82	0

BAULD'S ALFRED SHAFT

Shaft No. 16 of Figure 79 (4362E 9199N collar altitude 90 feet) is Wm. Davies Shaft (Thureau, 1883, No. E). This is probably the same as Bauld's shaft (Thureau, 1883, section). Scaled off from Thureau (1883, sketch 1) the section was:

	feet	*inches*
Quaternary		
Surface	0	11
Mersey Coal Measures		
Sandstone	4	6
Shale (clod)	1	6
Sandstone	4	7
Shale	2	4½
Sandstone	9	8½
Shale	1	7

Sandstone	2	4
Shale	2	2
Sandstone	10	3
Shale	2	0
Sandstone	6	10½
Shale	3	0
Sandstone	4	4
Shale containing "*Glossopteris browniana*"	1	10½
Coal, fireclay in parts	2	0
Sandstone bottom	60	0

NICHOLAS AND WILLIAMS SHAFT

Shaft No. 5 of Figure 78 (at 4353E 9208N collar altitude 60 feet) is Nicholas and Williams Shaft (Gould, 1861, No. F) sunk to a depth of 275 feet. Selwyn (1855) recorded:

Spreyton Beds	*feet*
Blue argillaceous marl or shale with numerous fossil shells	70
Hard grey mudstone and conglomerate rock, fossils scarce	200
	270

This shaft is the same as, or adjacent to a shaft recorded by Thureau (1883) as sunk by P. Crompton in 1853-1854 to a depth of 302 feet. This yielded (Thureau):

Spreyton Beds	*feet*	*inches*
Blue fossiliferous marls	187	6
Shell bed	14	0
	201	6

The spoil from this shaft is a mudstone containing numerous shells and R. D. Gee recovered some massive Permian limestone.

ILLAMATHA COLLIERY SHAFT

The succession in the workings of the Illamatha 2 Colliery near the main shaft (4313E 9214N, altitude of shaft collar 150 feet) was as tabled below. The shaft was 80 feet deep, mainly in Kelcey Tier Beds, with a shell bed just above the base of the Kelcey Tier Beds, in a similar position to that examined by Gould at the Don Colliery a few hundred yards to the NW.:

Mersey Coal Measures	*feet*	*inches*
Sandstone .... thicker than	5	0
Dark, carbonaceous mudstone ("clod")	3	0
Coal	2	0
Clay	0	6
Sandstone .... thicker than	3	6
	14	0

DULVERTON NO. 1 BORE

Drilled by the Mines Department between 19th September, 1934, and 13th October, 1934:—

	Thickness feet	Thickness inches	Recovery feet	Recovery inches
Quaternary				
Yellow clay	18	3	18	3
Blue clay	6	3	3	1
Mersey Coal Measures				
Sandstone	45	6	45	6
Blue mudstone or clod	1	0	0	9
Mudstone	5	0	4	7
Shale	0	6	0	6
Mudstone or Clod	3	2	3	2
Coal	1	5	Cuttings	
Grey streaky sandstone	62	11	21	0
Very hard white sandstone	3	0	2	3
Spreyton Beds				
Sandy mudstone	34	0	21	5
Pebbly mudstone	73	0	28	7*
	254	0		

* Plus cuttings.

DULVERTON NO. 2 BORE

Drilled by the Mines Department between 18th October, 1934, and 23rd October, 1934:

	Thickness feet	Thickness inches	Recovery feet	Recovery inches
Quaternary				
Surface soil	1	0	1	0
Mersey Coal Measures				
Yellow sandstone	34	0	1	0*
Clod	5	8	5	1
Shale	0	4	0	4
Clod	7	0	0	7
Coal	0	3	0	3
Clod	0	10	0	10
Sandstone	2	11	2	11
	52	0		

* Plus cuttings.

DULVERTON NO. 3 BORE

Drilled by the Mines Department between 25th October, 1934, and 31st October, 1934:

	Thickness feet	Thickness inches	Recovery feet	Recovery inches
Quaternary				
Clay	7	0	7	0
Tertiary?				
Basalt	2	6	2	6
Mersey Coal Measures				
Yellow sandstone	52	6	Cuttings	
Clod	7	0	3	0
Shale	0	2	0	2
Clod	3	10	2	10
Coal	1	9	Cuttings	
Sandstone	0	3	0	3
	75	0		

DULVERTON NO. 4 BORE

Drilled by the Mines Department between 2nd November, 1934, and 9th November, 1934:

	Thickness feet	Thickness inches	Recovery feet	Recovery inches
Quaternary				
Clay and boulders	12	0	12	0
Mersey Coal Measures				
Sandstone	47	8	41	8*
Clod	2	11	2	11
Shale	0	2	0	2
Clod	7	8	7	8
Shale	0	3	0	3
Clod	1	5	1	5
Coal	0	7	Cuttings	
Bottom sandstone	0	4	0	4
	73	0		

* Plus cuttings.

DULVERTON NO. 5 BORE

Drilled by the Mines Department between 12th November, 1934, and 16th November, 1934:

	Thickness feet	Thickness inches	Recovery feet	Recovery inches
Quaternary				
Clay and basalt stones	5	0	5	0
Mersey Coal Measures				
Sandstone	44	3	Cuttings	
Clod	2	4	1	11

Shale	0	2	0	2
Clod	2	5	2	0
Shale	0	2	0	2
Clod	4	9	2	5
Smut	0	10	0	4
Bottom sandstone	3	1	1	8
	63	0		

DULVERTON NO. 6 BORE

Drilled by the Mines Department between 20th November, 1934, and 22nd November, 1934:

	Thickness		*Recovery*	
	feet	*inches*	*feet*	*inches*
Quaternary				
Clay	27	0	27	0
Mersey Coal Measures				
Soft sandstone	19	0	19	0
Clod	3	9	3	9
Shale	0	4	0	4
Clod	1	3	1	3
Coal	0	10	Cuttings	
Bottom sandstone	0	10	0	10
	53	0		

DULVERTON NO. 7 BORE

Drilled by the Mines Department between 26th November, 1934, and 5th January, 1935:

	Thickness		*Recovery*	
	feet	*inches*	*feet*	*inches*
Quaternary				
Clay	12	0	12	0
Mersey Coal Measures				
Old drive	6	0	Nil	
Streaky grey sandstone	32	0	20	6
Grey sandstone	5	0	4	9
Micaceous sandstone	2	0	1	3
Hard white sandstone	3	0	3	0
Spreyton Beds				
Mudstone	107	0	44	3
Pebbly mudstone	57	0	21	3
Mudstone with shells	6	0	6	0
Jurassic				
Dolerite (intrusive)	6	8	Cuttings	
	236	8		

DULVERTON NO. 8 BORE

Drilled by the Mines Department between 9th January, 1935, and 15th January, 1935:

	Thickness feet	Thickness inches	Recovery feet	Recovery inches
Tertiary?				
Basalt stones and clay	26	5	26	5
Mersey Coal Measures				
Yellow sandstone	48	8	Cuttings	
Clod	2	11	1	9
Shale	0	1	0	1
Clod	2	6	2	3
Shale	0	4	0	4
Clod	5	0	4	8
Coal	1	5 (*sic*)	1	11 (*sic*)
Bottom sandstone	0	2	0	2
	87	6		

DULVERTON NO. 9 BORE

Drilled by the Department of Mines between 17th January, 1935, and 24th January, 1935:

	Thickness feet	Thickness inches	Recovery feet	Recovery inches
Tertiary?				
Basalt stones and clay	73	0	46	0*
Mersey Coal Measures				
Grey sandstone (bottom sandstone)	30	0	18	4
	103	0		

* Plus cuttings.

DULVERTON NO. 10 BORE

Drilled by the Mines Department between 29th January, 1935, and 2nd February, 1935:

	Thickness feet	Thickness inches	Recovery feet	Recovery inches
Quaternary				
Clay	28	0	28	0
Mersey Coal Measures				
Sandstone	45	5	Cuttings	
Clod	3	7	2	9
Shale	0	4	0	4
Clod	3	10	3	7
Coal	1	3	1	0
Bottom sandstone	0	2	0	2
	82	7		

JURASSIC

Dolerite

Jurassic dolerite in Devonport Quadrangle occurs in two ways. There is a large, continuous sill intruded near the top of the Permian System, and small, discontinuous sills intruded near the base.

The principal sill caps Kelcey Tier, and continues under Devonport to the coast at Mersey Bluff. It forms the summits of Ellias Hill and Bonneys Tier to the south. In a N-S section through Ellias Hill and Kelcey Tier the sill appears to be concordant, dipping northwards at about 350 feet per mile in concert with the enclosing sediments. The average thickness is about 200 feet. There are prominent platy joints exposed on Kelcey Tier and Mersey Bluff which usually occur in the lower parts of sills (P. A. Hill, pers. comm.) and the sill was probably more than 600 feet thick when intruded.

The same sill caps Dooleys and Staggs Hills, at Latrobe, and extends northwards under the Tertiaries to Pardoe Point and Horseshoe Reef (S. J. Mayne, pers. comm.). However, the base of the dolerite on Staggs Hill is lower stratigraphically than on Kelcey Tier, perhaps as much as 150 feet. Haines Bore and Staggs Bore, collared just below the dolerite, intersected only the lower marker sandstone of the Kelcey Tier Beds.

The sill outcrops between Northdown and Port Sorell. At Northdown, the Northdown Foreshore Bore was collared less than 100 feet below the dolerite, and met the Mersey Coal Measures immediately below the beach shingle.

The sill outcrops south and west of Port Sorell, and Hughes (1954) reported that it is intruded close to the base of the Permian System at the Pandora Mine, hornfelsing the basal conglomerate.

The sill is therefore transgressive on the regional scale, and rises stratigraphically from east to west. An intrusive centre probably occurs south or SE of Harford. The E-W component of the rate of transgression is about 75 feet per mile. At Harford, this sill was encountered in Burgess Bore about 800 feet below sea-level, but outcrops at the surface (at and above sea-level) less than half-a-mile away, on the Shipping Hill Road. This disparity is probably not due to faulting, but to marked pre-Tertiary relief in a sill nearly 1000 feet thick.

Minor sills occur in the basal conglomerate SE of Latrobe (Staggs, Racecourse, Ingrams and Bourkes Bores); in the Spreyton Beds at Dulverton (Dulverton No. 7 Bore) and at the SW edge of Bonneys Tier near Rays Creek; intruded at the base of the Permian System SW of Bott Gorge, on the hilltop NE of the Aitken Creek junction with the Don River, and on the hilltop north of the B.H.P. Quarry at Eugenana; intruded just above the Mersey Coal Measures on the bluff north of Tugrah Siding. The source for these lower sills, particularly at Latrobe and Dulverton, is most probably the Dulverton Dyke in the Sheffield Quadrangle (a fissure shared by Tertiary basalt and Jurassic dolerite).

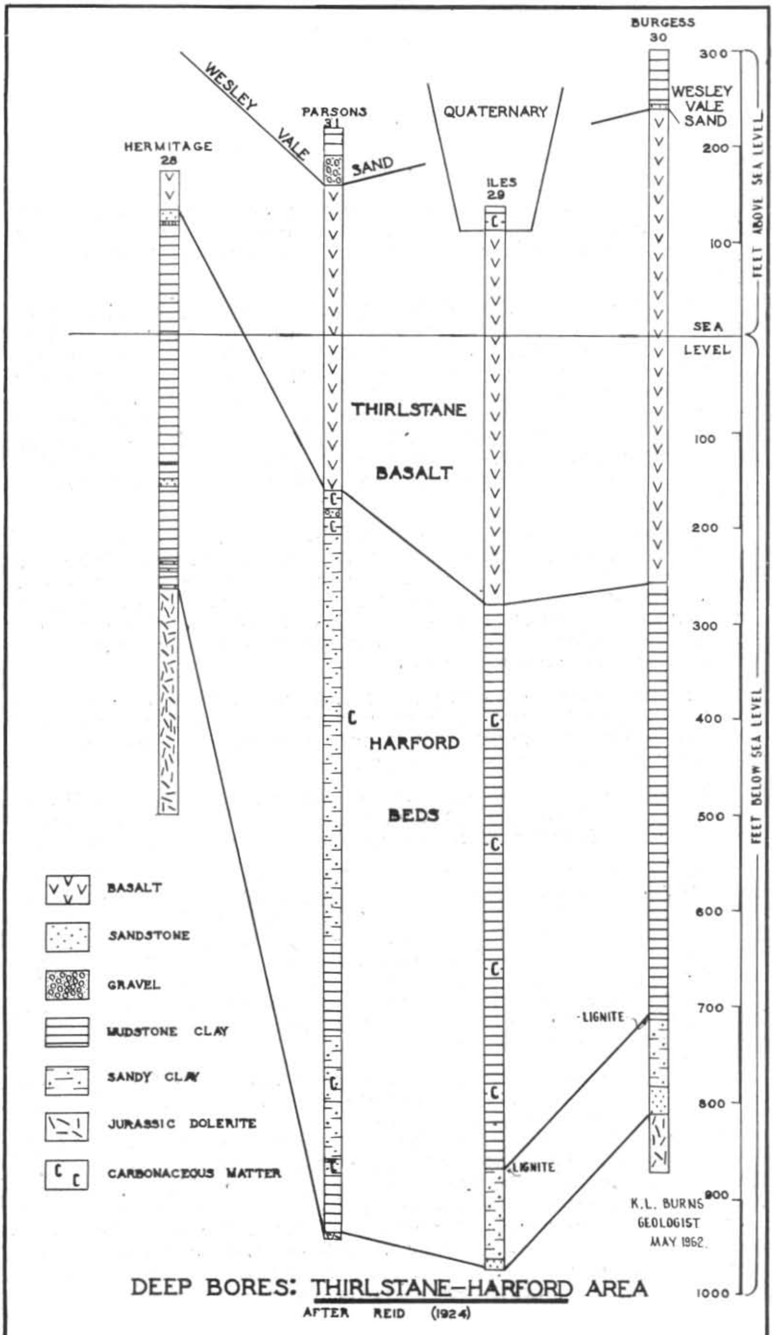


FIGURE 22.

5 cm

TERTIARY SYSTEM

The Tertiary deposits of Devonport Quadrangle occur in a number of deep leads, as shown in Figures 76 and 77. Deposits in the upstream parts of these leads were laid down under terrestrial conditions on a surface of considerable relief and there is, therefore, no direct connection between the sediments in one deep lead and the sediments in adjacent leads. The best example of this local control of sedimentation is "Lake Sheffield" in which sediments were deposited in a valley dammed by basalt (Burns, 1957a). Recognizing this local control, a succession has been named in only one group of deep leads—the Northdown-Moriarty complex of Figure 76. It would be expected that in the lower parts of the leads, or at a late stage of aggradation, the divides would be overtopped and sedimentation in one lead would be affected by that in its neighbours. This has occurred, particularly in the country west of the Dial Range where the divides were buried by the time of the last basalt flows which formed an extensive "lava plain".

Marine Tertiaries occur west of Wynyard, about 20 miles west of Devonport Quadrangle, in the country fringing Bass Strait. It is possible that many of the leads in the quadrangle contain marine intercalations near, or north of, the present coastline. A search was made for such intercalations by oil companies operating in the Northdown area in 1920-1930, but there is no record of their results in the most likely bore, which is the Northdown Beacon. However, the core recovered from this drill-site suggests that the bore missed the deepest part of the Northdown Lead and met bedrock at a shallow depth on its flanks.

Northdown-Wesley Vale-Moriarty Deep Leads

The succession in these 3 superimposed leads is (from the top):

Moriarty Basalt
Wesley Vale Sand
Thirlstane Basalt
Harford Beds

The *Harford Beds* is defined as comprising those clay, gravel and mudstone deposits intersected in Parsons Bore (4489E 9225N collar elevation 220 feet) between 379 and 1152 feet (Reid, 1924a, p. 105), where they overlie Jurassic dolerite and are overlain by the Thirlstane Basalt. The unit was encountered in the Hermitage, Iles, and Burgess Bores (Figure 22) where it consists of clay, sandstone, sandy mudstone, quartzite-pebble gravel and lignitic mudstone. The thickness varies from 392 to 773 feet. This unit does not outcrop at the surface. There may be occurrences on the hillsides west of the Hermitage, but this hillside is mantled by a waste of undifferentiated Tertiary rocks.

The *Thirlstane Basalt* is defined as that basalt intersected in Parsons Bore between 60 and 379 feet, and outcropping on Mr Parsons's property at Thirlstane. Pieces of core from this unit are lodged with the Department of Mines, Hobart. The maximum known thickness of this formation is 552 feet at Harford (Burgess Bore,

5 cm

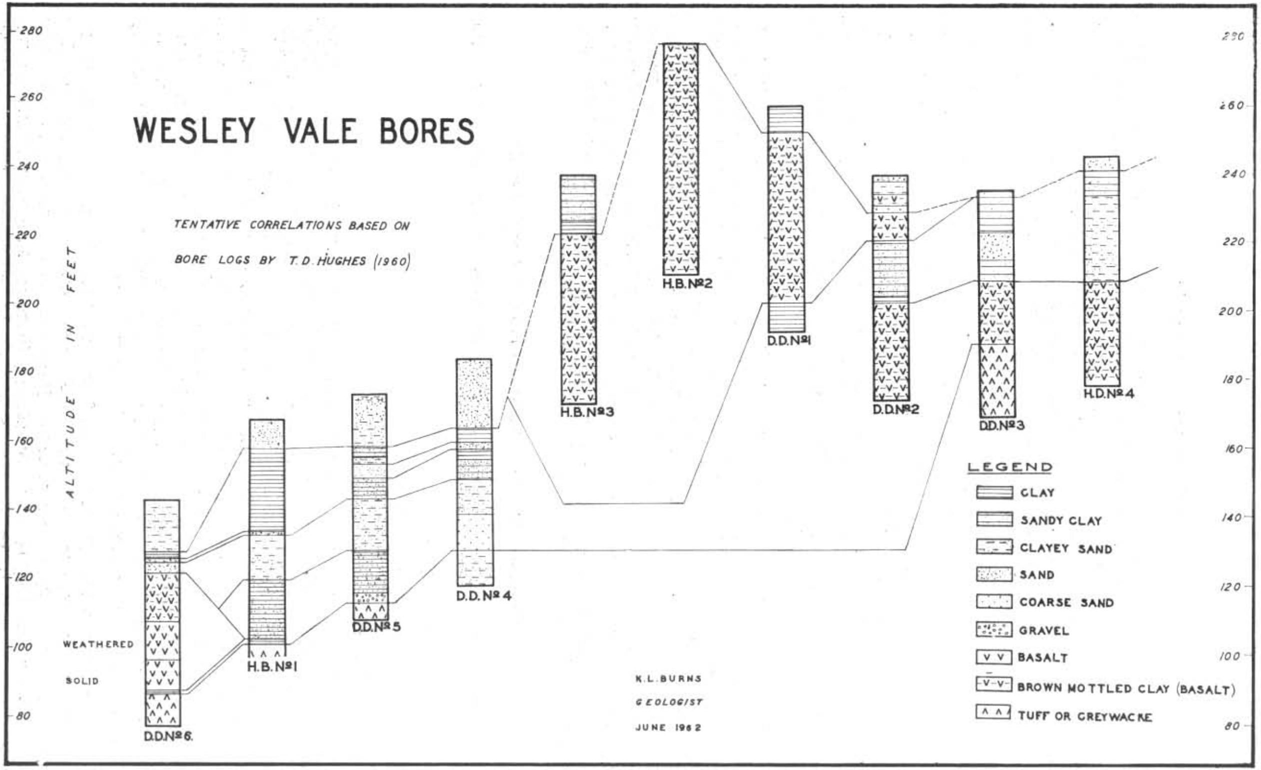


FIGURE 23.

collared at 4489E 9209N) and it appears to be a purely local development. This basalt outcrops at Morelands Point, at sea level; at sea level at Squeaking Point where it contains tree trunks; a few feet above sea level in the Panatana Rivulet where it forms the ford at Parkers Ford.

The *Wesley Vale Sand* is defined as that formation, predominantly sand or weakly indurated sandstone, which underlies the Moriarty Basalt on the face of the hill west of the township of Moriarty near 4427E 9237N. The unit is predominantly sand, with interbedded basalt, tuff, gravel, clay, and probably lignite.

The Wesley Vale Sand outcrops in the escarpment south of Morelands Point where it is 175 feet thick. The section at the top of the escarpment is (from the top):

	Feet
Sand and clay	26-65
Basalt (the edge of a channel fill of which the main portion has been eroded?)	0-34
Tuff and clay	c.77

This section is based on bore logs as in Figure 23 (after Hughes, 1961b). A blue clay with plant fragments is reported from near the base, near 4422E 9292N.

At Parkers Ford the Thirlstane Basalt is overlain by a succession correlated with the Wesley Vale Sand. After Burns (1960b) the succession is (from the top):

	Feet
Sand and clay layers	150+
Lignitic clay	1½
Blue clay with pyrite nodules	5
Basaltic tuff	40

Dr. Cookson has kindly identified the flora in the lignite as of probably Upper Oligocene age.

Sand containing beds of indurated mudstone occurs overlying basalt as far west as Mr Rundle's "Spring Hollow Farm" in the angle between the Tugrah and Stony Rise roads, where it was intersected in hand boring; similar sand overlies basalt at the site of the Mersey Hospital Medical Centre in Steele Street, Devonport. These deposits are probably the same age as the Wesley Vale Sand.

From Mr Burgess's property at Harford, the Wesley Vale Sand extends a considerable distance to the south and east as a thin sheet occurring in isolated patches on hilltops. It is possible to delineate a broadly undulating, gentle topography at the base of the formation, with a central valley termed the Wesley Vale Lead (Figure 77). The Wesley Vale Lead contains dolerite talus at its base where it runs through a buried gorge at Staggs Hill, east of Latrobe, with dolerite boulders in a sand matrix.

The *Moriarty Basalt* is defined as that basalt which overlies the Wesley Vale Sand and outcrops on the hilltop west of the township of Moriarty at 4427E 9244N. The Moriarty Basalt caps hilltops in the Moriarty-Northdown area and is deeply weathered. Contours on the base disclose a shallow lead running north under Northdown (Figure 77). The Wesley Vale Bores (Figure 23) went down 80 feet through the basalt in a small tributary lead but did not disclose fresh rock.

Kindred Lead

The Kindred Lead contains, apparently as a layer between basalt flows and extending onto a bench cut alongside the main channel, a deposit of well-rounded stream cobbles, about two miles north of Kindred. Deposits in the bottom of the lead are exposed on the right bank of the Forth River near Goldie Creek and are silicified talus, with large angular blocks of Precambrian quartzite in a matrix of silicified sand. Similar sub-basaltic quartzites north of Ballymacargy Falls include silicified residual gravels overlying Permian and baked Precambrian quartzite in which the tectonite fabric has been destroyed by heating. The lead contains a high proportion of pyroclastics which are best exposed in the creek east of Fulton Park but also occur at Forth township and inland from Lillicos Beach. East of Forthside Hill, south of the Bass Highway, there are outcrops of Jurassic dolerite occurring as a sub-basaltic boulder bed. Many of the blocks are very large and angular, and the deposit is interpreted as Tertiary talus.

In a tributary of the Kindred Lead, at the Ballymacargy Falls, there is exposed the following succession (from the top):

	Feet
Basalt, hackly jointed, vesicular, zeolitic	30
Basalt, columnar	2
Basalt, with sub-horizontal platy jointing undulating in the form of folds with 20 feet wavelength	5
Clay, white with small rounded basalt bombs av. 3 inches diam.	1
Sandstone, consisting of Precambrian rock fragments av. 0.1 inch diam. in a ferruginous cement	5
Boulder bed with subrounded boulders of Precambrian schist and quartzite av. 6 inches diam. but ranging up to 2 feet, in a ferruginous matrix of Precambrian pebbles av. 0.1 inch diam.	5

One of the best sections of the basalt is exposed in the cliffs at the Don Heads, in the lower part of the Kindred Lead.

Riana and Howth Leads

On the western side of the Howth Lead, near the Howth Railway Station, there is a coarse angular scree breccia derived from the Rocky Cape Group. On the coastline, Twelvetrees (1906b, pp. 38-39) described a heavy shingle resting on hard quartz conglomerate and noted (p. 34) the conversion of loose sediment into hard siliceous conglomerate by cementation beneath the basalt. A bed of sand outcrops inland, higher up the lead, between basalt above and below.

The Riana Lead contains a prominent bed of sand which outcrops around the coastal escarpment with basalt above and below. A sinkhole topography suggests that the sand extends for some miles up the lead. This prominent sand bed may be continuous with sand exposed along the coastal escarpment at about the same height at Burnie and may pass into marine Tertiaries at Doctors Rocks. The gravel and pipeclay in Adam Creek about 200 feet a.s.l. (Twelvetrees, 1906b, pp. 39-40) may be the same unit. The alluvial ground at Primrose Park containing Palaeogene leaves may be in the Riana Lead (Twelvetrees, 1906b, pp. 40-41).

Eugenana and Paloona Leads

The Eugenana Lead drained south into the Paloona Lead. It is filled with a thick deposit of sub-basaltic sand which probably reflects the damming of the Paloona Lead near Paloona by pyroclastics from a source hidden under the late basalts. The sand is overlain by vitric tuff just north of Paloona (post office). A bed of clay under basalt in this vicinity contains boulders of Ordovician conglomerate, quartzite pebbles (recycled from the Ordovician), basalt (bombs?), and large boulders of Jurassic dolerite (Burns, 1957b, p. 36).

The Paloona Lead has been discussed by Burns (1957a). It is a major drainage channel draining the Central Highlands with a broad valley at Sheffield and a narrow gorge between Lower Barrington and Paloona. This gorge was blocked by agglomerate, well-exposed in Hoggs Creek, and "Lake Sheffield" was formed upstream from the obstruction. The bottom bed in the Lead is a heavy wash, exposed north of Paloona Bridge. The lead crosses the present coastline east of Ulverstone and in common with many neighbouring leads reaches sea-level some miles inland.

Lodders Lead

Gravels occurring between Hays and Myrtle Creeks consist of chert sand recycled from the Duncan Conglomerate. In one place this sand contains large, loose boulders of sub-basaltic quartzite, a fact which suggests that the deposit post-dates some of the basalt. The deposits are Tertiary as they are dissected by Hays and Myrtle Creeks and pass under basalt to the north. The gravels are well-bedded and have structures reminiscent of the Duncan Conglomerate.

Turners Beach Lead

Thick sand in this lead is exposed where the lead is intersected by the Clayton River. The sand appears to overlie an irregular surface in basalt and is overlain by another basalt flow. On the coastal escarpment, at the Ulverstone Rifle Range, the top basalt is overlain by a thick deposit of quartz sand from which E. M. Smith (pers. comm.) has excavated marine shells of a modern type. This sand is a late deposit apparently filling an embayment in the escarpment cut into the stratiform volcanics of the lead. The embayment may be a meander bend of an upstream part of the Leith Lead.

Leith Lead

Sand overlies basalt at Leith and at Don Heads and appears to occupy a channel cut into older, stratiform volcanics. The channel runs parallel to the present coastline and is probably a post-Oligocene channel containing deposits perhaps equivalent to the Wesley Vale Sand but probably younger. The channel has been removed by the embayment at Lillicos Beach, and west of the Forth River, although, as has been noted, the late sands at the Ulverstone Rifle Range may occur in this channel. The filling of the lead probably occurred in the Miocene or Pliocene during formation of the Lower Coastal Surface.

Late Tertiary Deposits

The Lower Coastal Surface is defined in many places within the Quadrangle by late Tertiary terrestrial deposits which blanket older basalts and ignore sub-basaltic topography. Heavy shingle and buckshot gravel overlie Jurassic dolerite on Dooleys and Staggs Hills near Latrobe. South and east of Penguin, a layer of sand rests on an erosional surface which truncates basalt, Ordovician conglomerate, and Rocky Cape Group rocks. This deposit is post-basaltic, but is heavily dissected by modern streams. A similar deposit occurs in Sheffield Quadrangle capping the hill north of Aitken Creek at Nook. The Lower Coastal Surface is at a fairly uniform height where it crosses basalt, but in places where the bedrock contains a prominent lithological boundary close to this height, the boundary may be exhumed at the slightly lower or higher level, which occurs south of Penguin. There is a scree on the northern slopes of Sullocks Hill which is probably much older than Pleistocene as it is cut by the alluviated valley of Myrtle Creek. All these deposits are probably Tertiary, but for some a Quaternary origin cannot be definitely excluded, and these are shown as Cainozoic on the map sheet.

In Heybridge Creek, at Wesley Vale, and east of Northdown, a minor terrace is excavated in the coastal escarpment at the 200 foot level. This is covered with clay and sandy clay at Wesley Vale (Figure 23) and 8 feet of clay overlying 17 feet of sand at Northdown (H. R. Thomas, pers. comm.). These deposits are shown as Cainozoic on the map.

The Tertiary deposits in the headwater region of Adam Creek are sands, gravels and boulder beds derived from the Duncan Conglomerate and occur at the level of the Higher Coastal Surface.

Igneous Rocks

The Tertiary igneous rocks of Devonport Quadrangle are olivine basalt in composition. Textural variations are recognizable in hand specimen but the range of chemical variation is probably narrow (Spry, 1962b, pp. 273-274). In the field some flows may be recognized by their gross character, such as columnar, platy or hackly jointing, vesicularity, abundance of zeolites, and so on. This is more difficult in the Devonport Quadrangle than further inland as the basalt is not so deeply dissected and is more deeply weathered.

The principal rock type is lava, interbedded with sediments to form a stratiform pile. There is a small amount of vitric tuff near Paloona. Agglomerate is a common rock type in the interfluve between the Don and Forth Rivers, best exposed in Fulton Creek and occurs under "plateau-forming" basalt at Paloona, exposed in Hoggs Creek. Beds of white clay occur beneath or between basalts in places, containing rounded basalt cobbles which may be bombs.

Intrusive centres may be recognized by the following assemblage of characters: (1) contours on the base of the basalt are closed at the centre, indicating a closed depression with no exit; (2) lavas in the centre have a structure consistent with intrusive emplacement, such as a vertical flow structure, or have xenoliths from depth, and are not horizontally bedded; (3) direct evidence of intrusive emplacement may be in the form of a contact aureole in the country rock, or radial or ring dykes, or a drag-dip of deposits fringing the centre; (4) coarse agglomerate has a grain size decreasing away from the centre, breccia dips away from the centre.

These criteria are listed because in many cases not all of them can be recognized, so that in these cases there is some element of uncertainty. Volcanic centres, identified from one or several of these characters, are known or inferred on the North West Coast at Circular Head, Table Cape, Lorinna, Paloona, Upper Castra, Barrington, Dulverton (dyke), and Hampshire. In Devonport Quadrangle, the agglomerate underlying Forthside Hill suggests a proximate centre. A neck is exposed at sea-level in the left bank of the Leven River just upstream from Singletons Point. There is a closed depression, at least 200 feet deep, in the sub-basaltic contours (Figure 76) and a dyke radial to the neck runs up the hill on the right bank of the Leven River just downstream from Skeleton Creek. In a cutting on the old Nietta Railway, the dyke has metamorphosed Rocky Cape Group phyllite to quartzite over a width of several feet. There is another effusive centre in the Wesley Vale Lead just south of the boundary of the Devonport Quadrangle, the well-known Dulverton Dyke.

QUATERNARY SYSTEM

Quaternary rocks in Devonport Quadrangle consist principally of alluvial deposits on riverine plains, marine and coastal deposits on the coastal platform, and mass movement deposits on the escarpments.

The escarpment flanking the Dial Range has a discontinuous free face at the top, up to 400 feet high. Elsewhere the scarp is mantled by scree derived from the Duncan Conglomerate. On the eastern side of the range, the scree reaches down to the Lower Coastal Surface but does not extend across it. It is fixed by vegetation, has a soil profile developed on it, has no fresh additions, and in Dial Creek stands in high banks where undercut by the creek. On the western side of the range, the scree extends down into McBrides Creek to well below the level of the Lower Coastal Surface. This creek runs along the foot of the scarp, undercutting the scree, and the evidence of overwhelmed mine openings shows that the scree is moving slowly at its foot. The scree forms fairly stable fossil deposits, probably Pleistocene in age.

On Kelcey Tier the scree is blocky dolerite which mantles the top of the scarp except for a small free face at the very top. The scree supports vegetation, has no modern additions, is very deeply weathered on flat slopes, and is lateritized on the SW part of Kelcey Tier. At the NW part of the Tier, the scree is younger than Tertiary deposits, and it is probably Pleistocene in age.

Along the sides of the river valleys there are scree deposits on those portions not being actively undercut by the rivers, that is, on the valley sides separated from the stream channel by river terraces. There are screes composed of chert, just south of Allisons Road on the Leven River; of quartzite, in places between Sayers Hill and Porcupine Hill; mudstone or impure chert in the Forth and Wilmot Rivers above their junction. The sides of Dooleys and Staggs Hills are mantled with dolerite scree. Basalt scree is uncommon, occurring on the right bank of the Forth at Fulton Park, south of Sayers Hill, and on the left bank of Penguin Creek north of the iron mines.

The coastal escarpment has, generally, a steep upper portion and a gentle foot. The foot appears to be a scree deposit in many places, although possible shingle ridges occur just east of the Ulverstone Rifle Range. The scree is dolerite just east of Northdown. Where the scarp is in Tertiary sands, the slope is usually very gentle such as at the mouth of Pardoe Creek. Deposits at the foot of basalt scarps are very deeply weathered, and form a small wedge in the angle between the escarpment and platform.

The escarpments, particularly that between the Lower Coastal Surface and the Marine Platform, have numerous deep deformational shear slides or other mass movement zones, which are probably significant as erosion mechanisms but do not contribute significantly to deposits at the foot of the scarp. These slides have been discussed in some detail by Nye (1931a, b, c,) Hughes (1957b) and Burns (1957c, 1959b) and occur in Tertiary basalt or Permian mudstone. In some places the slides spread out across the Marine Platform as large bulbous toes, as at Northdown or immediately west of Goat Island. In other places the toes are absent and have been removed by erosion at the level of the platform. Some slides thus pre-date the emergence of the platform, others post-date it. In all cases the general movement of the slides has been arrested, many are deeply dissected by erosion, and they are ancient structures. Movements at the present time are usually small movements in small areas of the large slides. The landslides are so numerous that they can be used to define the escarpment.

The valley floors have well developed meander terraces, in part cutting bedrock, but usually cutting a valley fill of deposits ranging from coarse boulder beds to silt. At Paloona a very high proportion of the boulders are very large and have been derived from upstream above Lorinna, in the Central Highlands. The valley fill is probably largely a Pleistocene, fluvio-glacial deposit.

The large rivers meet the coast in embayments, or estuaries, and have built small deltas where they met the sea. The delta on the Forth is a symmetrical crowsfoot type. The distributaries are no longer active, and presumably the deltas have been exposed following the post-Milford drop in sea level.

On the Marine Platform the deposits are gravel, sand and clay. A heavy shingle covers most of the platform, from the mouth of the Clayton River west to Port Sorell, overlain in many places by sand and clay, or in some places by recent sand dunes. The principal sources of the pebbles are the Forth and Mersey Rivers, which drain glaciated highlands, and from the rivers the pebbles have been distributed along the coast by currents from the west. In the quietwater east of Mersey Bluff, a submarine shingle bar forms regularly and the shipping channel has to be dredged clear. The dredgings are dumped beyond Horseshoe Reef. Storms in Bass Strait build up high shingle ridges of this material at Turners Beach and Northdown Beach, and to a lesser extent at Lillicos Beach and the beach east of the Don Heads. Sometimes these will be removed in a following storm.

Structural Geology

PRECAMBRIAN

The term Frenchman Metamorphic Period was introduced by Spry (1957b, p. 106) for an inferred deformational period between the "older" and "younger" divisions of the Precambrian. The term Metamorphic Period was used "as it is mostly the results of regional metamorphism which distinguish these rocks" (Spry, pers. comm.). In 1962 Spry (p. 124) introduced the term "Frenchman Orogeny" for the series of metamorphic and tectonic events which produced the metamorphism and characteristic tectonic style of the Franklin Group of Central Tasmania (which resembles in these characters the Forth Metamorphics of Devonport Quadrangle). Spry considered that the Frenchman Orogeny preceded the deposition of the slightly metamorphosed "younger" division of the Precambrian but recognized that the evidence (1962a, pp. 121-122) is not conclusive.

In Devonport Quadrangle the Precambrian may be divided into two divisions, upper and lower. These terms are used in preference to Spry's "older" and "younger" as they carry no implications of relative age and are descriptively accurate, the upper division everywhere overlying the lower. The Upper Division is represented by the Rocky Cape Group and the Lower Division consists of the Ulverstone and Forth Metamorphics. The boundary between the two divisions occurs west of Ulverstone and is a flat-lying structure, the Singleton Thrust.

Two periods of folding are recognized in the Upper Division. These pre-date the Cooee Dolerite (700 million years B.P.). Spry (1962a, p. 124) introduced the term Penguin Movement for a late Precambrian tectonic event "separating the Rocky Cape Group from the Dundas Group". The term Penguin Orogeny is used here to embrace both periods of folding recognized in the Rocky Cape Group, and the periods are termed first and second phases, or P1, P2. The Singleton Thrust was active during the second period of folding, P2, but may have originated earlier.

TABLE 13

Correlation of Precambrian Tectonic Events

LOWER DIVISION	DIVISION BOUNDARY	UPPER DIVISION
Strain-slip cleavage in some areas	Singleton Thrust active	Second-phase of Penguin Orogeny (P2) forming a schuppen structure.
Second - phase of Frenchman Orogeny (F2) with metamorphism to chlorite grade, biaxial strain with principal component horizontal, Goldie Creek style folds (?) formed.	Transition	First-phase of Penguin Orogeny (P1) with metamorphism of low grade and isoclinal folding of interfolial style.
Interval (?)		Deposition of Upper Division (?).
First-phase of Frenchman Orogeny (F1) with metamorphism to garnet grade, principal component of strain vertical, Porcupine Hill style minor folds.		

Two periods of folding and accompanying metamorphism are inferred in the Lower Division. These are assigned to the Frenchman Orogeny of Spry, and the episodes will be termed first and second phases, or F1 and F2. The second phase is a widespread movement and accompanying structures are fairly readily identified. The first phase, F1, is recognized from relicts preserved in some areas and in practice includes all structures older than F2. F1 may itself comprise a number of movements, but textural studies by Spry indicate that it was probably a single major event.

The relationship between the phases of the Penguin Orogeny and the phases of the Frenchman Orogeny is not known. In the Upper Division P1, P2, and Palaeozoic structures occur. In the Lower Division there is a record of F1, F2, a late strain-slip cleavage, and Palaeozoic structures. The late strain-slip cleavage in the Lower Division is here correlated with the P2 phase of the Upper Division. This implies that F2 and P1 are probably contemporaneous, which implies in turn a telescoping of metamorphic facies on the Singleton Thrust. This is possible as the evidence indicates that the Singleton Thrust is a large and powerful structure. With these correlations, the Precambrian tectonic history becomes as in Table 13. It is emphasized that this is a correlation between known events in two divisions which although in contact, record strongly contrasting styles of deformation. The order of events in each division (columns 1 and 3 of Table 13) is established, but the correlation of events between divisions is conjectural.

In describing the Precambrian structure, it is convenient to describe the structures in the Forth Metamorphics, the Ulverstone Metamorphics and the Rocky Cape Group and to conclude with the evidence for the Singleton Thrust.

Forth Metamorphics

The rocks of the Forth Metamorphics are garnet-mica schist, quartzite and amphibolite which have suffered polyphase metamorphism (A. H. Spry, pers. comm.). The possibility of kyanite-grade rocks occurring is suggested by reports of Petterd (1893, 1896, 1910) of kyanite collected by Gould from the Clayton River in 1873. Petterd (1910 p. 61) reported " cyanite " as embedded in schist at the Clayton River, and (p. 103) that kyanite " also occurs near Forth township. Kyanite-bearing schist was not re-discovered in the present mapping.

The Forth Metamorphics abuts against the Ulverstone Metamorphics in the vicinity of Abbotsham and Spalford. The boundary between the two associations is defined arbitrarily at the contact between garnet-biotite-muscovite schist and chlorite-muscovite schist. There is amphibolite but no conglomerate in the Forth Metamorphics, and conglomerate but no amphibolite in the Ulverstone Metamorphics, so there are differences between them in addition to the difference in grade. The value of an arbitrary division of this kind is perhaps doubtful, but differences in lithology and grade have provided a useful initial division of the Precambrian in the Frenchman's Cap region and extension of the practice to Devonport Quadrangle does simplify comparison, and assemblages so defined do have a certain unity which facilitates recognition in the field.

Rocks of the Forth Metamorphics contain a number of foliations defined by compositional layering, dimensional orientation of mica, dimensional orientation of quartz and amphibole, and optical schistosity and transposition foliation S_2. Earlier S-surfaces are preserved as relicts in detached fold cores and are denoted collectively S_1. The S_1 class may be readily subdivided microscopically into foliations of several kinds but their generic relations are uncertain. The deformative and metamorphic episode in which S_2 was formed is of Precambrian age as shown by the structural and metamorphic hiatus between Forth Metamorphics and Palaeozoic rocks at Porcupine Hill. The foliation S_2 describes sweeping curves in plan resulting from two periods of post-metamorphic deformation which are identified as Tabberabberan.

STRUCTURES IN SCHIST

At the western margin of the Forth Metamorphics, near Abbotsham, the schist has a compositional quartz-muscovite layering which may be denoted S_1. In the field a dark banding due to layers rich in iron and possibly a primary compositional banding, is visible, describing isoclinal folds about S_1. S_1 is a penetrative schistosity

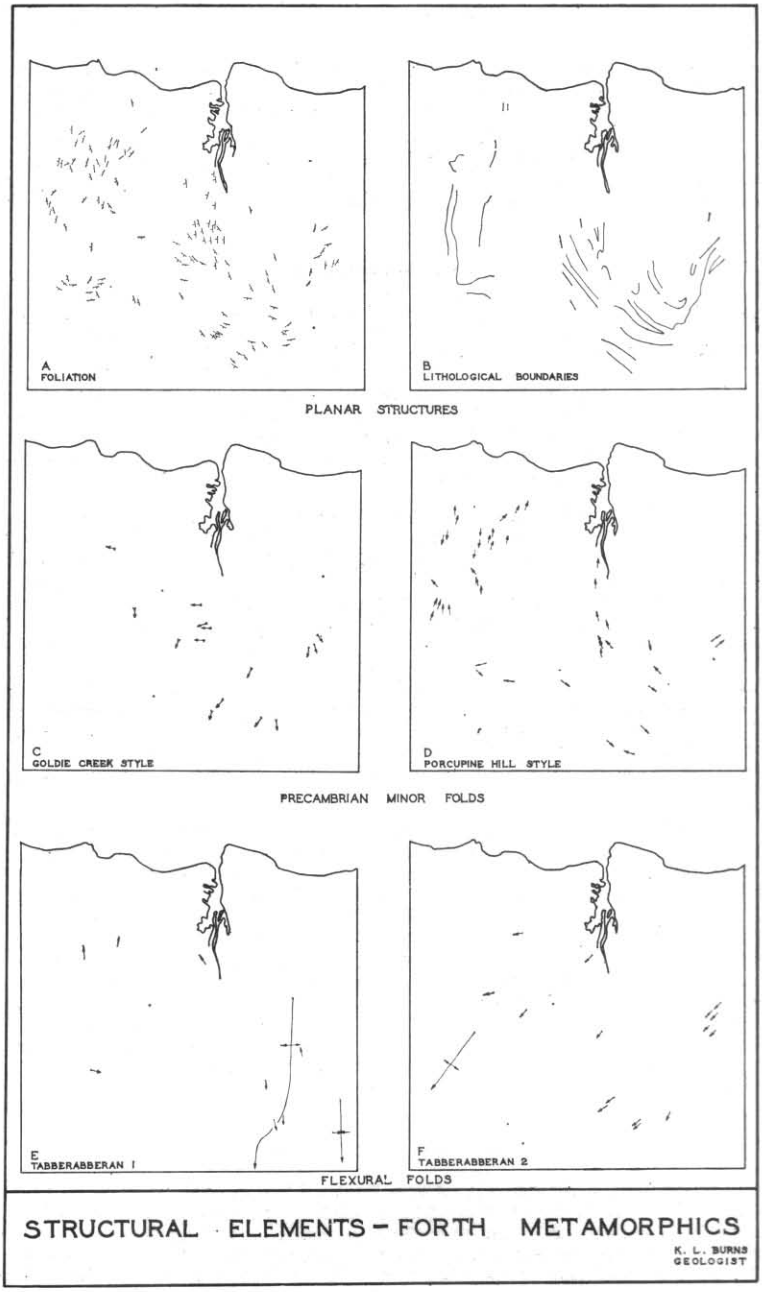
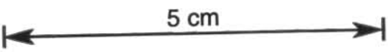

A
FOLIATION
B
LITHOLOGICAL BOUNDARIES
PLANAR STRUCTURES
C
GOLDIE CREEK STYLE
D
PORCUPINE HILL STYLE
PRECAMBRIAN MINOR FOLDS
E
TABBERABBERAN I
F
TABBERABBERAN 2
FLEXURAL FOLDS
STRUCTURAL ELEMENTS – FORTH METAMORPHICS
K. L. BURNS
GEOLOGIST

FIGURE 24.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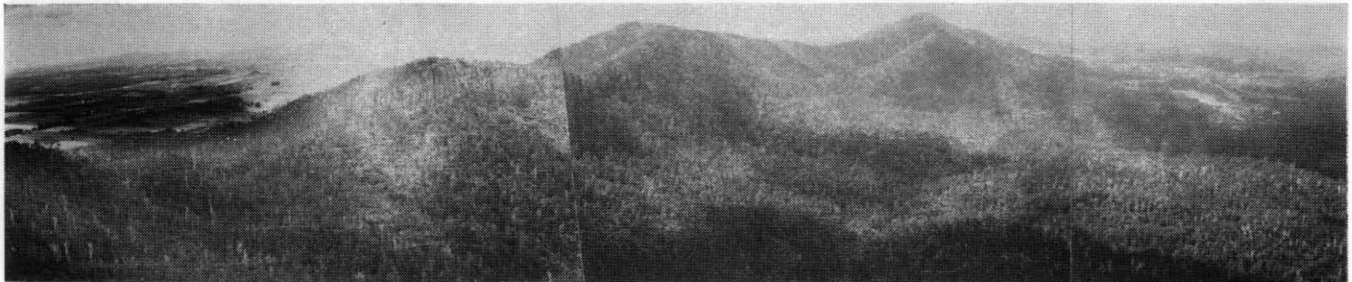
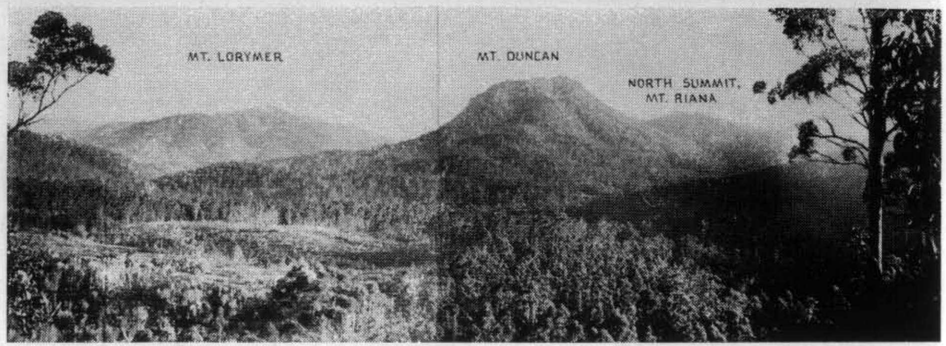




TOP :- THE GNOMON, MT. DIAL AND MT. MONTGOMERY FROM MT. DUNCAN (LOOKING NORTH). THE BREAK OF SLOPE AT THE FOOT OF THE ESCARPMENT IS THE POSITION OF GOULD'S (1867) "GREAT BREAK" AT THE ORDOVICIAN-CAMBRIAN BOUNDARY.

BOTTOM:- MTS. LORYMER AND DUNCAN (LOOKING SOUTH FROM MT. MONTGOMERY).

Plate 1.

Plate 2.—Dimensionally oriented chert pebbles in Duncan Conglomerate, near Devon Consols.

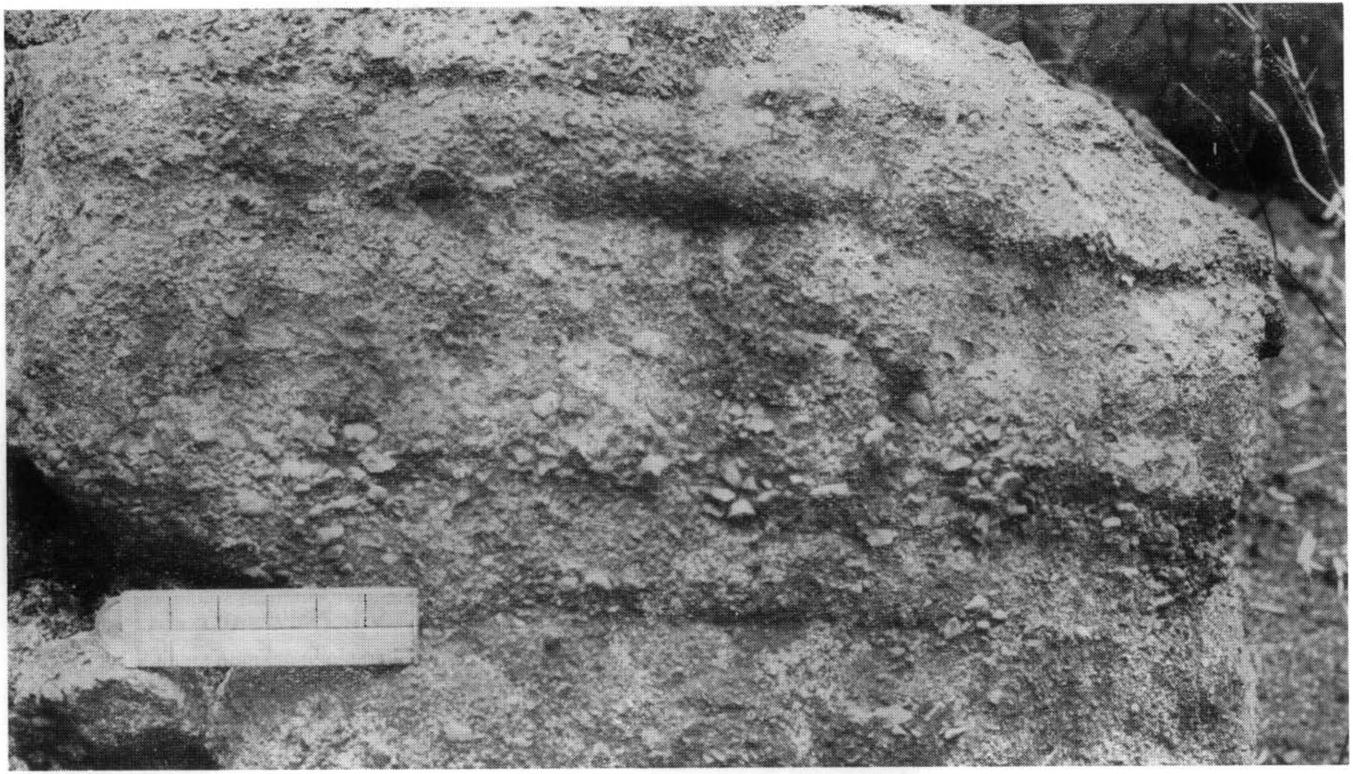


Plate 3.—Banded conglomerate of Duncan Conglomerate, near Devon Consols.

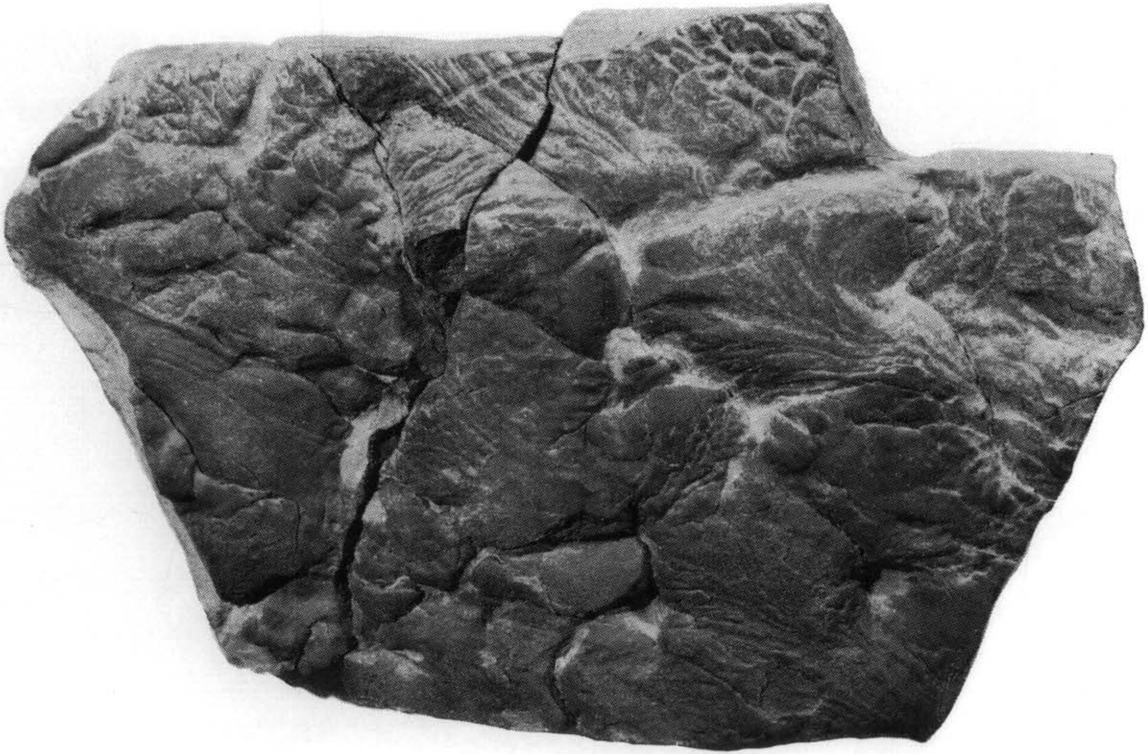


Plate 4.—Squandramous flow casts in Rocky Cape Group, Sulphur Creek.

Plate 5.—Syndromous flow casts in Rocky Cape Group, Blythe Heads.

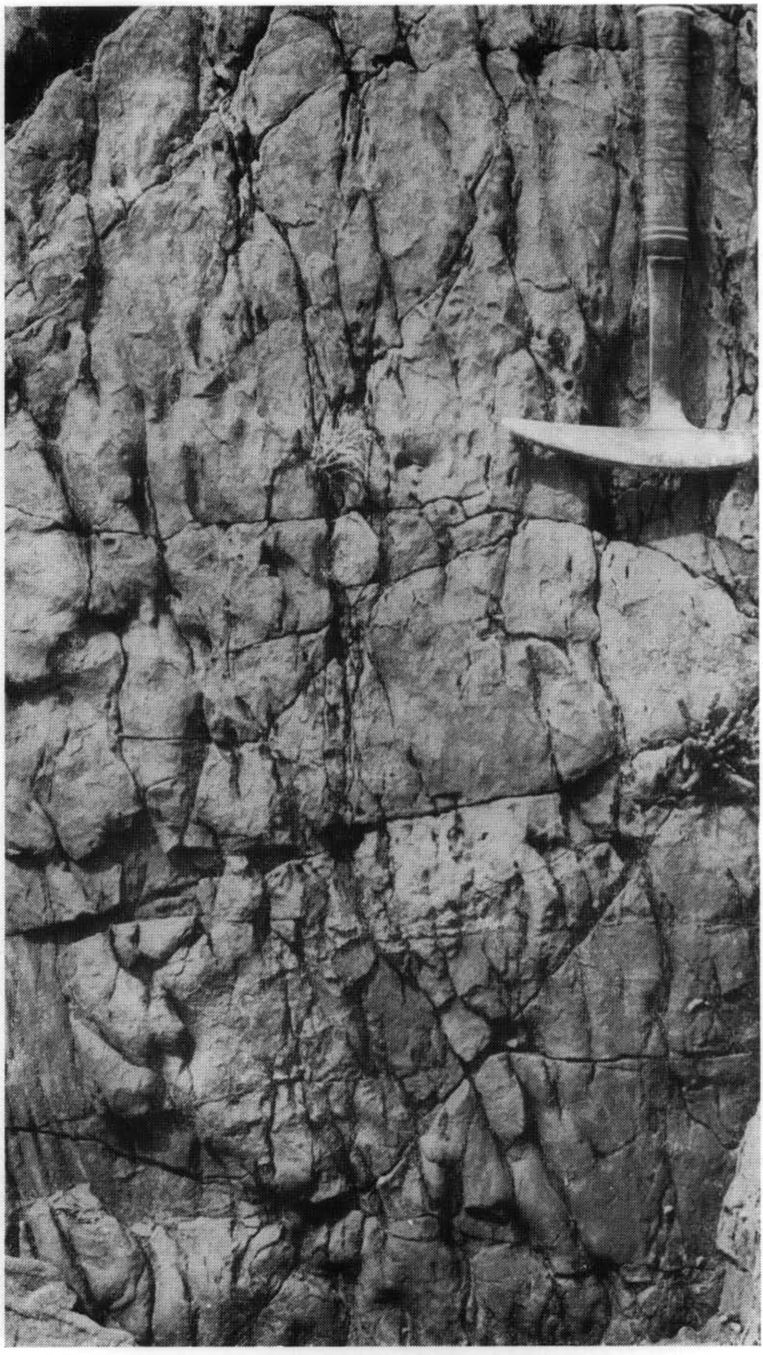


Plate 6.—Flow casts modified by jointing and by Precambrian cleavage, Blythe Heads

Plate 7.—Pebble-free bands overlying conglomerate, Goat Island.

Plate 8.—Tectonic interdigitation of quartzite and schist, Picnic Point.

Plate 9.—Foliated quartzite, Picnic Point.

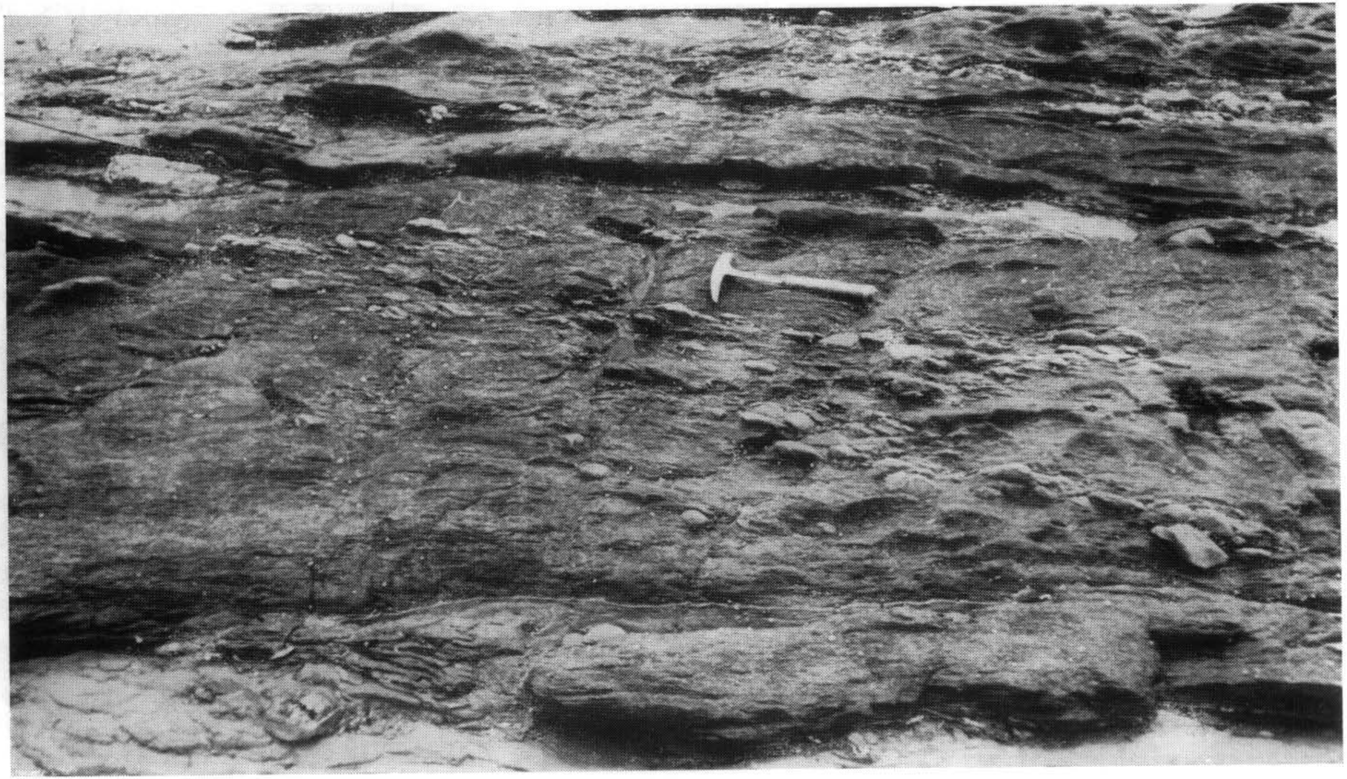
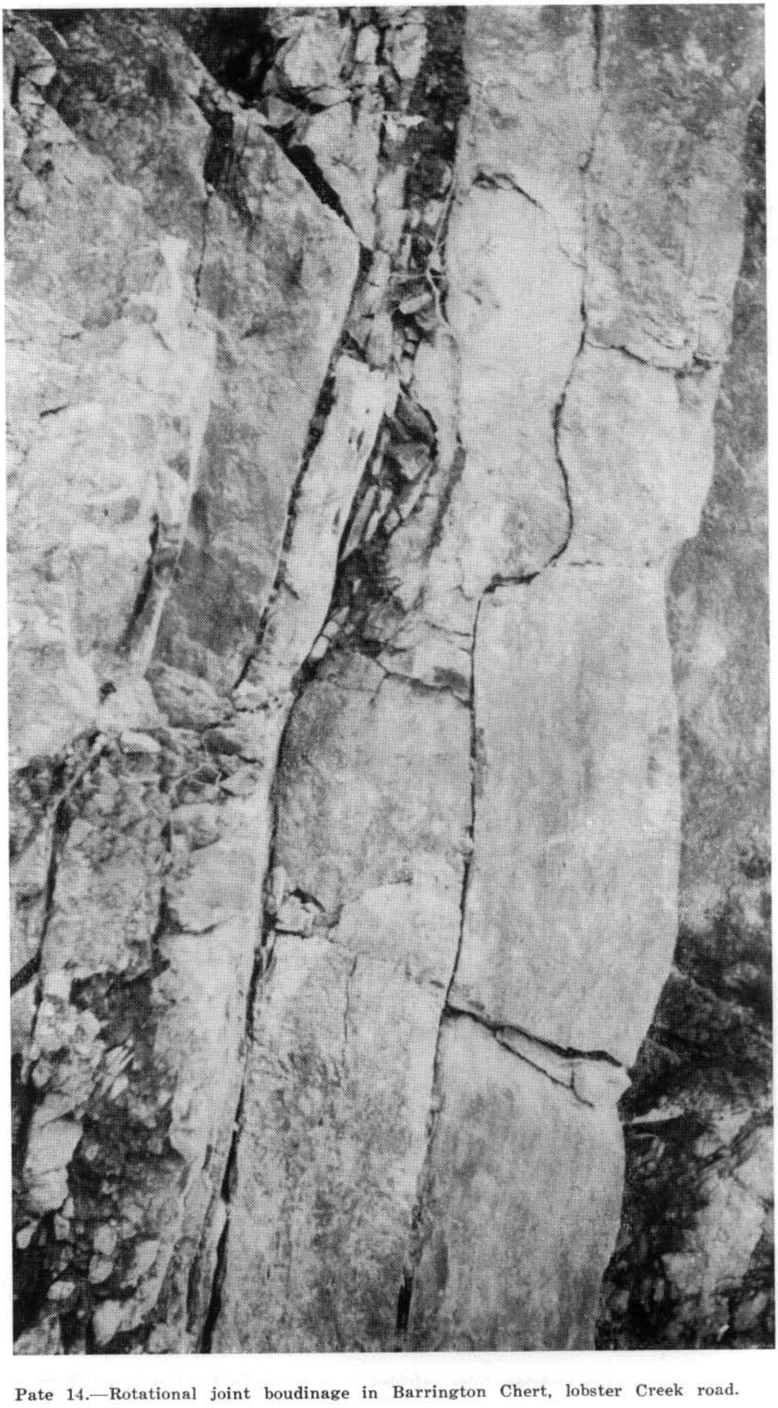


Plate 10.—Band of tectons marking transposed lithological layering, Goat Island.

Plate 11.—Tabberabberan conjugate fold in foliated quartzite of the Ulverstone Metamorphics, Picnic Point.

Plate 12.—Disjunctively folded veins, Forth Metamorphics, Ballymacargy Creek.

Plate 13.—Isoclinal Precambrian folds refolded in a small Tabberabberan antiform, Picnic Point.



Pate 14.—Rotational joint boudinage in Barrington Chert, lobster Creek road.

Plate 15.—Rotational-joint boudinage, Sulphur Creek.

Plate 16.—Boudinaged bedding cleavage, shore platform, Sulphur Creek.

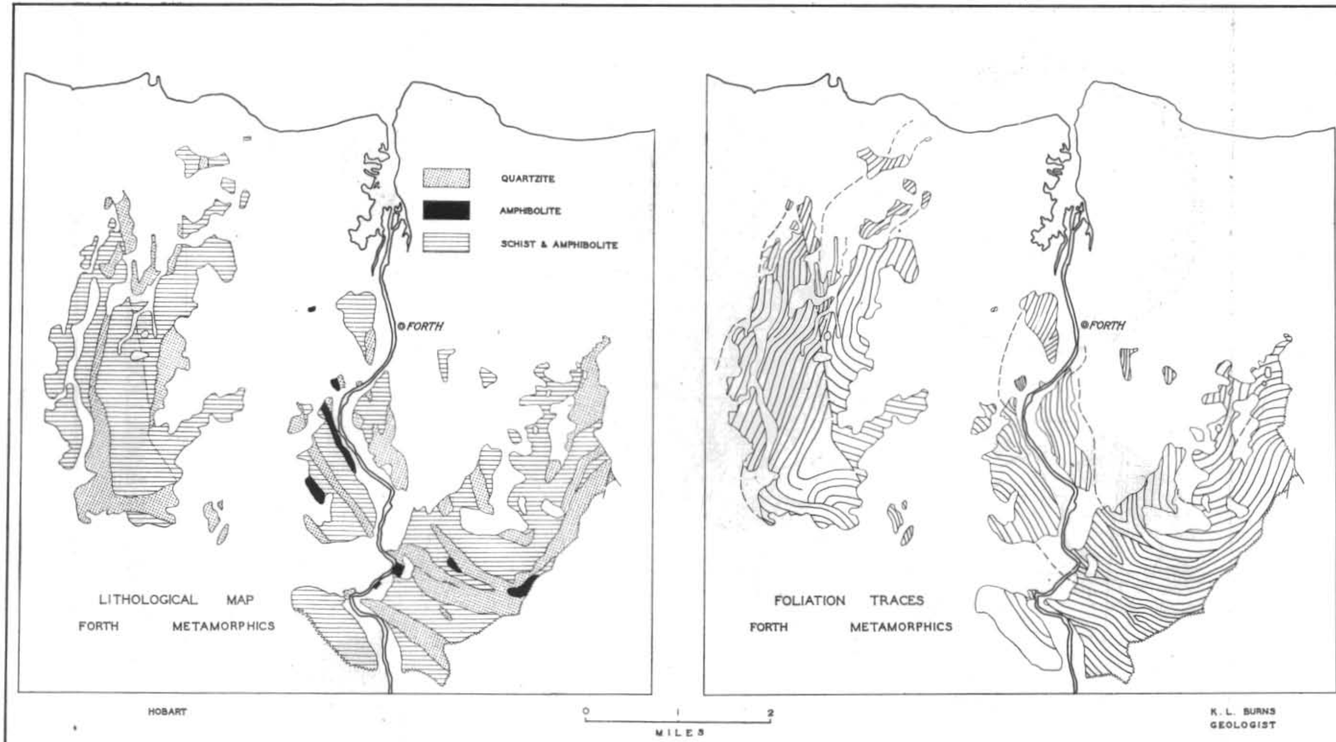

QUARTZITE
AMPHIBOLITE
SCHIST & AMPHIBOLITE
FORTH
LITHOLOGICAL MAP
FORTH METAMORPHICS
FORTH
FOLIATION TRACES
FORTH METAMORPHICS
HOBART
0 1 2
MILES
K. L. BURNS
GEOLOGIST

FIGURE 25.

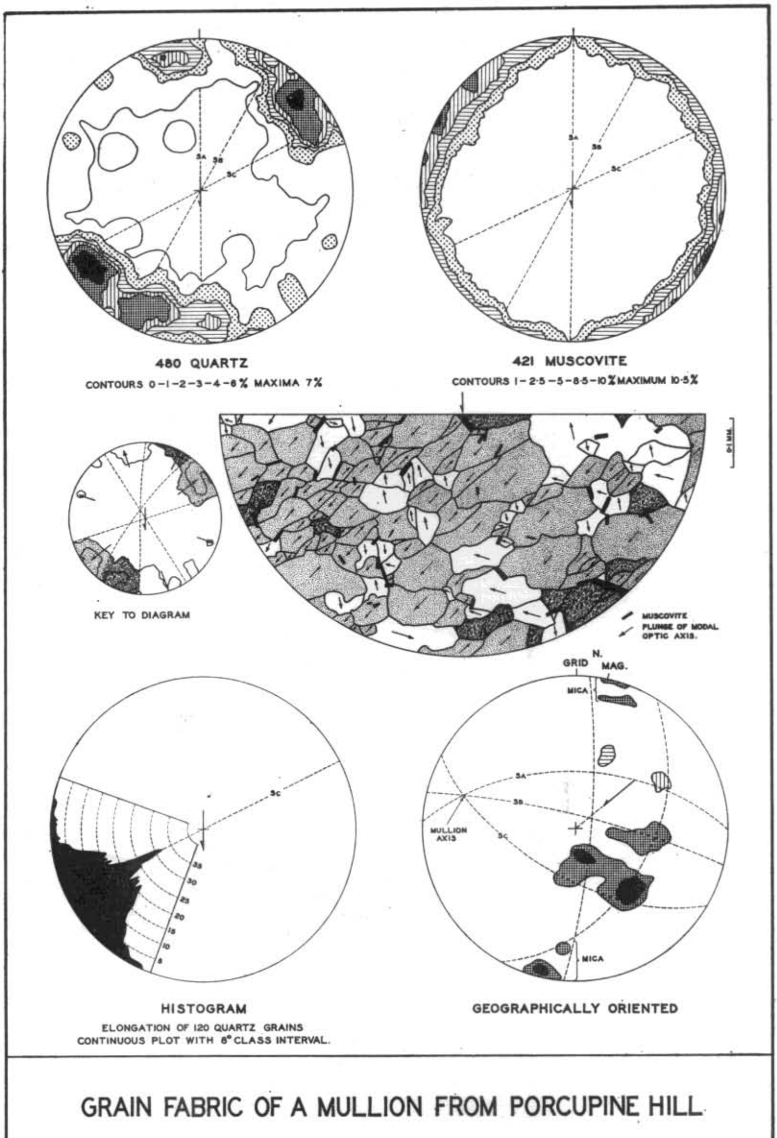


Figure 26.

5 cm

with enveloping surfaces near-horizontal and is refolded as open, upright symmetrical folds of 6 inches wavelength. The regionally-extensive foliation, S_2, is an axial foliation and appears as a wide-spaced crenulation cleavage with foliae marked by oriented grains of syntectonic biotite. The compound fold form is the type M on Σ of Ramsay (1962, Fig. 13).

In the Clayton River, one mile east of Abbotsham, S_2 is closely spaced and S_1 may be identified only in thin section. Some outcrops are strongly pencilled with the lineation S_1 x S_2 being the only macroscopic structure. Yet further east, on the Forth River, S_1 is completely obliterated mesoscopically and is visible only in thin section as occasional detached cores of isoclinal folds. S_1 is usually a mica foliation but is sometimes a quartz-mica compositional layering. S_2 is a schistosity formed by alignment of coarse, recrystallized muscovite and biotite.

There are hazards in identifying the latest, macroscopically dominant foliation as S_2 everywhere. However, the assumption is justified by the resultant continuity of S_2 so derived, as in Figures 24 and 25. For this reconnaissance work, the planar structures earlier than S_2 are grouped together collectively as S_1. Sub-classes of S_1 occur but in general only their interactions with S_2 have been observed and not their interactions with each other. Where foliations earlier than S_2 are preserved, B (1, 2) folds are formed. At the mouth of Goldie Creek a compositional foliation of interlayered quartzite and schist is folded into long-limbed isoclinal folds with axial surfaces parallel to S_2 and fold axes pitching steeply in S_2, near 90°. The limbs are attenuated to half the crestal thickness and in some places the quartzite layers break up into bands of quartz-augens in the schist. In an adjacent outcrop about 200 yards south of the mouth of Goldie Creek there is a belt of greenschist interlayered with the schist. The greenschist has a chlorite-actinolite compositional layering which is folded with the same style and orientation as the folds in the schist. The style and orientation is distinctive and is named the "Goldie Creek Style". At Goldie Creek the style is isoclinal B (1, 2) folds of steep axial plunge, where S_1 is a compositional layering, probably bedding, in schist and a metamorphic banding in amphibolite. Belts of granoblastic amphibolite have garnet-hornblende compositional layering and layers of secretion quartz. The quartz veins are folded into long-limbed isoclinal disjunctive folds which are abundant in the schists in certain areas. In every case observed, the axes of these folds plunge within 20° of the down-dip direction of S_2. Folds of this style are abundant in certain outcrops and the median orientation in each outcrop is shown in Figure 24c. They are confined to belts of schist and amphibolite and their manner of interaction with folds of the "Porcupine Hill Style" (described below) is unknown.

STRUCTURES IN QUARTZITE

Several foliations occur in the quartzite, such as a compositional quartz-muscovite foliation (Sa of Figure 26) which consists of alternating layers from one-quarter to one inch thick, a foliation due to the dimensional elongation of quartz (Sc of Figure 26) where the quartz occurs as flattened lenses or augens, and a second mica foliation (Sb of Figure 26) which is marked by alignment of muscovite grains. The foliation due to dimensional elongation of quartz gives a fibrous appearance to otherwise massive quartzite and is very prominent on weathered surfaces of micaceous quartzite ("quartz schist"). In vitreous (mica-free) quartzite this foliation is sometimes visible as a grain or linear fracture pattern on freshly broken surfaces. The second mica foliation outcrops on compositional surfaces (Sa) as mica trails or glossy lines on the surfaces due to concentration of mica at the foliation trace. The compositional foliation Sa is found folded in places with the mica foliation Sb parallel to the axial planes of the folds, so that Sb is younger than Sa. In most outcrops, however, the 3 foliations are sub-parallel to each other (and to S_2 of the adjacent schist).

Linear structures consist of minor folds of the type B (Sa, Sb) and lineations formed at the intersections of foliations. There is no quasi-penetrative puckering or crenulation of any foliation. No outcrops occur in which the lineations have variable plunge and each body of quartzite is superficially homogeneous in this respect. For example, the quartzite "fish" nearest the river at Sayers Hill has a strongly-developed mullion structure which pitches between 75° and 85° north in S_2 and has no other mesoscopic lineations, while an adjacent quartzite on the eastern side (apparently rooted) has a number of minor folds and cognate lineations which plunge close to 30° north in the foliation but have no superposed or refolded lineations. No outcrop with mesoscopic triclinic fabric has been located. The predominant minor linear structure in the quartzite is a mullion structure which includes both fold mullions and irregular mullions. In almost all outcrops this structure pitches within 20° of the horizontal in S_2. An exception is the inferred tectonic "fish" at Sayers Hill which appears to have suffered bodily rotation. The style and orientation of this mullion structure contrasts markedly with the "Goldie Creek Style" and is termed the "Porcupine Hill Style". Representative orientations are shown in Figure 24.

The characteristics of the "Porcupine Hill Style" mullions are shown diagrammatically in Figure 26. This is a sample from just below the base of the Ordovician in the first gully SW of the summit of the hill. While various interpretations may be placed on this grain fabric and samples in isolation must be treated with caution, it does illustrate the nature of the foliations and the well-defined girdle normal to the mullion axis. The texture has not the pronounced mortar structure typical of the Ulverstone Metamorphics.

GENERAL FEATURES

The most striking features of the Forth Metamorphics are the parallelism of S-surfaces of different types, and a consequence of this, which is the concordance of lithological layering with the young foliation S_2. Lithological alternations on a scale between one and twelve inches thick form the layering in schist and quartzite. Thicker alternations in the quartzite resemble flaggy bedding. In many bodies of quartzite the bedding is parallel to the boundaries of the bodies and to S_2 in adjacent schist. In schist, these small-scale lithological alternations are preserved only in fold hinges.

Lithological alternations on a scale between one-quarter and three inches thick in amphibolites are due to layers rich in garnet, chlorite, actinolite, or sometimes albite, and result from metamorphism. This layering is generally parallel to S_2 and is found refolded about S_2 as axial plane in only restricted areas.

The belts of schist and amphibolite are about half-a-mile wide and are separated by belts of quartzite. Within the schist belts there is an alternation of lithologies from muscovite-albite schist to garnet-biotite schist to interlayered quartzite and schist to banded amphibolite. The succession in any traverse across the schist belts, such as that at the mouth of Goldie Creek, yields a pattern which bears no systematic relationship to the widths of the belts. If isoclinal folding occurs there should be regions in which S_2 is at a high angle to earlier foliations and this does not occur on the scale of the major lithological alternation. If a single quartzite band is followed it terminates, not in a plunging fold nose, but as a pointed wedge. This suggests that each lithological unit is to be regarded not as a fold core but as a tectonically emplaced, rootless body. The strong foliation control of lithology is due to the rotation, towards parallelism with S_2, of lithological layerings of various origins and the correspondence is quite marked, as illustrated by Figure 25.

Ulverstone Metamorphics

The Ulverstone Metamorphics consists of quartz-muscovite-chlorite rocks which abut against the Forth Metamorphics on the eastern side and underlie Rocky Cape Group on the western side. The assemblage is exposed on the coastline west of Ulverstone, at Gawler and at Spalford, but outcrops are very poor in the intervening areas.

At Ulverstone the unit occurs in two, possibly three, basement wedges which were formed in the Palaeozoic. The wedges consist of Metamorphics and Rocky Cape Group in association and have east-facing asymmetry. Cambrian rocks dip off the western sides while the eastern edges are steep reverse faults which thrust Precambrian over Cambrian (Figure 41).

The dominant foliation is a schistosity, S_2, which is a mica foliation in schist and micaceous quartzite. The foliation is usually steeply-dipping and the mapping shows it forms large sweeping curves in plan which are probably due to Tabberabberan refolding. The foliation is a transposition surface and controls the major lithological layering. While recrystallization of mica and chlorite along S_2, or transposition into parallelism with S_2, has obscured the identity of earlier S-surfaces, there are interfolial folds in pelite at Abbotsham and in quartzite at Gawler which preserve earlier S-surfaces in fold hinges.

The compositional S-surfaces older than S_2 include bands of heavy minerals in quartzite, quartz-mica layering in schist and pebble-rich, pebble-free, bands in conglomerate. These are denoted collectively S_1. It should be emphasized that S_1 is a collective term and refers to any S-surface predating S_2 and may include a number of structures of different ages. In detailed work at Goat Island it has not yet been possible to subdivide S_1 into generic classes but such a subdivision should be possible at Picnic Point and in the basement wedge to the west, where there is evidence of phases preceding the B(1,2) folding.

SPALFORD AREA

The boundary between the Forth and Ulverstone Metamorphics is concealed at Spalford but is parallel to the foliation S_2 which is the dominant structure in the two assemblages.

The Spalford Conglomerate lies about one-half mile west of the eastern edge of the Ulverstone Metamorphics, and has been mapped from a train of boulders in the soil near Spalford. A cutting in deeply weathered rock in the Clerke Plains Road shows the conglomerate is a belt about 50 feet wide with margins parallel to S_2.

The only outcrop of indurated (unweathered) rock is about 10 feet in diameter on the roadside at Spalford. Pebbles consist of quartzite, some white, others red and others with a black-and-white banding. The pebbles are rounded to subrounded, spherical to subspherical. Some are platy (oblate ellipsoids) with the flattened sides parallel to S_2. The matrix is quartz-chlorite schist with a mica foliation curving around the pebbles but generally parallel to the regional S_2. Some of the platy pebbles are boudinaged, indicating vertical extension, with boudin axes near-horizontal.

GAWLER AREA

The townships of Ulverstone and Gawler are probably sited on a "basement wedge" or Palaeozoic thrust block with the boundary fault running SW through Gawler, but there are no Cambrian rocks preserved in the fault angle. The wedge consists of a central belt of strongly lineated quartzite flanked on each side by schist. The lineations are fold mullions and intersections of penetrative S-surfaces, which sweep in an arc convex to the SE. The foliation traces in schist follow the same arc. At the SW end of the arc, at the base of the Rocky Cape Group, there is a sharp twist in plan of the lineation pattern, and bending in the schistosity, so that at the base of the Rocky Cape Group the foliation is subparallel to the bedding in overlying Rocky Cape Group quartzite. The deflection occurs in a zone about 400 yards wide below the base of the Rocky Cape Group and is consistent with west-side-south translation of the Rocky Cape Group relative to the Metamorphics.

A. H. Spry (pers. comm.) has examined a quartzite from the NE end of this belt. The mica forms a weak girdle normal to the lineation with a strong maximum defining the regional foliation S_2. The quartz has a girdle normal to the lineation, containing a pair of maxima, with an overall symmetry approaching orthorhombic. The mullions are formed by folding of an inherited, passive mica foliation S_1 which is visible as a colour banding in the quartzite and which defines isoclinal similar folds with axial surfaces parallel to S_2.

PICNIC POINT AREA

Picnic Point is unique in this area in that the Precambrian structure is triclinic on the mesoscopic scale—in other areas S_1 is not visible mesoscopically and the triclinic fabric is observable on only microscopic scales. A. H. Spry (pers. comm.) has found quartz grain fabrics similar to those at Gawler.

A flaggy layering and lamination in quartzite, probably bedding (So), is folded into tight, isoclinal folds with a penetrative axial-surface foliation (S_1). The quartzite is strongly lineated and fold mullions are common. Some of the mullions are boudinaged, with boudins occurring up to 50 feet long. The boudinaged mullions form spindle-shaped bodies which close in plan and section. Some thin quartz layers in schist have the same form and are long spindles or tectonic inclusions. The quartz has a mortar texture with different patterns of optic orientation in grains of different habit.

The overall triclinic symmetry and polyphase genesis is exemplified mesoscopically by some plunging B(0,1) folds which have younger lineations superposed upon them.

GOAT ISLAND

The Ulverstone Metamorphics of Goat Island occur, in association with Rocky Cape Group, in a Palaeozoic basement wedge within the Dial Range Trough. The outcrop on the intertidal platform has been examined in some detail and the general geology is shown in Figure 27. The boundary between the Rocky Cape Group and the Ulverstone Metamorphics is a fault, the Singleton Thrust, and Goat Island is a window in the thrust as the B(1,2) axial structures in the Metamorphics plunge toward the thrust trace and in one place the bedding in the Rocky Cape Group dips away from it.

Five periods of deformation are deduced in the Ulverstone Metamorphics at Goat Island. The B(0,1) phase is inferred from adjacent areas and no direct evidence of its occurrence has been found at Goat Island. The quartz-mica foliation and lithological layering (pebble-rich and pebble-free bands) is termed S_1 and may be a tectonic foliation. The schistosity, S_2, is the dominant foliation, and axial B(1,2) structures are the dominant lineations. A strain-slip cleavage, S_3, is confined to a narrow zone along the footwall of a late fault crossing Goat Island and is younger than S_2. Superposed as perturbations are post-metamorphic folds assigned to the Tabberabberan, which are discussed elsewhere in this paper (p. 188).

The principal structural elements include the foliation, S_2, B(1,2) folds, and the morphological elements of ellipsoidal bodies of quartzite. The quartzite bodies have many of the characters of original pebbles in a conglomerate, but the term pebble is not applicable as many of the bodies are not original pebbles but fragments of pebbles, and some of the bodies are probably fragments of layers. While the rock at Goat Island was probably a conglomerate originally, the volumes of pebbles have not been conserved, and the rock is now an assemblage of deformed pebbles,

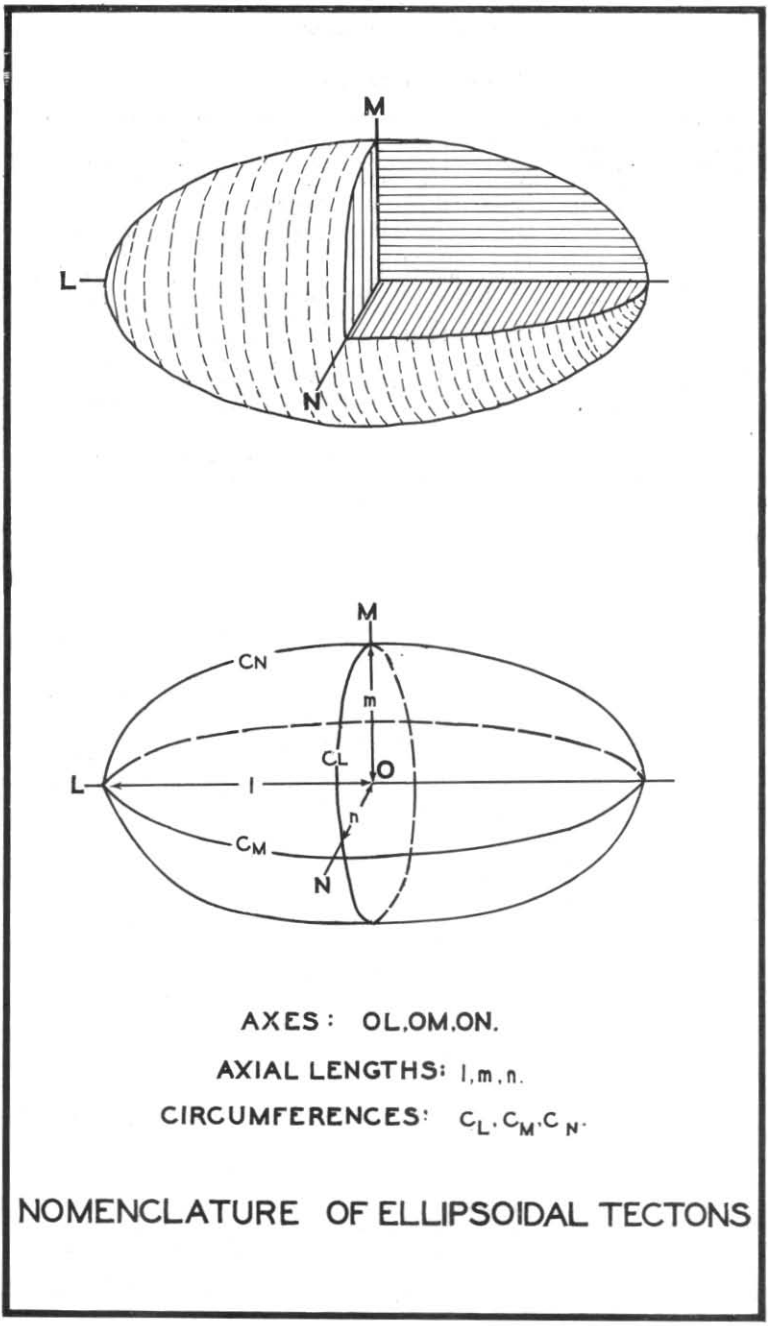

M
L
N
M
CN
m
CL
O
L
l
n
CM
N
AXES: OL,OM,ON.
AXIAL LENGTHS: l,m,n.
CIRCUMFERENCES: CL, CM, CN.
NOMENCLATURE OF ELLIPSOIDAL TECTONS

FIGURE 28.

5 cm

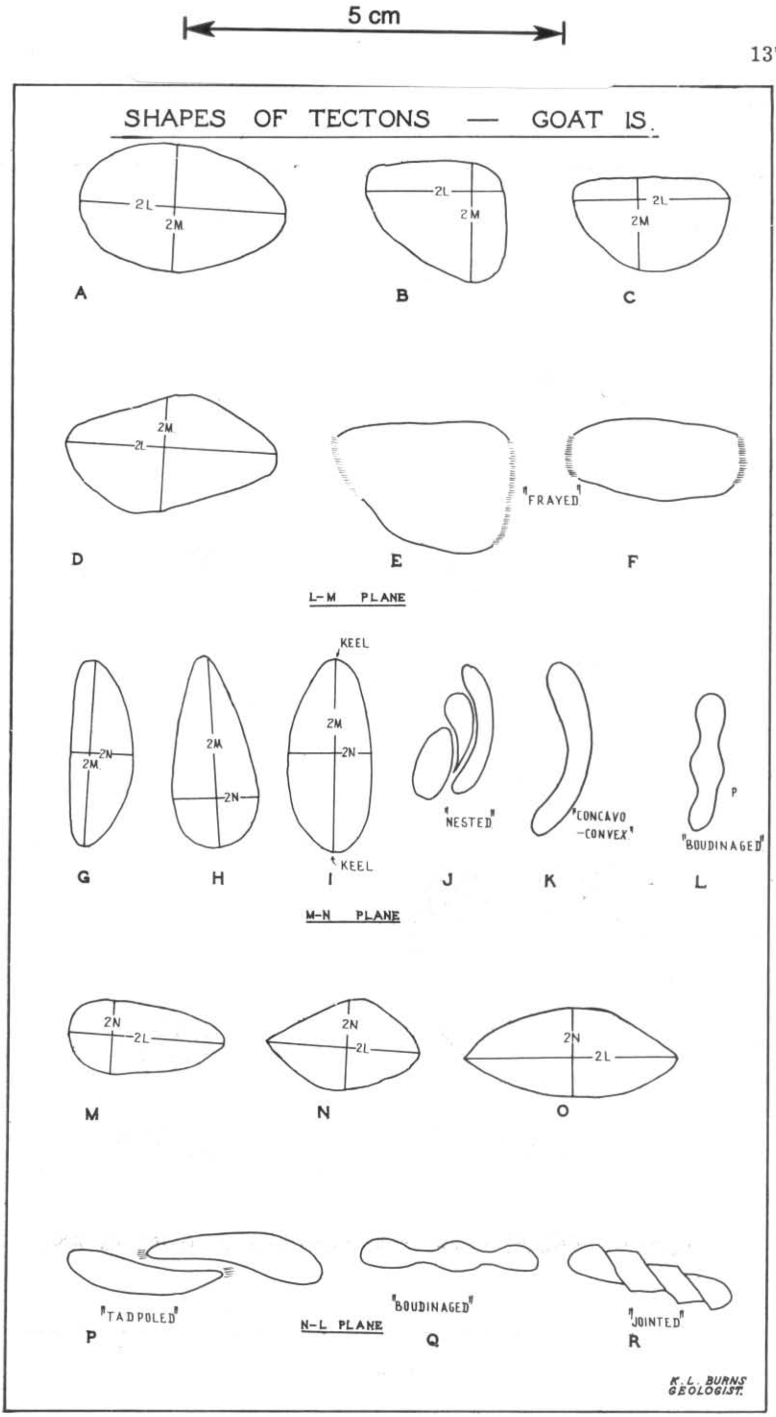
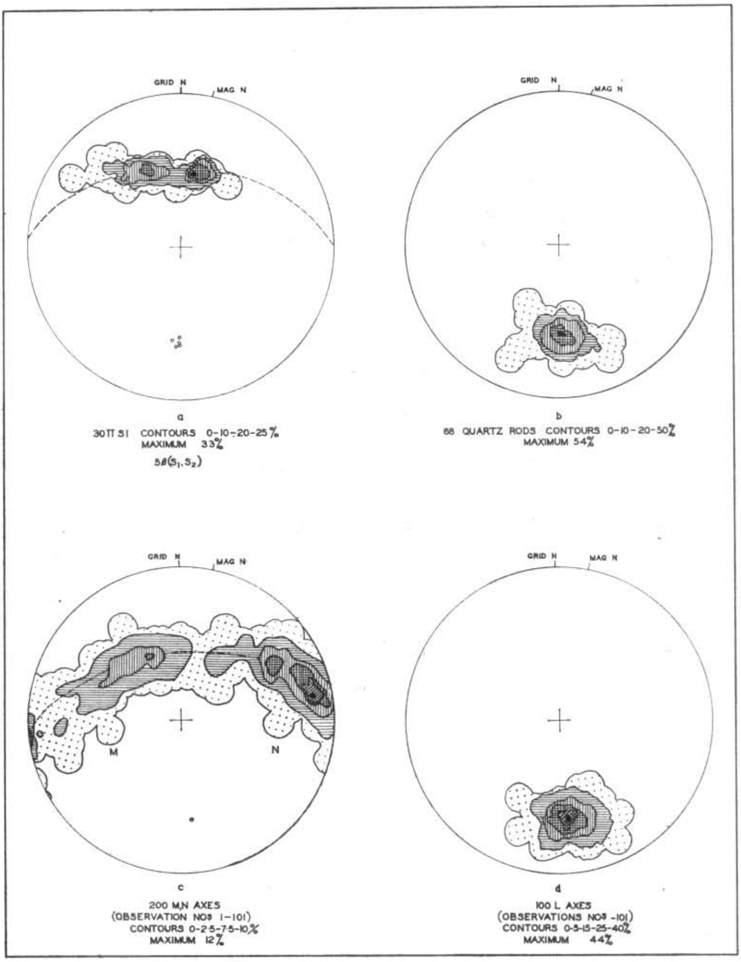

5 cm
SHAPES OF TECTONS — GOAT IS.
2L
2M
A
B
C
D
E
F
"FRAYED"
L-M PLANE
KEEL
2N
G
H
I
J
K
L
"NESTED"
"CONCAVO -CONVEX"
"BOUDINAGED"
M-N PLANE
M
N
O
"TADPOLED"
N-L PLANE
"BOUDINAGED"
"JOINTED"
P
Q
R
K.L. BURNS GEOLOGIST.

FIGURE 29.



LAMBERT PROJECTIONS FOR SUBAREA 2, GOAT ISLAND

FIGURE 30.

5 cm

fragments of pebbles and tectonic inclusions derived from interbedded quartzite. The term "tecton" has been used by Burns (1963b) for tectonic "fish" of this type which are probably mainly derived from pebbles, although they no longer preserve the original pebble volumes, and which may include tectonic inclusions derived from layers or mullions: as there is no suitable alternative term its use is continued here.

The principal morphological elements of ellipsoidal tectons are labelled in Figure 28. Only a small proportion of the tectons approach this idealized shape, the majority showing departures from it of one kind or another. The principal variations are shown in Figure 29. Burns (1963b) showed by means of a detailed analysis, that for tectons without concave surfaces, the mean shape is an ellipsoid with the morphological elements related as follows, where $r^3 = lmn$, $l/r = 1.83$; $m/r = 0.98$; $n/r = 0.57$ and for the modal values, $l{:}m{:}n = 2.08{:}1{:}0.51$. There are variations depending upon the manner of measurement and treatment of data but a good approximation to the central tendency is given by $l{:}m{:}n = 2{:}1{:}0.5$. Of a number of possible quantities, it has been shown that the most significant is the eccentricity in the LN plane. Thus the "average" shape of the non-concave tectons can be summarized as a shape with an eccentricity in the LN plane close to 0.89 and axes related to each other as above.

The orientation of tectons is conveniently expressed in terms of the orientation of L-axes and LM-planes. These are in close agreement with the orientation of quartz rods and S_1 in some B(1,2) folds of subarea 2 (Figure 63) as shown in the Lambert projections of Figure 30. The tecton shape and orientation is thus consistent with the B(1,2) folding and was presumably acquired at that time.

The modal LM-plane is parallel to S_2 but is fairly strongly perturbated about it. In subarea 2, the modal axial plane for minor B(1,2) folds is parallel to S_2 but is again strongly perturbated. The L-axes and axes of B(1,2) folds are strongly aligned. These relationships, the tecton shapes discussed above, and the grain fabric (a sample of which is illustrated in Figure 35) led Burns (1963b) to conclude that the movement picture has axial symmetry with orthorhombic tendencies, the infinity-fold axis being parallel to the B(1,2) axes, and the principal component of strain being an extension parallel to the infinity-fold axis. This corresponds to stretching in a N-S direction and shortening in all directions at right angles. A similar movement picture may be obtained by squeezing in the middle a tube of toothpaste which is open at both ends. The final fabric in many areas has a symmetry lower than axial (orthorhombic) due to non-coincidence of certain symmetry elements in the movement picture and the inherited fabric. The grain fabric is triclinic.

The structures resulting from this deformation are shown in the structural-element maps of Figures 31 and 32. There seems to have been variation in the relative magnitudes of the principal components of strain, so that in subareas Nos. 1-4 the lateral components are small relative to the principal extension and very broad, open folds result with LM-planes and axial planes of minor B(1,2) folds strongly perturbated. On the platform, however, (areas Nos. 5-10 and 13-18) the lateral component is relatively large and the folds have a higher ratio of amplitude to wavelength.

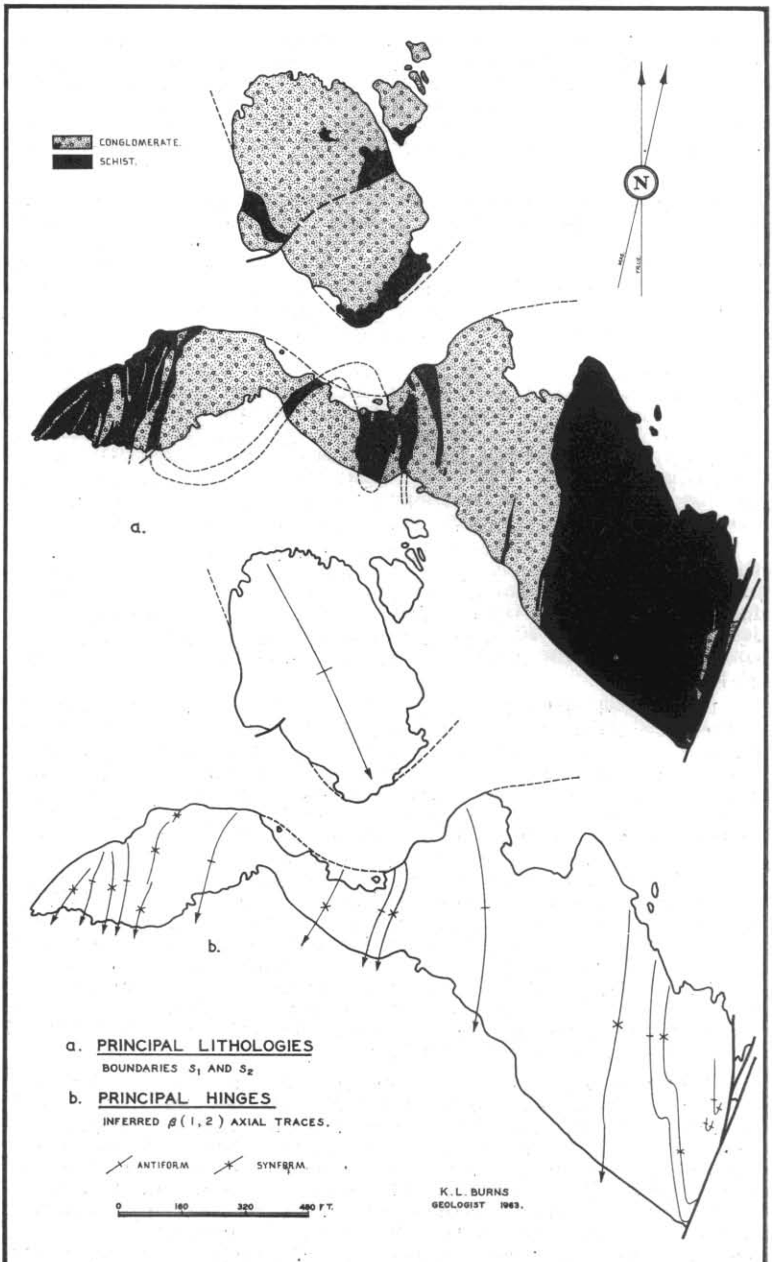


FIGURE 31.

5 cm

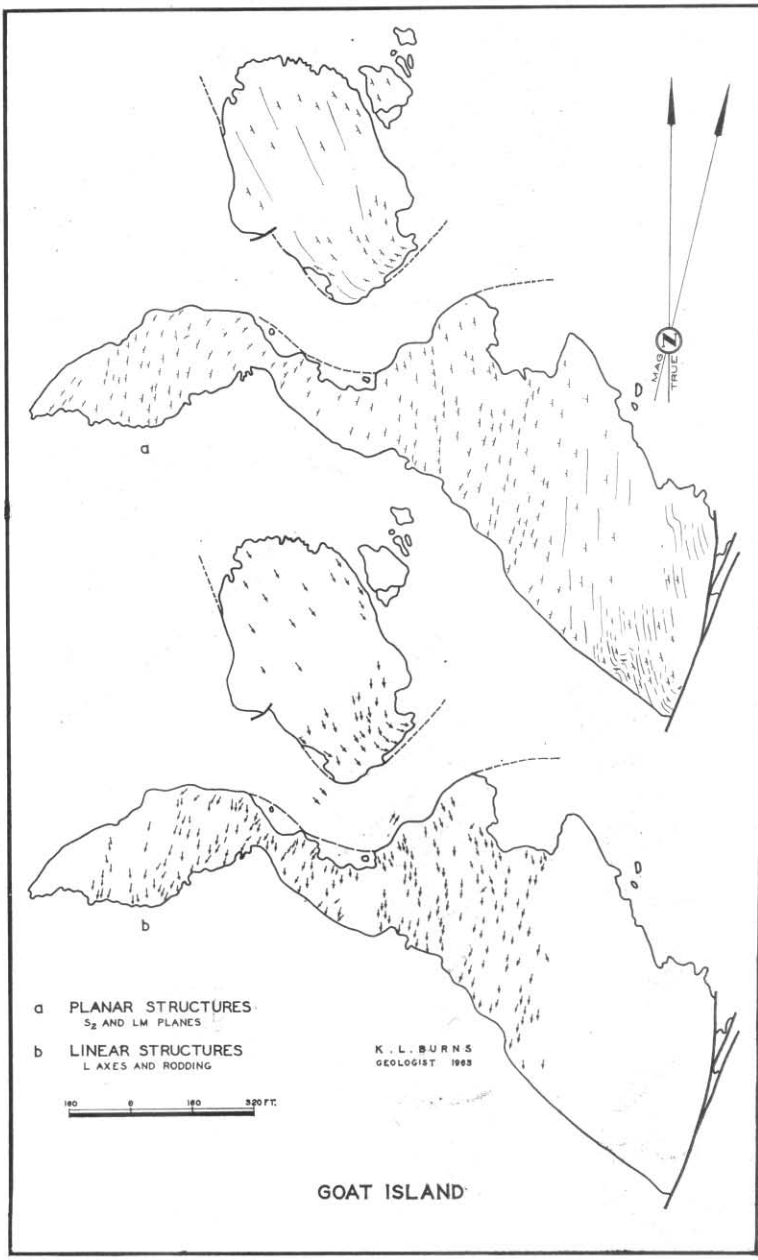

MAG
TRUE
N
a
b
a PLANAR STRUCTURES
S2 AND LM PLANES
b LINEAR STRUCTURES
L AXES AND RODDING
K. L. BURNS
GEOLOGIST 1963
160 0 160 320 FT.
GOAT ISLAND

FIGURE 32.

5 cm

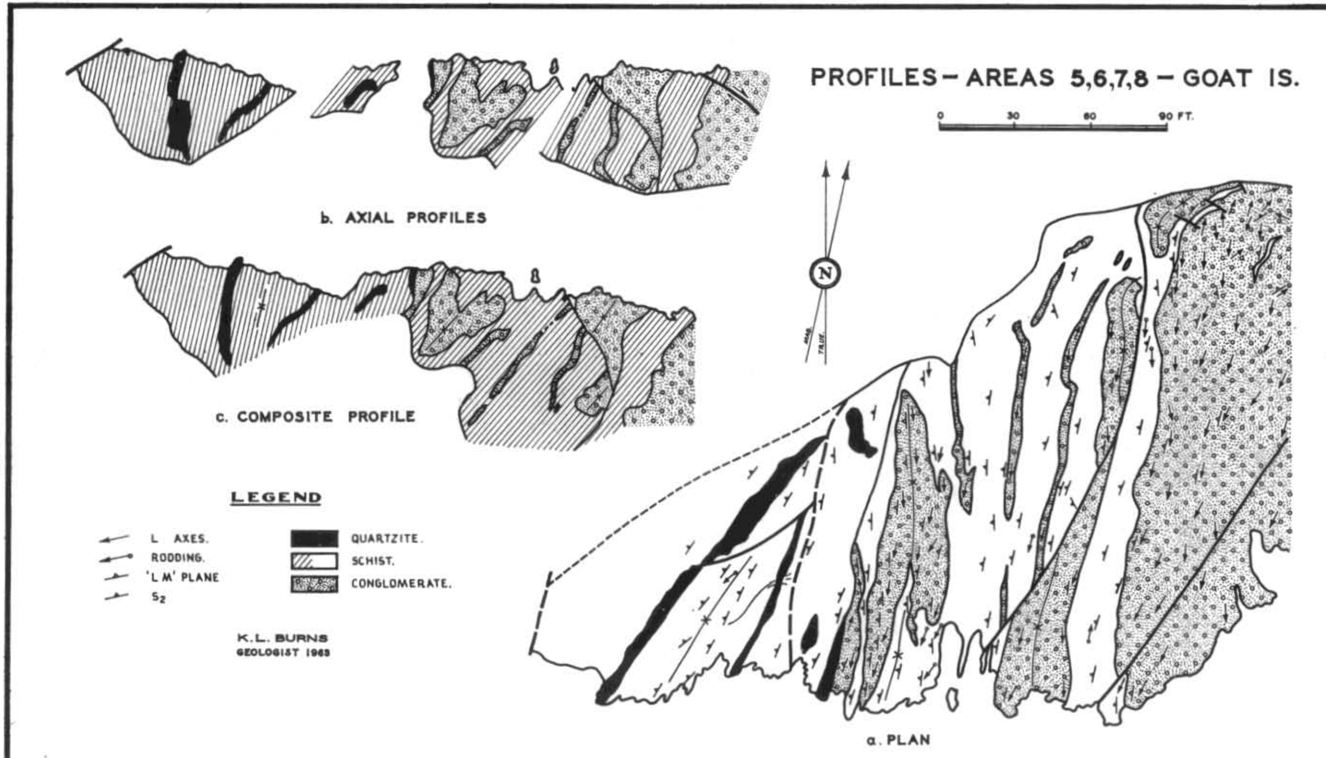


FIGURE 33.

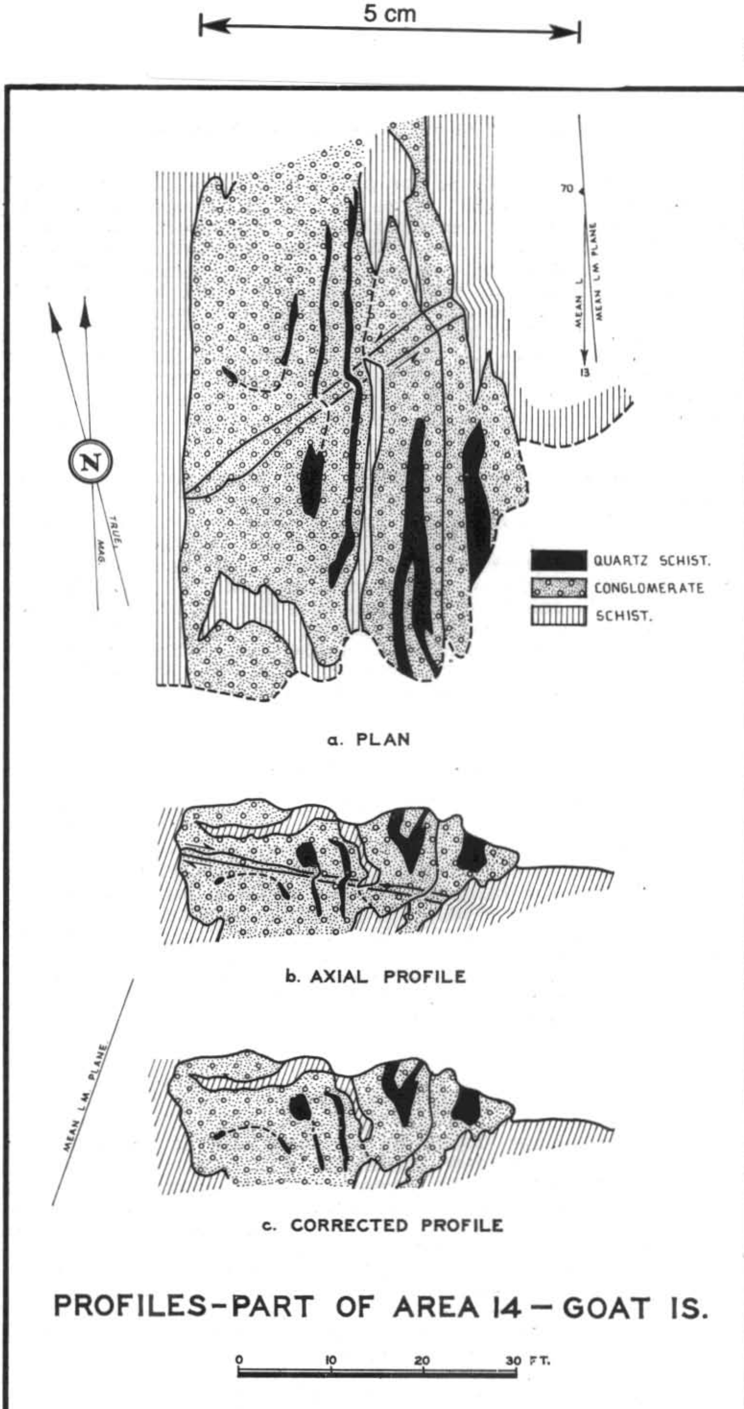

5 cm
70
MEAN L
MEAN L.M. PLANE
13
N
TRUE
MAG.
QUARTZ SCHIST.
CONGLOMERATE
SCHIST.
a. PLAN
b. AXIAL PROFILE
MEAN L.M. PLANE
c. CORRECTED PROFILE
PROFILES-PART OF AREA 14 — GOAT IS.
0
10
20
30 FT.

FIGURE 34.

Profiles of two areas of the platform are shown in Figures 33 and 34. The lithologies occur as strips transposed towards parallelism with S_2. It appears that the transposition mechanism has been a " slicing up " of fold limbs when the attenuated thickness is reduced to dimensions comparable with the tecton diameter, a slicing-up of fairly open folds, and there has not been very tight isoclinal folding. Thus any lithological strip is not necessarily a fold core and many strips are sliced-up limbs. Although detailed textural studies would be required in order to obtain conclusive proof, the profiles provide strong presumptive evidence that this has occurred. This pattern is probably important in the Precambrian in other areas of Tasmania, such as in the Central Highlands.

Later than the B(1,2) folding is a wide-spaced crenulation cleavage which occurs in a narrow zone along the footwall (north side) of the fault trending NE through Goat Island. The cleavage extends to a distance of about 30 feet from the fault but at this distance is little more than close-spaced jointing. The cleavage has a consistent sense of movement (sinistral) on both limbs of the large B(1,2) fold of Goat Island and like the fault to which it is related, is younger than the folding. The age and affinities of this structure are unknown but it appears to be Precambrian and is tentatively correlated with the P2 phase in the Rocky Cape Group which has the same general age relationships.

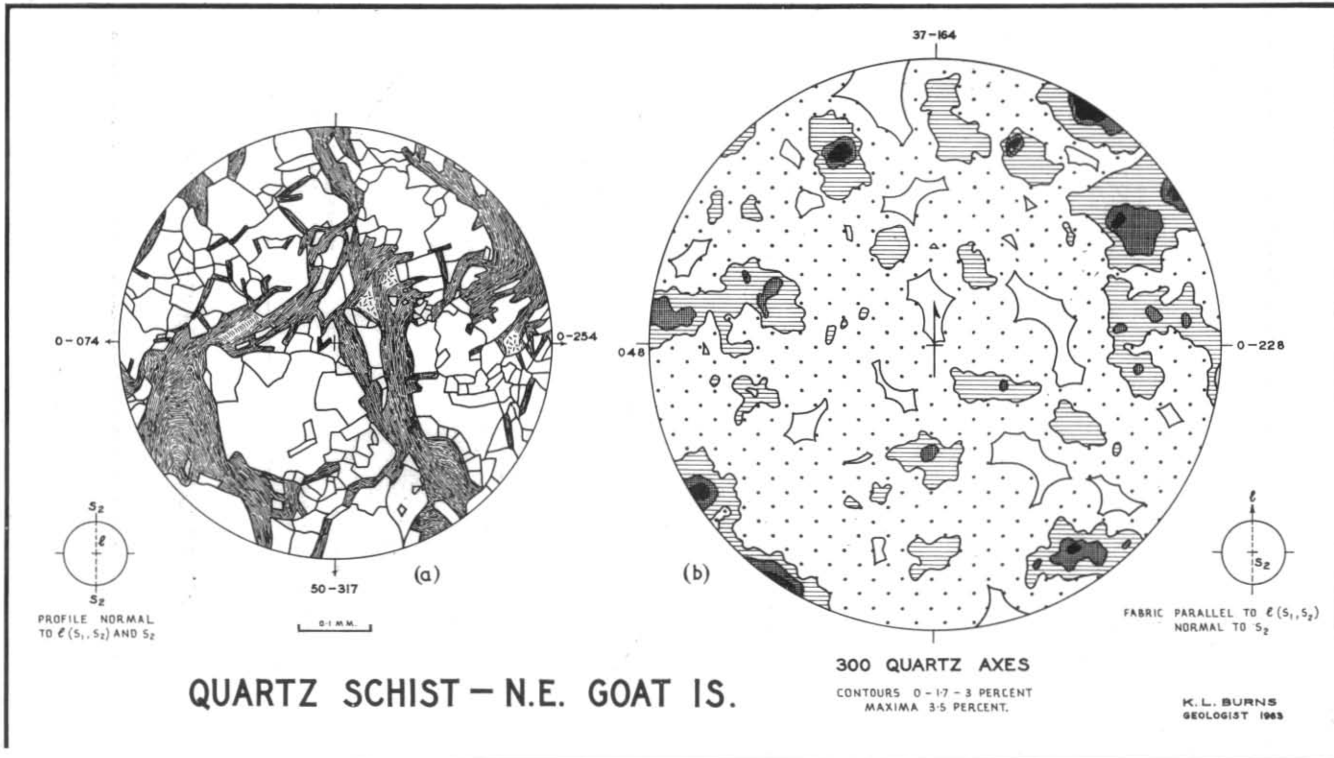
Rocky Cape Group

The two periods of folding in the Rocky Cape Group are widespread and there is a certain uniformity of style over wide areas. Because of the scale of the structures, the largest folds having wavelengths of less than 200 feet, interruptions to outcrop, and the failure of lithological markers to be of much use in such a structure, it is not possible to establish continuity through the area of the Rocky Cape Group in the sense of tracing single faults or folds and each exposure has to be treated in isolation. The tectonic succession has been established and dated at Sulphur Creek and Blythe Heads, and the Rocky Cape Group at Ulverstone has a similar structural pattern.

SULPHUR CREEK.

The Rocky Cape Group on the headland at Sulphur Creek consists of flaggy-bedded sandstone with interbedded phyllite overlain unconformably by Ordovician conglomerate and sandstone. The unconformity is, in detail, very irregular with the conglomerate filling hollows in the bedrock. Except for minor bedding-plane thrusts within the conglomerate there is the evidence of these irregular contacts to show that translation along the unconformity has not occurred and therefore structures of the Rocky Cape Group which do not affect the conglomerate are of pre-Ordovician age. The pre-Ordovician structures are folds of the first generation (P1) and associated faults. In Figure 36 faults and folds of this generation are shown truncated by the base of the conglomerate on the tip of the headland.

FIGURE 35.


37-164
0-074
0-254
50-317
048
0-228
(a)
(b)
S2
ℓ
S2
PROFILE NORMAL TO ℓ (S1, S2) AND S2
0·1 MM.
ℓ
S2
FABRIC PARALLEL TO ℓ (S1, S2) NORMAL TO S2
300 QUARTZ AXES
CONTOURS 0 - 1·7 - 3 PERCENT
MAXIMA 3·5 PERCENT.
QUARTZ SCHIST — N.E. GOAT IS.
K. L. BURNS
GEOLOGIST 1963

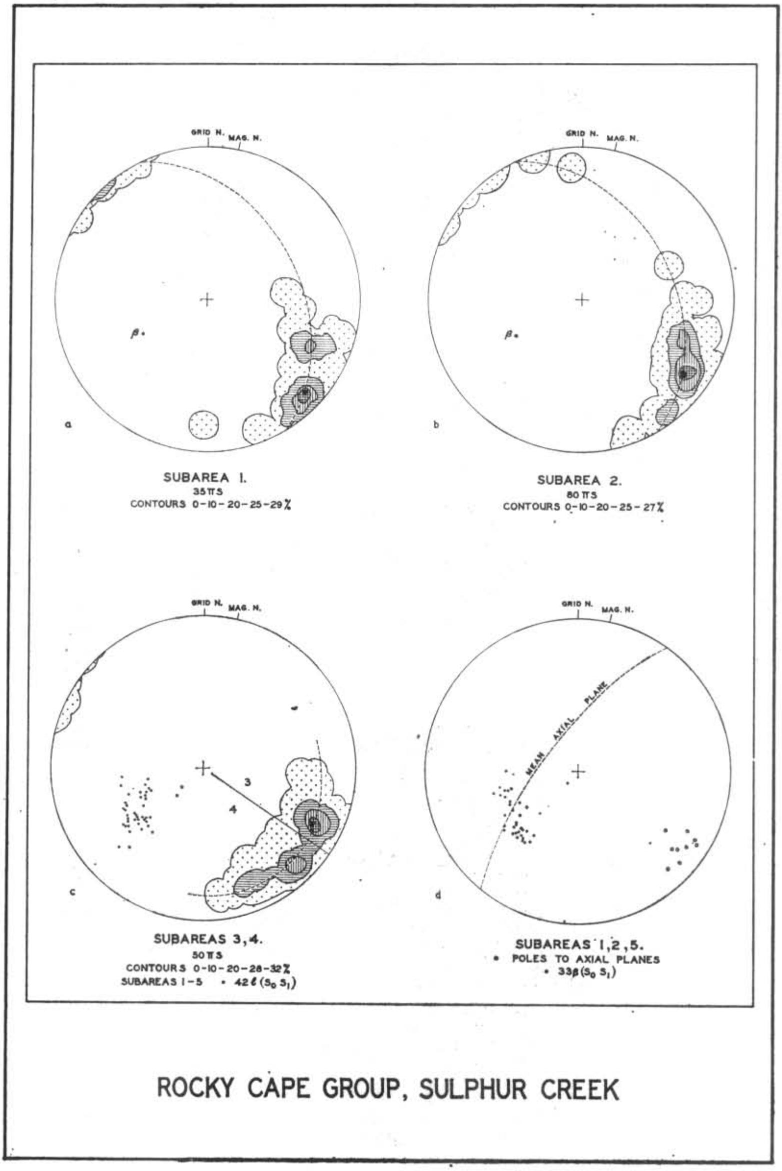
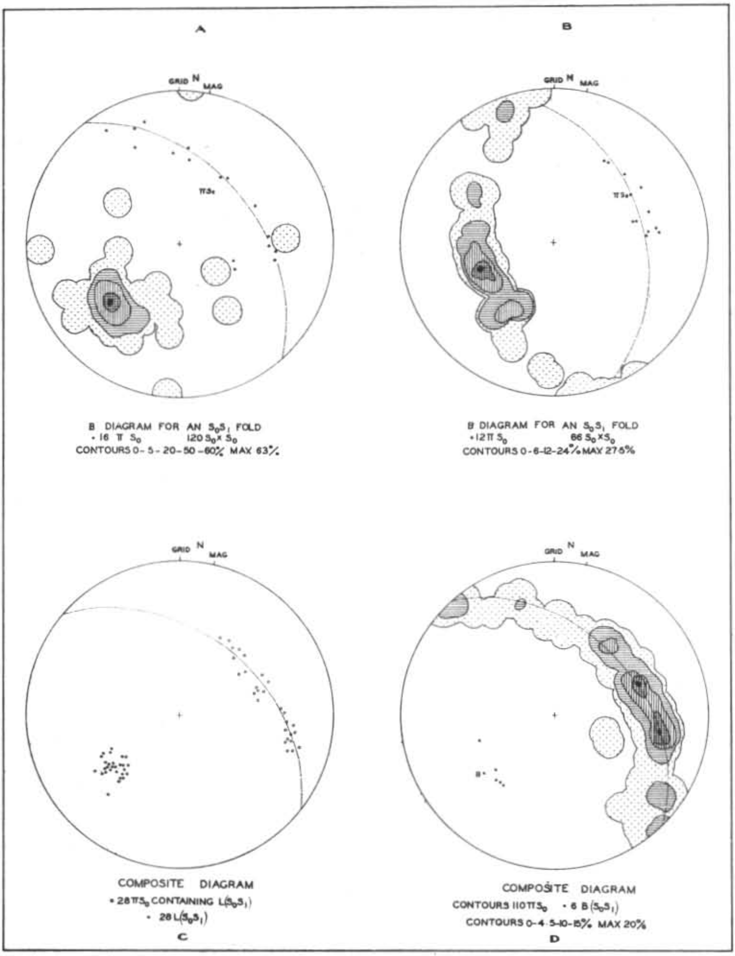


FIGURE 37.

5 cm



FOLDS IN SUBAREA 5, SULPHUR CREEK

FIGURE 38.

5 cm

The minor first generation folds are tight, almost isoclinal, with a strong foliation S_1 parallel to the axial surface in phyllite. In the sandstone there is a group of related planar and curviplanar structures which are the same age as S_1 but have differing orientations and characters. These include bedding cleavage (Sb) fracture cleavage (Sf), concentric shear joints (Sc), and rotational shear joints (Sr). Bedding cleavage is a close-spaced planar fissility, subparallel to bedding, diverging from bedding (So) by no more than a few degrees. In one place a number of cleavage surfaces occur within a single bed which, from the graded bedding, is demonstrably a single lithogenetic unit. In one place the bedding cleavage is necked down by boudinage. The concentric shear joints are closely related to the bedding cleavage but splay and diverge to enclose lenticular areas of sandstone in a pattern reminiscent of boudinage. These " pseudo-boudins " outcrop in weathered bedding surfaces as rounded swells, with axes pitching in two directions at right angles in a chocolate-tablet structure. Offsetting Sb and Sc are rotational shear joints, Sr, which were formed penecontemporaneously with the other structures. Fracture cleavage does not occur at Sulphur Creek but is prominent further west. This group of related quasi-penetrative foliations is denoted collectively S_1.

Bedding plots for areas 1-5 yield β maxima which are essentially parallel (Figures 37 a, b, c, 38d) and coincident with β maxima measured from single folds in sub-area 5 (Figure 38 a, b), so the region is homogeneous with respect to B(0,1), the effects of Tabberabberan structures being small. The axial planes are oriented near 74NW035 with the fold axes pitching 52° south, yielding a plunge of 49-236.

BLYTHE HEADS

An antiform of the second generation (P2 phase) was found at Blythe Heads in which the lineation formed at the intersection of fracture cleavage (Sf) and bedding (So) is well-developed and has been refolded. The fracture cleavage has itself been crenulated in places. The fold has a wavelength of several hundred feet and is an open, disharmonic antiform facing east, with bedding inverted throughout the structure. The sense of shear indicated by the fracture is constant around the fold so it is a second-generation structure, post-dating the fracture cleavage.

The orientations of the principal structural elements are summarized in Figure 39. The lineation spread in Figure 39c is markedly reduced on flexural unwinding of the fold as in Figure 39d. The second generation folds are thus flexural-slip and refold lineations of the first phase.

This antiform is crossed by a brecciated fault zone, younger than the folding, which contains a dyke of dolerite similar to those at Cooee. If it is the same age as the Cooee Dolerite, which is extremely probable, the dyke shows that the second-generation folds are pre-700 million years B.P.

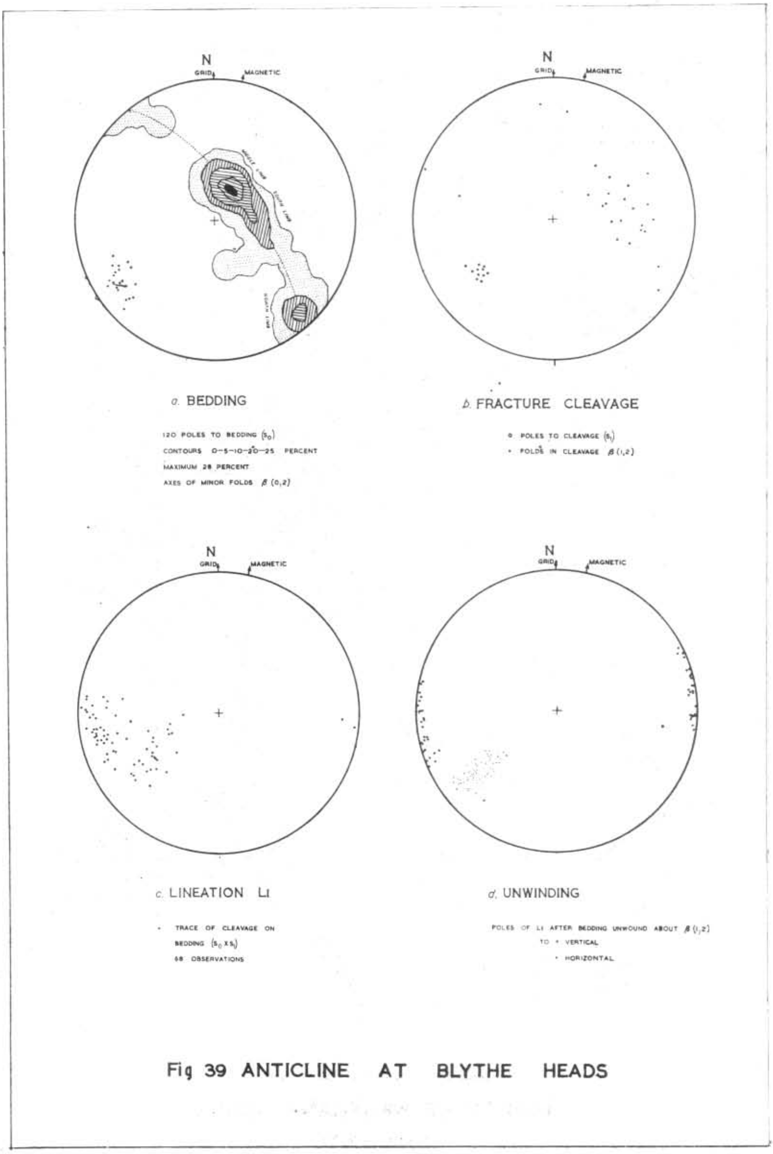
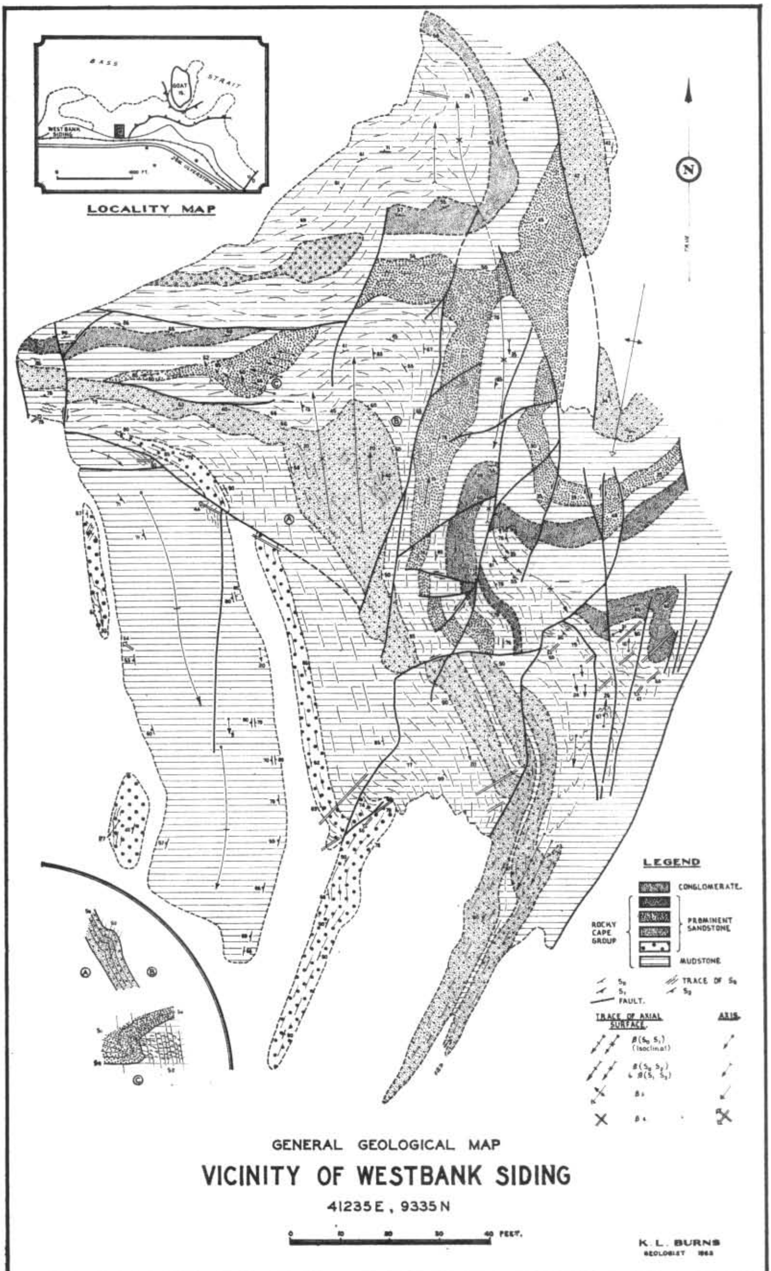

N
GRID
MAGNETIC
a. BEDDING
120 POLES TO BEDDING (S_0)
CONTOURS 0–5–10–20–25 PERCENT
MAXIMUM 28 PERCENT
AXES OF MINOR FOLDS β (0,2)
b. FRACTURE CLEAVAGE
POLES TO CLEAVAGE (S_1)
FOLDS IN CLEAVAGE β (1,2)
c. LINEATION L1
TRACE OF CLEAVAGE ON
BEDDING (S_0 X S_1)
68 OBSERVATIONS
d. UNWINDING
POLES OF L1 AFTER BEDDING UNWOUND ABOUT β (1,2)
TO VERTICAL
HORIZONTAL
Fig 39 ANTICLINE AT BLYTHE HEADS

FIGURE 39.



BASS
STRAIT
GOAT IS.
WEST BANK SIDING
LOCALITY MAP
N
LEGEND
CONGLOMERATE.
ROCKY CAPE GROUP
PROMINENT SANDSTONE
MUDSTONE
TRACE OF S_0
FAULT.
TRACE OF AXIAL SURFACE.
AXIS.
(Isoclinal)
GENERAL GEOLOGICAL MAP
VICINITY OF WESTBANK SIDING
41235E, 9335N
0 10 20 30 40 FEET.
K. L. BURNS
GEOLOGIST

FIGURE 40.

IRON CLIFFS

The Rocky Cape Group at the Iron Cliffs consists of sandstone and mudstone, folded into a small anticline of variable plunge and axial trend close to north. The limonite emplacement was post-folding and pre-Ordovician so that the Rocky Cape Group was here folded in pre-Ordovician time.

Although Burns (1961b) thought that the Rocky Cape Group and the Cambrian rocks had been folded together, a strong disharmony occurs at this contact where exposed on the coastline further north, and folding of the Cambrian rocks occurred without sympathetic deformation of the Precambrian. In this case no conclusions can validly be drawn as to the time relations of folding in the two rock groups. The Iron Cliffs anticline is a pre-Ordovician structure which refolds a bedding fissility which is analogous to the early foliations at Sulphur Creek and the fold is probably a second-generation structure.

GOAT ISLAND

At Goat Island, Rocky Cape Group overlies Ulverstone Metamorphics, the boundary being the Singleton Thrust.

The Rocky Cape Group contains only scattered B(0,1) hinges but bedding cleavage in sandstone and slaty cleavage in mudstone is well developed. In some B(0,2) hinges there is a coarse strain-slip cleavage which grades into a crenulation cleavage. The B(0,1) and B(0,2) folds are virtually co-axial and may be differentiated with certainty only in such areas as " C " of Figure 40 where the axial foliations intersect each other. At Goat Island the influence of Tabberabberan deformation is much stronger than at Sulphur Creek and considerable refolding of the Precambrian structure has occurred.

The Singleton Thrust

The Singleton Thrust is the major Precambrian structure in Devonport Quadrangle. It forms the boundary between the Upper and Lower Divisions and is generally flat-lying but has been refolded and is interrupted by Tabberabberan faults.

There are marked differences in character between the Upper and Lower Divisions. The Lower Division shows medium and low grade metamorphism, the Upper Division is unmetamorphosed or " relatively unmetamorphosed ". Sandstone and mudstone of the Upper Division preserve clastic textures but rocks in the Lower Division are coarsely recrystallized tectonites with cataclastic textures. In the Devonport Quadrangle, the greatest contrast is in the nature of lithological boundaries, which are controlled by transposition foliations in the Lower Division but in the Upper Division are usually bedding. These differences are most marked in the Ulverstone area and at Mt Remus where the two divisions are juxtaposed. Spry (1962a, p. 122) regarded this juxtaposition as evidence in support of an unconformity between the Divisions, although he recognized (p. 121) that the evidence is not conclusive. These differences in character suggest either an unconformity or a thrust.

Conglomerate in the Rocky Cape Group contains pebbles of quartzite resembling quartzite in the Lower Division. This could be regarded as evidence for an unconformity between the Divisions, the pebbles of metamorphosed, foliated rocks having been derived from erosion of the Lower Division during deposition of the Upper. However, similar pebbles occur in the Spalford Conglomerate within the Lower Division so that any hypothesis requiring a single erosion period coincident with the base of the Rocky Cape Group is untenable. The boundary between the divisions is therefore not necessarily an unconformity.

Structures in the Lower Division are truncated upwards at the Singleton Thrust, particularly the foliation S_2, at Gawler, on the South Road near Singleton's Point, and at Goat Island. The thrust is a structural and metamorphic hiatus. At Goat Island, the structure in the Rocky Cape Group is such that bedding in the Rocky Cape Group must be truncated downwards at the thrust in the area west of the island. This is in accord with the general structure of the Rocky Cape Group, from which a large, basal thrust may be reasonably inferred over a wide area.

The thrust plane is a smooth, polished structure where exposed at Goat Island with only a thin layer of what could be weathered mylonite upon it. It is overlain by a chaotic breccia which consists of boulders of Rocky Cape Group, and Ulverstone Metamorphics containing S_2, as tabular blocks 3-20 feet in length set in a patchwork quilt arrangement with negligible matrix between blocks. The foliation S_2 of the Metamorphics is disoriented as between blocks. East of Goat Island the breccia contains mainly slabs of the Metamorphics, and west of Goat Island largely Rocky Cape Group, but this is probably only due to differences in depth of erosion.

The movement on the thrust post-dates the B(1,2) folding in the Metamorphics, and is the same age or younger than the second-generation folding in the Rocky Cape Group. It is likely to be the same age as the second phase (P2) in the Rocky Cape Group, that is, pre-700 million years B.P.

The correlation chart (Table 13) implies that there is a period of deformation common to the Upper and Lower Divisions in which the Lower Division was metamorphosed. This is not inconsistent with the differences in character between the Divisions, as these are generalized characters, and in detail there are some low-grade rocks within the Lower Division and some higher-grade rocks within the Upper Division which appear to be " midway between the 'older' and 'younger' [divisions] in their degree of deformation, and the contacts between some 'older' and 'younger' types . . . are not sharp " (Spry, 1962a, p. 123). While the differences in character of the two divisions may be explained in terms of an unconformity representing a period of deformation, they may also be explained in terms of a thrust which juxtaposes rocks formed in different tectonic environments with different degrees of deformation but not necessarily at different times. With regard to the metamorphism, there would be a " telescoping " of metamorphic facies on the thrust. If this correlation is correct, it also means that the thrust has acted as a powerful decollement surface with structures that were formed during thrusting, in the Upper Division, being absent or of very reduced intensity in the Lower Division.

CAMBRIAN

The Tyennan Orogeny was defined by Browne (1949) as that tectonic movement represented by the unconformity between Ordovician rocks above, and supposedly Cambrian rocks below, in the Tyenna Valley of SW Tasmania. Carey and Banks (1954) identified the rocks below this unconformity as Precambrian and re-defined the Tyennan Orogeny to mean the movements immediately preceding, accompanying and immediately following the deposition of the Cambrian Dundas Group.

TABLE 14.

Principal Events of the Tyennan Orogeny

	Erosion
	Jukesian Movement
	Hydration of Precambrian hematite
Upper	Intrusion of keratophyre with accompanying mineralization
Cambrian	Folding and termination of deposition
	Megabreccia formed by gravity downsliding
	— — — — — — — — — — — — — — — —
	Cover stripped from Rocky Cape Geanticline
	Deposition of lower part of Radfords Creek Group
	Submarine erosion
	Deposition of Motton Spilite
	Deposition of Barrington Chert with gravity downsliding
Middle	Submarine erosion
Cambrian	*Hardstaff Movement*
	Gentle folding and faulting
	— — — — — — — — —
	Deposition of Cateena Group
	Deposition of Lobster Creek Volcanics

The Tyennan Orogeny is here regarded as those movements which accompanied deposition of the Cambrian System and which had terminated by the time of inception of Ordovician sedimentation. Two principal movements are recognized, the Hardstaff Movement of the Middle Cambrian and the Jukesian Movement which commenced in the Lower Upper Cambrian. The principal events of the Tyennan Orogeny are summarized in Table 14.

Lobster Creek Volcanics

The Lobster Creek Volcanics occupies an axial belt of massive rocks of igneous derivation, similar to belts that occur in the Cambrian in other parts of Tasmania. Carey (1947a) showed that volcanics on the West Coast include lava flows, pyroclastic breccia and tuff. Campana *et al.* (1958) considered another belt to be effusive fragmentals, and Solomon (1960) suggested a submarine volcanic pile. Burns (1961a) considered one belt to be an accumulation of waterlaid fragmentals, and suggested (1964c) that another might be a large sill intrusive at the base of the Cambrian System.

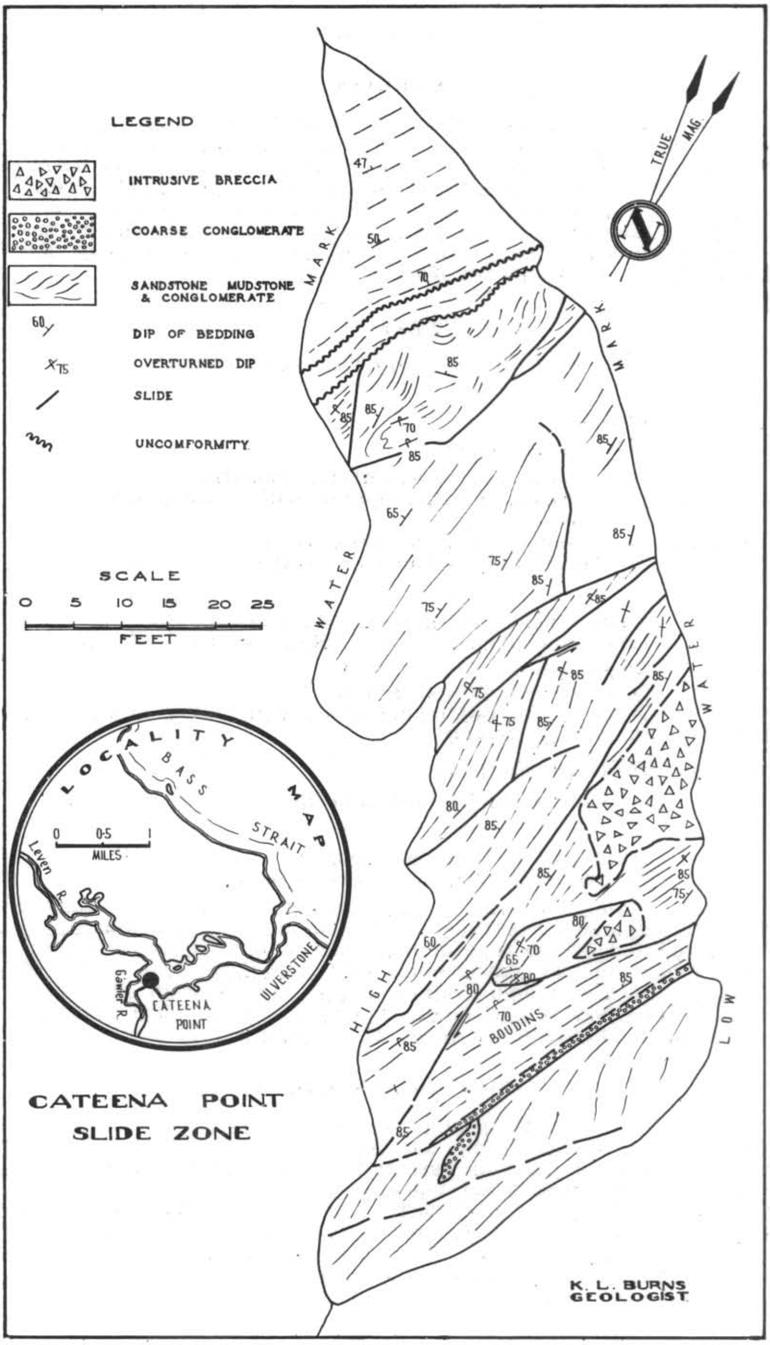

LEGEND
INTRUSIVE BRECCIA
COARSE CONGLOMERATE
SANDSTONE MUDSTONE & CONGLOMERATE
DIP OF BEDDING
OVERTURNED DIP
SLIDE
UNCOMFORMITY
SCALE
0 5 10 15 20 25
FEET
LOCALITY MAP
BASS STRAIT
0 0·5 1
MILES
Leven R.
Gawler R.
CATEENA POINT
ULVERSTONE
CATEENA POINT SLIDE ZONE
TRUE
MAG.
HIGH WATER MARK
LOW WATER MARK
BOUDINS
K. L. BURNS GEOLOGIST

FIGURE 42.

One or several of these hypotheses may be applicable to the Lobster Creek Volcanics. The rocks are similar to volcanics in other thick belts in that they are massive, largely structureless, coarse-grained, and near-acidic in composition. The volcanics either underlie the Cateena Group disconformably or are an intrusion through them of laccolithic form. The time of emplacement on either view was pre-Middle Cambrian as the volcanics are overlain unconformably by the Barrington Chert. However, SE of the Dial Range there is a belt of volcanics of similar stratigraphic position and petrological type which contains lapilli tuff and agglomerate (Burns, 1957a) so it is probable that the Lobster Creek Volcanics is also "effusive fragmentals" in Campana's terminology. It has, however, a ridge-like form which suggests a buried volcanic pile.

Cateena Group

The distribution of lithologies and the observed current directions are consistent with the Cateena Group having been deposited in a linear trough oriented N-S or NE-SW. Macro-graded intercalations of coarse clastics are probably due to cyclic failure in submarine embankments and are probably not due to cycles of tectonic significance. Sedimentary folds occur in the group at Cateena Point as shown in Figure 42. These folds are interpreted as sedimentary because congested regions are uncleaved, the folds are the same age as slides which have their soles penetrated by flame structures, and the folds occur in company with minor structures such as sedimentary boudinage and intrusive autobreccia. The folds are interstratal and unconformities at the top of the slide zone indicate that they are opencast. The folds were probably formed by gravitational slumping resulting from overloading at a time of high rate of deposition as implied by the associated macro-graded unit (Burns, 1964b). The structure of the slide zone is imbricate with the axial surfaces in general heeling backward which supports their identification as opencast. The fold axes, unwound, were oriented NW and if formed across the slope indicate a lateral slope (E-W component) approximately equal to the axial slope (N-S component) in the Dial Range Trough at this time. The axial slope is of the order of 175 feet per mile from the thickness variations in some formations. The sedimentary folds are regarded as indirect results of cyclic processes in deposition and not as the result of a discrete tectonic event such as tilting.

Hardstaff Movement

The base of the Barrington Chert is identified as an unconformity, the Hardstaff Unconformity. The existence of this unconformity is inferred from the general geology in the vicinity of Hardstaff Creek although it is not possible to specify any outcrop in which this is exposed. In the creeks running off Mt Lorymer into Hardstaff Creek there is bad exposure in the mudstone beneath the chert, and there is evidence of differential movement at the base of the chert so that even if found, the unconformity may be obscured by deformation structures.

The evidence in favour of the unconformity is primarily the truncation of underlying stratigraphic units at the base of the chert. In Hardstaff Creek, the Kerrison Volcanics run up the side of Mt Lorymer to stop abruptly at the base of the chert in two

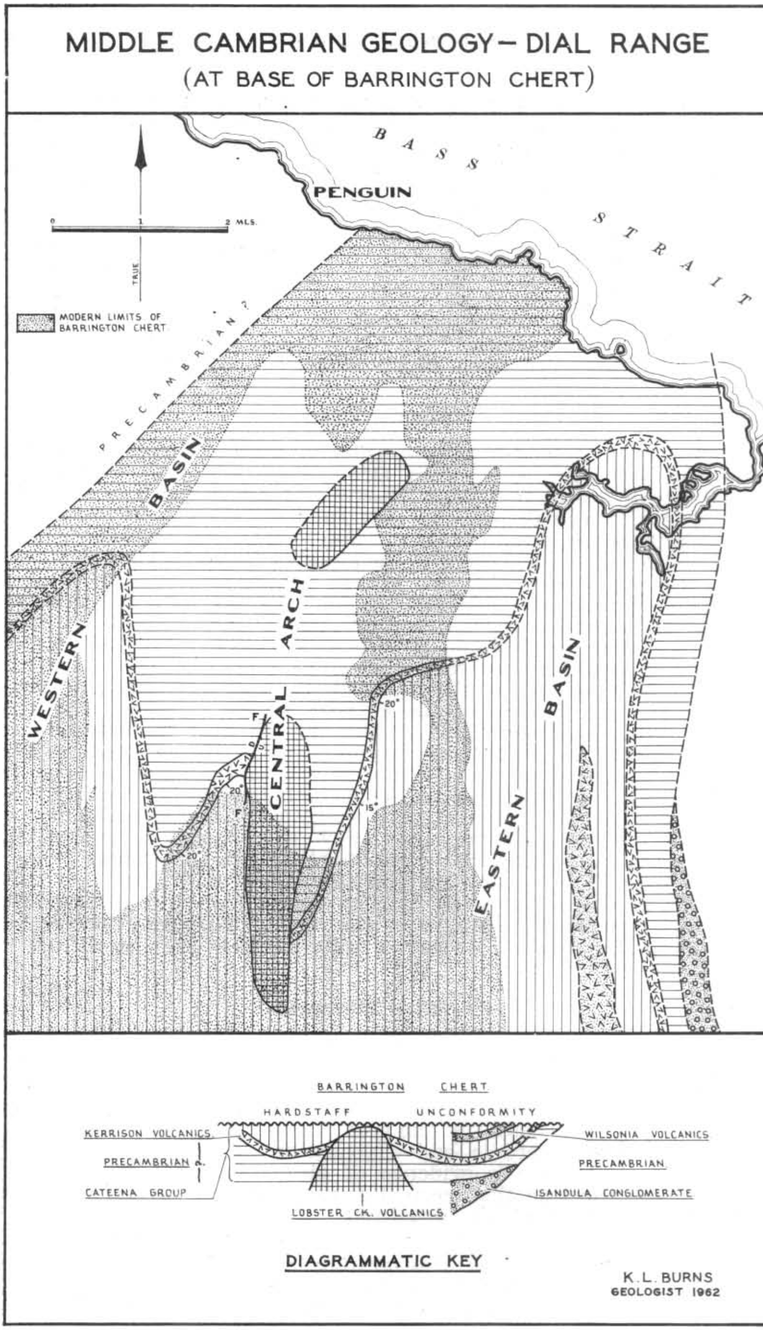


FIGURE 43.

5 cm

localities. A faulted boundary between the Lobster Creek Volcanics and the Cateena Group at the mouth of Hardstaff Creek seems to be truncated at the base of the chert—the chert overlies Cateena Group mudstone in one place, and volcanics in others. On a regional scale, the base of the chert is transgressive and in several places the thickness of mudstone between the volcanics and the chert is less than 100 feet. These relations can be explained in terms of a flat thrust, but to do so implies a thrust sheet of considerable dimensions, extending over some hundreds of square miles. An unconformity is the simplest hypothesis. The discovery of boulders of identifiably older rocks in the base of the chert would clinch the matter, but none have been found.

The general geological relationships in Hardstaff Creek are summarized on the map sheet and in the composite profile of Figure 60. The truncation of stratigraphic units underlying the chert is shown in this diagram, but the angle of discordance has been emphasized in later deformation owing to different mechanisms of folding in the chert and mudstone. The angle of discordance was originally about 20°.

On a regional scale it is possible to construct a palaeogeologic map at the base of the chert as in Figure 43. This map is a conjecture of the surface geology at the time deposition of the Barrington Chert began. Tabberabberan deformation has been only partly unwound as complete unwinding gives a picture rather difficult to relate to the modern geology (it amounts to a very oblique projection of the diagrammetic key of Figure 43 with the volcanic formations outcropping in wide, almost parallel, E-W strips and not in the accentuated narrow belts of the figure). The Rocky Cape Geanticline on the west of the trough, and the Forth Nucleus on the east of the trough, were probably highs at even this early stage, but were not emergent. From this figure, the expression of the Hardstaff Movement may be deduced as broad, gentle folding with minor faulting, the folds having limb-dips not exceeding 20°, and reflecting underlying lithological inhomogeneities.

Barrington Chert and Motton Spilite

The Barrington Chert and the Motton Spilite together form a unique lithological association within the Cambrian System. Throughout Tasmania, the Cambrian consists dominantly of mudstone and sandstone, acid to intermediate volcanics, and subordinate conglomerate. In the context of these lithologies, the chert-spilite association appears as an interruption to normal sedimentation.

Following the Hardstaff Movement the normal clastics were swamped by siliceous material. The mud-carrying currents were not cut off completely as the Barrington Chert contains beds of mudstone and conglomerate and much of the chert is impure chert or even siliceous mudstone.

The chert is a thick tongue lying along the axis of the Dial Range Trough (Figure 6). The maximum thickness shown in this figure is a very conservative estimate which allows for all conceivable thickness duplications by thrusting as in Figure 60. From the axial portion the thickness drops rapidly to a fairly uniform 250 feet on the flanks of the trough.

A fairly large flat-lying structure within the Barrington Chert occurs in Rogers Creek (see above, p. 43). This is a sedimentary structure with steeply-dipping chert bands truncated upwards against a fused boundary at the base of flat-lying chert. This may be an unconformity representing open-cast interstratal folding, but as it occurs in a formation with dramatic thickness changes, an erosional base which seems to have been a steep-walled channel, zones of autobrecciation and pull-apart structure and a number of small-scale soft-sedimentary recumbent isoclinal folds, the possibility exists that this is a sedimentary thrust and that a large mass of semi-indurated chert slid into the axial region from the flanks.

Only remnants of the Motton Spilite are preserved so the original form of this formation cannot be reconstructed. There is an abrupt cut-off on the western edge (Figure 6): for example, the Radfords Creek Group directly overlies Barrington Chert in Walloa Creek but at least 2000 feet of Motton Spilite overlies Barrington Chert at North Motton. The Radfords Creek Group is transgressive across the Motton Spilite and the data suggest that this transgression is due to considerable erosion.

Radfords Creek Group

At the southern end of the Dial Range the Radfords Creek Group is a repetitive mudstone-sandstone succession with at least one formation of volcanics. The Group overlies the Barrington Chert with apparent conformity in Walloa Creek but in the Leven River east of Mt Lorymer it abuts against Motton Spilite and contains boulders and lithic fragments derived from the spilite.

In the Sugarloaf Gorge near Gunns Plains there is a formation or formations of quartz conglomerate containing pebbles derived from the Rocky Cape Group to the west. A quartzite-pebble conglomerate is interbedded with Cambrian mudstone at Loyotea and may be equivalent. The Sugarloaf Gorge occurrence is interbedded with mudstone of the *Leiopyge* horizon and dates the first emergence of the Rocky Cape Geanticline as near the boundary between Middle and Upper Cambrian.

Beecraft Megabreccia

At the northern end of the trough the Beecraft Megabreccia and its correlates, the Teatree Point Megabreccia and the rocks of the Westbank Chaos, abut against Precambrian basement on the west side of the trough, overlie Motton Spilite in the centre of the trough, and, at Westbank, Precambrian basement on the eastern side of the trough. This relationship was interpreted by Banks (1962a, fig. 11, p. 139) as an unconformity between the megabreccias and the Radfords Creek Group. However, the Beecraft Megabreccia could be regarded as a facies variant of the Radfords Creek Group, and the relationships within the Group could be due to a transgression northwards. On either view the total development was the same—the flanks of the trough were uplifted and the cover was removed, in part by gravitational down-sliding of marginal deposits towards the axis of the trough. The trough was quite narrow as the allochthonous lithologies constitute a facies somewhat different from the Dundas Group and are possibly an unstable-shelf association. The basin became asymmetrical in profile with a narrow downwarp adjacent to the western margin and probably tilted south.

During deposition of the Radfords Creek Group, the currents continued to be from the north, but in the autochthonous beds of the Teatree Point Megabreccia they were heavily overloaded with chert detritus which was deposited as very thick beds of granule conglomerate. This may have been derived by recycling from allochthonous chert sliding down into the trough, or from an emergent high of Barrington Chert.

There is sufficient correspondence between the palaeogeology inferred from the internal structure of the sediments and the palaeogeology inferred for the base of the Dial Group (Figure 44) to justify regarding the movements accompanying sedimentation as the initiating movements of the Jukesian Movement, and sedimentation to have been terminated as a consequence of this movement.

Jukesian Movement

An apparent unconformity on Mt Jukes was described by Hills (1914), but discounted by Bradley (1954), as evidence of a tectonic movement. The term Jukesian Movement was defined by Carey and Banks (1954) to mean those movements represented by the unconformity between the Cambrian Dundas and Ordovician Junee Groups. An unconformity in this position has been reported from several Tasmanian localities and reviewed by Solomon (1962, p. 321) but in some areas there is apparent conformity.

In the Devonport Quadrangle the Dial Group overlies the Cambrian unconformably. The base of the conglomerate transgresses all formations from the base of the Cambrian to the top. Boulders of keratophyre resembling that intruding the Beecraft Megabreccia are found, with boulders of spilite, in the conglomerate in one locality near Myrtle Creek. The bulk of the Duncan Conglomerate is recycled Barrington Chert. Boulders of limonite, from a deposit which in places replaces Cambrian conglomerate (Burns, 1961b), occur in the conglomerate. No outcrop of the unconformity is exposed, except perhaps in the headwaters of Hardstaff Creek where the angular discordance is 15°. There are possibilities of decollement movement at the base of the Ordovician as discussed by Solomon (1962, p. 321) but not of such magnitude as to explain the regional transgression. Looking at the Tyennan Orogeny as a whole, the change in sedimentation is more pronounced, and the extent of erosion much greater, for the Jukesian than for any other movement.

A palaeogeologic map of the base of the Ordovician is shown in Figure 44. Cambrian sediments are lacking on the flanks of the Dial Range Trough, and the Rocky Cape Geanticline and Forth Nucleus are emergent features. Within the trough there is a central uplift composed of Barrington Chert with low limb-dips (about 15°) but high structural relief (approaching 1,000 feet). The fairly tight syncline at the western margin was at least partly formed during deposition of the Radfords Creek Group. The

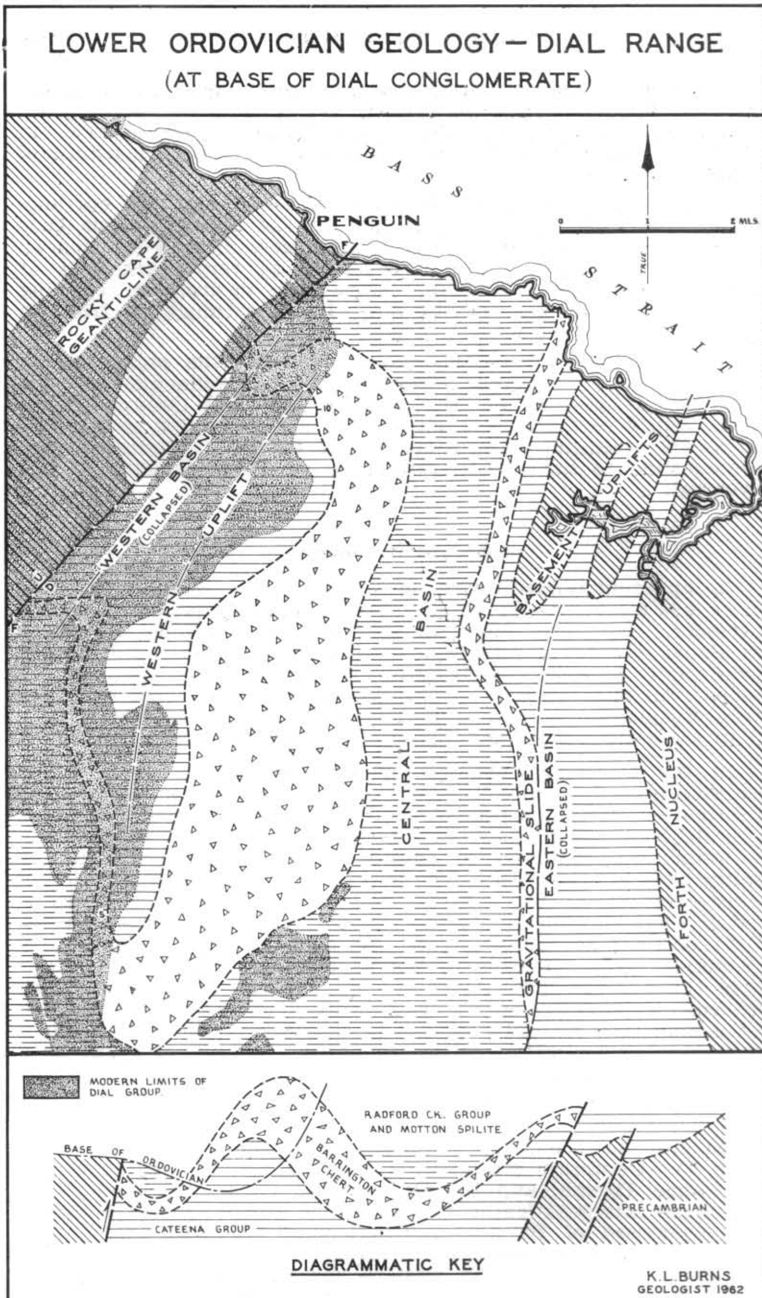


FIGURE 44.

5 cm

palaeogeology of the eastern margin of the trough is conjectural, but the possibility of low-angle thrusts in the sediments, originating in the mantle or possibly in the basement, cannot be discounted.

At the time of deposition of the Beecraft Megabreccia the trough was topographically negative with respect to the flanks, a situation almost completely reversed by the Lower Ordovician. Sedimentation was halted by this topographic reversal consequent upon the Jukesian Movement. The initial emergence of the central anticline of chert may be marked by the granule conglomerate of the Teatree Point Megabreccia.

Solomon (1962, p. 320) equated the Jukesian Movement with "horst and graben type tectonics" in early Ordovician time, accompanying deposition of the lower parts of the Ordovician System. The unconformity between the Gnomon Mudstone and Duncan Conglomerate on Mt Dial may reflect activity of this kind but could be a merely local effect such as landsliding or "bull-dozing" by boulders or masses of the detritus forming the Duncan Conglomerate.

TABBERABBERAN OROGENY

The Tabberabberan Orogeny occurred in Tasmania after the deposition of the Bell Shale (Lower Devonian) and before the deposition of the Eugenana Beds (Upper Middle Devonian). The orogeny included a number of phases, one of which appears to pre-date the Upper Lower (or Lower Middle) Devonian Spero Bay Group (Banks, 1962c, pp. 184-185; Solomon, 1962, p. 323). The orogeny probably occurred in the interval of time which includes the Lower Middle and Middle Middle Devonian.

In the Devonport Quadrangle a variety of Tabberabberan structures can be classified according to the geographic orientation of the principal axes of strain. In some areas it can be shown that structures of one class post-date structures of another, and by combining observations from many areas, a succession of phases may be established as in Table 15. These 6 phases may be grouped together as two movements, the Eugenanan Movement and the Loonganan Movement, with an Intermediate Phase between them. The two movements differ in the relative magnitude of the principal horizontal components of stress. Within each movement, the phases are probably essentially contemporaneous, reflecting perturbations in boundary conditions or stress magnitudes, although in some cases there is clear evidence of time differences between phases.

Eugenanan folds trend between NW and north, the swing in trend in some localities being probably due to Loonganan refolding. The principal Loonganan folds trend SW but in some areas there are minor, contemporaneous, conjugate folds trending NW. For descriptive purposes, it is convenient to define regional axes: *B*, parallel to the Eugenanan trend in any area; *C*, vertical; *A*, at right angles to *B* and *C*. The small letters, a, b, c, in Table 15 indicate the magnitude of strain in these axial directions. The evidence for the succession of phases, and the relevance of the stress regimes (after Harland and Bayly, 1958) was discussed by Burns (1963b). For present purposes, the schedule of Table 15 is adopted as a convenient descriptive framework.

TABLE 15 Phases of the Tabberabberan Orogeny

Symbol	*Type of Structure*	*Deformation Plane*	*Relative magnitudes of principal components of strain*	*Regime*	*Occurrence*	*Evidence of Age*
			EUGENANAN MOVEMENT			
E1	Folds and related faults	AC	a > b > c	Primary thrust	Eugenana (first folding); widespread folding, faulting; axial cleavages in some areas	Earliest recognized event
E2	Faults	AB	a > c > b	Primary wrench	The Gnomon (tear faults); very restricted occurrence	Probably contemporaneous with E1
			INTERMEDIATE PHASE			
E3	Folds	AC	c > b > a	Secondary gravity	Eugenana (second folding); Applebee Creek; very resstricted distribution	Post-dates E1 at Eugenana
			LOONGANAN MOVEMENT			
L1	Folds	BC, BA and intermediate planes (all contain B)	b > a = c	Secondary radial	Eugenana (third folding); widespread folding	Later than E1 at Eugenana, Sulphur Creek. Probably later than E3 at Eugenana
L2	Faults (and joints?)	BA	b > c > a	Secondary wrench	Kaines Creek and vicinity (transcurrent faulting); Sugarloaf Gorge (oblique-slip faulting); widespread jointing?	Later than E1 in Sugarloaf Gorge. Later than, or contemporaneous with L1. Jointing later than E1 at Sulphur Creek
L3	Faults	BC	b > a > c	Secondary thrust	Sugarloaf Gorge (thrusts); the Gnomon (minor thrusts); restricted distribution	Later than E2 at the Gnomon. Later than E1, L2 in Sugarloaf Gorge. Possibly contemporaneous with L1 in part.

The evidence available indicates that the Housetop Granite in the extreme SW corner of the Quadrangle post-dates E1, and that at least some of the mineralization post-dates L1.

EUGENANA

The Melrose Basin (Figure 45) is a brachysyncline elongated N-S. Gordon Limestone in the centre is surrounded by a rim of Moina Sandstone. The underlying rocks are Precambrian at the north end of the basin and Cambrian at the south, so the basin overlies the margin of the Dundas Trough. The basin rim is not continuous but is interrupted by a number of Devonian and Tertiary faults.

At the Eugenana quarries at the northern end of the basin (see Figure 15), three periods of folding are recognized and are dated as pre-Upper Devonian.

First Generation Folding (E1 phase): The Gordon Limestone carries a well-marked foliation which is coated in places with films of slickensided calcite and graphite. The attitude is fairly uniform at 60E357 (Figure 46a). Thin lenses of chert are folded into rounded, open folds of several inches amplitude with axial surfaces forming smooth, continuous curves within the limestone foliation and axes pitching 15° south in the foliation. Seams of dolomite and calcite which lie parallel to the foliation are boudinaged, the boudin axes plunging nearly 20° south. The index fossil, *Maclurites,* occurs in the limestone and 8 examples were found with the complete basal surface exposed, recognized by the presence of the nucleoconch and 4 whorls, the outer whorl expanding rapidly (Banks and Johnson ,1957). The axial ratios of the elliptical basal sections are between 1.5 and 1.7 for undeformed fossils, but examples were found with ratios as high as 5.2, implying considerable deformation. The field observations are shown in Figure 46b, and a plot of " normal planes " (Clark and McIntyre, 1951) in Figure 46c. The intersection of normal planes is near A for the highly deformed fossils, and near B for the less deformed. The long axis of the basal plane may be regarded as a vector, of magnitude equivalent to the axial ratio, which initially had similar magnitudes but different orientations in different fossils. The resultant magnitude is proportional to the amount of extension in the direction of the vector, so that the deformed fossils with largest axial ratios lie nearest the direction of maximum extension. The long axis of highly deformed fossils (Figure 46d) is in the foliation plane and the normal to this axis is thus near kinematic *b*.

The various minor structures plotted in Figure 46d indicate a modal fold axis near 23-162 and axial plane 60E357.

Second generation folding (E3 phase): The limestone contains rounded open folds ranging from several inches to 5 feet in wavelength and from a fraction of an inch to two feet in amplitude. The folded S-surface is the foliation formed earlier. Early-formed seams of boudinaged calcite are refolded. The fold axes have a mean azimuth of 180°, with plunges of up to 20° north and south (Figure 47a).

5 cm

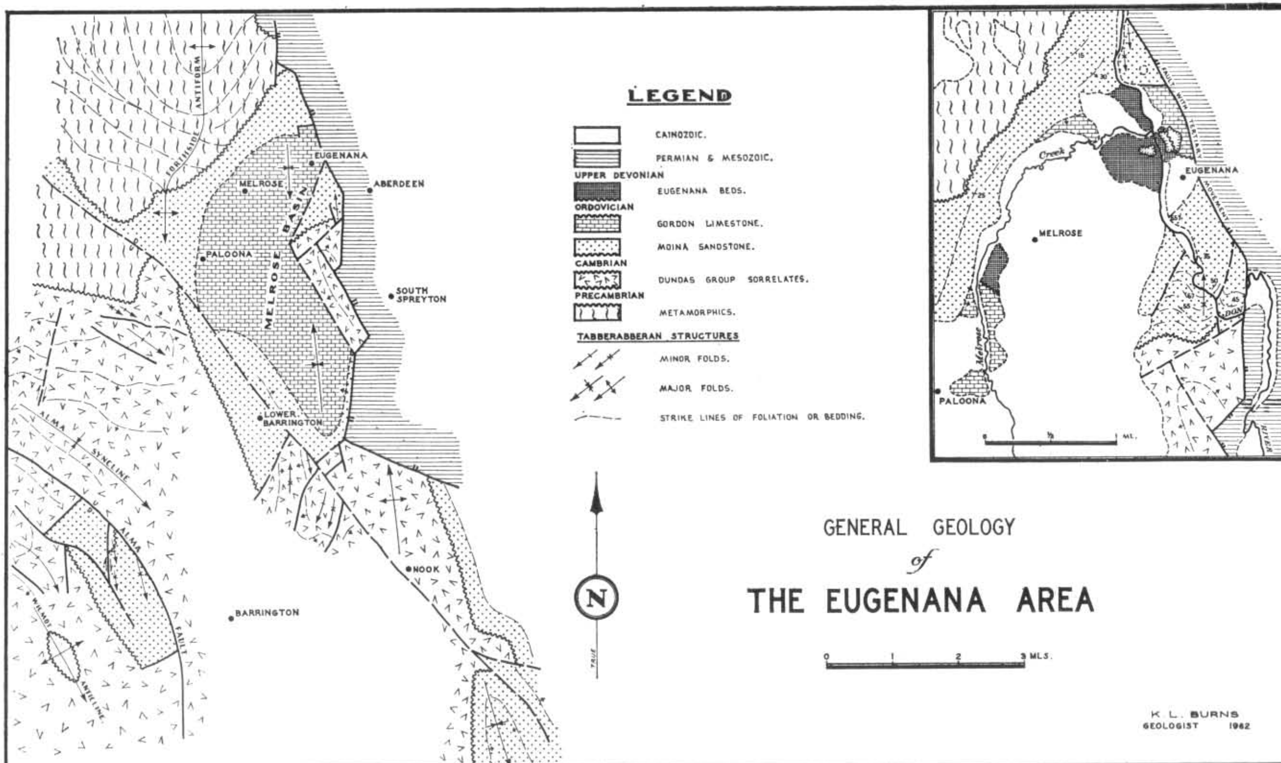


FIGURE 45.

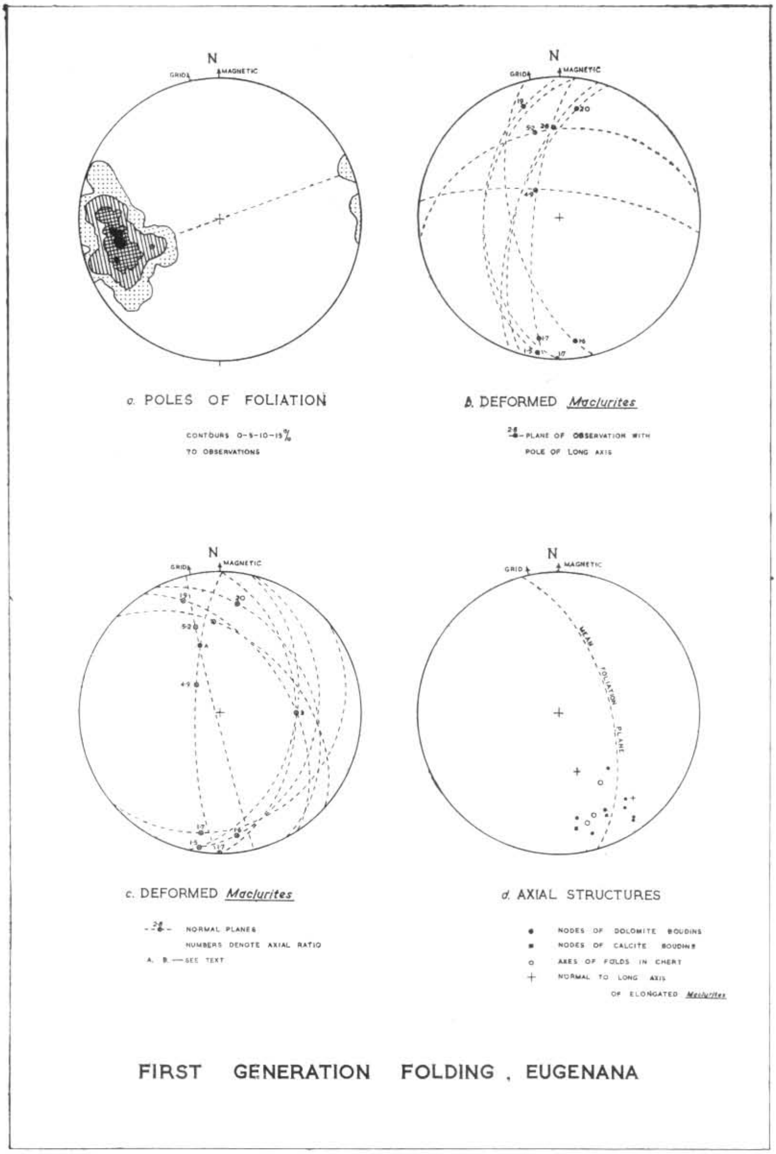

N
GRID
MAGNETIC
a. POLES OF FOLIATION
CONTOURS 0-5-10-15%
TO OBSERVATIONS
b. DEFORMED Maclurites
PLANE OF OBSERVATION WITH
POLE OF LONG AXIS
c. DEFORMED Maclurites
NORMAL PLANES
NUMBERS DENOTE AXIAL RATIO
A, B — SEE TEXT
d. AXIAL STRUCTURES
MEAN FOLIATION PLANE
NODES OF DOLOMITE BOUDINS
NODES OF CALCITE BOUDINS
AXES OF FOLDS IN CHERT
NORMAL TO LONG AXIS
OF ELONGATED Maclurites
FIRST GENERATION FOLDING, EUGENANA

FIGURE 46.

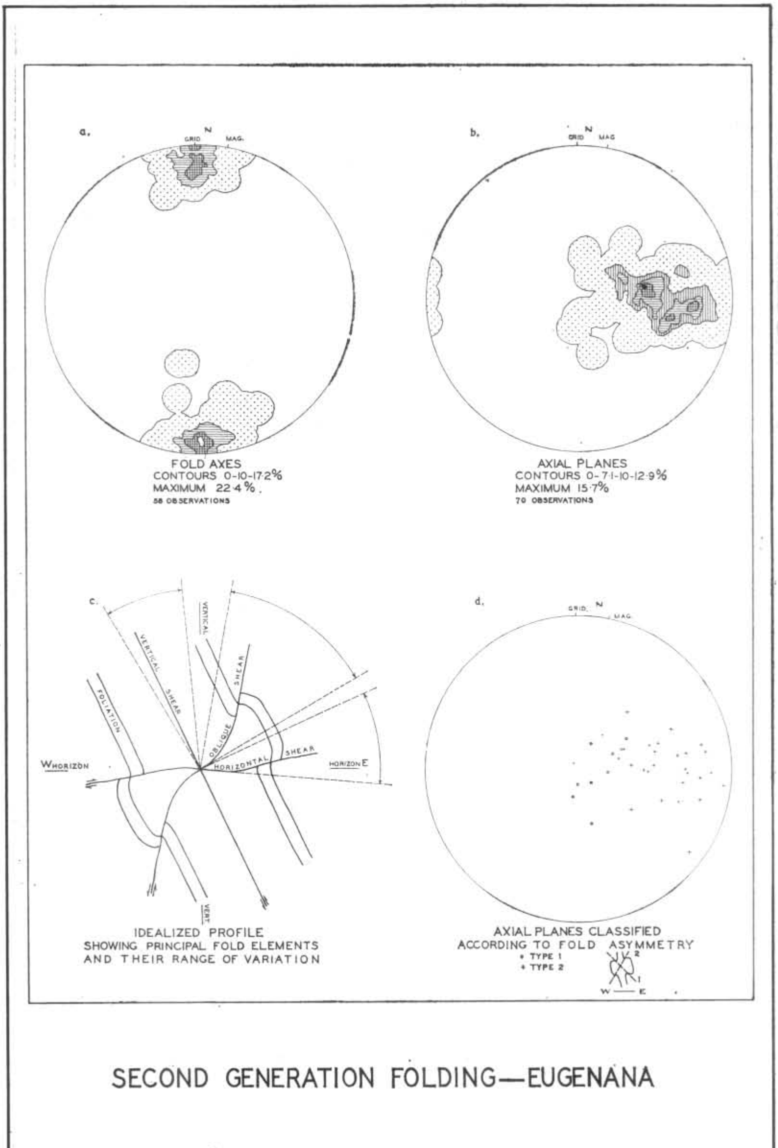
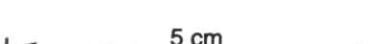

a.
N
GRID
MAG.
FOLD AXES
CONTOURS 0-10-17·2%
MAXIMUM 22·4%
58 OBSERVATIONS
b.
N
GRID
MAG
AXIAL PLANES
CONTOURS 0-7·1-10-12·9%
MAXIMUM 15·7%
70 OBSERVATIONS
c.
VERTICAL
VERTICAL
SHEAR
FOLIATION
SHEAR
OBLIQUE
HORIZONTAL
SHEAR
W HORIZON
HORIZON E
VERT
IDEALIZED PROFILE
SHOWING PRINCIPAL FOLD ELEMENTS
AND THEIR RANGE OF VARIATION
d.
GRID
N
MAG
AXIAL PLANES CLASSIFIED
ACCORDING TO FOLD ASYMMETRY
+ TYPE 1
+ TYPE 2
W — E
SECOND GENERATION FOLDING—EUGENANA

FIGURE 47.


5 cm

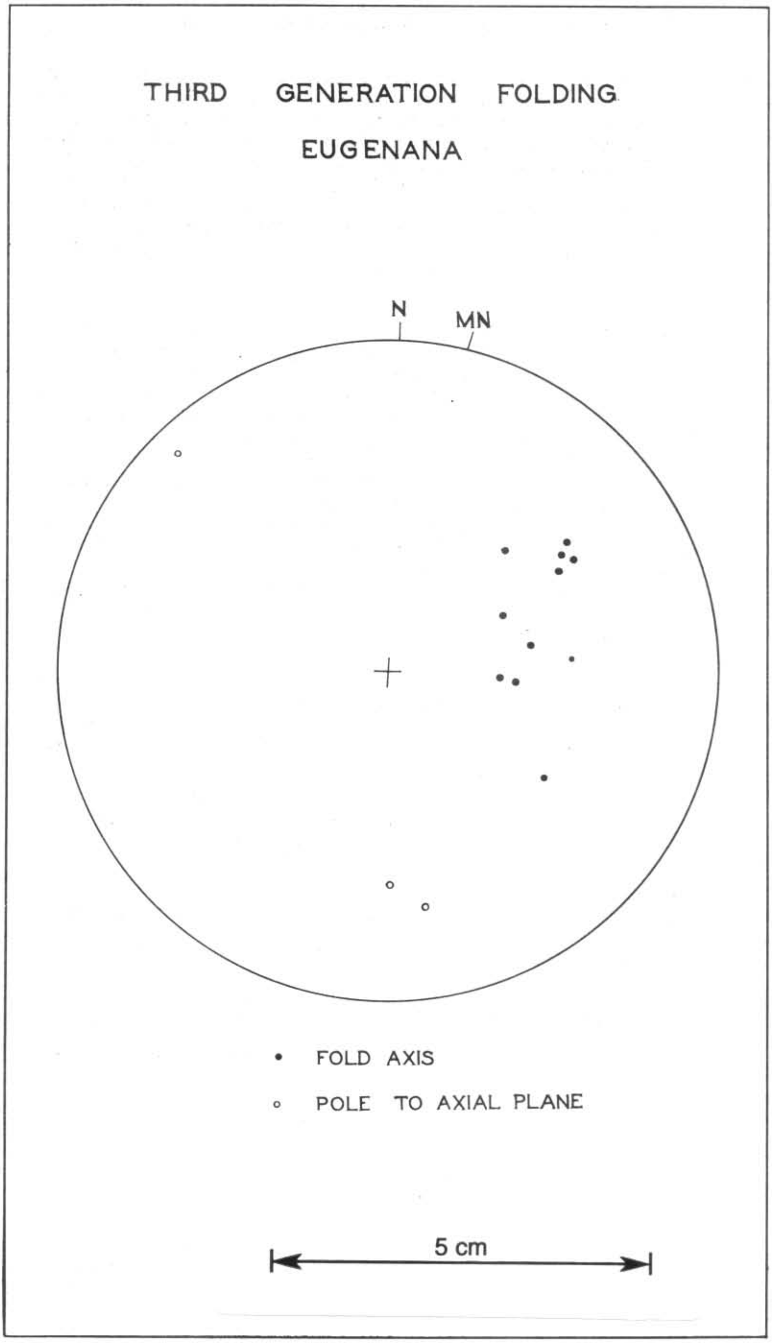

THIRD GENERATION FOLDING
EUGENANA
N
MN
• FOLD AXIS
◦ POLE TO AXIAL PLANE
5 cm

FIGURE 48.

The orientation of the axes is nearly that of the first-generation folds, but the style is very different. Axial surfaces cut across the foliation instead of being parallel to it. The dispersion of foliation planes in Figure 46a is due to this refolding. The first deformation was by slip on infinitesimally-spaced surfaces, as is shown by the deformation of fossils into continuous, smooth curves. However, the foliation now outcrops as a regularly-spaced fissility with cleavage planes of 0.1-0.25 inch separation. The spacing is due to reworking of the foliation in the second period of folding, some cross-cutting calcite seams being offset on discrete microlithons parallel to the foliation.

The folds are of variable style, including rounded, carinate, and zig-zag undulations. The more acute styles have faulted axial surfaces, and many of the folds are merely zig-zag bends near one, or between two, knick surfaces. Observations of folds from many places on the south face of the B.H.P. quarry show that the general style may be regarded as conjugate, as shown in Figure 47c. The great majority of the folds are, however, only parts of this idealized style. Knicks along oblique shears are most common, knicks along horizontal shears are rare, and folds with a complete conjugate profile are exceedingly rare. It may be regarded as a field of oblique shear folds, with occasional conjugate folds occurring at places within the field. The vertical and horizontal shears differ in the fold styles associated with them but have overlapping ranges of orientation as shown in Figure 47d. Many of the oblique shears, in particular, are cylindrically curved about the fold axis.

Lineations on the shear surfaces form a complex system which consists of an early set of calcite mullions parallel to fold axes and a later set of slickensides at a high angle to fold axes. There has been considerable deformation of the early lineations during development of the late ones.

The fold style is consistent with vertical shortening and lateral extension. Folds of this style occur elsewhere only in Applebee Creek where an early fracture cleavage in conglomerate of the Moina Sandstone has been refolded in a like fashion.

Third generation folding (*L*1 *phase*): In Rundle's quarry there are folds of conjugate profile which refold the early foliation. The axes and axial planes are at large angles to those of the second-generation folds and are plotted in Figure 48. The folds are open and rounded, with conjugate profile but without axial shears. They contrast with second-generation folds which have shears well developed but which are rarely of conjugate profile.

The style and orientation set these folds apart from those described earlier. They post-date the folds of the first generation, and have orientations markedly different from the folds of the first two generations, so probably were formed in a third movement phase.

SULPHUR CREEK

On the headland at Sulphur Creek the basement is Precambrian sandstone and mudstone of the Rocky Cape Group. The overlying rocks are conglomerate, sandstone and mudstone of the Dial Group.

The conglomerate is folded into open centroclinal folds with gently-dipping limbs. Three basins east of the headland are termed "west", "middle", and "east", in Figure 49. The folds were formed as a result of two phases of movement and are small but similar to larger structures in the hinterland. Minor structures are faults, joints and bedding.

Faults: The faults are flat thrusts, sub-parallel to bedding, which follow curved paths between beds and disappear along bedding planes. A few small folds rest disharmonically on the thrusts showing that folding accompanied faulting. Observed faults are plotted in Figure 50d and have a mean strike of 340° with the direction in the fault plane at right angles to the slip being near 005°. The faults were probably formed in the E1 phase and their intersection at an azimuth of 245° probably reflects L1 folding of the thrusts.

Joints: Conjugate shear joints occur in several beds in the rim of the east basin. These are of interest as they are widespread on the north coast of Tasmania. The bisector of the acute dihedral angle usually trends NNW, and at one time they seemed likely to yield information on axial directions. Lode deposits at the Stormont bismuth mine (Burns, 1959a) are infillings of joints of this type. Measurements of the joints in three localities in the east basin are shown in Figure 51, and data for 9 localities in Figure 51d. The principal axes of strain, A, B, C, in the figures, are uniformly oriented throughout the basin. The joints are therefore younger than the folding which produced the basin, that is, post-L1. Some of the joints have small amounts of strike-slip movement on them, one striated plane off-setting an early thrust (in area No. 1 of the east basin, Figure 49). They appear to be younger than L1 but still Devonian, and are assigned to the L2 phase.

Bedding: β diagrams for the 3 basins are shown in Figure 50, and for some subareas of the east basin in Figure 52. The diagrams generally yield girdles with a number of maxima, except for the west basin which is a near-cylindrical fold assigned to the L1 phase. In the other folds, the interference of E1 and L1 has led to non-cylindrical forms and the usual methods of β analysis are incapable of defining axial directions. With refined methods discussed by Burns (1963b) some deductions are possible, but for present purposes it suffices to point out that the Sulphur Creek folds are similar to many of the major folds of the hinterland and indiscriminate bedding analysis will not be of much use in these.

Basement: In the Rocky Cape Group of the Precambrian basement which underlies the Ordovician conglomerate, there are minor flexural refolds of the Precambrian foliation in the phyllite. There are rounded, open folds trending east of south and correlated with E1, and open to conjugate folds plunging west and correlated with L1. The folds are disharmonic in style and restricted to a single band of phyllite in subarea No. 2 (Figure 49) where they die out against quartzite both up and down in the profile. The folds are small and are merely perturbations of the Precambrian structures. The Eugenanan folds have axial planes oriented 87NE171 and axes 74-001, and the Loonganan folds have axial planes 84S275 and axes 59-265, which agree with the orientation of Tabberabberan structures in the overlying Ordovician conglomerate.

5 cm

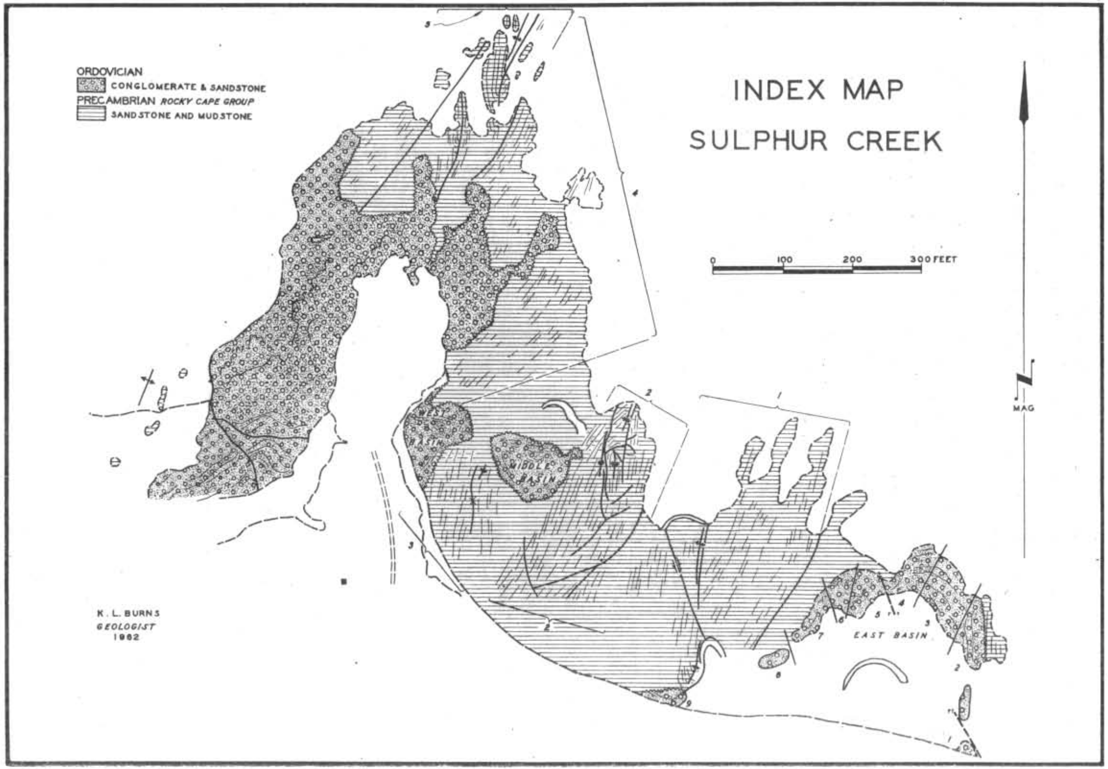


FIGURE 49.

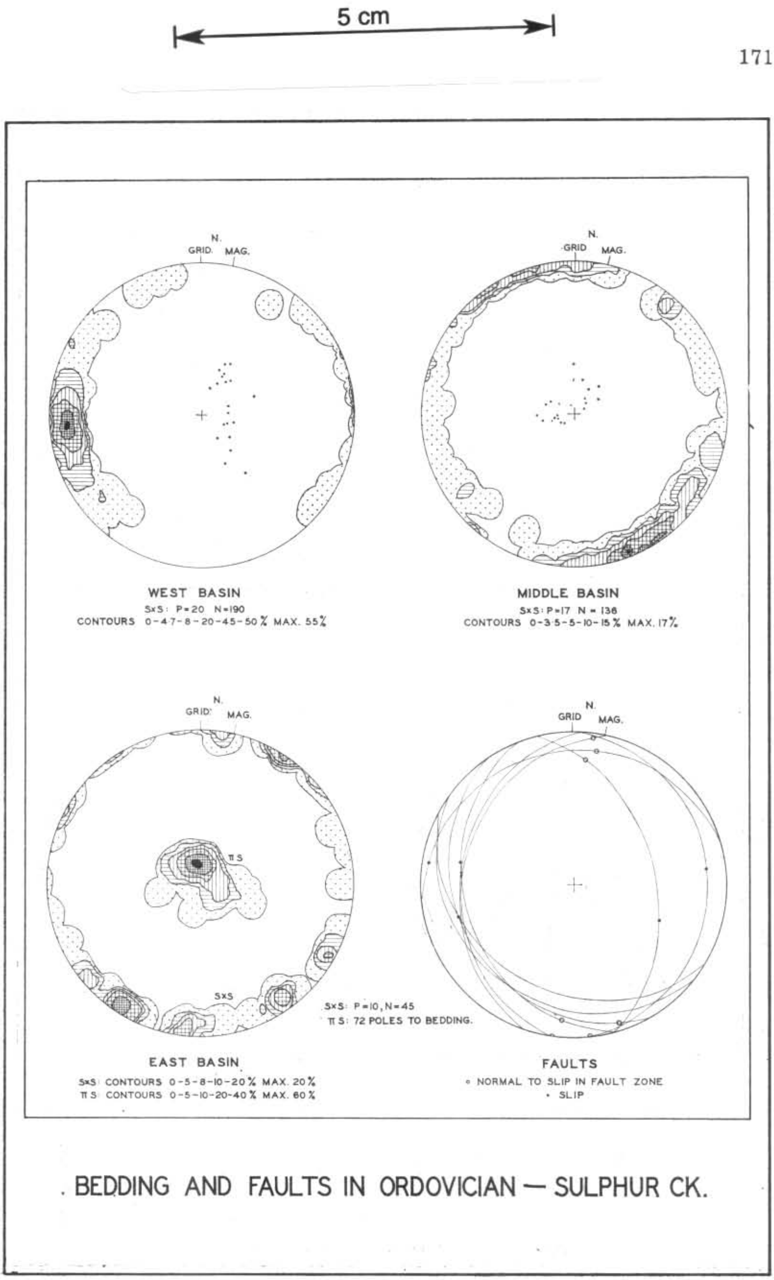

5 cm
N.
GRID
MAG.
WEST BASIN
SxS: P=20 N=190
CONTOURS 0-4·7-8-20-45-50 % MAX. 55 %
N.
GRID
MAG.
MIDDLE BASIN
SxS: P=17 N=136
CONTOURS 0-3·5-5-10-15 % MAX. 17 %
N.
GRID
MAG.
πS
SxS
SxS: P=10, N=45
π S: 72 POLES TO BEDDING.
EAST BASIN
SxS: CONTOURS 0-5-8-10-20 % MAX. 20 %
π S: CONTOURS 0-5-10-20-40 % MAX. 60 %
N.
GRID
MAG.
FAULTS
∘ NORMAL TO SLIP IN FAULT ZONE
· SLIP
BEDDING AND FAULTS IN ORDOVICIAN — SULPHUR CK.

Figure 50.

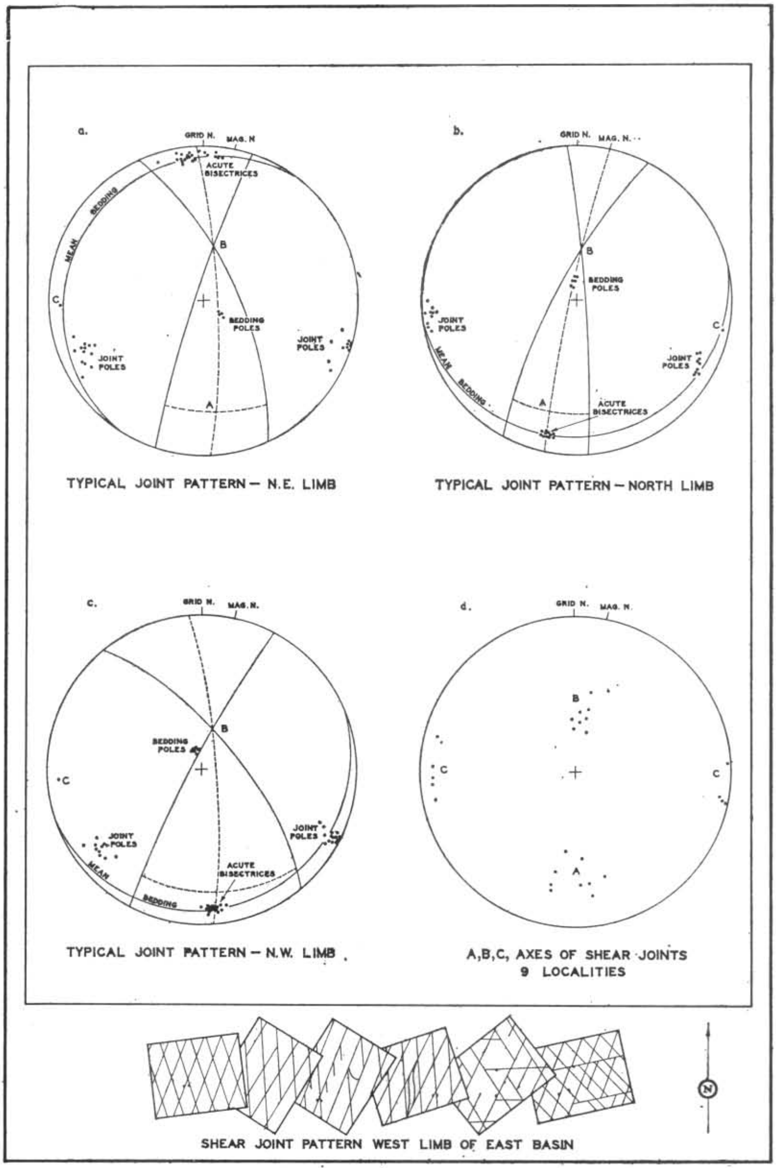


FIGURE 51.

5 cm

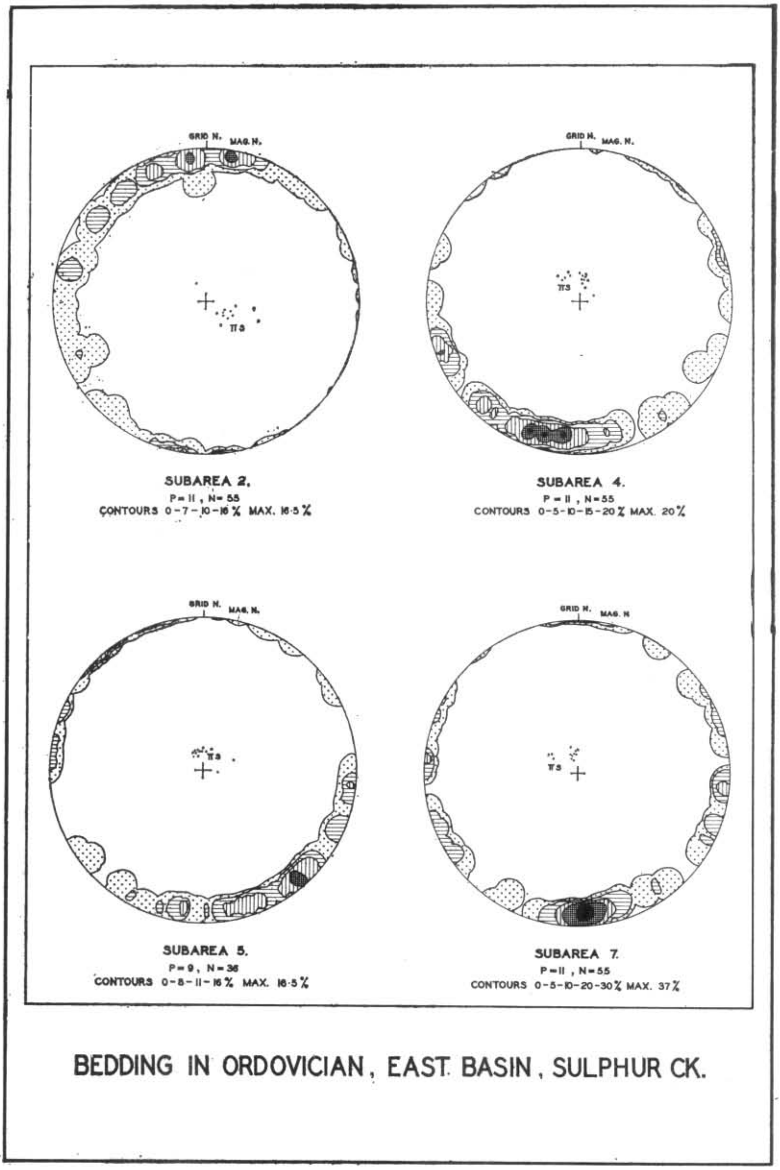
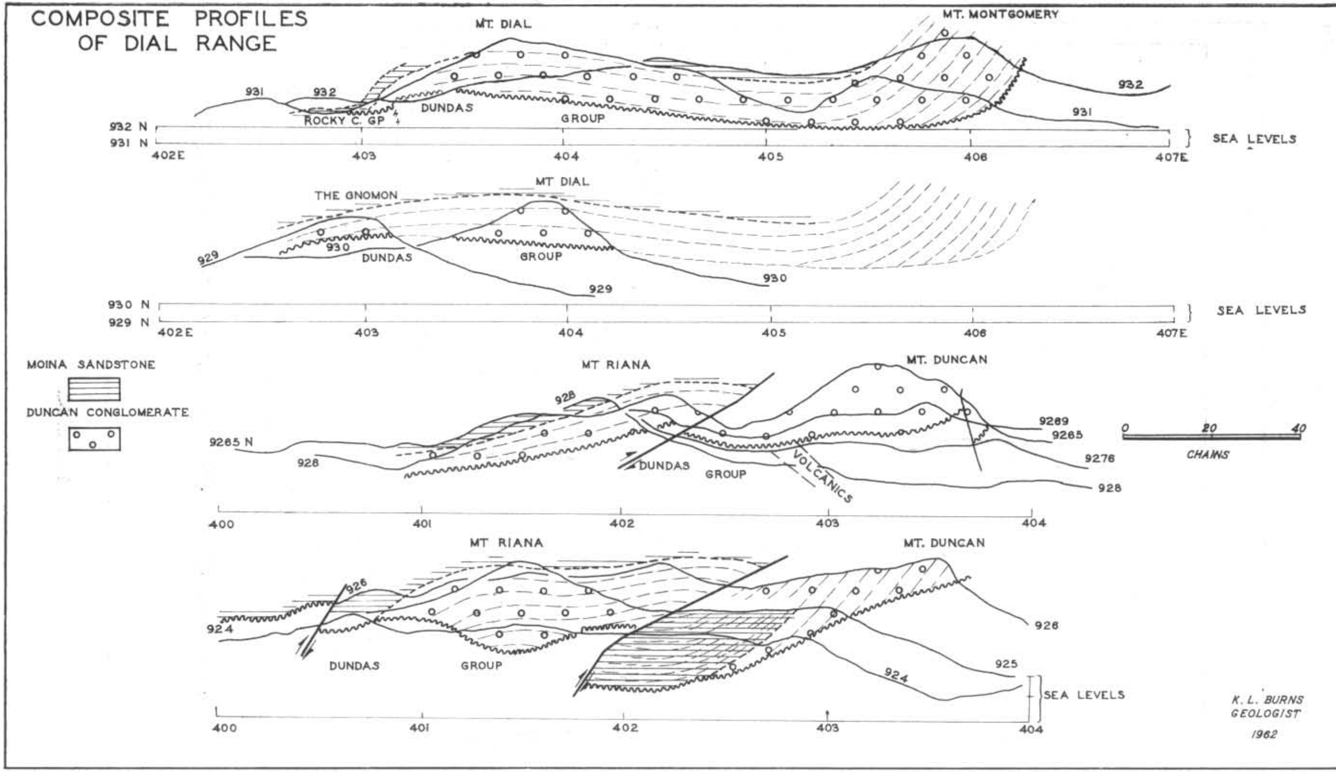


FIGURE 52.

5 cm



COMPOSITE PROFILES OF DIAL RANGE
MT. DIAL
MT. MONTGOMERY
931
932
ROCKY C. GP
DUNDAS
GROUP
932 N
931 N
SEA LEVELS
402E
403
404
405
406
407E
THE GNOMON
MT DIAL
929
930
DUNDAS
GROUP
930 N
929 N
SEA LEVELS
MOINA SANDSTONE
DUNCAN CONGLOMERATE
MT RIANA
MT. DUNCAN
928
9265 N
9269
9265
9276
DUNDAS
GROUP
VOLCANICS
0
20
40
CHAINS
400
401
402
403
404
MT RIANA
MT. DUNCAN
926
924
925
DUNDAS
GROUP
SEA LEVELS
K. L. BURNS
GEOLOGIST
1962

FIGURE 53.

PENGUIN

At the north end of the Dial Range is a shallow, faulted basin which runs under Penguin township to Bass Strait. The Penguin Fault is small, a post-Ordovician re-activation of an underlying inhomogeneity which runs through the basin. The dips on the east limb range from 5° to 25° (from direct measurement or from computation of the trace of marker horizons on topography) and 11 measurements yielded a β of 10-247 which has not much significance. Near the Devon Consols mine a fault oriented 13E187 passes through massive Duncan Conglomerate and is refracted to 25NE137 (with striae plunging 16-098) in overlying bedded conglomerate. In Myrtle Creek two intersecting thrusts dip 30W162 and 35W022 and have a number of minor subsidiaries. The thrusts intersect in a line near 30-257, which in the main thrust is perpendicular to 10-004. These splayed and refracted thrusts suggest a principal axis of stress close to 360°. The bisector of the acute dihedral angle between shear joints in Moina Sandstone at Myrtle Creek also has this orientation.

The Penguin Basin is probably a compound structure formed by superposed folding, the refracted fault at the Devon Consols mine suggesting an E1 trend close to 360°.

IRON CLIFFS

The geology of the Iron Cliffs mine, at the western boundary of the Dial Range Trough, was described by Burns (1961b). The limonite reef was offset by steeply-dipping dextral faults striking near 105°. Other post-ore structures include a single minor fold, which refolds the laminated limonite and has an asymmetrical profile, an axial surface striking SE and an axis near 75-110. These structures are later than a transposition foliation in the Cambrian mudstone (probably formed in the E1 phase) and are probably L1 structures.

MT DIAL

The Moina Sandstone of Mt Dial is folded into a shallow syncline with trough line plunging north at 400 feet per mile, with azimuth of 360°. Profiles normal to this trend are shown in Figure 53 (top two drawings) and the profile is apparently fairly uniform except for variations on the western side due to stratigraphic thinning of the Duncan Conglomerate. If allowance is made for high original dips, the fold is a gentle anticline and the apparent syncline in the overlying sandstone is a compound form largely reflecting thickness changes in the conglomerate.

THE GNOMON

The lower part of the south face of the Gnomon is the exhumed surface of a large fault described by Hughes (1953). The fault strikes near 300°, is vertical, and the principal component of movement is a dextral strike-slip. A crush breccia forming the north wall of the fault has some caves eroded in it, and in these there are exposed a number of minor faults which include transcurrent faults, oblique-slip faults and a thrust oriented 26NW045. The

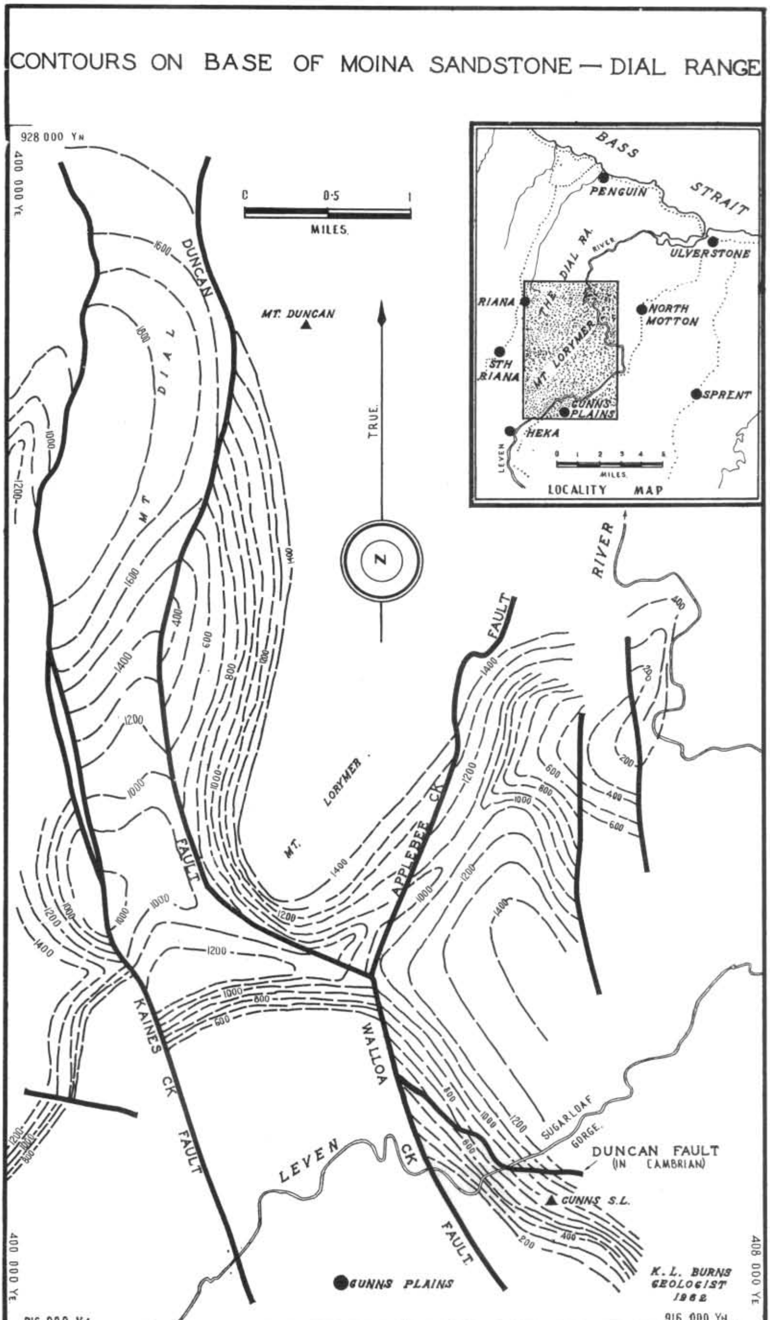


FIGURE 54.

5 cm

transcurrent faults may be second-order shears, but the others imply reworking of the major fault. The major fault is assigned to phase E2, the thrust to L3. The profiles of Figure 53 show a dramatic change at the Gnomon Fault, so the E2 phase is probably largely contemporaneous with E1 folding. A similar pattern occurs in the Liena Gorge and at Round Hill.

MT DUNCAN

The dominating feature of the area south of Mt Duncan is the Duncan Fault. This fault dips 25° west near Mt Duncan and has a stratigraphic throw varying from 0 to 1200 feet. The slip is probably uniform and of the order of 1000 feet. The variable stratigraphic throw is due to the fact that the fault strikes near 180° and intersects obliquely a tongue of Duncan Conglomerate which has axis striking about 220°.

North of Mt Duncan, the Duncan Fault follows the unconformity at the base of the Ordovician. It may terminate at the Gnomon Fault, or continue to the north as a flat thrust at the base of the Duncan Conglomerate. There is no evidence that the Gnomon Fault continues downward into Cambrian rocks and it appears to be confined to the upper plate of the Duncan Fault.

South of Mt Duncan the Duncan Fault swings sharply SE around the nose of Mt Lorymer to link up with the Walloa Creek Fault (Figure 54). Between Mt Duncan and Mt Lorymer the fault trace on the topography is very nearly horizontal but the fault is near the base of the Ordovician at Mt Duncan, about 2000 feet higher in the succession two miles south, and about 100 feet above the base of the Ordovician at Mt Lorymer. The fault probably developed with undulations coaxial with the slip.

South of Mt Lorymer the situation is complicated by later movements, but it appears that the Duncan Fault steepens and the trace of the fault runs through Cambrian rocks, the movement probably being distributed through a number of steeply-dipping shears. The fault is an early thrust, related to the E1 phase, and has been reworked in parts, and folded in others, in the vicinity of Mt Lorymer.

SUGARLOAF GORGE

The term Sugarloaf Gorge is used in preference to the older term Leven Gorge of Twelvetrees and others, to avoid confusion with gorges higher up the Leven River. The name Sugarloaf is taken from the hill termed by the local inhabitants " Gunns Sugarloaf " at the upstream end of the Gorge. Three conglomerate outcrops occur in the gorge: western, central and eastern as in Figure 55. The western outcrop consists mainly of flaggy sandstone and is equated with the Moina Sandstone. The central and eastern outcrops may be either Cambrian conglomerate or basal conglomerate of the Moina Sandstone repeated by faulting in an imbricate fault zone. There is evidence in favour of both alternatives:—

At the top of Gunns Sugarloaf, the central conglomerate outcrop is truncated at the base of the western one. This truncation may be either a fault or an unconformity.

5 cm

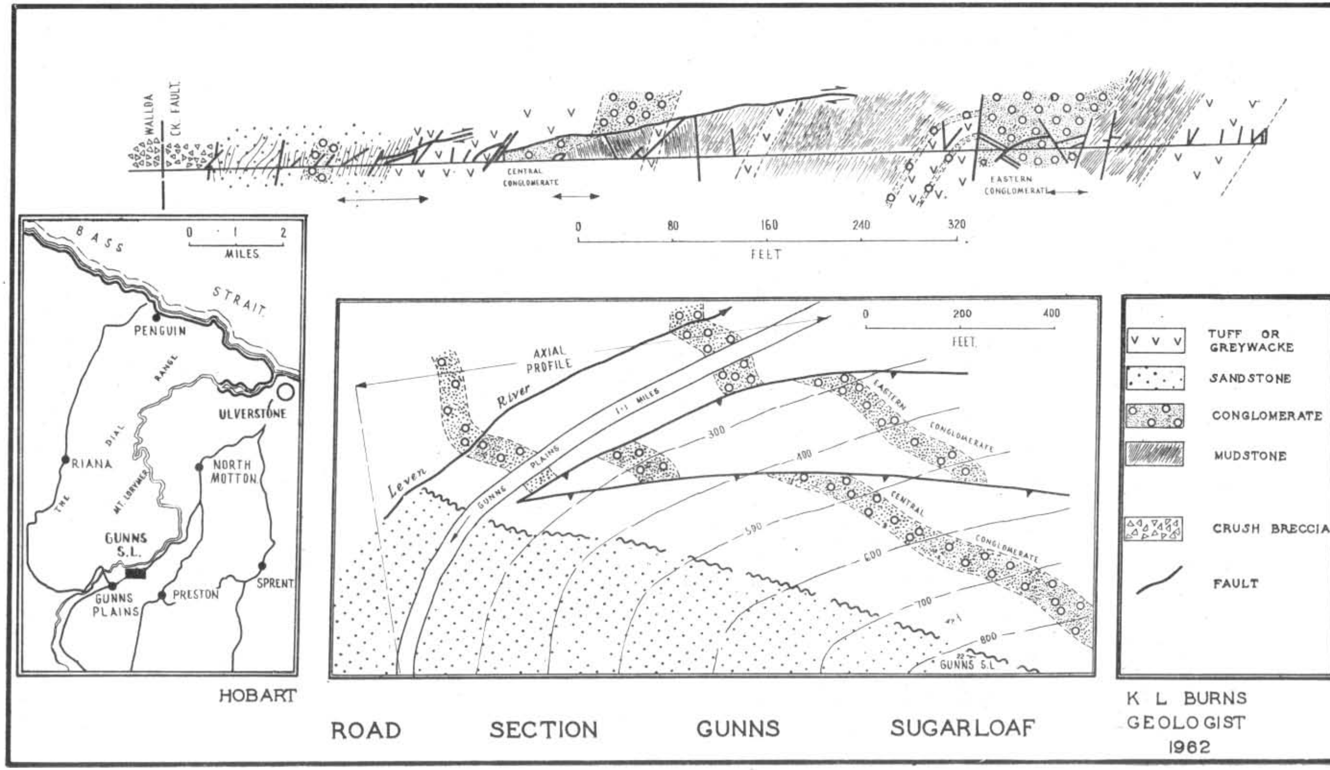


FIGURE 55.

The eastern boundaries of the central and eastern outcrops appear to be unconformities, but there has been strong differential movement at these contacts (Figure 56) and the existence of unconformities cannot be proven.

Banks (1956, p. 184) found Cambrian fossils in mudstone between the central and eastern conglomerate outcrops. This discovery is compatible with either view.

A band of Cambrian mudstone, dipping 34° east, occurs within the eastern conglomerate. However, this band is a fault sliver and contains lenticular tectonic inclusions of conglomerate and is not a bed.

A possibly transitional passage between mudstone and conglomerate at the western edge of the eastern outcrop is a vertical fault making a very small angle with the road cutting, and patches of conglomerate in the mudstone are windows through the fault surface.

There is quartzite-pebble conglomerate interbedded with Cambrian mudstone at Loyotea which makes the Cambrian age of the quartz-pebble conglomerate of the Sugarloaf Gorge a tenable hypothesis. There are a large number of faults in the Sugarloaf Gorge, the rocks occupying what is in reality a large fault zone, and imbricate faulting is a tenable hypothesis.

The detailed stratigraphy suggests that the east and central conglomerate outcrops are probably a single lithology repeated by faulting and are probably not the same unit as the western conglomerate outcrop.

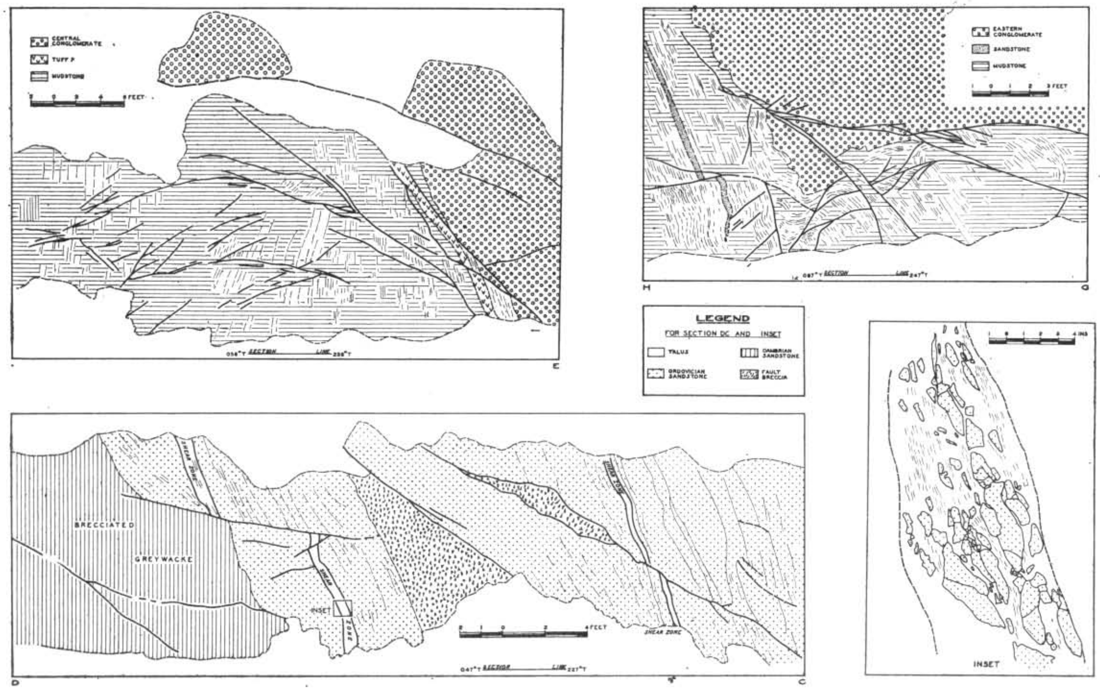
A number of minor folds in the mudstone are open and concentric, with axial surfaces near vertical except where rotated in the vicinity of some later faults. The mean plunge is 10-164 (Figure 57a) and one minor fold in the Moina Sandstone has this plunge. The folds are Tabberabberan and equated with E1.

There are three principal classes of faults: break-thrusts, high-angle faults, and low-angle faults.

The break-thrusts are sub-parallel to bedding and curve over the crests of minor folds in two opposed senses. The direction in the fault plane normal to the slip is parallel to the fold axes (Figure 57d). The fault planes form a sheaf co-axial with the fold axes. The faults were thus formed penecontemporaneously with folding and are equated with E1. The Duncan Fault is probably a member of this class.

The high-angle faults are best developed in the Moina Sandstone which is not parallel-bedded but is a stack of lenses emplaced by faults sub-parallel to bedding. Included with these faults are shear zones, which have wide fault zones containing lenticular tectonic inclusions of wall-rock (Figure 56). The faults are oblique-slip (Figure 57b). On the basis of arguments adduced by Burns (1963b) these faults are regarded as having been formed by reworking of earlier faults. They are probably wrench-normal faults reworking steeply-dipping members of the older break-thrust class. They belong to a secondary-wrench regime, L2, and it is likely that the major Walloa Creek Fault of Figure 54 belongs to this class.

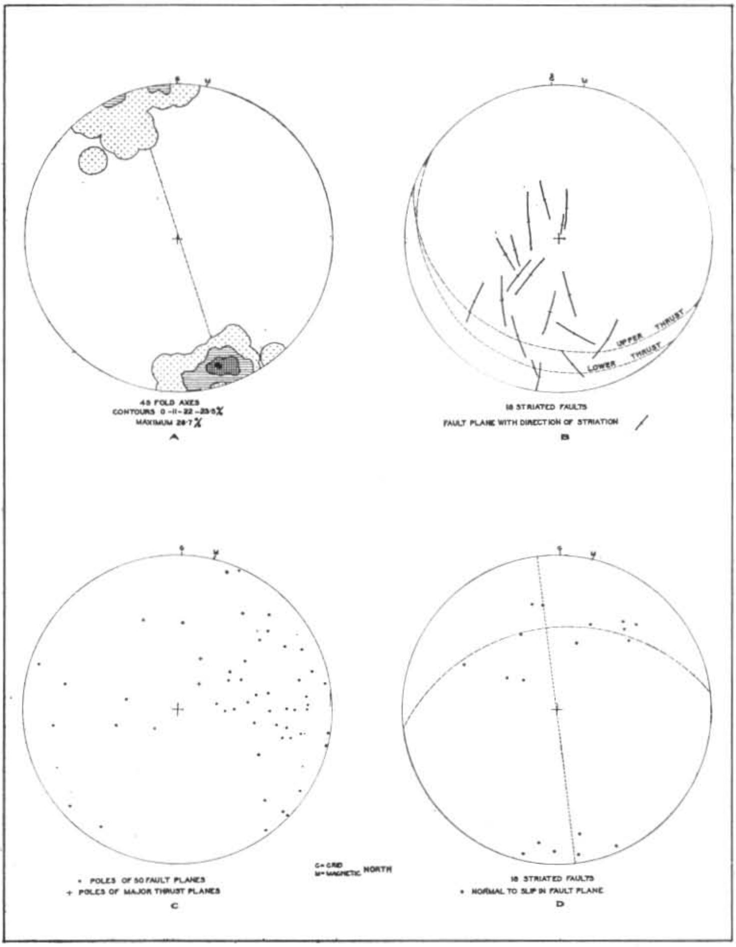
5 cm



DETAILS OF ROAD SECTION–GUNNS SUGARLOAF

K.L. BURNS
GEOLOGIST 1965

FIGURE 56.



LAMBERT PROJECTIONS OF FOLDS AND FAULTS

SUGARLOAF GORGE

FIGURE 57.

5 cm

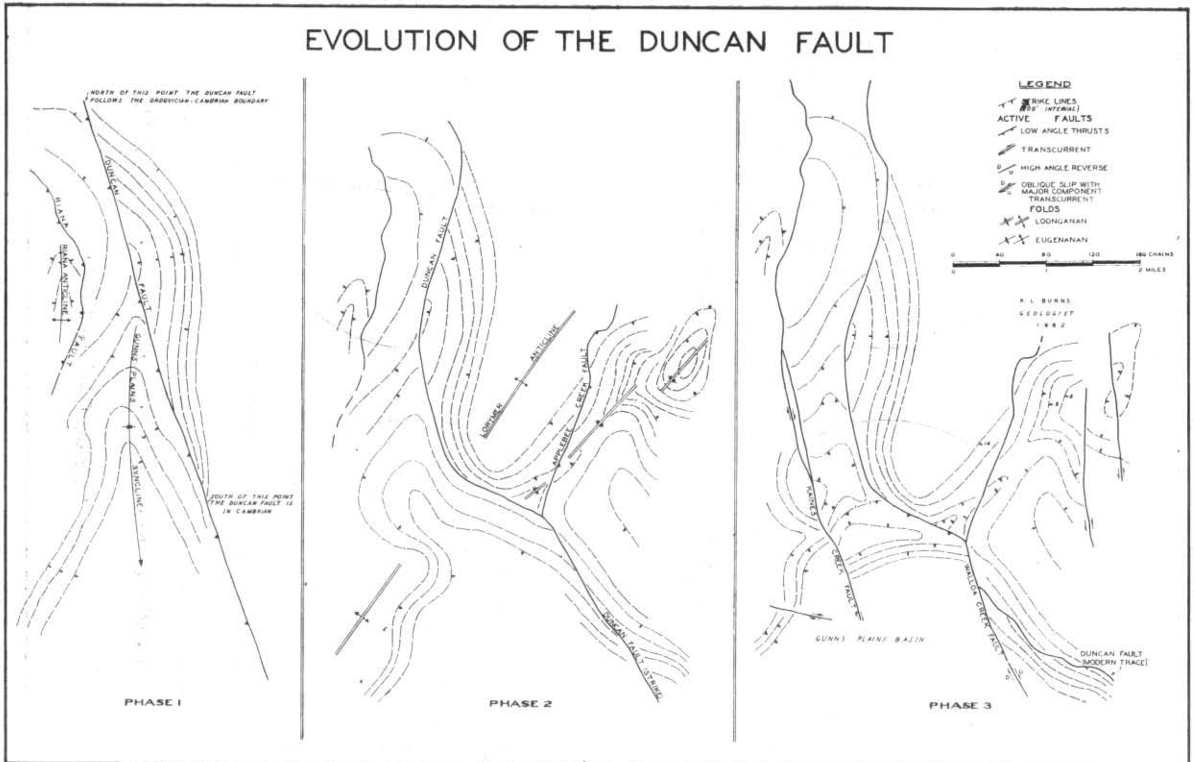

EVOLUTION OF THE DUNCAN FAULT
NORTH OF THIS POINT THE DUNCAN FAULT FOLLOWS THE ORDOVICIAN-CAMBRIAN BOUNDARY
DUNCAN FAULT
RIANA FAULT
RIANA ANTICLINE
GUNNS PLAINS SYNCLINE
SOUTH OF THIS POINT THE DUNCAN FAULT IS IN CAMBRIAN
PHASE 1
DUNCAN FAULT
LORYMER ANTICLINE
APPLEBEE CREEK FAULT
DUNCAN FAULT (STRIKE)
PHASE 2
LEGEND
STRIKE LINES
ACTIVE FAULTS
LOW ANGLE THRUSTS
TRANSCURRENT
HIGH ANGLE REVERSE
OBLIQUE SLIP WITH MAJOR COMPONENT TRANSCURRENT
FOLDS
LOONGANAN
EUGENANAN
0 40 80 120 160 CHAINS
2 MILES
K. L. BURNS
GEOLOGIST
1962
RAINES CREEK FAULT
WALLOA CREEK FAULT
GUNNS PLAINS BASIN
DUNCAN FAULT (MODERN TRACE)
PHASE 3

FIGURE 58.

The low-angle faults form a third class. These faults are the youngest, offsetting earlier faults as in Figure 56, section DC. They are imposed structures developed largely independently of inherited inhomogeneities and are assigned to a secondary thrust regime, L3.

NORTHERN GUNNS PLAINS

There is a complex fault network at the northern end of Gunns Plains between Walloa and Kaines Creeks, SW of Mt Lorymer. The Duncan Fault becomes steeper southwards, and is apparently folded around the end of Mt Lorymer. In the upper part of Walloa Creek the lineations in the fault surface indicate oblique-slip with the major component being strike-slip, presumably a late-stage reworking of the fault. The Walloa Creek Fault is vertical with movement in the sense of dextral strike-slip together with west side down, and appears to be an oblique-slip fault synchronous with, or slightly younger than, the Loonganan folding as it forms a major discontinuity in the Loonganan fold profiles. The Kaines Creek Fault has lineations indicating pure strike-slip movement at the rim of the Gunns Plains Basin, but further north the fault contains a fault sliver which is relatively uplifted with respect to the rocks each side. At Kaines barites mine there is a complex succession of intersecting faults with thrust faults common. In the quarry at Riana (4003E 9240N) there is a succession of mineralized brecciated thrust zones followed by unmineralized strike-slip faults. The fault sliver may therefore have been developed at the intersection of an early thrust with a late transcurrent fault of the same strike. At the northern rim of Gunns Plains, between Kaines and Walloa Creeks, there is a small, tight overfold or thrust linking the Kaines Creek and Duncan Faults.

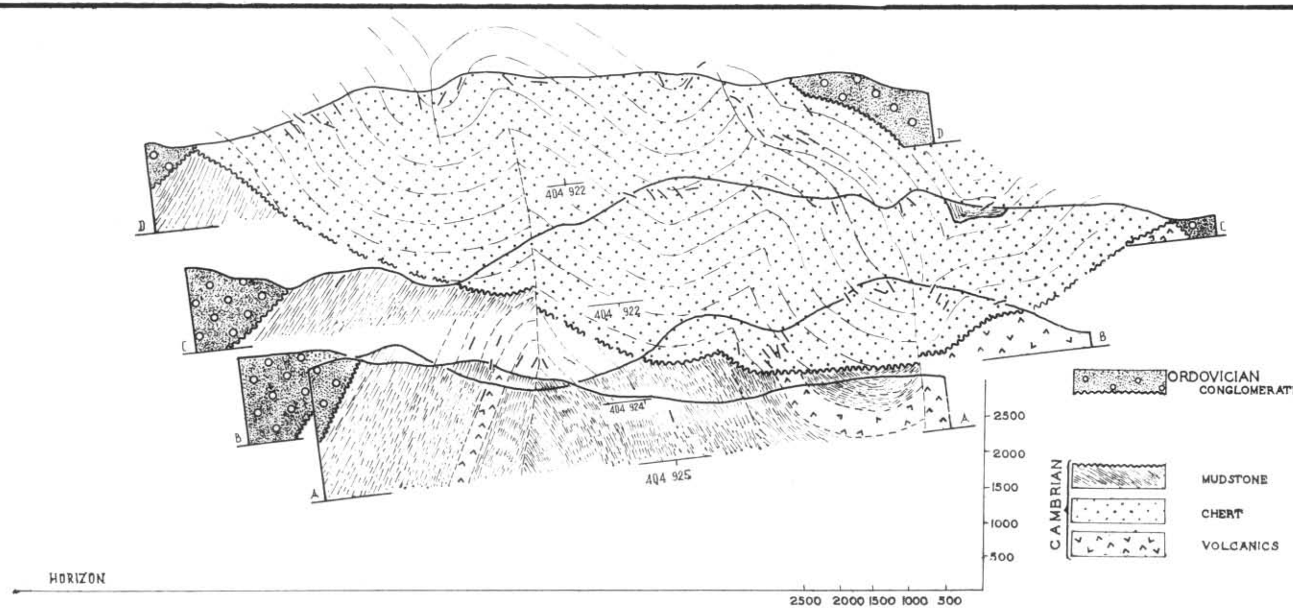
The network is fairly complex, and there are uncertainties in critical areas due to poor exposure or Tertiary cover, but with a movement succession E1, L1, L2 and L3, as deduced from the Sugarloaf Gorge, a reasonable picture of the development of the network can be constructed as in Figure 58.

MT LORYMER

Mt Lorymer is a wedge of Barrington Chert at least 2800 feet thick. The general form is a doubly-plunging anticline elongated in a NE-SW direction, parallel to a number of small, open flexural folds exposed on the northern crest of the range. The general structure is shown in Figure 59.

The general structure is consistent with superimposed folding on Eugenanan and Loonganan trends. By indirect methods discussed by Burns (1963b) it is possible to construct a profile of the mountain normal to the Eugenanan trend, as shown in Figure 60. This shows the primary structure of the chert as a transgressive lens, folded into open concentric folds with related faults. These folds coincide in position with folds in the underlying mudstone which have a carinate style and a limited development of slaty cleavage along axial inflections. The general fold style is competent-incompetent as might be expected in view of the marked contrast in lithological character of the mudstone and the chert.

5 cm



COMPOSITE VERTICAL PROFILE OF MT LORYMER

K.L. BURNS
GEOLOGIST
1962

FIGURE 60.

5 cm

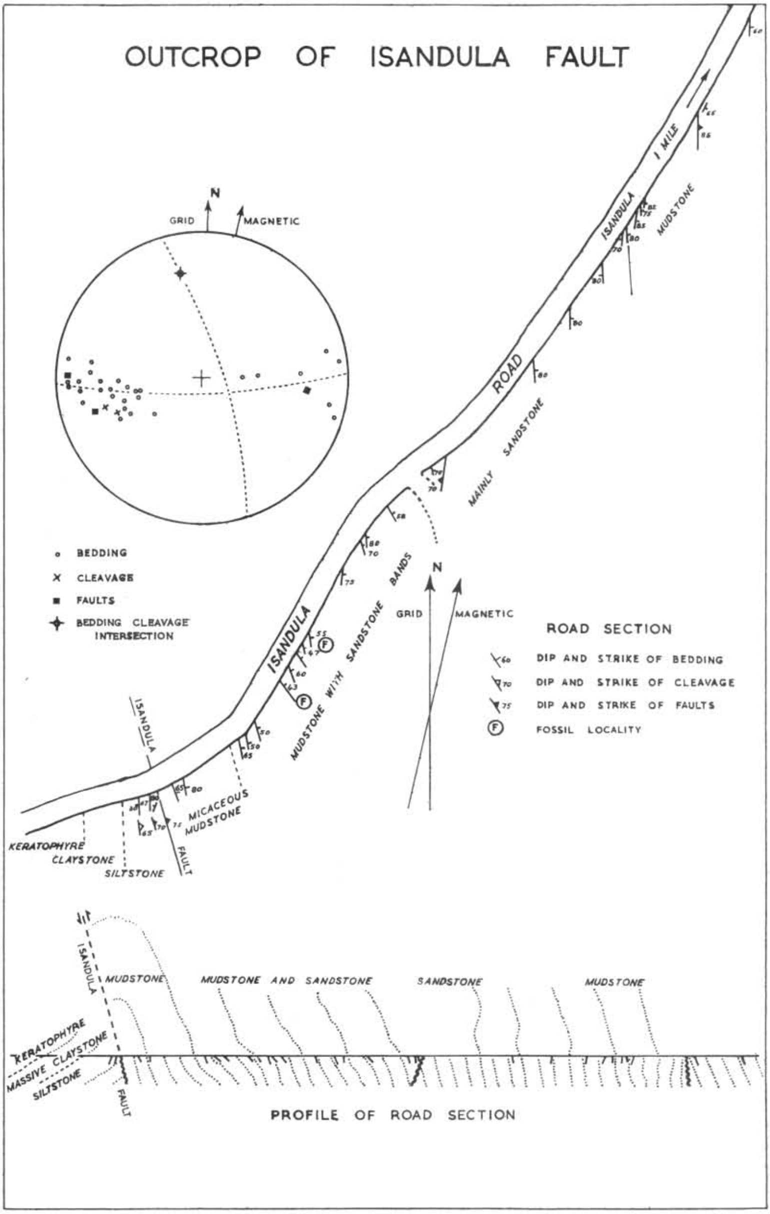
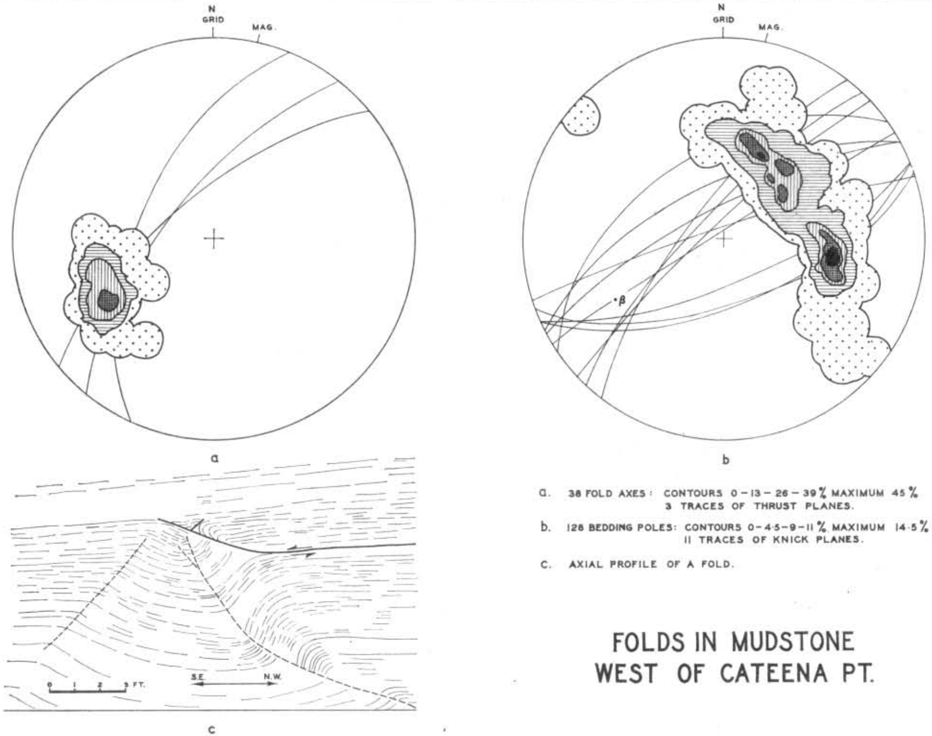


Figure 61.

5 cm



a. 38 FOLD AXES: CONTOURS 0 – 13 – 26 – 39 % MAXIMUM 45 %
3 TRACES OF THRUST PLANES.

b. 128 BEDDING POLES: CONTOURS 0 – 4·5 – 9 – 11 % MAXIMUM 14·5 %
11 TRACES OF KNICK PLANES.

c. AXIAL PROFILE OF A FOLD.

FOLDS IN MUDSTONE
WEST OF CATEENA PT.

FIGURE 62.

Wilsonia

The Wilsonia area is 4-5 miles south of Ulverstone with general geology as shown in Figure 4. The folds in the Cambrian mudstone have a fairly strong and widespread slaty cleavage which usually crosses bedding without deflection, but in some areas bedding has been kinematically active and the cleavage forms very gentle sigmoids in some beds. A small portion of this area is shown in Figure 61. Contours of 362 bedding intersections yield a 16% maximum plunging 12-357, a plunge that is maintained with little variation over quite a wide area. Two large faults, the Isandula and Wilsonia Faults, cross the area. The faults dip close to 75E340 with a total stratigraphic throw of 1200 feet, west side down. The faults are generally concordant with the folding and are presumably the same age, formed in the E1 phase. The faults appear to be continuous with the large north-dipping thrusts in the Alma Syncline and have a comparable throw.

Figure 4 is a result of intensive mapping and is generally correct, but there are problems in the relationship of the Isandula Conglomerate to the mudstone further north (is it a tectonic intrusion, a diataphral breccia, or an infolded primary lens?). In the West Gawler River, the relationship of formations above and below the Isandula Road must remain uncertain in the absence of palaeontological dating.

Cateena Point

In the Leven River west of Cateena Point, near the mouth of the Gawler River, Cambrian mudstone contains a number of folds with orientation and general style as shown in Figure 62. The folds are disharmonic and rest on thrusts which disappear along bedding. The axial surface is usually marked by a fault, although in some cases the hinge region is a " stack " of break-thrusts. The folds are asymmetrical and axial planes dip north although there are contraposed forms as in the figure. The modal fold axis is 38-240 and most of the axial knick surfaces strike 240°. These folds are of a " steep axial-plunge secondary type " formed in bedding with an inherited steep dip and are assigned to the L1 phase.

Penguin Foreshore

The Beecraft Megabreccia unconformably overlies quartzite of the Rocky Cape Group on the foreshore immediately east of Penguin. The beds in the megabreccia dip west towards the unconformity and are truncated by it, having been deposited against a steep face. The surface of the unconformity is polished, with grooves and striae plunging between 22-086 and 26-118 with a median near 26-100. A large fold of several hundred feet wavelength plunges toward the unconformity and terminates on it, with β near 25-120. The fold is similar in style to those at Cateena Point and is assigned to the L1 phase. The unconformity has acted as a major inhomogeneity during deformation, both on the foreshore at Penguin and at the Iron Cliffs to the SW.

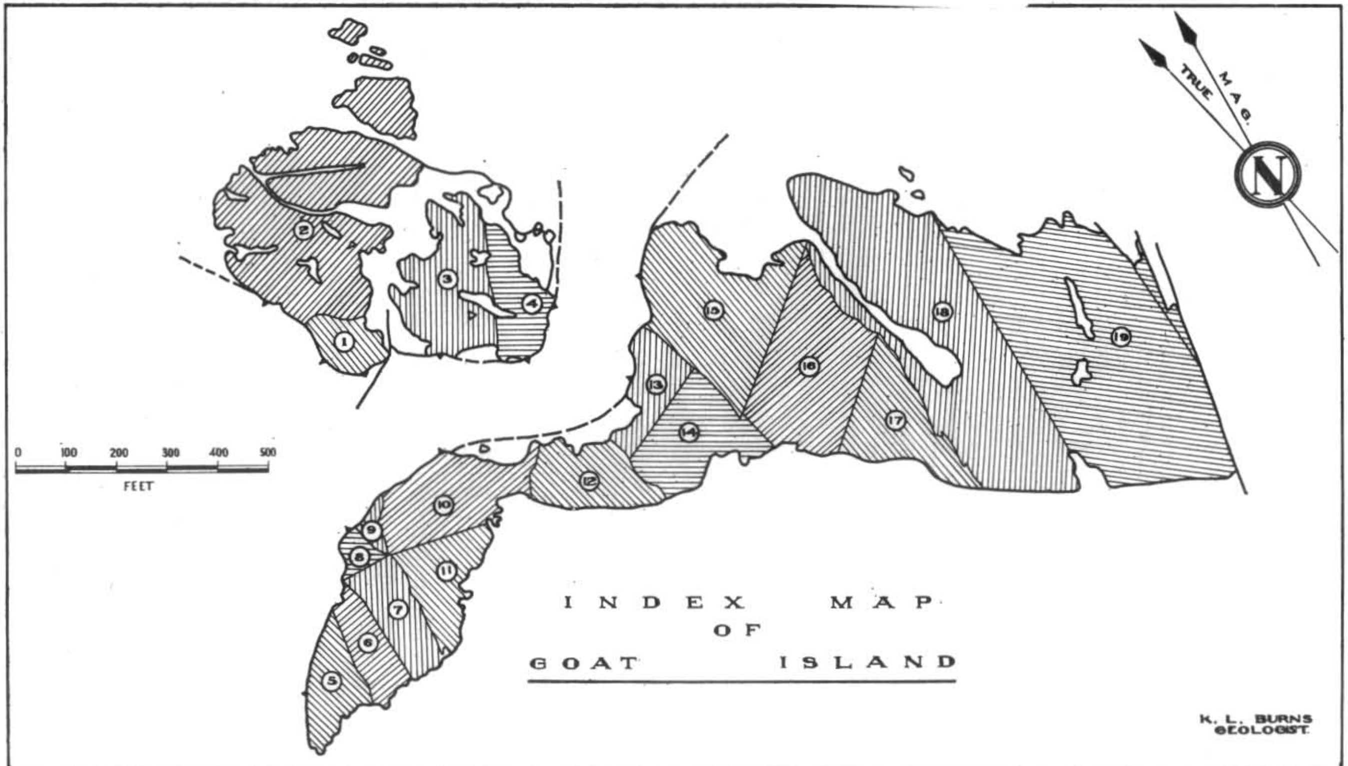

INDEX MAP OF GOAT ISLAND
K. L. BURNS GEOLOGIST
TRUE
MAG.
N
0 100 200 300 400 500
FEET
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19

FIGURE 63.

A number of thrust surfaces are exposed at intervals along the intertidal platform between Penguin and Lodders Point, marked by thick sheets of chloritic mylonite. There is possibly only one thrust, undulating along the platform at an altitude close to sea-level. In each exposure there is a major thrust plane with dip-slip movement, with observed orientations 45E202 (striae pitching 80N), 30E192 (striae pitching 55N) and 23W177 (striae pitching 80N). In each locality are second-order shears, oriented, for example, 30S112 (striae pitching 5W) and 35S117 (striae pitching 35W). The common intersection is near 20-160 and the faults are identified as E1 phase. They do not seem to be important structures.

GOAT ISLAND

Late-stage, post-metamorphic structures in the Rocky Cape Group and in the Ulverstone Metamorphics at Goat Island include two generations of folds identified as Tabberabberan.

In the Rocky Cape Group, folds correlated with the Eugenanan phase are open, upright, nearly concentric folds with a coarse axial strain-slip cleavage in hinge regions, the cleavage offsetting Precambrian foliations. The axial trend is near 360°.

Folds correlated with the Loonganan rest disharmonically on N-S strike faults, frequently as symmetrically opposed pairs of opposite vergence to form an overall conjugate style with two divergent axial trends. Folds of this phase are best developed in areas of west-dipping bedding (Figure 40) and are only weakly formed in east-dipping or flat-lying beds. In beds with thin or flaggy bedding the folds reach amplitudes of 10 feet or so, but in finely-layered rocks such as mudstone with well-developed Precambrian foliations the folds are developed as very small, closely-spaced, virtually penetrative, crenulations. Axial plunge in these folds is meaningless as the folds are superposed with planar axial surfaces and the plunge is controlled by the inherited dips. The significant quantities are the attitudes of the axial surfaces and the orientation of their line of intersection, which is nearly vertical.

In the Ulverstone Metamorphics at Goat Island the Tabberabberan structures are small scale and are virtually only perturbations of the Precambrian structure, as shown by Figure 63 (in which, except for subarea No. 19, the subareas are homogeneous with respect to the Precambrian foliation and lineation) and Figure 64. In subarea No. 19, adjacent to the Westbank Fault, there are open gentle folds in the Precambrian foliation S_2 with the largest fold of about 50 feet wavelength. The folds are asymmetrical with gentle western limbs and steeply-dipping eastern limbs. The modal axis is 16-193 in an axial surface marked by a wide-spaced strain-slip cleavage which is oriented 78W016 (Figure 65). The folds are identified as Eugenanan, and have an axial trend so significantly divergent from the strike of the Westbank Fault as to indicate that they probably ride disharmonically on the fault. In other areas at Goat Island, Eugenanan folds are minor crenulations of the Precambrian foliation, with a mode at 20-001 in subareas Nos. 7 to 14 (Figures 63, 66).

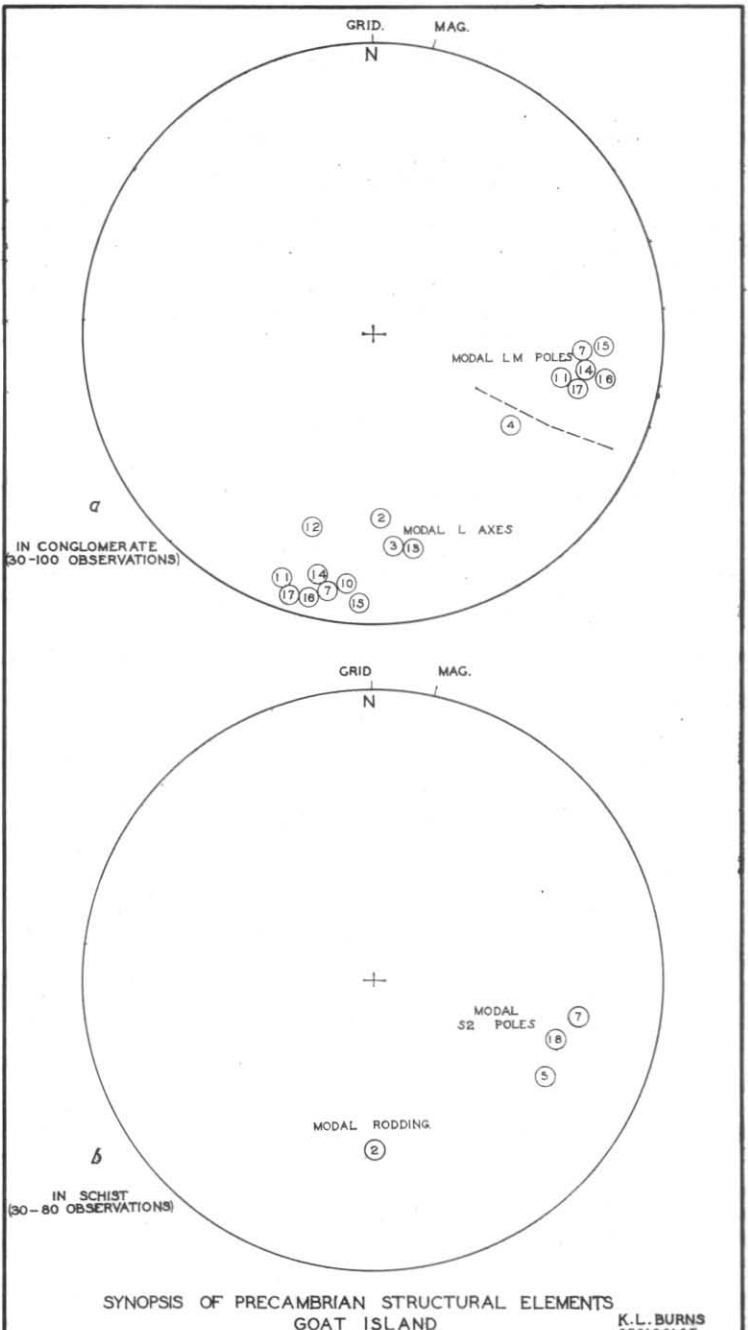
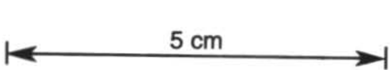

GRID.
MAG.
N
MODAL LM POLES
7
15
14
11
16
17
4
a
IN CONGLOMERATE
(30-100 OBSERVATIONS)
2
12
MODAL L AXES
3
13
11
14
10
17
16
7
15
GRID
MAG.
N
MODAL
S2 POLES
7
18
5
MODAL RODDING
2
b
IN SCHIST
(30-80 OBSERVATIONS)
SYNOPSIS OF PRECAMBRIAN STRUCTURAL ELEMENTS
GOAT ISLAND
K.L. BURNS
GEOLOGIST

FIGURE 64.


5 cm

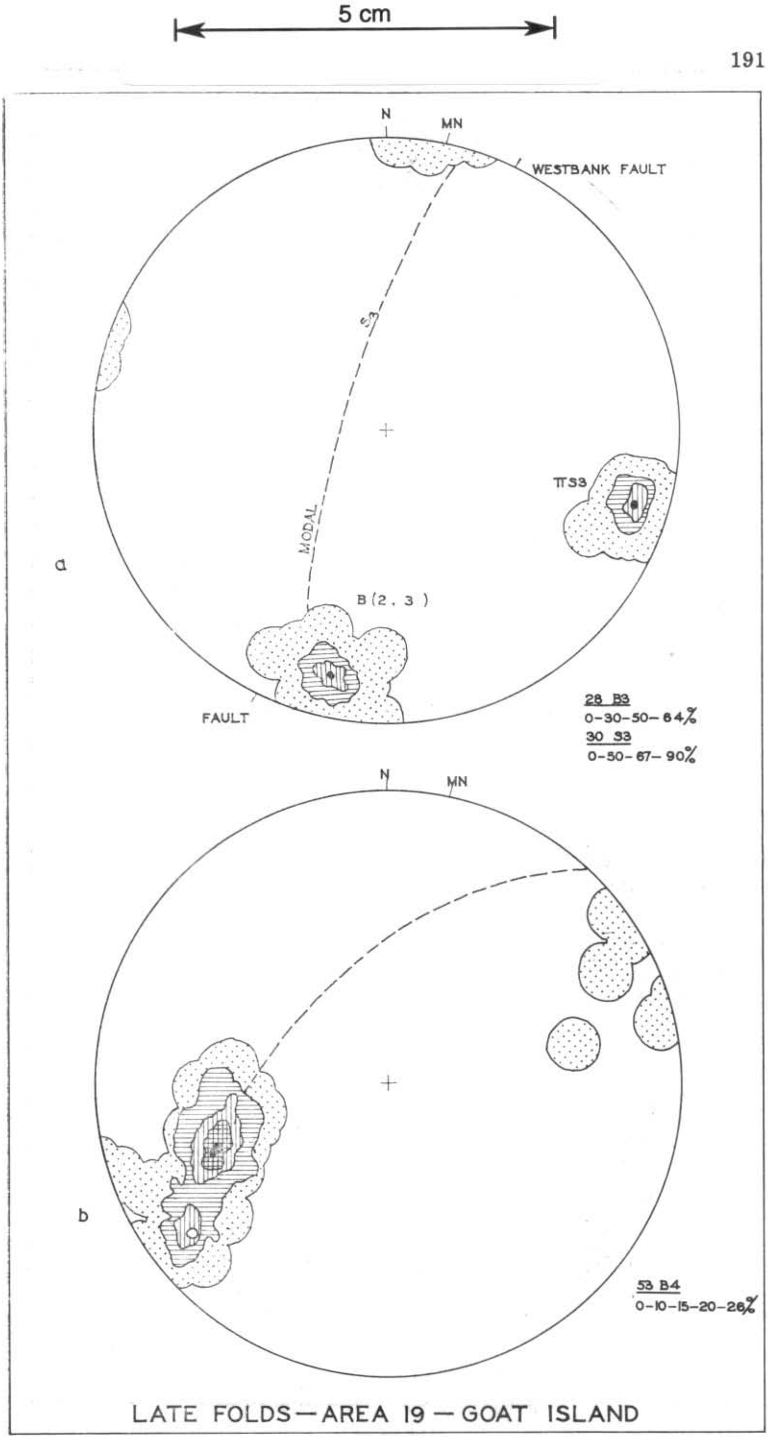

5 cm
N
MN
WESTBANK FAULT
S3
MODAL
πS3
a
B (2, 3)
FAULT
28 B3
0-30-50-64%
30 S3
0-50-67-90%
N
MN
b
53 B4
0-10-15-20-26%
LATE FOLDS—AREA 19—GOAT ISLAND

FIGURE 65.

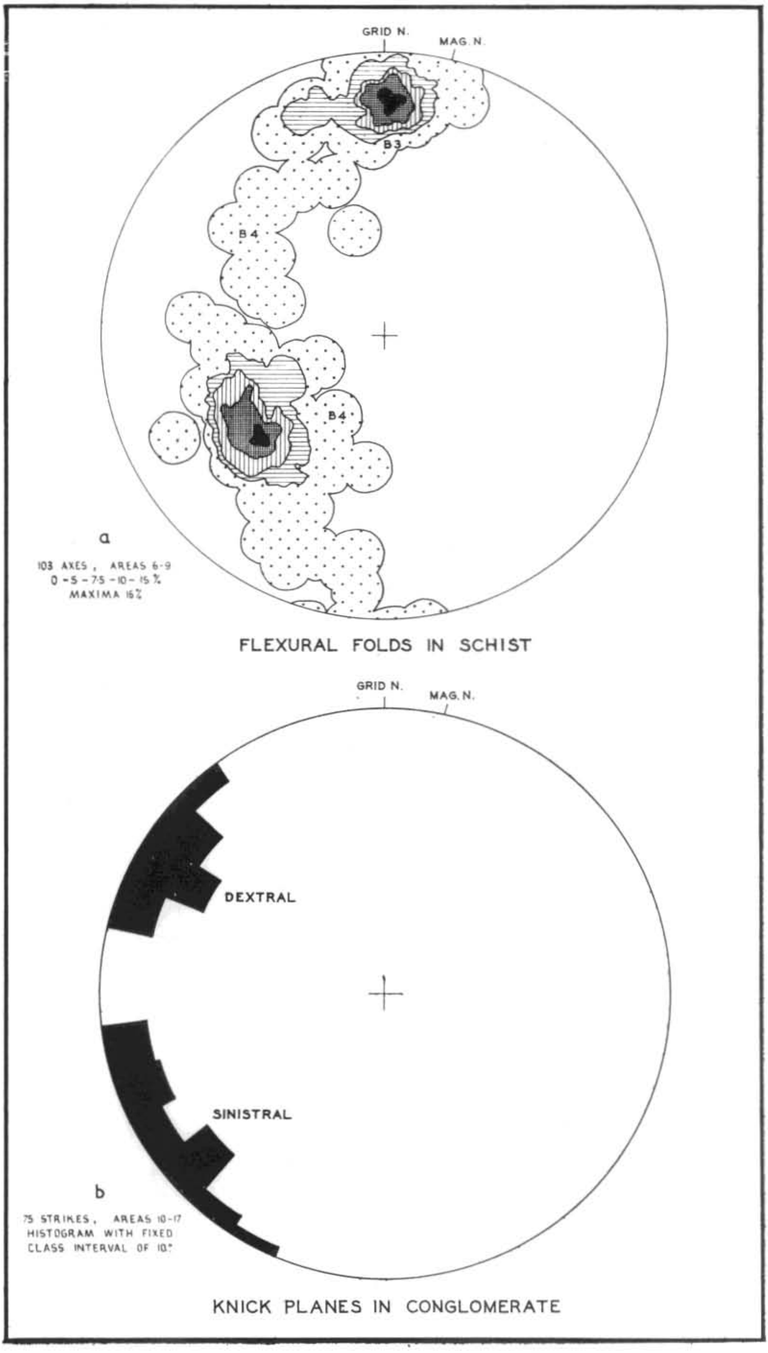
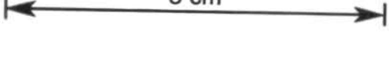

GRID N.
MAG. N.
B3
B4
B4
a
103 AXES , AREAS 6-9
0 - 5 - 7.5 - 10 - 15 %
MAXIMA 16%
FLEXURAL FOLDS IN SCHIST
GRID N.
MAG. N.
DEXTRAL
SINISTRAL
b
75 STRIKES , AREAS 10-17
HISTOGRAM WITH FIXED
CLASS INTERVAL OF 10°
KNICK PLANES IN CONGLOMERATE

FIGURE 66.


5 cm

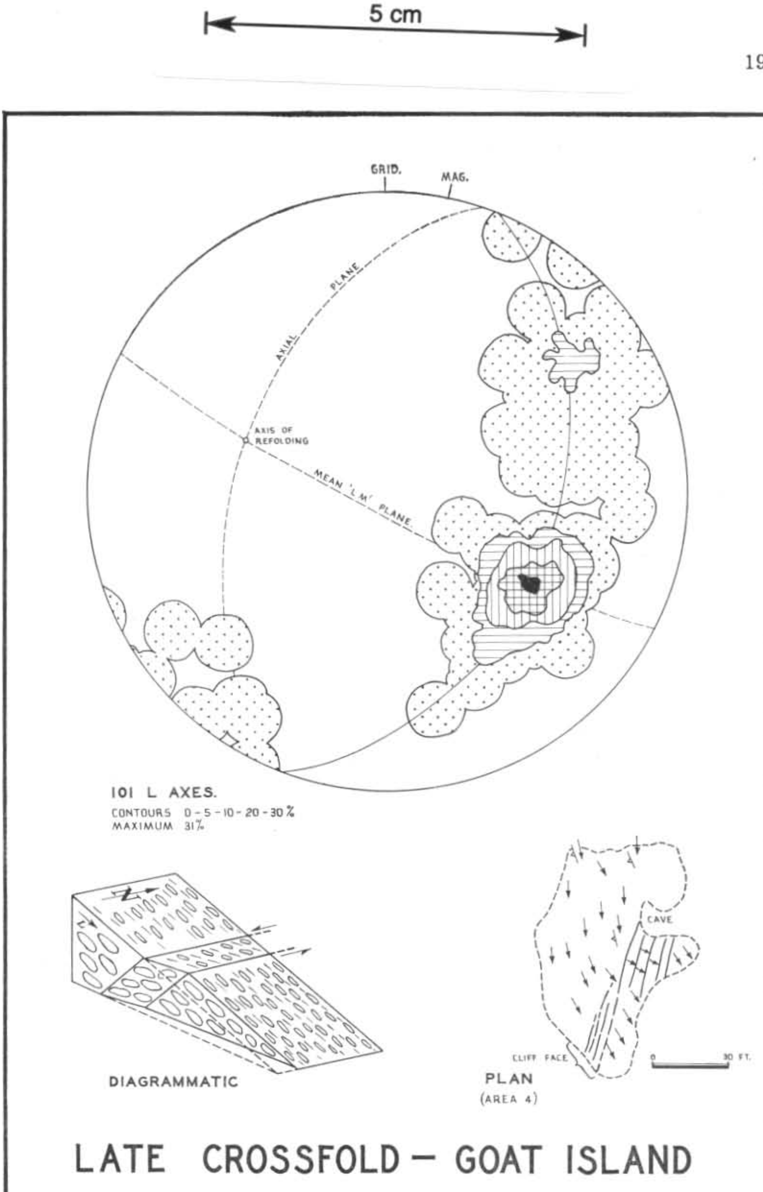

5 cm
GRID.
MAG.
AXIAL PLANE
AXIS OF REFOLDING
MEAN 'LM' PLANE
101 L AXES.
CONTOURS 0 - 5 - 10 - 20 - 30 %
MAXIMUM 31%
DIAGRAMMATIC
CAVE
CLIFF FACE
0
30 FT.
PLAN
(AREA 4)
LATE CROSSFOLD — GOAT ISLAND

FIGURE 67.

5 cm

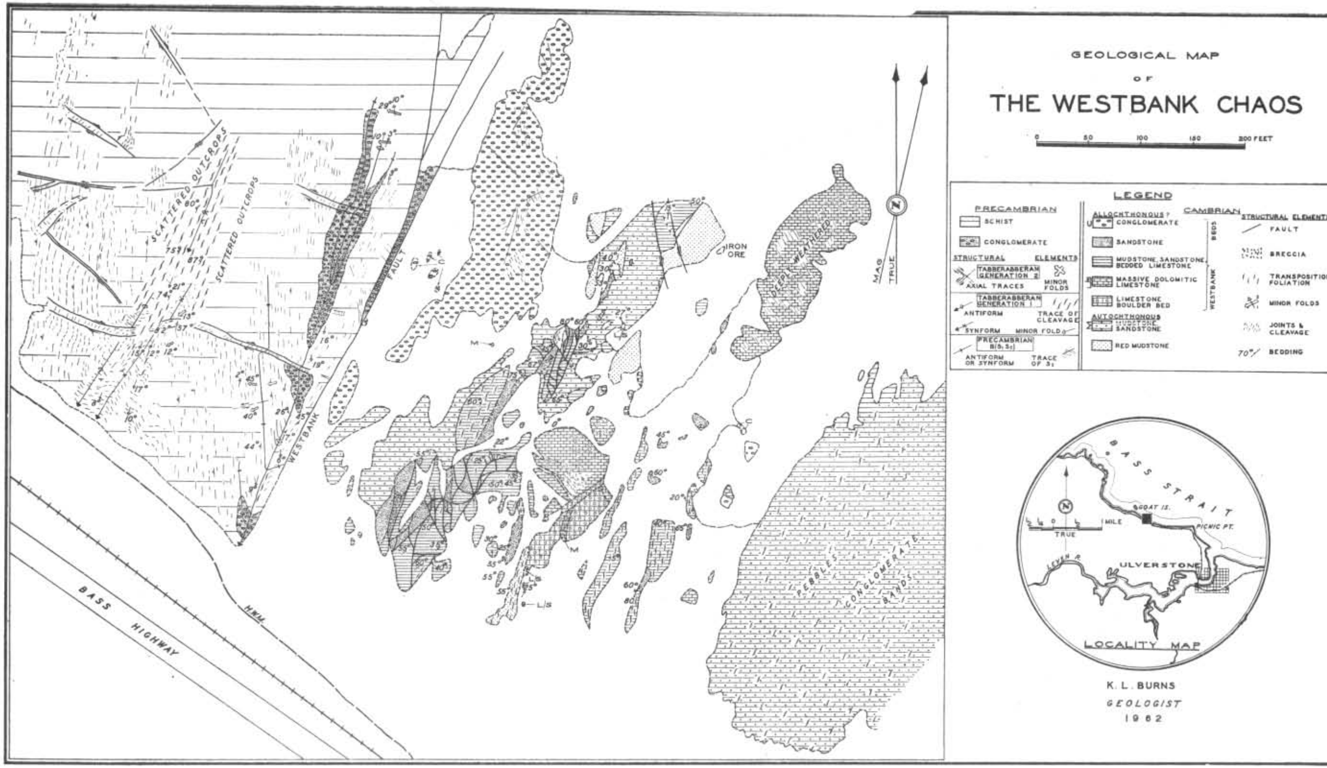


FIGURE 68.

Minor crenulations assigned to the Loonganan are superposed on the Eugenanan folds. In the vicinity of the Westbank Fault, the superposed folds are well-developed on the gently-dipping western limbs of the earlier folds, but are of markedly reduced intensity or absent on the steeply-dipping eastern limbs. The mode of Figure 65b reflects this inherited modal dip. The axial traces of the Eugenanan folds are offset on axial knick planes of some large Loonganan folds. The interference of phases has produced triangular-shaped domes in places.

A fairly large fold at the SE corner of Goat Island is identified as Loonganan. In the diagram (Figure 67) the mode at 42-122 is the modal orientation of the L-axes (long axes) of tectons in this vicinity. The subsidiary mode at 25-056 is the orientation of the L-axes inside knick bands of the type illustrated in Figure 67b. The dimodal distribution reflects the abrupt "knicking" that occurs in these fault-like bands. The axial plane of this fold is 48NW020 and the axis 49-291. The exceptionally high symmetry is due to the coincidence of several factors, the axial plane being oriented normal to both the mean LM-plane of tectons and the attitude of L-axes in that plane so that the axis of refolding of the LM-plane is 90° from the modal L-axes.

Minor crenulations in subareas Nos. 7 to 14 (Figures 63, 66a) include a Eugenanan mode at 20-001, a strong Loonganan mode at 43-230, and a weak mode near 47-301 which scarcely shows up on the diagram but is fairly prominent in some small areas. The dimodal distribution of Loonganan axes shows that the line of intersection of the axial knick surfaces is at an angle to the foliation so that two divergent groups of axes are formed simultaneously.

In the conglomerate on the platform south of Goat Island, there are numbers of knick bands such as are shown diagrammatically in Figure 67. A map of one of these bands is shown in Figure 34. The knick bands are non-penetrative structures which run in straight lines across the outcrop like vertical faults. There are two classes, members of one class having sinistral displacement and striking SW, and members of the other class having dextral displacement and striking NW. In Figure 66b, plotted from field notes, modal strikes are near 227° and 297°. These strikes, combined with the axial directions of minor crenulations (Figure 66a) define knick bands oriented 87NW227 and 87NE297 with a line of mutual intersection within 4° of vertical. The knick planes are purely imposed structures and this line of intersection may be related almost directly to the regional **C** axis.

WESTBANK CHAOS

At West Ulverstone the outcrop of Cambrian rocks is interrupted by two basement wedges. Each wedge rides on a high angle reverse fault with western side upthrown. The easternmost or Ulverstone Fault has 1600 feet of unsheared Cambrian mudstone on its downthrown side where it crosses the Leven River. On the shore of Bass Strait less than 50 feet of strongly sheared Cambrian mudstone is preserved on the downthrown side of the fault, just west of Picnic Point (Figure 41).

5 cm

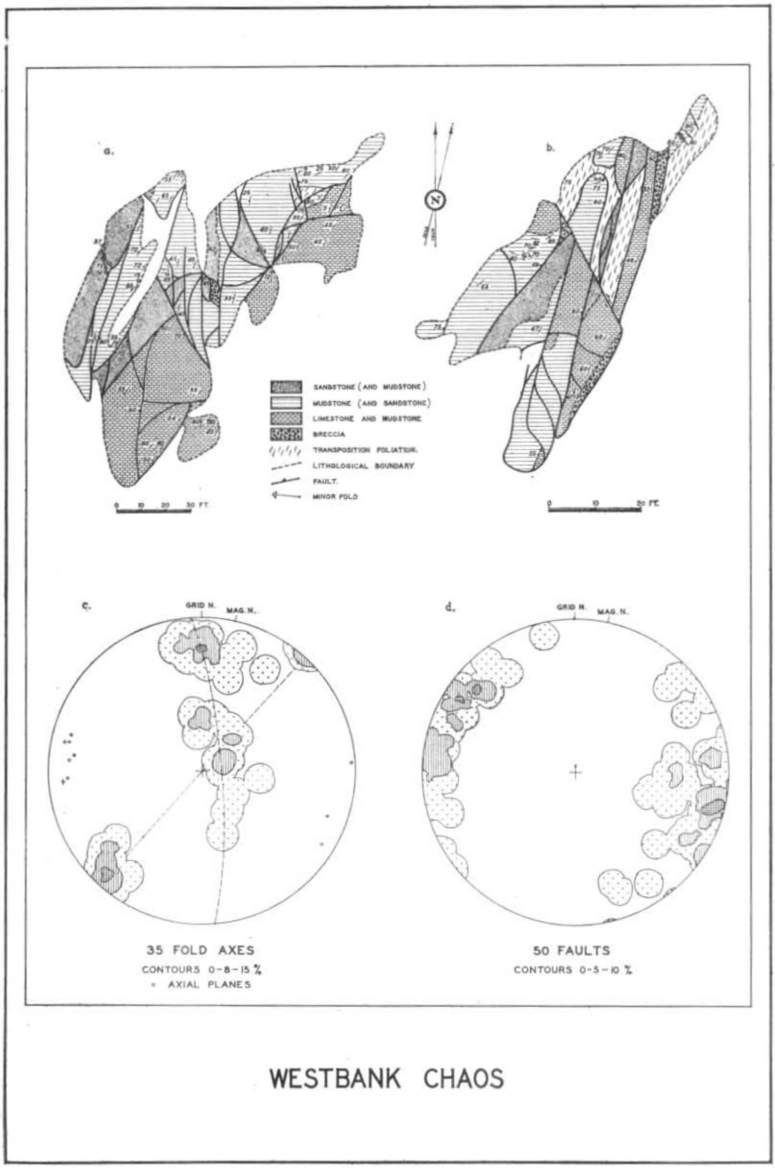


FIGURE 69.

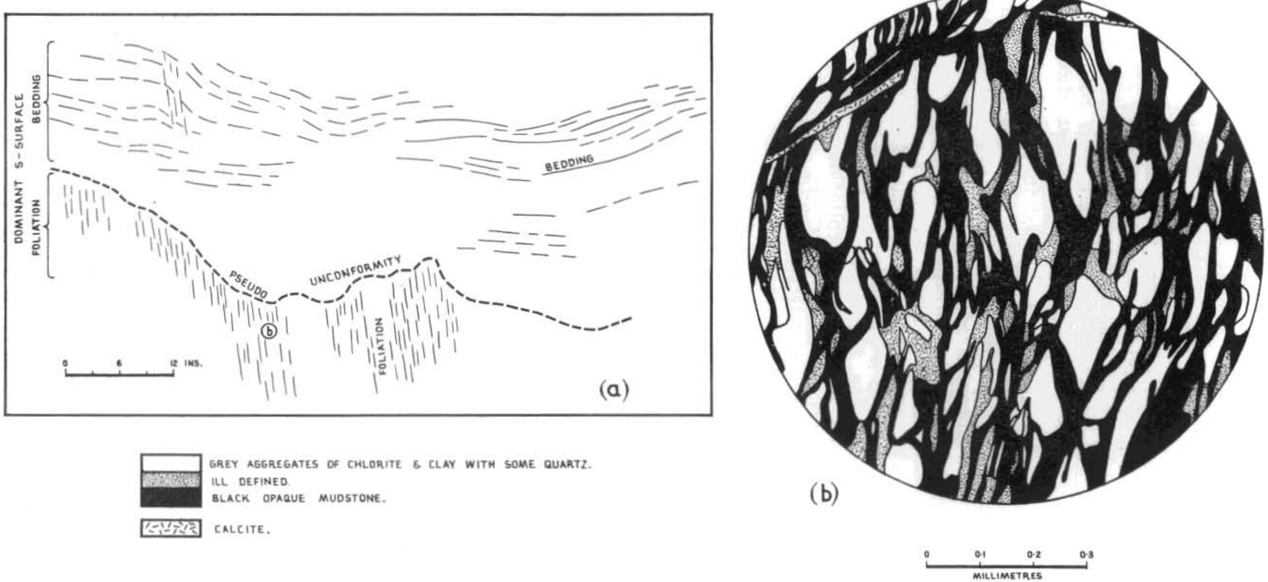


FIGURE 70.

FOLIATION IN THE WESTBANK CHAOS

K.L. BURNS
GEOLOGIST 1963

The western or Westbank Fault is entirely within Precambrian at the Leven River but preserves on its downthrown side on the coastline several hundred feet of Cambrian rocks. These rocks are strongly sheared and are termed the Westbank Chaos (Figure 68). The terms mylonite or gouge are not appropriate and the term chaos has been adopted because it implies affinities with megabreccias. The rock is a tectonically sheared megabreccia, as discussed by Burns (1964a).

Folding in the Westbank Chaos consists of gentle open folds in the large slabs, trending to 220° and 360°, and tight isoclinal folds in the small slabs plunging on steep axes (Figure 69c). The steeply plunging folds have axes forming a girdle in the foliation dipping 70E355 parallel to the axial surfaces. This girdle is interpreted as due to the superposition of constantly-oriented axial planes on elements of bedding which were oriented at all directions in the slabs. The folds are identified as Eugenanan, and the foliation (Figure 70) is a transposition foliation similar to that in sheared Cambrian rocks at the Iron Cliffs. The foliation is not confined to the mudstone matrix of the Westbank Chaos, but is developed inside some of the large boulders (Figures 69 a, b, 70). The large boulders are intersected by numerous faults shown in Figures 69a, b, and plotted in Figure 69d. The measurements indicate a mean strike parallel to the Westbank Fault. The faults have an unusual style with pairs of faults linked by sigmoidal shears and these shears are themselves linked by further sigmoidal shears. Some of the faults are brecciated but the majority are zones of concentrated shear. The faults intersect with small triangles of sheared rock at their junction but without discernible offsetting. They are interpreted as ductile shears formed in the E1 phase with the folds and foliation.

The group of open folds with upright axial surfaces and axes near 10-211 are identified as Loonganan.

LOBSTER CREEK

In the central part of the Dial Range Trough east of Mt Montgomery the principal folds are the Lobster Creek Anticline and the Library Syncline. Outcrops are poor and direct evidence of the development of these structures is lacking. In the Library Syncline the chert contains minor folds plunging SW and NW. The north-trending folds in the chert carry a strongly-developed rotational-joint boudinage in some areas, and some folds have an axial-plane or "bc" jointing developed in the hinges. In Myrtle Creek at 4093E 9337N the trace of this jointing on bedding in the hinge of a minor fold plunges near 30-002 and is refolded on axes near 50-272.

In the country NW of North Motton the traces of the synclinal troughs, defined by outcrops of Motton Spilite, swing around the nose of the Mt Lorymer perianticlinal structure in a pattern resembling the refolded Cuenabres Syncline of de Sitter (1960). This is not so much refolding of the axial traces as migration of the crestal traces due to compounded movements, the crestal traces being "culminations" in de Sitter's sense and not axial trends.

This point has been deliberately emphasized on the map sheet, in the small basin at the south end of the Library Syncline, by showing the constituent axial trends inferred from minor folds, which are oblique to the trough line of the basin.

South-east of Mt Montgomery the Lobster Creek Anticline swings through 90°. Allowing for the transgressive base of the Barrington Chert in this vicinity, the anticline has a fairly regular form for most of its length. The fold is upright and fairly open and the swing in trend is considered to be due to superposed folding on axes plunging steeply west. It is difficult to see the swinging crestal trace as compounded from successive vertical movements, and there appears to have been rotation in plan during the second phase. This implies the existence of an important decollement at the base of the Duncan Conglomerate of Mts Montgomery and Dial, and as strong differential movements at the base of the thick wedges of Ordovician conglomerate occur at several places on the North Coast such a decollement would not be unusual. The general structure is therefore interpreted as "competent-incompetent cross-folding".

EASTERN BASEMENT

The Precambrian rocks on the eastern flank of the Dial Range Trough constitute a palaeogeographic unit which is termed the Forth Nucleus. The rocks contain a group of Precambrian foliations which are nearly parallel to each other, the most important being a lithological layering and a young, strongly-developed, mica foliation. For present purposes these may be denoted, collectively, S_2, and regarded as widespread, strongly-developed, penetrative, parallel foliations. In the Ulverstone Metamorphics the foliations are folded into a large, open fold trending SW through Spalford, a post-metamorphic fold equated with L1.

In the Forth Metamorphics, the foliation is folded into a number of large open folds, the best-defined being the Forthside Antiform. This fold has an axial surface which continues upward to form the axial surface of a fold in overlying Ordovician rocks at the south end of Porcupine Hill. The crestal trace is sharply deflected at the unconformity at the top of the Precambrian, reflecting the differences in initial orientation between the basement foliation and the bedding in the Ordovician rocks. This fold is regarded as Eugenanan.

For the Forth Metamorphics as a whole, analysis of the foliation indicates superposed refolding on two trends, the Eugenanan axes (in the Forthside Antiform) being near 12-176 and the Loonganan near 45-229 (Figure 71). This contrasts with the cylindrical refolding found by Gee (1963) in the Raglan Range.

Minor folds, of the Loonganan phase particularly, are widespread but generally of small amplitude. They vary from rounded, open flexural folds to zig-zag crenulations and refold Precambrian foliations, pencilling and rodding in the schist. In the quartzite minor folds occur only in thinly-laminated rocks and are well-developed only on Porcupine Hill within a few hundred yards of the base of the Ordovician. Figure 24 e, f shows their modal orientation in a number of localities. Near the mouth of Goldie Creek zig-zag to rounded, post-metamorphic crenulations in the schist are identified as Loonganan. They die out downwards in

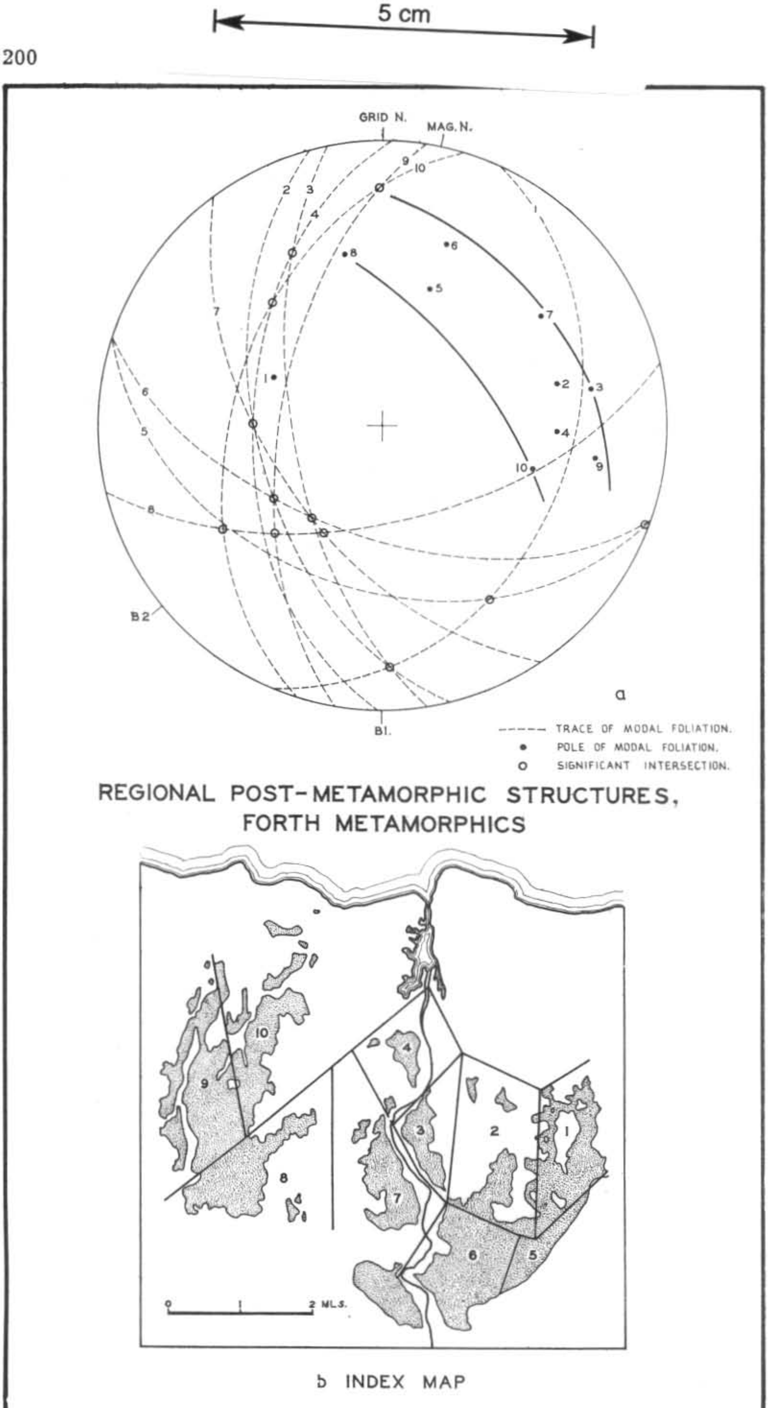

5 cm
GRID N.
MAG. N.
B2
B1.
a
TRACE OF MODAL FOLIATION.
POLE OF MODAL FOLIATION.
SIGNIFICANT INTERSECTION.
REGIONAL POST-METAMORPHIC STRUCTURES,
FORTH METAMORPHICS
0 1 2 MLS.
b INDEX MAP

FIGURE 71.

their profile (northwards) against jointed but uncrenulated quartzite. The general style is therefore competent-incompetent, the foliated schist being crenulated while the flaggy-bedded quartzite is folded into broad arcs.

JURASSIC

The Dulverton Dyke occurs just south of the Devonport Quadrangle in a NE striking fault fissure which displaces Permian strata and contains dolerite outcropping in the form of a string of small necks.

The fissure is probably Jurassic in age. There are a number of small faults in the Mersey Coalfield which trend NE and may also be of Jurassic age, but apart from these, no Jurassic faults can be recognized.

TERTIARY

Early Tertiary

Permian rocks and Jurassic dolerite occupy a belt of country extending from the Don River to Port Sorell. This is the Mersey Basin of Johnston (1888, p. 129), among others, and is here termed the Mersey Graben. The flanks of the graben, west of the Don River and east of Port Sorell, are Lower Palaeozoic and Precambrian rocks. The first-order structural relief of the graben approaches 1,000 feet.

The Mersey Graben has been considered as part of a larger structure called the Tamar-Port Sorell Graben (Banks, 1958a, p. 247), as the Port Sorell Graben (Banks, 1962e, p. 241), and as part of the Cressy Graben (Banks, 1962e, p. 242, after the Cressy Trough of Carey, 1947b, p. 38). However, the continuation of the Cressy Trough north beyond Frankford to the coastline has not been demonstrated, Carey (1947b, p. 37) citing Frankford as the northern limit of the postulated lake therein.

Regional reconnaissance suggests that the western boundary of the Cressy Graben, the Tiers-making fault at Blackwood Creek, continues through Deloraine, Weegena, Kimberley, Railton and Nook, to form the western boundary of the Mersey Graben at Tugrah, and then continues out to sea through Lillico's Beach.

Between Nook and Tugrah, the western boundary of the graben is not one but a number of faults, which in places follow earlier Tabberabberan faults. At Eugenana the boundary is the Aberdeen Fault, which throws Lower Palaeozoics against the lower part of the Kelcey Tier Beds and has a throw of the order of 600 feet. North of Eugenana, the throw on the Aberdeen Fault decreases, and is taken up in an *en echelon* fashion by the Tugrah Fault. The Devonport Fault, where it reaches the western boundary of the graben west of the Don River, may be another *en echelon* fracture of this system. In the region between the overlapping " feather ends " there are a number of small cross-faults and tilted blocks. The pattern is irregular, as is to be expected in the presence of powerful, pre-existing basement inhomogeneities at shallow depth.

5 cm

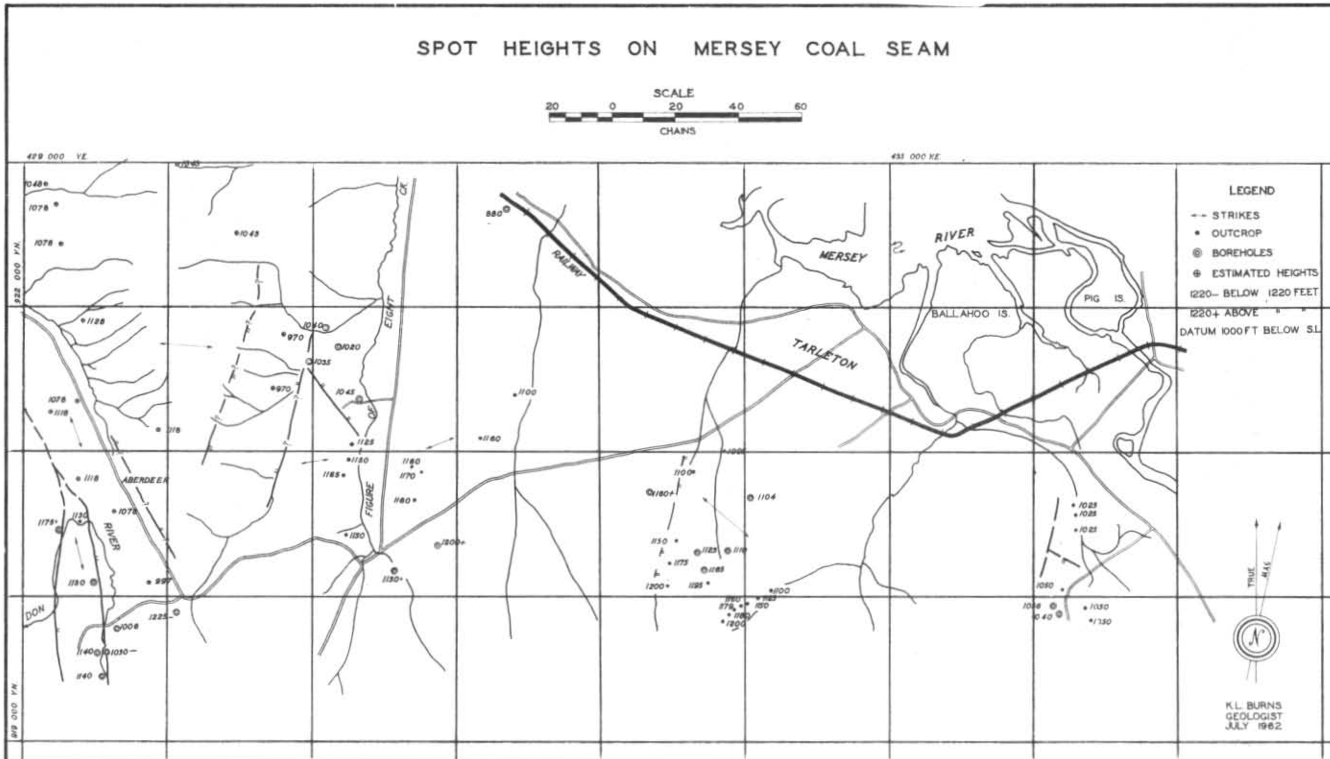


FIGURE 72.

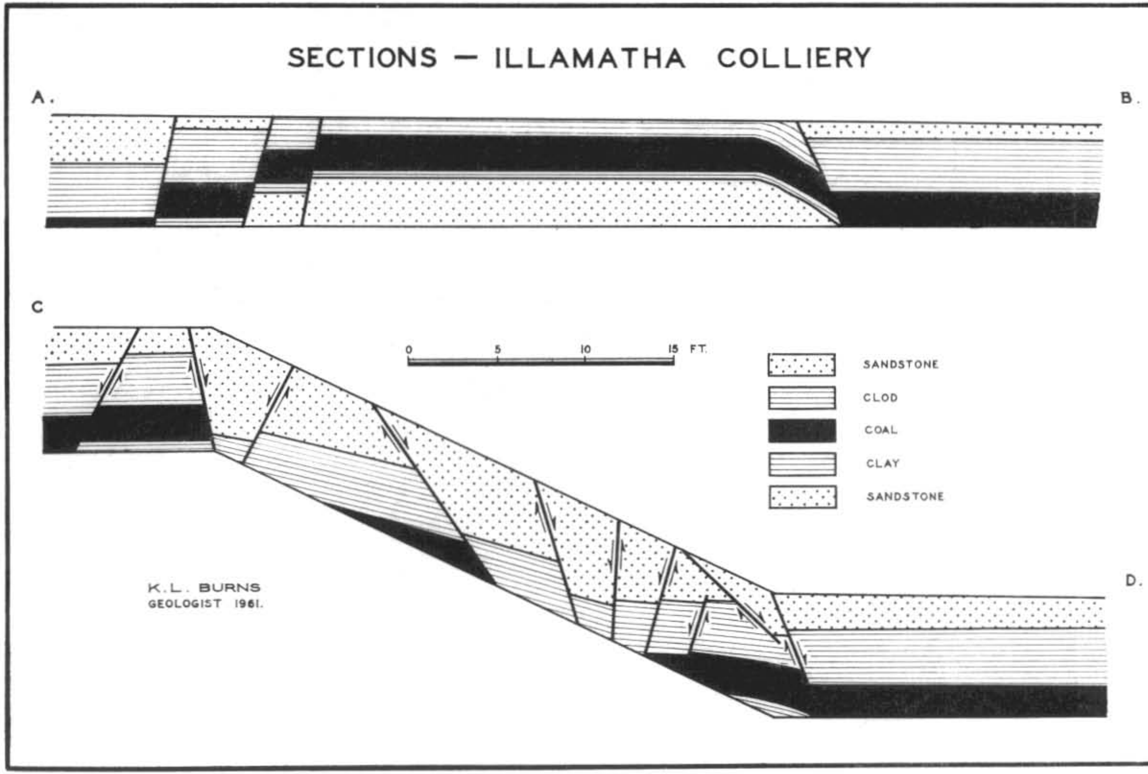


FIGURE 73.

5 cm

5 cm

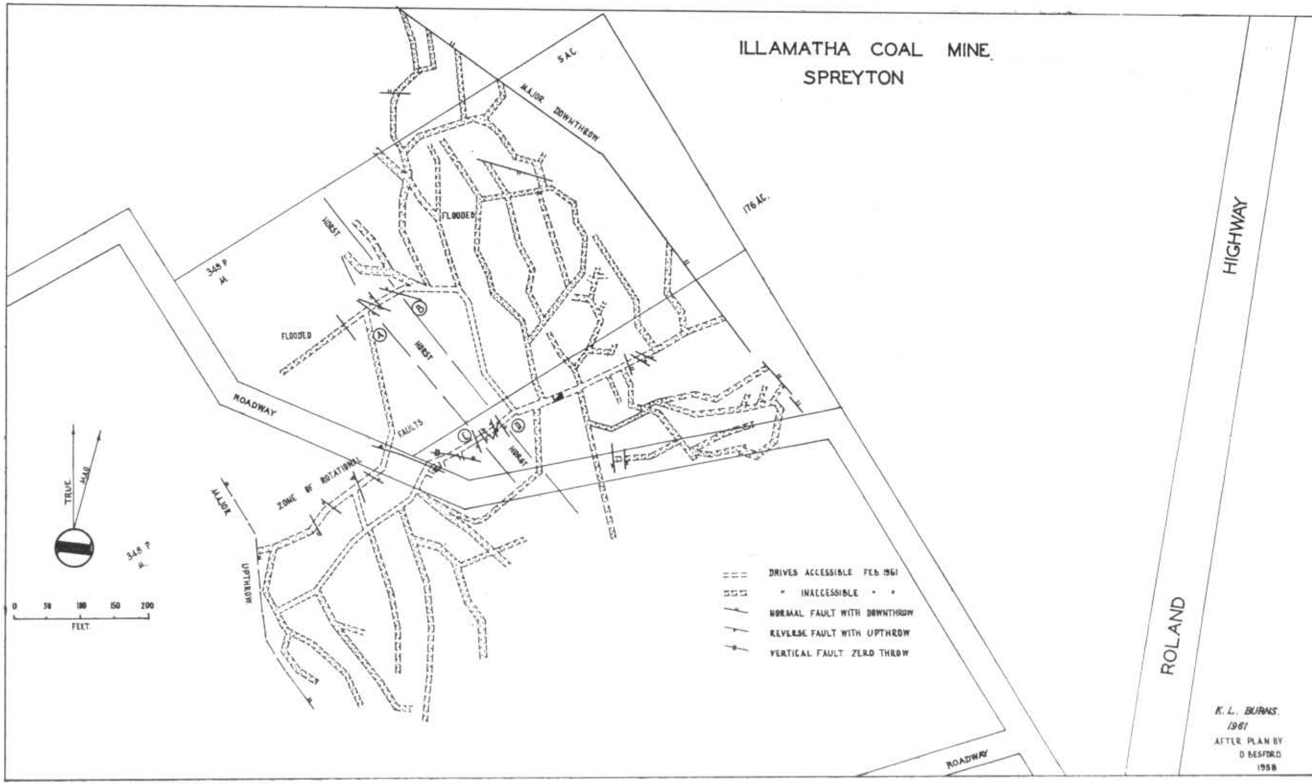


FIGURE 74.

The eastern boundary of the graben is a fault running the length of Port Sorell. This throws Permian basal conglomerate at the Pandora Mine (Hughes, 1954) against dolerite overlying Mersey Coal Measures at the Northdown Foreshore Bore, so it has a nett total throw of the order of 600 feet. South of the Port Sorell estuary, the fault continues into un-mapped country but the linear feature seems to disappear, possibly by dissipation of throw among faults of divergent trends. Although the western boundaries of the Cressy and Mersey Grabens may be a single, continuous structure, the eastern boundaries are very probably more complex.

The internal structure of the graben is difficult to determine because two possible markers, the base of the Permian System and the high-level dolerite sill, have variations in relief (in the first case) or of thickness and stratigraphic position (in the second case) which approach the epeirogenic relief in order of magnitude. Perhaps the most suitable marker is the Mersey Coal Measures which is utilized where possible.

The graben has internal horst and graben phenomena as second-order structures of the order of two miles wide. Dooleys Hill is one such structure, a small graben. The belt of dolerite running through Staggs Hill to Horseshoe Reef is probably another fault-bounded strip, as is probably the belt of dolerite running from Thirlstane to Point Sorell. Kelcey Tier may be regarded as part of a second-order structural terrace.

The regional dip of the strata in these second-order fault blocks is northwards. The dip on Kelcey Tier and Ellias Hill is about 330 feet per mile to the north, the dolerite sill dipping parallel to the enclosing sediments. On Dooleys Hill the base of the dolerite falls from nearly 200 feet at Latrobe to sea-level at Ambleside, at about 100 feet per mile. On Staggs Hill, the base of the dolerite falls from 200 feet near Latrobe (350 feet in Panatana Rivulet just south of the map boundary at 4445E 9190N) to sea-level near Pardoe Creek, at a rate of nearly 100 feet per mile.

Because of the *en echelon* arrangement of faults, the maximum throw is obtained on features which zig-zag through the graben. The Devonport Fault has a throw of less than 200 feet at Devonport, and nearly 600 feet along the west side of Dooleys Hill. South of Frogmore Lane, the throw is only 200 feet or so, and most of the movement has been taken up on Dooleys Fault. East of Latrobe, the throw on Dooleys Fault is transferred to a fracture *en echelon* with the Devonport Fault, the Latrobe Fault. Available data suggest that the coal seam lay 450 feet above the collar of Atkinsons Bore (Figure 17) and it is at minus 237 feet in the Racecourse Bore, so the Latrobe Fault has a throw of 862 feet at Latrobe. However, between Sassafras and the Great Bend, the coal seam probably occurred 455 feet above the collar of Bourkes Bore, and not far above the collar of Ingrams, so the total throw there is 405 feet. Thus between Latrobe and about 442E 917N the throw on the Latrobe Fault decreases from 862 to 405 feet, an amount of 457 feet. This change in throw may be a result of different regional dips on different sides of the fault, or could be due to a branch fault with an average downthrow to the north of 457 feet and a trend parallel to Dooleys Fault through 4430E 9185N.

On the small scale, the faults are of many kinds and of many trends, as shown in the underground plans for the various coal-

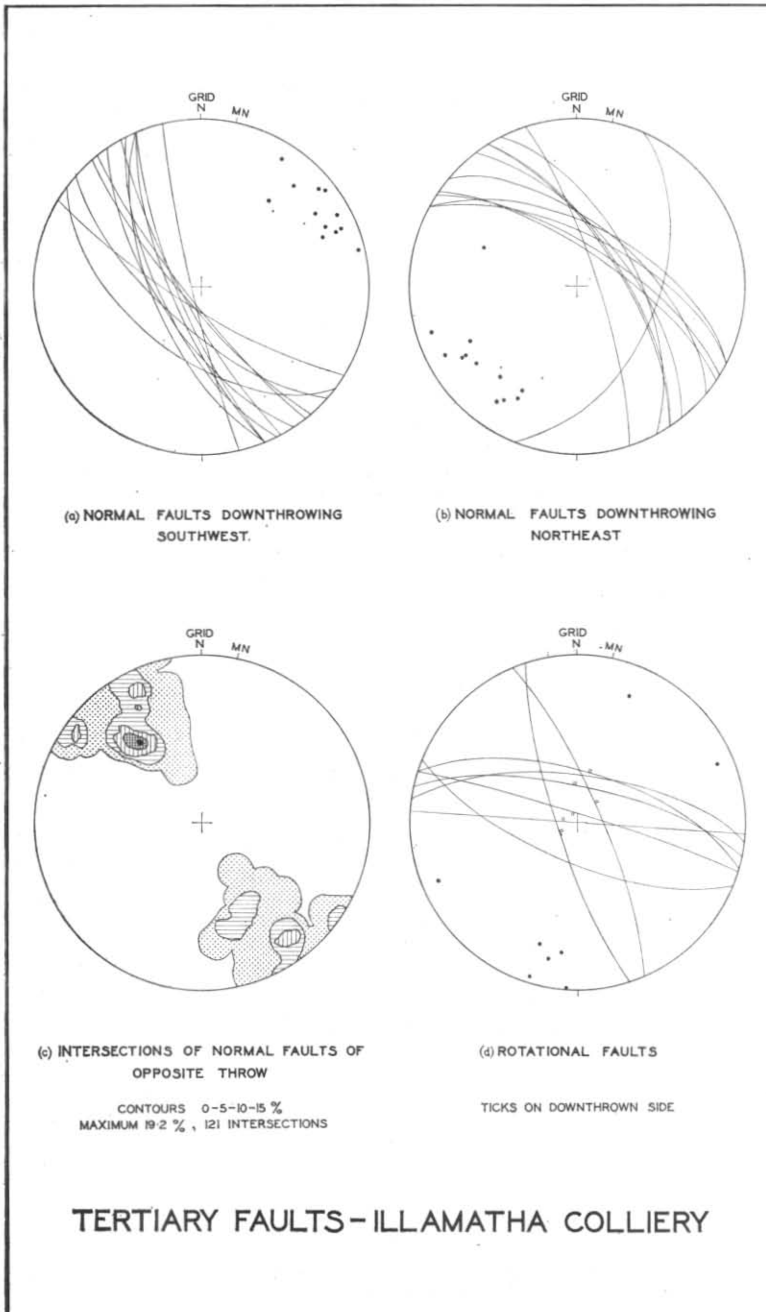


FIGURE 75.

5 cm

mines. Some of these faults are probably Jurassic. Two fairly-well defined systems of faulting may be recognized, a " horst and graben forming system " which strikes NW, and which occurs in the Illamatha Colliery (Figure 74), and rotational faults striking WNW. The " graben-forming " faults are normal faults, with hades of 10°-20°, forming a conjugate set (Figure 75). The mean strike is 315°17′ for faults with SW hade, and 309°37′ for faults with NE hade. The profile of one horst formed by these faults, in the Illamatha Colliery, (Figure 73) is not uniform, due to the effect of the rotational faults.

The rotational faults have hades near zero, a throw which varies from point to point along their length, and a mean strike near 290° (Figure 75). The relationship to the graben-making faults has not been observed. The two fault classes, graben-making and rotational, probably correspond with the 333° and 287° maxima of Banks (1958a, p. 245).

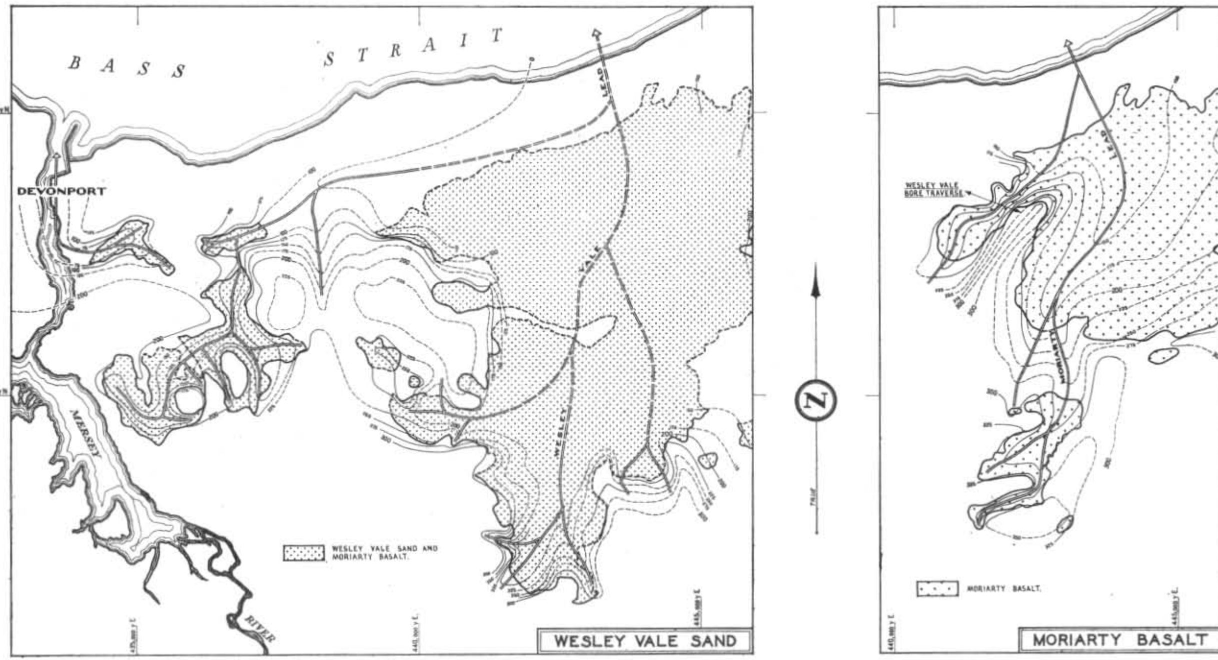
The Northdown Deep Lead poses a problem in Tertiary palaeogeography. The deep lead occupies, for the most part, the country lying between the Staggs Hill and Point Sorell-Thirlstane fault blocks, and could be interpreted as a second-order graben active during the Oligocene, in which sedimentation proceeded apace with subsidence. On the coastline the evidence is fragmentary, and appears to be contradictory. In the Northdown Beacon Bore, the recovery of large-diameter dolerite core suggests that dolerite was met at shallow depth which would imply a Northdown Graben, but with the dolerite only a few hundred feet lower than the dolerite in flanking fault blocks, not over a thousand feet lower. In contradiction, indurated mudstone, regarded as Permian, outcrops just east of the Quadrangle boundary on the coastal escarpment SE of the Northdown Foreshore Bore (an outcrop shown in Figure 8 of Burns, 1963a) within the " Northdown fault-block ", which indicates that the block is likely to be a horst, not a graben. The deep bores in the Northdown Deep Lead (particularly Parsons and Iles Bores) occur between dolerite north and south, apparently within the Thirlstane-Point Sorell fault block, and field evidence suggests that the dolerite struck at great depth in these bores is the same as that outcropping on the surface in the vicinity. The Northdown Deep Lead therefore appears to be an erosional channel between Harford and Thirlstane, and not tectonically controlled. This view requires the dolerite sill to be about 1,000 feet thick, and with a base dropping south from the Northdown Foreshore at a rate exceeding 200 feet per mile which is not impossible and is consistent with the general behaviour of the dolerite in this area.

At this stage Reid's (1924a) identification of the Harford Beds as Tertiary must be accepted, and hence the existence of a deep channel, the Northdown Deep Lead, between Harford and Thirlstane. The exit of the lead may be on the coast between Northdown and Pardoe Point, or it may cross the coastline east of Port Sorell. Field evidence suggests that the channel is post-faulting, erosional, and not a second-order graben active during the Oligocene.

There is some evidence that the Mersey Graben is not simply a structural low in a field of faults which extends outside the graben. If the graben is merely one feature in a general field, there should be a pattern of second-order structures in the western flank, which has not been recognized. In addition, the available information for

5 cm

FIGURE 77.



BASE CONTOUR MAPS - NORTHDOWN AREA

0 40 80 120 160 200 CHS.

K. L. BURNS
GEOLOGIST 1962

the Mersey Coalfield (see Figure 72) shows fault blocks dipping NE or NW within the graben, but dipping steeply along the western edge. The western edge is not simply that part of the pattern where the faults throw Permian rocks against basement, but has a special character. The graben is to be regarded as a wide fault zone with a broken-up, downthrown interior and a largely unaffected western flank.

Middle Tertiary

The Tertiary rocks of Devonport Quadrangle are a stratiform pile of terrestrial sediments and basaltic lavas, which in the lower parts are valley-filling and in the upper parts are " plateau-forming ". At a late stage a discordant drainage pattern developed, discordant in the sense of being independent of the older valleys, and the valleys were filled with sands sometime between the Upper Oligocene and the Pleistocene.

The palaeotopography is shown in Figure 76. The pre-basaltic drainage pattern is youthful, with deep meandrine gorges of relief comparable to the modern gorges. The drainage pattern is probably Oligocene in age. The leads cross early Tertiary faults without any indication of fault control in location or direction, so the faulting must have occurred much earlier. The epeirogenic relief had been reversed by the Oligocene, Kelcey Tier being a topographic high bounded on the west by a fault-line scarp against the topographic lowlands formed on the upthrown side of the Aberdeen Fault. This fault-line scarp was mantled with talus, remnants of which are preserved under basalt on the eastern fall of Forthside Hill, with large dolerite boulders up to 5 feet long.

Dolerite occurs under basalt just north of Paloona (township) in a position difficult to reconcile with Kelcey Tier as a source. This suggests that an outlying sill occurred on Porcupine Hill, which would imply that the interfluves in the country west of the Aberdeen Fault were at a level fairly close to the sub-Permian unconformity.

Many of the leads reach sea-level some distance inland from the present coastline. The sediments are terrestrial in the Paloona and Kindred leads at altitudes of 200 feet, and at sea-level in the Motton Lead. In the Northdown Lead, the Harford Beds were found in bores to continue to about 1,000 feet below sea-level. No marine deposits were found in drilling, so the sediments imply either considerable post-Oligocene rise in relative sea-level, subsidence concurrent with deposition, or aggradation behind a rising barrier which could be due to volcanic or epeirogenic activity, and which could have been situated near the present coastline or as far away as the Otway Channel.

The internal structure of the Tertiaries is uncertain in many leads. The section of the Riana Lead on the coastal escarpment indicates a fairly level layer of sand sandwiched between basalt flows. However, uniform level blankets of sand or lava are rare, and many formations are probably lenticular, filling channels cut into older units. The Thirlstane Basalt of Figure 22 and the Moriarty Basalt of Figure 23 are channel fills. At early stages of the inundation, when interfluves still remained to confine the run-off from the interior, such channels would be confined within valley walls and would be elongated parallel to the lead. When divides were overtopped, the channels would tend to follow the basalt thalweg, and this may have occurred in the Leith Lead, the western tributary of the Wesley Vale Lead, and perhaps in the Moriarty Lead, which are younger channels formed at a later date.

From the palaeotopographic maps it is possible to estimate the maximum amount of tilting that has occurred since the Oligocene. For some leads, it is possible to find the present level of the bottom of the lead at two widely separated points. For example, the bottom of the Paloona Lead is at about 100 feet a.s.l. at Paloona (bridge) and at about 400 feet a.s.l. at West Kentish (Luttrell's Bridge), points 8 miles apart. This gives a grade on the lead of about 40 feet per mile. The grades on the Wesley Vale Lead and Moriarty Lead (Figure 77) are similar. If the slope of the Lower Coastal Surface is due to tilting, on unwinding this slope, the leads have a restored grade near zero. The Tertiary streams may have had low grades, such as the present Leven River which falls at about 20 feet per mile near its mouth, but grades lower than 25 feet per mile are unlikely. If there has been post-Oligocene tilting, it was no more than 50 feet per mile, and was probably less than 25 feet per mile.

Late Tertiary

The Lower Coastal Surface is a terrestrial landform with a seaward slope of about 50 feet per mile. There is no evidence of its having a different slope in different areas, so that if the slope is a superimposed feature, the tilting was uniform across the whole region. However, the slope is probably primary, not superimposed.

Its age is post-Oligocene at Wynyard, and in Devonport Quadrangle it post-dates the Wesley Vale Sand and the Parkers Ford beds (Upper Oligocene) and pre-dates the major river valleys which were entrenched to present levels by the end of the Pleistocene. The surface is therefore Miocene to Pleistocene, probably mainly Pliocene, in age.

This surface is characterized by a " striking regularity of profile and a lack of all but a few large monadnocks and, inland, the junction with the higher coastal surface appears generally cliff-like " (Davies, 1959). The junction with the Higher Coastal Surface is just south of Lower Wilmot and between Sprent and Upper Castra and is a dissected but fairly pronounced escarpment about 12 miles inland from the coast.

In Devonport Quadrangle the surface is marked by a striking accordance of summit levels in basalt country, benches or bevelled hilltops in Palaeozoic and Precambrian rocks, patches of laterite, very deep weathering, a few patches of sand and gravel, youthful dissection and a pronounced escarpment at the lower edge. The laterite occurs between the Don and Gawler Rivers, at an altitude of 750 feet between Sprent and Spalford, and 400 feet near the coast.

The sands occurring between Sullocks Hill and Penguin are probably piedmont deposits younger than the surface, as are laterite on Staggs Hill, wash on Dooleys Hill (A. S. Rundle, pers. comm.) and sands on the Buttons Creek-Clayton River divide, but in general the surface is erosional and deposits are small and isolated.

Davies (1959) said that on the North Coast some basalts appear younger than the surface, others appear older and have probably been downwarped into their present position. In the Northdown area, the Wesley Vale Sand is older than the surface, and the Moriarty Basalt is probably older. The bottom of the Wesley Vale Sand is at sea-level at the coast, rising inland. The palaeotopography at the base is irregular (Figure 77) but in general the formation forms a wedge between a base rising southwards, and a top rising southwards at a slower rate. Near Harford there are disconnected patches of sand capping hilltops at the level of the Lower Coastal Surface which are regarded as Wesley Vale Sand, exhumed, and not as deposits younger than the surface.

The topography at the base of the Moriarty Basalt is subdued (Figure 77) but rises southwards generally faster than the modern topography so that the formation is confined to a coastal strip.

In general, the Tertiary formations in the Northdown area appear to dip seaward more steeply than the Lower Coastal Surface, which truncates the Tertiary structures. However, there are regions of accordance where the surface has exhumed an older discontinuity. Somewhat the same situation has been recorded for the Henty Surface. Twidale (1957, pp. 10-11) obtained evidence of marine terraces at an altitude of 400 feet, evidence regarded as inconclusive (Twidale, 1957, p. 12; Blissett, 1962, p. 86) but which suggested that the Henty Surface might be of marine origin (Davies, 1959). Subsequently, however, marine limestone, probably Oligocene, was discovered at the same altitude as the terraces (Blissett, 1962, p. 75) which confirmed a marine hypothesis, but which appeared to show that the Henty Surface is an Oligocene marine surface exhumed in the late Pliocene.

As far as can be determined, the Lower Coastal Surface has a uniform seaward slope throughout Devonport Quadrangle, although there may be a slope component to the east. In particular, there is no detectable variation in slope or altitude across known faults so that there has been negligible post-Pliocene activity along them.

Economic Geology

SOILS

The soil on the Tertiary basalt is one of the most valuable resources of Tasmania, but no regional survey is available. However, the work of Loveday and Farquhar (1958) is probably applicable to the Devonport region. Reid (1928) also made a brief general mention of this area.

A red soil is developed on Cambrian spilite and mudstone in some areas. In favourable situations, such as on the Lower Coastal Surface at North Motton, the soils are only marginally inferior to Tertiary basalt soils, as might be expected from the similarity in composition of spilite (Table 6) and basalt (Spry, 1962b). However, the greater part of the spilite is wasteland. There is no obvious reason for this, and soil research may indicate a remedy.

NON-METALLIC MINERALS

Non-metallic minerals produced include talc, asbestos, graphite, silica, limestone, clay, sand and gravel, and aggregate.

The industry provides regular employment and its products are essential for development. However, many deposits, particularly of sand and gravel, have been exploited in haphazard fashion. Easily discovered deposits have been largely worked out and expansion of reserves requires the introduction of treatments to upgrade the marginal deposits, and a much more intensive study of the Quaternary and Tertiary deposits than has been possilbe to date. Such a study would be assisted by records of grade and tonnage produced from various localities, but figures are available only for recent years, and even then are not comprehensive.

Talc

Talc has been recorded from several localities in Devonport Quadrangle, but there has been only limited production from a deposit near Gawler.

Orchard Creek: Petterd (1910, p. 74) described a vein two feet wide, of yellowish-white colour, occurring on the west branch of the Clayton Rivulet.

Clayton River: Taylor (1955, p. 50) described talc pseudomorphing tremolite-actinolite in the serpentinite at Clayton River near 4189E 9289N.

Gawler: The talc deposit at Gawler occurs 800 yards west of Gawler township in the Ulverstone Metamorphics at 4138E 9275N. The country rock is schist with foliation striking 122° and dipping 75° to 80° to the SW. The talc occurs in lenses with long axes parallel to the foliation. The western lens is 90 feet long and 6 feet wide, the eastern lens 60 feet long and 5 feet wide.

The talc was described by Hughes (1951a) as entirely talc with a little iron-staining but no other minerals. The schist is quartz-mica schist containing a little talc.

Analyses are as follows:—

	1	2	3
SiO_2	61.60	64.5	64.3
Al_2O_3	1.91 }	21.6	22.8
Fe_2O_3	0.57 }		
CaO	....	Nil	Nil
MgO	30.76	3.0	2.6
Na_2O	....	0.2	0.2
K_2O	....	6.2	5.7
Ignition Loss	5.22	3.8	3.7
	100.06	99.3	99.3

(1) Talc from Gawler (Reg. No. 698/50).
(2, 3) Schist from Gawler.

Analyst: C. J. Penman.

The deposit was operated by H. Templar in 1936, L. W. Smith at a later date, and A. Pearson in 1945. Present workings are in an adit driven at 127° for several hundred feet, just below the basalt.

Three grades of talc were produced. First grade was white in colour, second grade was blue-white (Hughes, 1951a) or yellowish (Manson, 1947), third-grade was ironstained yellow or red. Manson (1947) found the iron stain might be removed with 35% HCl applied at the rate of 16 lbs/ton.

Recorded production is as follows (Hughes, 1951a):

	Tons
1928	32
1929	23
1930	13
1931	15
1932	5
1933	9
1934	5
1936	3.04*
1944	4
1945	152.75†
1946	49
1948	22

* Valued at £7 16s.

† Valued at £532.

Asbestos

Taylor (1955) recorded cross-fibre chrysotile as veins in dark-green serpentinite on the left bank of the Clayton River at 4189E 9289N. The dark green serpentinite occurs in bands 6 to 10 feet wide which strike 330° and dip steeply NE. The fibre veins strike normal to the banding. The veins range from hair-width to 6 mm wide, averaging 2 mm. The average length is 3 to 6 inches. The fibre is of good quality, but prospecting pits show it does not improve in quantity at depth. There is a small amount of slip-fibre chrysotile grading into picrolite.

At the extreme eastern margin of the outcrop, a shaft was sunk 30 feet and a drive taken 40 feet westward. The shaft followed down the serpentinite boundary. The dump carries a white slip-fibre amphibole (tremolite-actinolite) as bunches up to one foot in length, but with short fibres. Much of this has been converted to talc but conversion is incomplete as the talc is still fibrous.

Near 4187E 9284N there are a few short veins of asbestos, 1-2 mm wide, and small amounts of slip-fibre. At the southern extremity of the serpentinite belt, near 4183E 9275N, there are only a few hair veins, several inches in length.

In the Forth River, near 4222E 9258N, the veins range from hair width up to 2 mm and are up to 3 inches long.

The asbestos resources are negligible, with cross-fibre chrysotile occurring in only one area, near 4189E 9289N.

Graphite

Graphitic schist has been recorded from a number of localities.

Ulverstone: A sample of coarse plumbago from the Leven River was presented to the Royal Society of Tasmania by Mrs. T. Walker in 1856. Petterd (1910, p. 141) recorded abundant graphitic schist on the beach two miles west of the Leven River. (See analysis 1, Table 7).

Clayton River: Schist around the Clayton River is graphitic in places such as at 4185E 9235N. Taylor (1955, p. 48) recorded " several pockets of pure graphite."

A. Pearson sold graphite from an adit driven 40 feet into dark micaceous schist of the Forth Metamorphics one mile south of the Bass Highway near the Ulverstone Rifle Range. The schist is a quartz-muscovite schist with tiny sheets and flakes of graphite and possibly amorphous carbon, with a carbon content of 0.6%. The material was admixed with imported graphite for paint production.

Production recorded by Hughes (1951c) is:

	Tons
1940	5
1941	5
1943	7*
1949	5

* Valued at £10 10s.

Paloona: Graphitic schist in the Ulverstone Metamorphics north of Paloona Bridge carries 5% carbon.

Silica

Silica deposits occur at Forth and Ulverstone.

John Dunham's Prospect: John Dunham's quartzite deposit at Forth (4226E 9266N) is a pure, massive quartzite without mica and with a little hematite staining, as described by Carey (1945, plan 973a) and Keid (1956). The quartzite is a layer within the Forth Metamorphics. Carey estimated the reserves at 850,000 tons. Other quartzite occurrences within the Metamorphics are usually micaceous and too impure for use as flux, although a flaggy-bedded quartzite just north of Goldie Creek may be sufficiently pure.

Leven Prospect: Dickinson (1942, plan 669) described quartzite within the Ulverstone Metamorphics on the banks of the Leven River at the mouth of Masons Creek (4142E 9305N). The rock has a mortar texture and the deposit is, in depth, probably Precambrian quartzite, although it is overlain by sub-basaltic quartzite at the bottom of the Motton Deep Lead. The deposit carries 98.70% silica, 0.70% alumina, 0.02% ferric iron oxide. Dickinson reported 1,000 tons shipped by 1942 and production since then has been:

1943 .... 295.5 tons valued at £295 10s.

1945 .... 1.0 tons valued at £2 10s.

Dickinson estimated reserves of selected stone at 25,000 tons

Limestone

Limestone outcrops in Devonport Quadrangle in the Melrose Basin (Figure 45). It has been quarried for nearly 100 years from outcrops in the NE part of the basin at Eugenana.

The principal quarries are shown in Figure 15. Cummings, Raymond, and Co. (the Don River Trading Company) commenced mining limestone in 1868, near their tramway. In 1925 Messrs. Cornelius and Dally were operating a lime-burning plant on the west side of the Don River, while B.H.P. (Broken Hill Proprietary) were extracting limestone from a large open cut on the east side of the river. In 1925 at about the same time as the Tasmanian Cement Company were investigating deposits at Railton, the Melbourne-registered Devonport Cement Company acquired options over 700 acres adjoining B.H.P. and Cornelius and Dally, and extending up the floor of the Melrose Valley from the Don River to Paloona (township). However, plans for cement manufacture were abandoned. In 1937, A. R. Rundle was operating a lime-burning plant at the SE corner of the outcrop. In the post-war period, H. Hallett's Melrose Agricultural Lime Company began treating the B.H.P. dumps, and took over the principal deposits when B.H.P. closed down in 1947. Hallett's Quarry, west of the Don River, was opened up and worked till about 1961. Operations at present are on the east side, adjacent to the old B.H.P. pit, at Hallett's New Quarry (Leases 378 P/M, 397 P/M, 398 P/M).

The limestone has been discussed previously by Thureau (1883), Reid (1925a, b,) Henderson (1937) and Hughes (1957a). A radically different interpretation is here given for the deposits.

The limestone occurs in two ways. The "bedrock limestone" is the Ordovician Gordon Limestone, which is downfolded into a large brachysyncline. The bedrock is strongly foliated, the foliation having a modal dip of 65° east, and a strike close to north. It contains the fossils *Maclurites* and *Girvanella*, which occur fairly low down in the Gordon Limestone at a height above the base of approximately 500 feet. A bore sunk by B.H.P. went to a depth of 250 feet below the level of the Don River without passing out of limestone. The bedrock is heavily fissured in places, the fissures being filled by *terra rossa* and sandstone of Devonian age.

The "limestone megabreccia" is a coarse boulder bed which overlies the bedrock limestone. Boulders in the megabreccia are from 5 to over 20 tons in weight. The foliation is disoriented as between boulders, that is, the attitude of the foliation in any block is different from the attitude in neighbouring blocks. The megabreccia is cemented by *terra rossa*. Within the megabreccia are two cavern fillings of mudstone and sandstone. One occurs halfway up the face of Hallett's Quarry at the western end (Figure 16), the other occurs at the top of Hallett's Quarry at the eastern end.

The limestone rock is of good quality. Hughes (1957a, p. 26) listed 17 analyses which average over 89% calcium carbonate. Analyses of the *terra rossa* are given in Table 10. Reid (1925a) stated that the *terra rossa* is a suitable material for Portland Cement.

In 1925 (Reid, 1925b) B.H.P. were shipping 50,000 tons per annum to Newcastle for use as metallurgical flux. 100,000 tons of low grade material was being dumped. In 1936, B.H.P. shipped 237,648 tons valued at £56,592, while two other producers produced 779 tons valued at £1,389/15/-. Hughes (1957a, p. 142) reported shipment at a maximum rate of 300,000 tons in 1939, but the rate declined from that point till shipment ceased in 1947. Since that time, the Melrose Agricultural Lime Company has re-worked the B.H.P. dumps for road and railway ballast and concrete aggregate, and has quarried limestone for agricultural purposes.

Production in recent years has been:

	Agricultural Lime		Construction Purposes	
Year	Amount tons	Value £	Amount cu. yds	Value £
1958	4,641	11,037	5,788	6,798
1959	4,309	9,588	7,125	7,866
1960	3,289	7,515	4,392	8,142
1961	2,744	5,488	2,935	3,188
1962	4,216	8,432	2,147	2,636
1963	3,521	6,552	2,454	2,640

Reid (1925b) estimated that there is 50,000,000 tons of limestone available above sea-level on the western side of the Don River. The principal reserves of " limestone megabreccia " are west of the Don River, south of Hallett's Quarry and at Cornelius and Dally's old site. The principal reserves of bedrock limestone are immediately east of the B.H.P. Quarry (500,000 cubic yards) and about 400 yards north where limestone outcrops each side of the railway (over 1,000,000 cubic yards). These estimates are conservative and approximate, but show that at the present rate of extraction there are reserves for some hundreds of years.

Crushed aggregate is produced for engineering purposes. This market has suffered with the advent of " hotmix " methods of carpeting roads. There does not appear to be any valid basis for the exclusion of limestone by the principal construction authorities, as the temperature of the hot-mix is well below the decomposition temperature of calcite, and although the aggregate is pre-heated, the amount of decomposition is negligible. Limestone is a good material for non-skid surfaces as it will not take the high polish of other rocks.

A finely-ground " flour of limestone " is produced for agricultural purposes. Maintenance of the industry depends upon three factors—production costs, selling methods, and the demands of agriculture. The market is competitive, and it has become necessary for producers to supervise transport, delivery to the farm, perhaps to organize the spreading, and to make long-term finance available. The demand has been reduced in recent years as a result of investigation by soil scientists. In krasnozemic soils, lime is used to improve clover nodulation by lowering the acidity and improving the survival rate of *Rhizobium,* and to render available molybdenum which is often fixed and so not available to plants. In podzolic soils, lime is used to assist the break-up of heavy ground and to reduce acidity to tolerable levels for pasture growth and weed eradication (Loveday and Farquhar, 1958, pp. 45-46; Twelvetrees, 1911, pp. 112-114). However, it has been found that drilling lime at the rate of two hundredweight per acre is sufficient to ensure nodulation, and that, on established pasture, application of molybdenum at the rate of 1.5 ounces per acre gives a response comparable to limestone at one ton per acre. The use of molybdate superphosphate, following these results, has reduced the market for lime.

However, lime still has a big part to play in agriculture. Many of the krasnozems are short of lime, and that which is present is concentrated in the surface layers. The soils are friable, or " snuffy ", so that with heavy cropping erosion losses can reduce the available calcium to deficiency level. On these soils, lime is essential for pasture development and cannot be replaced by molybdenum (Loveday and Farquhar, 1958). In general, it appears that principal uses in the immediate future will be for correcting calcium deficiencies in heavily-cropped krasnozems, for breaking up heavy soils, and for pasture development on podzols. The uses should create sufficient demand to maintain a stable industry at Eugenana indefinitely. In addition, it might be noted that Eugenana is well situated with respect to transport, and from the point of view of Tasmanian mineral resources, the limestone and clay at Eugenana might be validly included among the potential reserves of the cement industry at Railton.

The production costs at Eugenana are probably fairly high due to quarrying difficulties. In the limestone megabreccia the proportion of non-carbonate rocks in the quarry face can be very high, so that an uneconomic quantity of calcium carbonate is obtained per yard of face advance. However, the non-carbonate rock breaks fairly cleanly from the limestone, and with semi-manual methods the grade of rock delivered to the crusher is very close to the analyses quoted. The megabreccia forms a fairly dangerous face, but costs of explosives may be lower.

The cleanest reserves are in the foliated bedrock limestone east and north of the B.H.P. Quarry. A study of the geology offers possibilities of reduced extraction costs, but these possibilities are not being exploited at the present time. There is a large Tertiary fault along the eastern side of the outcrop, downthrowing Permian mudstone on the east against limestone on the west. The mudstone is fairly soft, and it should be reasonably cheap to cut a slot, by ripping, into the hanging wall of the fault. In this way a long face could be developed parallel to the foliation, and the quarry face could advance westwards with a considerable reduction in extraction costs compared to the present method of advancing along the strike.

Clay

Clay occurs as deposits interbedded with Cainozoic, Tertiary, Permian and Cambrian rocks, and as residual deposits derived from a variety of rock types.

Cainozoic

Clay occurs on the bench cut into the coastal escarpment east of Northdown; on the Marine Platform on the left bank of the Gawler River near its mouth; at high water mark on the neck of Cateena Point; and on the right bank of the Gawler River west of the township where it was once used for brick manufacture.

Tertiary

A highly siliceous, white kaolin clay is interbedded with correlates of the Wesley Vale Sand at Parkers Ford (Burns, 1960b, p. 60). Work done in the Department of Mines Laboratories showed that this is a highly siliceous kaolin with poor colour and brightness. Impure brown clay was intersected in drilling at Wesley Vale (Figure 23). Thin, impure clay occurs beneath or between basalt at the north end of Kelcey Tier (Burns, 1958), at the Ballymacargy Falls, at Paloona (Burns, 1957b, p. 36), south of Forth (Burns, 1959b, Fig. 28), and in Adam Creek (Twelvetrees, 1906b, pp. 39-40). Clay deposits on top of Mission Hill at Penguin were described by Hughes (1950, plan 1163) as "Newbolds Prospect", analyses being as follows:—

	Sample 1	*Sample 2*
	%	%
SiO_2	47.44	57.84
Al_2O_3	19.62	22.19
Fe_2O_3	17.63	6.73
TiO_2	1.87	1.04
CaO	Tr.	Tr.
MgO	Tr.	1.19
Na_2O	0.14	0.38
K_2O	0.17	3.7
Moisture at 105°C	2.12	0.86
Ign. Loss	11.33	6.24
	100.37	100.17

Permian

Clay occurs in the "Coal Horizon" of the Mersey Coal Measures at Tugrah, at Denny's Colliery, at the Illamatha Colliery, and at the Alfred and Sherwood Collieries.

Cambrian

Clay occurs in the Cateena Group, outcropping at Alma, Sprent, NW of Barrington, and SW of Gawler. A sample from 411E 926N, west of Gawler, was tested in the Laboratories of the Department of Mines (Manson and Farquhar, 1963) and found to be unsuitable for brick making without additions of clay from other sources. The best quality material occurs between Sprent and Upper Castra and despite the poor quality at Gawler, is still felt to offer economic possibilities.

Residual Deposits

Residual clay occurs overlying Devonian dolerite in the headwaters of Adam and Hardstaff Creeks. Hughes (1950, plans 1161, 1163) described "Lloyds Prospect" which overlies Rocky Cape Group east of Singletons Point at 4127E 9319N, where the clay averages less than 4 feet in depth and was analysed as follows:—

	Bores 1-4	Bores 5-7
SiO_2	70.0	52.44
Al_2O_3	13.18	20.06
Fe_2O_3	6.51	12.25
TiO_2	1.19	1.33
CaO	Tr.	Tr.
MgO	0.91	1.26
Na_2O	0.14	0.13
K_2O	1.25	1.95
Moisture at 105°	1.60	2.32
Ign. Loss	5.42	8.26
	100.28	100.00

Another deposit, "Healey's Prospect", was described by Hughes (1950, plan 1163) on the right bank of Buttons Creek near 41785E 9290)N overlying Precambrian Metamorphics. It is at least 10 feet deep in places.

Sand and Gravel

Sand and gravel deposits in Devonport Quadrangle are of four types:

(1) Early Tertiary sand interbedded with, or underlying, basalt.

(2) Late Tertiary sand overlying basalt or older rocks at the level of the Lower and Higher Coastal Surfaces.

(3) Scree deposits on escarpment.

(4) Quaternary deposits on the Marine Platform or valley floors.

Early Tertiary

There are ferruginous, argillaceous sand deposits in the Eugenana, Abbotsham, Penguin, Riana, and Iron Cliffs Leads which have been worked in places but are of poor quality. There are deposits in the upper part of the Turners Beach Lead which have not been worked. Hughes (1953, p. 22) described deposits in the Lodders Lead near Lobster and Hays Creeks which have been worked fairly extensively. The quality is variable and operators have used only those parts of suitable quality. Burns (1960b) reported that at the base of a Tertiary succession correlated with the Wesley Vale Sand at Parkers Ford there is about 10 feet of very coarse to granule size sand with interstitial clay and lenses of fine sand. This deposit extends from inland of Squeaking Point northwards to west of Hawley, but has not been extensively prospected, probably because the coarse sand is often overlain by many feet of fine sand. At Hawley the deposit is very coarse, from granule to pebble size. Testing strengths of the sand at Parkers Ford vary between 4000 and 6000 lbs (crushing strength) as tested at the Goliath Cement Works (Sample NA417, 7/12/59, Cement ratio 3:1, one month old at test).

Late Tertiary

Late Tertiary deposits overlie basalt and older rocks at a level near the Lower Coastal Surface. These deposits are fairly well sorted and have been the principal source of building sand.

Blake (1928c) described a sand depcsit on the divide between Buttons Creek and the Clayton River west of the serpentinite. The overburden is 18 inches of sandy loam. The sand is white, even-grained, containing pieces of quartzite and secretion quartz such as occurs in the bedrock of Precambrian quartzite. The maximum thickness observed by Blake was 3 feet. Analyses are as follows:—

Constituents	*Unwashed Sand*	*Washed Sand*
SiO_2	97.20	97.68
Fe_2O_3 with some Al_2O_3 ..	3.40	2.40
Ignition Loss	0.22	0.10
	100.82	100.18

Blake reported the sand as suitable for concrete work, and a mechanical analysis is as follows:—

	Unwashed	*Washed*
Retained on 10 mesh	3.4	0.6
Retained on 20 mesh	2.7	3.4
Retained on 30 mesh	9.6	14.0
Retained on 40 mesh	10.7	18.6
Retained on 60 mesh	28.2	37.2
Retained on 80 mesh	19.9	19.6
Retained on 100 mesh	9.2	4.8
Retained on 120 mesh	4.4	1.2
Passes 120 mesh	11.7	0.6
	99.8	100.0

Deposits overlying basalt have been worked behind Penguin on the Mission Hill and north of Mt Montgomery. Deposits overlying Cambrian rocks have been worked on Sullocks Hill, in the headward regions of Library and Mannings Creeks. Deposits overlying Precambrian have been worked east of Abbotsham, on Porcupine Hill, and west of the Clayton River as described by Blake. Deposits of probably late Tertiary age have been worked east of the Clayton River where it emerges onto the Marine Platform. Tertiary sands overlying Ordovician rocks have been worked at the head of Adam Creek and south of the Don River at the Denny Gorge. Deposits on the Tugrah Road, overlying Permian, have been worked in a limited fashion.

Cainozoic Scree Deposits

Chert scree mantles Mt Lorymer and the Dial Range, but there are only minor workings at Mt Lorymer, west of The Gnomon at the end of the Iron Cliffs Road, east of Mt Montgomery on the Dial Road, and at the southern end of Mt Riana. Scree from Precambrian quartzite has been mined at Sayers Hill, across the Don Valley from Tugrah Siding, and east of the Forthside Road north of Melrose.

Dolerite scree on Kelcey Tier and Dooleys Hill, and basalt scree in Penguin Creek and south of Sayers Hill, may have some use for aggregate.

Cainozoic Deposits on the Marine Platform

One of the principal sources of fine screening for sealed highway construction has been the Pleistocene cobble deposits on the Marine Platform at Turners Beach, Leith, and east of Devonport. The principal output now comes from modern beach shingles which occur on the coastline in storm beaches between Ulverstone and Port Sorell. The principal source appears to be the Forth River, although some may be reaching the coast via the Leven or Mersey Rivers. The storm beach deposits are reported to be transient, and one contractor stockpiles certain sizes should they appear along the coast. This beach-mining industry is an important one, and as the deposits at Northdown Beach are largely untouched due to access difficulties, it appears capable of expansion. The effect of mining terrace gravels in the Forth and Wilmot Rivers, should it ever be undertaken, is unknown but it may affect the coastal industry. The elimination of flooding in the Forth by projected hydro-electric undertakings may also have an adverse effect. The dredgings from the Port Frederick channel, at present dumped at sea, are reportedly mainly cobbles.

Production in recent years has been:

	Amount	*Value*		
	tons	£	s.	d.
1954	387.5	....		
1955	542.5	1,627	10	0
1958	5,922	13,086	0	0
1960	515	3,800	0	0
1961	453	3,199	0	0
1962	375	2,561	0	0
1963	518	3,793	0	0

Crushed Metal

Precambrian quartzite has been quarried at the outskirts of Ulverstone on the Gawler Road, on the hilltop east of Abbotsham and at Singletons Point. Precambrian sandstone and mudstone have been used for road works, derived from small openings in Penguin Creek. In recent years the Ulverstone Council has used Cambrian mudstone from the Isandula Road and from a quarry near Riana. At Devonport, crushed metal has been obtained from a dolerite quarry on the Stony Rise Main Road. A quarry just north of Horsehead Creek is now abandoned. Basalt is obtained from a quarry on the foreshore at East Devonport. At Latrobe, dolerite talus at the south end of Dooleys Hill was mined at one time.

Recorded production is as follows:—

Dolerite, Stone's Quarry, Stony Rise Main Road, 580 yards in 1960, valued at £1,052.

Basalt, Devon Metal Supplies, East Devonport, 9,528 yards in 1961, valued at £9,905.
Devonport Council 6,686 yards in 1961, valued at £838.

COAL

The Mersey Coalfield

The Mersey Coalfield may be divided into 10 distinct areas of which the 7 occurring in Devonport Quadrangle are listed below with their workings. Areas at Nook, Dulverton and the mouth of Caroline Creek are in Sheffield Quadrangle.

(1) *Tugrah*: The Don Mining Co., a subsidiary of the River Don Trading Company.

(2) *Denny Gorge*: Denny's Colliery and The Novelty Colliery.

(3) *Bott Gorge*: The Mersey Coal Company.

(4) *West Spreyton*: The Don Colliery, the Spreyton No. 2 Colliery, the Aberdeen Colliery, the Illamatha Nos. 1 and 2 Collieries.

(5) *East Spreyton*: The Russell Colliery, Spreyton Nos. 1 and 3 Collieries.

(6) *Tarleton*: The Denison, Riley Nos. 1 and 2, Spreyton Nos. 4 and 5, Southern Star, Coventry (or Tarleton) Nos. 1 and 2 Collieries.

(7) *Sherwood*: The Alfred and Mersey Collieries.

The locations of these collieries are shown on Figures 78, 79, 80, together with the principal shafts, boreholes, adits, outcrops, and tramways. Localities are stated in the text in terms of land blocks, such as are used for title purposes, and these are also shown on the Figures. A number such as Devon 6/13, in connection with mining leases, refers to the bound volumes of survey plans for the County of Devon, in this case Book 6 No. 13, held by the Mines Drawing Office, Department of Lands and Surveys, Hobart. "Underground Plan" refers to underground surveys of mines compiled at intervals during the life of a mine. These plans are held by the Chief Inspector of Mines, Hobart. There has been considerable confusion in previous literature due to the unsatisfactory system of naming collieries and the difficulty of identifying and locating them. For example, the name Tarleton was applied to several mines in the same general area, but which operated at different periods. The name Spreyton Colliery was applied to at least five different workings, and most of these were cleaning up operations within older collieries with different names. To prevent further confusion, the collieries are here assigned new names or numbers, where this is desirable. Production figures have been drawn mainly from Annual or Quarterly Reports of the Department of Mines, but some have been estimated.

Periods of Operation, Mersey Collieries

Tugrah

Coal discovered 1862. Mine began producing 1865, was operating in 1883, closed probably 1888.

Denny Gorge

Denny's: Operated from 1855, closed before 1861.
The Novelty: Operated 1938-9.

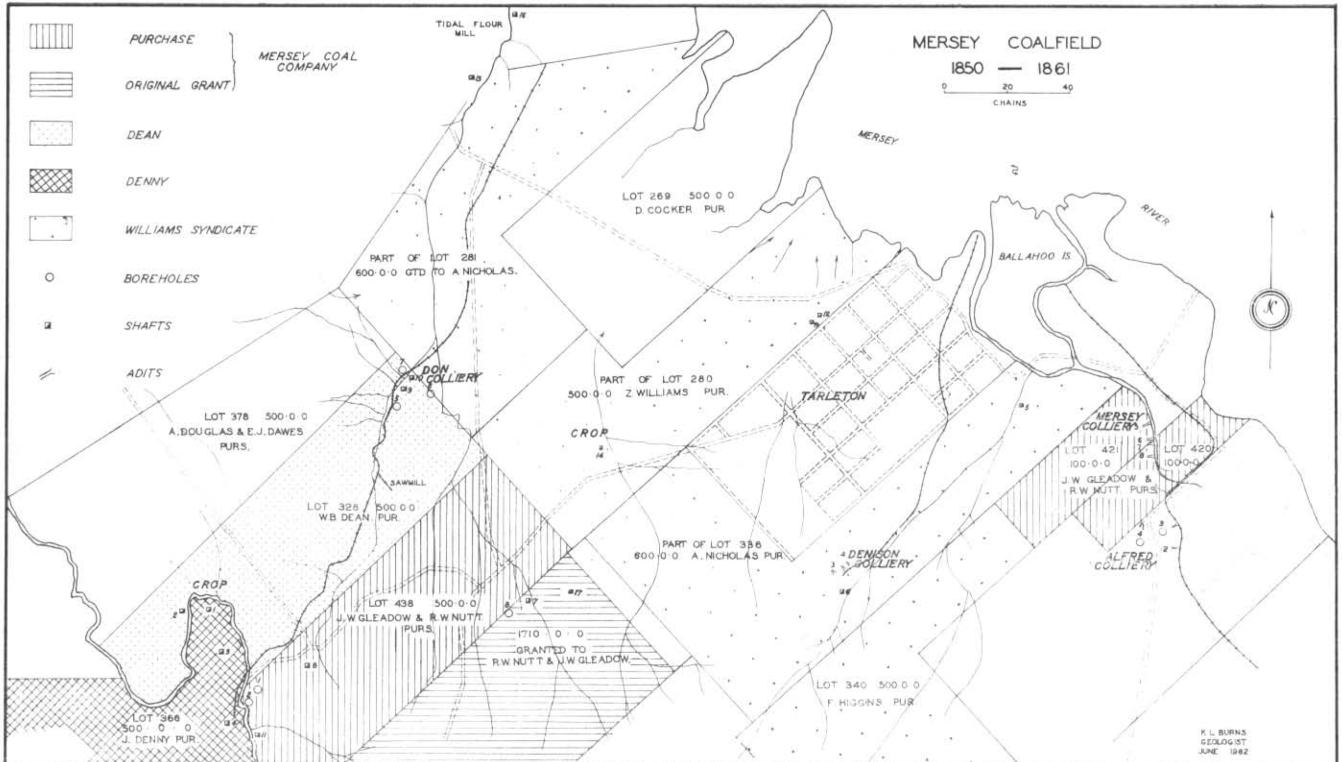


FIGURE 78.

5 cm

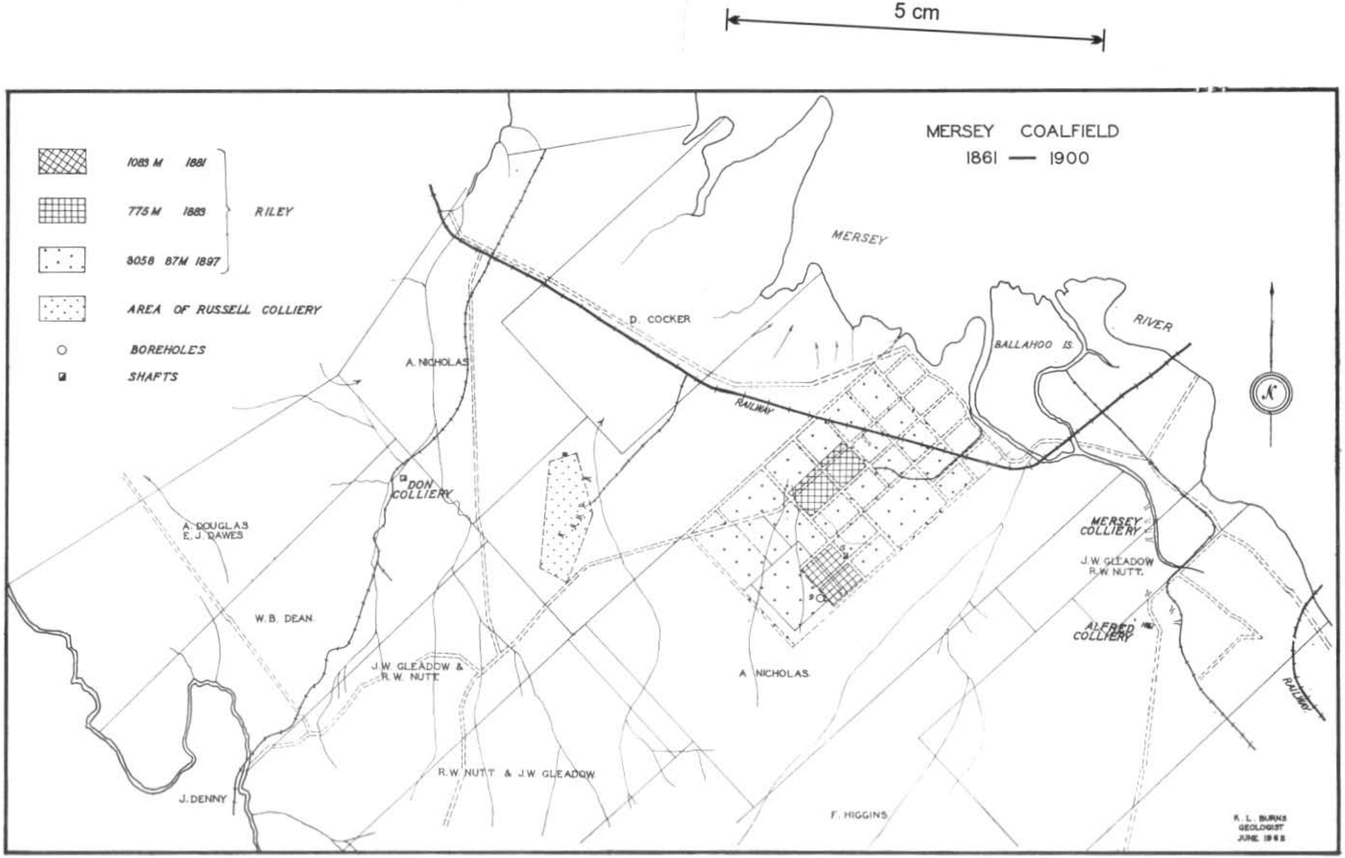
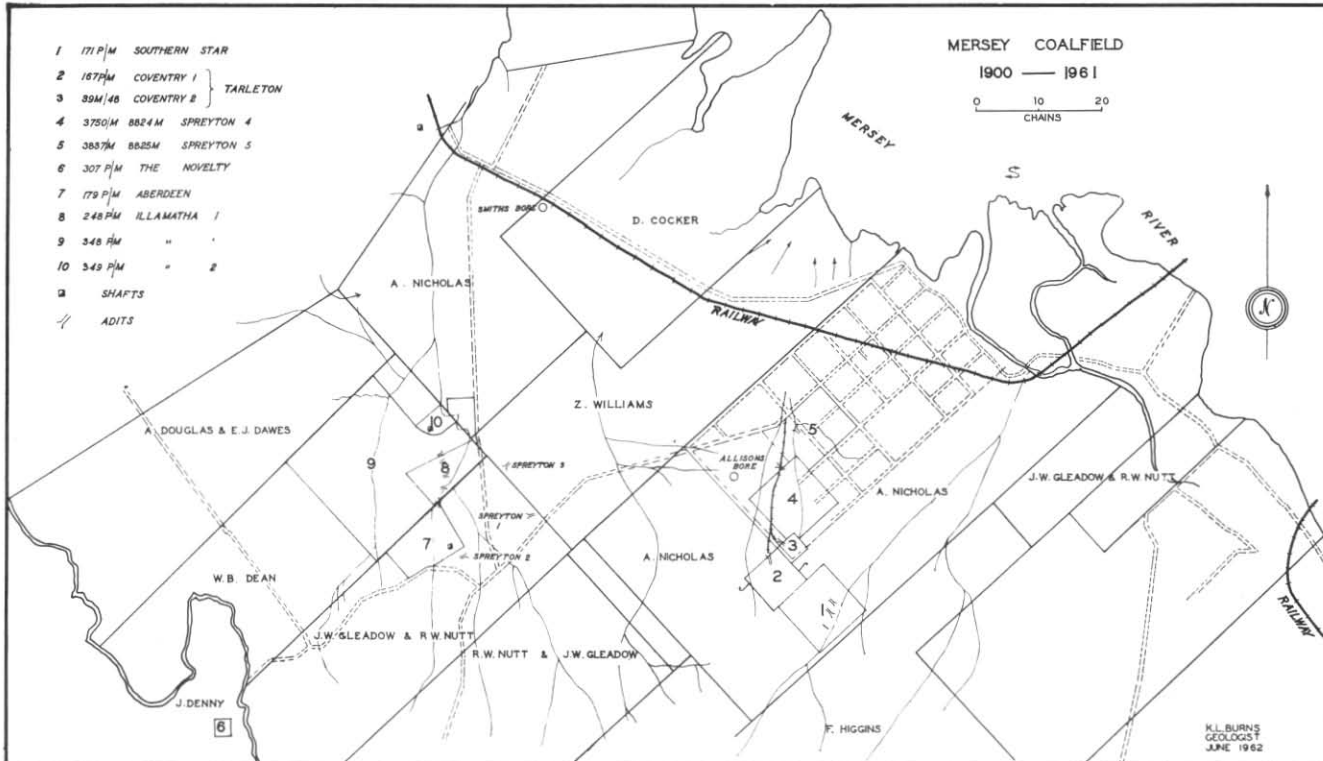

5 cm
MERSEY COALFIELD
1861 — 1900
1083 M 1881
775 M 1883
8058 87M 1897
RILEY
AREA OF RUSSELL COLLIERY
BOREHOLES
SHAFTS
MERSEY
RIVER
BALLAHOO IS.
D. COCKER
RAILWAY
A. NICHOLAS
DON COLLIERY
A. DOUGLAS
E. J. DAWES
W. B. DEAN
J.W. GLEADOW &
R. W. NUTT
R.W. NUTT & J.W. GLEADOW
A. NICHOLAS
MERSEY COLLIERY
J.W. GLEADOW
R.W. NUTT
ALFRED COLLIERY
J. DENNY
F. HIGGINS
RAILWAY

FIGURE 79.

FIGURE 80.



5 cm

Bott Gorge

First coal discovery on field was here, in 1850. Production in 1853.

West Spreyton

Prospected by Teasdale in 1900.

Don: Producer from about 1857, finished before 1883.
Spreyton No. 2: Producer 1903-4.
Aberdeen: Producer 1931-1950.
Illamatha No. 1: Producer 1903-1942.
Illamatha No. 2: Producer 1943-1960.

East Spreyton

First discovery in this area in 1855.

Russell: Not a producer till after 1861. Probably began producing sometime in the period 1867-1870, with the last year of production being 1899.
Spreyton No. 1: 1902-03.
Spreyton No. 3: 1904-08.

Tarleton

First discovery in this area about 1855.

Denison: First production 1855, possibly ceased by 1861.
Riley No. 1: Producing about 1881, closed prior to 1891.
Riley No. 2: Producing about 1883 to 1900.
Spreyton No. 4: Producing 1909 to about 1916.
Spreyton No. 5: Producing from about 1917 to 1923.
Southern Star: 1931-36.
Coventry No. 1: Producer 1931 to about 1939.
Coventry No. 2: Producer from about 1939 to 1946.

Sherwood

First discovery in this area was shortly after the discovery at the Bott Gorge, prior to purchase of Lots 420 and 421.

The Alfred: Producer from about 1858 to about 1880.
Mersey: Producer from 1861 to sometime earlier than 1890.

Mining Properties in the Mersey Coalfield

MERSEY COAL COMPANY—DON RIVER HOLDINGS

The Mersey Coal Company held, at the Don River, Lot 438, of 500 acres, Gleadow and Nutt, and a Lot of 1710 acres, Nutt and Gleadow (Figure 78). The second lot was granted on a Location Order purchased from Mr. Robinson, famous for his humanitarian work among the aborigines. The company was floated upon the initial coal discovery in the district (Fenton, 1891). The original outcrop, at the mouth of Bott Gorge, was described by Milligan (1852) and Gould (1861). Six drayloads were raised from this outcrop and shipped to Launceston in 1853.

The company then proceeded to explore the remaining ground, spending £17,000 by 1855, working in a fashion condemned by Selwyn (1855) as extravagant. Fenton (1884, p. 319) recorded an exenditure of £100,000. Work on these holdings had ceased by 1860.

Shafts Nos. 7, 8, 11, and 17 were sunk as shown on Figure 78. Shaft No. 7 (Gould, 1861, No. K) was a deep shaft sunk one mile from the river, entirely in fossiliferous beds, or "fossiliferous limestone shales" (Selwyn, 1855) which underlie the coal. The shaft reached between 250 and 300 feet before work was stopped by an inflow of water. Shaft No. 8 (Gould, 1861, No. O) was sunk 50 feet. Shaft No. 17, with a borehole, started in a small outlier of coal measure sandstone, but found no coal (Selwyn, Pl. V, Fig. 1).

Boreholes Nos. 1, 2, and 8 were sunk as shown on Figure 78. Bore No. 1 cut coal at 134 feet depth. Bore No. 2 was sunk searching for a lower coal seam, to a depth of at least 110 feet (Dean, 1855). This is probably Firth's borehole which passed through the coal in the first 7 feet and went 250 feet below the coal. Bore No. 8 was also sunk in search of a lower coal seam, near the shaft "where the water runs out the top" (Dean, 1855).

A tramway was partly built across Dean's land to the Mersey.

The result of this work was the proving of "one or two acres" (Selwyn) of coal near bores Nos. 1 and 2 at a depth of 134 feet. This coal was never worked.

MERSEY COLLIERY

This mine was located on the bluff overlooking the Mersey floodplain at Sherwood, a few hundred yards north of the Alfred Colliery, on Lots 420 and 421, each of 100 acres, Gleadow and Nutt (Figure 78). It was probably opened by Bennett, the then lessee of the Alfred Colliery, in 1861 (Gould, 1861, p. 6) and was operated by the Mersey Coal Company (Thureau, 1883, Fig. 2; Twelvetrees, 1911, p. 108). The mine was probably closed before 1890.

The colliery was confined to a small fault block. Faults on the south side, against the Alfred workings, (Reid, 1922, p. 224) probably trend NW and downthrow 25 feet to the SW. The western boundary was probably the same large NE trending fault which further south cut off the Alfred workings on the west side.

The coal was extracted by adits Nos. 5 to 8 (Figure 78) which were driven into the cliff from the bank of Ballahoo Creek (Gould, 1861; Thureau, 1883, No. I; Reid, 1922, p. 227). One of the adits, essentially unchanged in 1961, was figured by Thureau (1883, Fig. 2).

According to Reid, this colliery was a regular producer for a number of years, and shipped a large amount of coal. No production figures are available, but the mine area contained about 40,000 tons, and probably all of this was extracted.

DENNY'S COLLIERY

This colliery was located on Lot 366, 500 acres, J. Denny. In 1855, coal was worked at the mouth of Denny Gorge, but the colliery was abandoned after a few years.

Shafts Nos. 1, 2, 3, and 4, were sunk (Figure 78). Shaft No. 1 was sunk near an outcrop in the bed of the Don River but the coal ran out against a large fault. Shaft No. 2, across the fault, went to a depth of 80 feet without meeting coal. Shaft No. 3 (Gould, 1861, No. L) was sunk along the strike from No. 1, cutting coal at a depth of 20 feet. Shaft No. 4 (Gould, No. N) met coal at 18 feet depth.

The tramway to the Mersey River at "Swan Bay" (now known as Flour Mill Bay), which had been commenced by the Mersey Coal Company, was completed and a wire rope haulage installed to the hilltop at Aberdeen, east of the mine. The coal was shipped from "Dean's Point", which is the headland east of Flour Mill Bay.

Total production is unknown, but is estimated at 10,000 tons. By 1855, 8 tons had been raised from Shaft No. 3. Most of the production came from Shaft No. 4, and amounted to 3,000 tons for the first year (Fenton, 1891, p. 88).

NOVELTY COLLIERY

This colliery was located on Lease 307P/M, held by H. J., H. T. and L. F. Foster and J. F. Roberts, covering an area surrounding the old main shaft of Denny's Colliery. The mine operated in 1938, producing 508 tons, and 1939, producing 85 tons.

DON COLLIERY

This was situated in the NE corner of Lot 328, 500 acres, W. B. Dean (Figure 78). Note that the Don Mining Company had no connection with this colliery. After the closing of Denny's Colliery, Dean sank a shaft at the Don and shipped some coal. The mine was then let to Z. Williams (Fenton, 1891, p. 88) and was in operation in 1861 (Twelvetrees, 1911, p. 108). The main shaft was destroyed by fire in 1922 (Reid, 1922, p. 288).

Bores Nos. 5, 6, and 7 (Figure 78), which reached the coal at depths of 70, 90, and 100 feet respectively, were sunk in 1857 (Hainsworth, 1888). In 1861 Gould sank a shaft on the site of Bore 7 to satisfy himself that fossiliferous mudstone overlies the coal. Previous to this, Dean sank Shaft No. 10 of Figure 78 (Gould, 1861, No. J). Williams sank the main shaft, Shaft No. 9 of Figure 78 (Gould, 1861, No. I).

The colliery was cut by a NW trending fault, downthrowing 14 feet to the east, which within the triangle of bores met a westerly fault downthrowing 20 feet to the south (Gould, 1861, p. 7).

No production figures were recorded. The coal accessible from these shafts is calculated at 32,000 tons.

WILLIAMS'S COMPANY

The blocks taken up by Williams's Syndicate consisted of Lot 281, 600 acres and Lot 336, 640 acres, in the name of A. Nicholas; Lot 280, 500 acres, Z. Williams; Lot 340, 500 acres, F. Higgins; all at Tarleton, together with Lots of 536, 640, and 624 acres, in the name of A. McNaughton, at the Nook. The Tarleton blocks are shown in Figure 78. In 1851 Williams commenced exploration for a Hobart syndicate which purchased a large area of land extending from the Mersey to the Don. After sinking exploratory shafts and bores the syndicate concentrated on the Denison Colliery, and probably operated a colliery at Nook.

The Denison Colliery is described below. Only the exploratory workings are described under this heading.

Shaft No. 5 (Figure 78) is Nicholas's and Williams's Shaft, sunk to a depth of 275 feet (Gould, 1861, No. F), but barren of coal (Fenton, 1891). This shaft is very probably the same as that described by Thureau (1883) as sunk by P. Crompton in 1853 and 1854 to a depth of 302 feet. Selwyn (1855) considered that this shaft commenced below the coal but Williams denied it. Thureau agreed with Williams. The writer supports Selwyn's opinion. It may be noted that R. D. Gee (pers. comm.) obtained fossiliferous, dense blue Permian limestone from the spoil of this shaft (in 1962), almost certainly basal Permian.

Shaft No. 6 (Figure 78) was sunk by Williams near the Denison Mine. Starting below the coal, the shaft went to a depth of 65 feet (Thureau, 1883, Level Plan). Shafts Nos. 5 and 6 have been confused by some authors.

Shafts Nos. 12 and 13 (Figure 78), or "Williams's New Pits" were sunk 40 feet to a sandstone correlated by Gould with the "rough sandstone" which lies 10-12 feet above the coal (Gould, 1861, No. H; Reid, 1922, p. 226).

Shaft No. 14 is located on Figure 78 from a description as three-quarters of a mile north of the Denison Colliery, and is one of the few openings that have not been located on the ground.

The shaft was sunk 40 feet, and at a depth of 20 feet crossed a fault downthrowing NE. A bore from the bottom of the shaft went through sandstone and marl to meet coal at a further 15 feet (Gould).

This discovery was visited by both Selwyn and Gould, but was not exploited in their time.

DENISON COLLIERY

This colliery was located on Lot 340, 500 acres, F. Higgins, on the south face of the hill, at the SW corner of Tarleton township. The workings were close to, and probably partly contained within, the Southern Star Lease 171P/M. This mine was operated for a Hobart syndicate by Z. Williams. The name Tarleton was sometimes used for this mine, Williams being recorded as manager of the Tarleton Coal Mines (von Stieglitz, 1947, p. 29). Dean (1855) reported Williams preparing the first shipment. According to Twelvetrees (1911, p. 108), operations had ceased by 1861 but von Stieglitz (1947, p. 10) said the mine was still working in 1877.

A cross-section was given by Johnston (1888, opposite page 170). Shaft No. 6 (Figure 78) started below the coal, and was barren. The coal was won from at least three short adits (at Nos. 3 and 4 of Figure 78). Upon driving 300 feet due west from the south-westernmost tunnel a great downthrow was met. Another fault bounded the workings on the east side. The colliery was thus situated on a small horst (Twelvetrees, 1911, p. 108).

No production figures are available, but an estimate is made of a maximum of 15,000 tons. A group of mines worked in this area, and this figure was derived, in the first instance, by calculating the coal available in the area and subtracting from this the amounts abstracted by later mines.

RUSSELL COLLIERY

This colliery worked the western end of Lot 280, 500 acres, Z. Williams (Underground Plan 255, 1895). Coal was first discovered in this vicinity by Williams in 1855, but it appears that the prospect had not been exploited by 1861. The colliery was owned by T. Hainsworth, with Joshua Mackey as Mine Manager in 1897. The output was delivered by tramway to the railway line (Figure 79).

The mine was worked from a number of adits driven under the eastern face of the hill, the adits from the western face being driven at a later time by Allison. A large number of small faults trending NW were encountered (Figure 81).

Production commenced after 1867, probably in 1869, and had ceased by September, 1899.

No figures are available before 1897. Quarterly Reports give the following figures: 1897, 586 tons (third quarter only); 1898, 2263 tons; 1899, 1366 tons.

Total production is estimated at 100,000 tons.

ALFRED COLLIERY

The Alfred Colliery was located on a lot of 640 acres, Alexander Clerke, at Sherwood. Thureau (1883) showed the workings occupying much of the centre of this land, but the mine area was much smaller than he showed it, and further east. The earliest date recorded for this colliery is 1858. In 1861, Mr. Bennett was the lessee, Johnson owning the land (Gould, 1861). The mine was working in 1877 (von Stieglitz, 1947, p. 10). In 1883, Davies was the owner (Thureau, 1883) and in 1888 Johnston referred to this as Crompton's Colliery. The mine closed about 1880.

The workings were bounded on the west by a fault trending NE, and on the north by another fault against the Mersey Colliery. The coal was worked from adits Nos. 1 and 2 (Figure 78) which were driven by Bennett just above the level of the alluvium. The main tunnel is the northernmost, driven in a creek re-entrant. This cut the seam 390 feet from the entrance (Reid, 1922, p. 224).

Bore No. 3 of Figure 78 (Gould, 1861, No. C) was Johnson's Bore to the coal. This may be the same as Crompton's Bore (Gould, 1861, pp. 4-5; Johnston, 1888, p. 132; Reid, 1922, p. 224) which met the coal at 80 feet 6 inches in depth.

Bore No. 4 (Figure 78) was put down by subscription to nearly 500 feet in search of a second coal seam (Gould, 1861, No. D). According to Thureau (1883) it was sunk by Bauld in 1858, meeting coal at 53 feet 6 inches and going down to a total 300 feet 1½ inches. An amended log was published by Reid (1922, p. 225). Twelvetrees (1911, p. 108) apparently confused bores Nos. 3 and 4 (Figure 78) as he described a bore which met 18 inches of coal at a depth of 80 feet 6 inches (Bore No. 3) but which went an additional 250 feet below the coal (Bore No. 4).

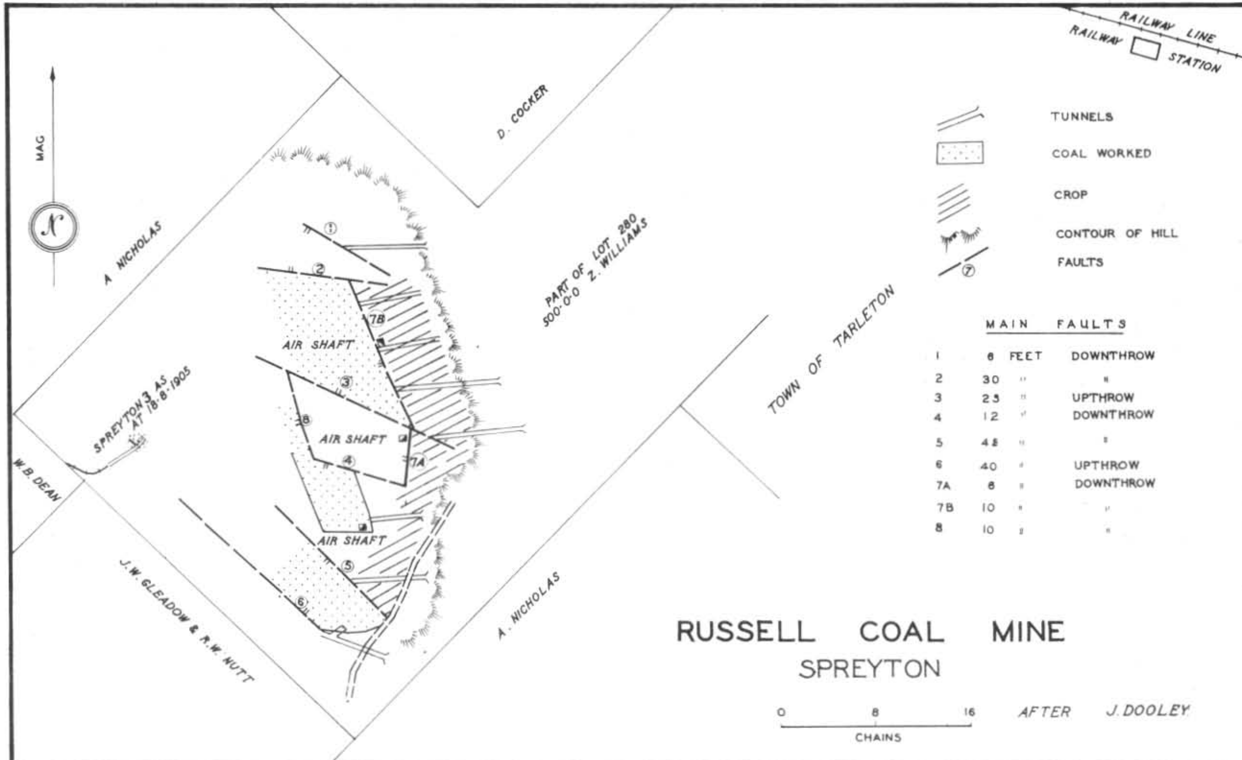


FIGURE 81.

5 cm

Shaft No. 16 (Figure 79) is William Davies's Shaft which went 60 feet to the coal (Thureau, 1883, No. E). This is probably the same as Bauld's Shaft (Thureau, 1883, Sketch 1).

No production figures are available. The area worked contained 100,000 tons, most of which was probably extracted.

RILEY'S COAL MINES

Riley worked areas in the Tarleton township; first, a southern lease, here called Riley No. 1; second, a northern lease, Riley No. 2. Later he took out an extended lease over the remainder of the township (Lease 3058/87M of 274 acres, dated 1897).

Riley No. 1

This colliery, also known as the Tarleton Coal Mine (Thureau, 1885, Section) was located on lease 1083M of 20 acres (Devon 6/48, 1881; Thureau 1883, No. P). It operated for a short period between 1881 and 1891. In 1909 the Spreyton No. 4 operated contiguous workings.

Riley worked much of the SW corner of Tarleton township. Shaft No. 15, Figure 79, known as Riley's Shaft, was sunk 51 feet to the coal (Thureau, 1883, Level Plan). A 35 feet shaft and workings on the south boundary of Lease 89M/43, in existence when the lease was surveyed in 1944, may have been part of Riley's workings.

No production figures are available. The total output probably did not exceed 10,000 tons.

Riley No. 2

This mine was located on Lease 775M, of 20 acres (Devon 6/13, 1883). The names Wakeham and Lobley were associated with Riley in this venture. The mine worked from 1883 to about 1900. At a later date, Allison extracted Riley's pillars. The workings suffered from water troubles, all openings north of the road being now flooded.

No figures are available but production is estimated at 20,000 tons.

SPREYTON NO. 1

This was located near the SW corner of Lot 280, 500 acres, Z. Williams, and was known as Allison's Coal Mine or the Spreyton Coal Mine. It worked land adjoining the old Russell Colliery on the SW side. There is no record of the mine before 1901, and production had probably ceased by 31st March, 1903. There was a main tunnel with the seam faulted at 420 feet.

Production was:

1902	1709 tons
1903	382 tons (first quarter)
Total	2091 tons

SPREYTON NO. 2

This was located west of Figure-of-Eight Creek at Spreyton, adjacent to the Aberdeen Colliery on either the north or south side. On the Devonport Map Sheet the mine is shown at the site of an old adit south of the Aberdeen. However, the reported difficulties with faulting and influx of water suggest that the mine should properly have been located north of the Aberdeen, perhaps between Illamatha Nos. 1 and 2 (see Illamatha No. 1). If this is the case, the tunnel south of the Aberdeen may have been Teasdale's Prospect (see Aberdeen Mine). Figure 80 adheres to the location given on the Devonport Map Sheet.

The mine was opened by Allison in 1903 and operated as the Spreyton or Allison's Coal Mine. Quarterly Reports for September, 1904, report the mine abandoned due to faulting and influx of water.

There was a single main tunnel, surveyed 23.1.04 (Underground Plan 257).

Production—

1903	706 tons	(last three quarters)
1904	444 tons	(first two quarters)
Total	1150 tons	

SPREYTON NO. 3

This was situated on Lot 280, Z. Williams, as shown on Figures 80 and 81, based on Underground Plan 257 (survey of 18.8.1905).

After leaving Spreyton No. 2, Allison went to the east side of the road. The mine probably closed in 1908, when Allison moved to Tarleton. A small area was worked from a low tunnel with a short tramway to the main road as shown on Figure 81.

Production:

	tons	
1904	865	(last two quarters)
1905	817	
1906	1584	
1907	1417	
1908	851	
Total	5034	

SPREYTON NO. 4

The Spreyton No. 4 Colliery was situated on Lease 3750M of 40 acres (Devon 2B 22/4), later 8824M (Figure 80).

This mine was variously known as the Spreyton, Allison's, or the Mersey Colliery. Lease 3750M was granted to John Allison and John Allison Jnr. in 1908, cancelled 6.12.1918, restored 10.1.1919, and cancelled 15.2.1922 (Devon 36/36). It was renewed as 8824M by John William Allison in 1922 (Devon 33/2) and finally cancelled 26.2.24.

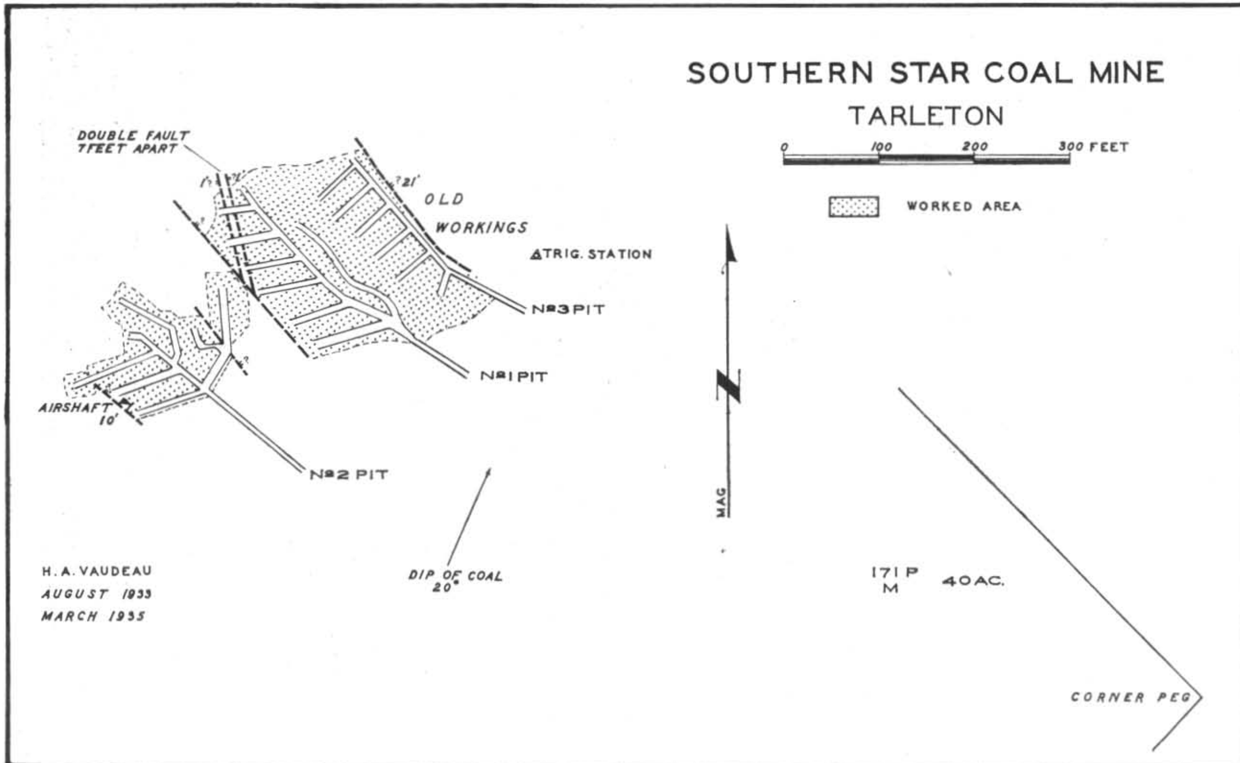

SOUTHERN STAR COAL MINE
TARLETON
0 100 200 300 FEET
WORKED AREA
DOUBLE FAULT 7FEET APART
21'
OLD WORKINGS
TRIG. STATION
Nº3 PIT
Nº1 PIT
Nº2 PIT
AIRSHAFT 10'
MAG
DIP OF COAL 20°
H. A. VAUDEAU
AUGUST 1933
MARCH 1935
171 P M
40 AC.
CORNER PEG

FIGURE 82.

The mine probably began operating in 1909. It was operating in 1911 (Twelvetrees, 1911, p. 109). Production had practically ceased by 1916. Reid (1922, p. 223) said the mine had been in continuous operation for 40 years, but this includes the period of operation of Riley's working.

The Annual Report for 1909 recorded Allison as sinking 7 bores on the NE side of the hill and driving a tunnel from the SW side to meet the coal. Reid (1922, p. 223) recorded dip tunnels about 1200 feet long, using longwall methods of extraction.

Production figures for the various Spreyton Collieries are not differentiated in the Annual Reports, but a lift in production in 1909 provides a reasonable date for initial production from Spreyton No. 4. The figures for 1909 to 1916 are probably mainly Spreyton No. 4, those for 1917-1923, Spreyton No. 5.

The output, of 80 to 90 tons per month (Annual Report, 1912, p. 63) was sold in Latrobe:

	tons
1909	1543
1910	1591
1911	1496
1912	956
1913	1164
1914	1000
1915	270
1916	673
Total	2696

SPREYTON No. 5

This colliery was situated on Lease 3837M, of 40 acres, later 8825M (Devon 27/3, 1908; 33/3, 1922). It was operated by the Allisons under the name of the Spreyton Colliery. A little work was done on the "Spreyton Seam" near Tarleton railway station. Allison worked from a tunnel driven SE under the tramway (Figure 80) and extracted pillars from the old Riley No. 2, from about 1917.

Production:

	tons
1917	350
1918	421
1919	657
1920	782
1921	272
1922	583
1923	55
Total	3120

Note: Allison opened a new pit at Dawson's Siding, producing 189 tons in 1923, and 179 tons in 1924. This mine was sold to J. A. Wauchope of the Mersey Valley Oil Co. and renamed the Mersey Valley Colliery. It produced 37 tons in 1925, then ceased.

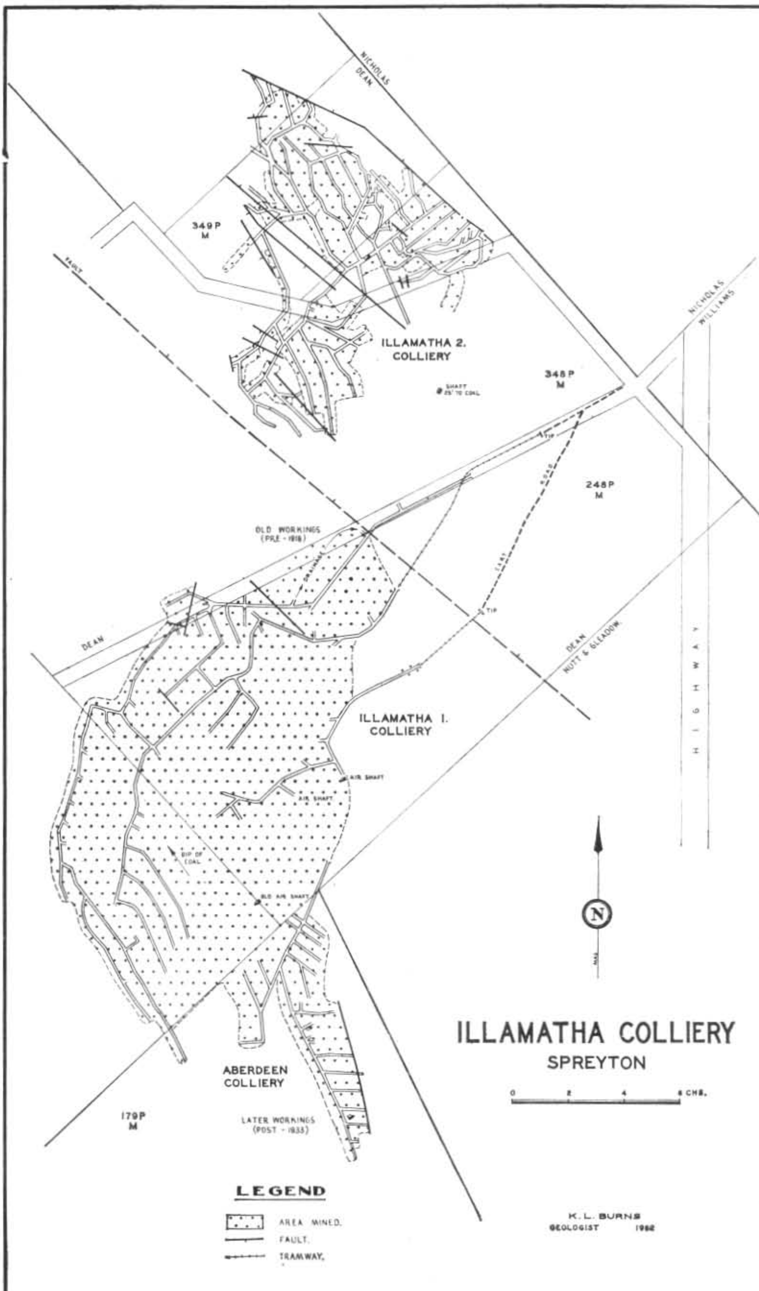


FIGURE 83.

5 cm

SOUTHERN STAR COLLIERY

This mine was situated in Lease 171P/M of 40 acres (Devon 36/36), adjoining the old Denison workings on the west side.

The lease was taken out in the names of W. T. Gower and J. Wilson in 1931; later changed to William Thomas Gower; and later still to Hedley Bott and Thomas Donnelly. Production was recorded in the name of Gower and Sons. This was one of ten small mines operated about the time of the depression, supported by the Goliath Portland Cement Co. at Railton.

The mine was worked by three adits. No. 1 was operating in 1933, No. 2 in 1935, and No. 3 was abandoned by December, 1935 (Underground Plan No. 1.) (See Figure 82).

The production, all sold to the Goliath Portland Cement Company, was:

	tons
1931	97
1932	582
1933	Nil
1934	468
1935	279
1936	411
Total	1837

Note: Following the closure of the Southern Star, Bott worked at South Spreyton (or Nook). Production was recorded under the names H. Bott, J. Bott, and Jeffrey Bros.

ABERDEEN COLLIERY

This mine was situated at Spreyton (Figure 80) on lease 179P/M of 29 acres.

There is a record of exploration in this vicinity by Teasdale (a mine operator from Dulverton) about 1900, but there was no production. The exploratory workings are conceivably those shown on Figure 83 north of Illamatha No. 1. The Aberdeen Mine proper began producing about 1931, and was closed in 1950.

The mine was worked by a tunnel driven from the NW angle. Figure 83 shows the workings known in 1933. No. 1 Pit operated till 1938 (Underground Plan 281). The location of No. 2 Pit is unknown, but it may have utilized the same access tunnel.

Production figures are listed below. For the years 1947 to 1950 the returns were grouped with those from the Illamatha and perhaps 3000 tons was raised from the Aberdeen.

	tons
1931	928
1932	1382
1933	1583
1934	1962
1935	2353
1936	1927
1937	2054
1938	2051
1939	1070
1940	1949
1941	1921
1942	1322
1943	849
1944	804
1945	787
1946	1198
1947-50	3000 (estimated)
Total	25,199

ILLAMATHA No. 1

The mine was opened on Lease 248P/M, of 20 acres, (Figure 80) in the valley of Figure-of-Eight Creek at Spreyton, and the later workings are immediately north of the earlier.

Lease 248P/M was held by F. V. Bound, but was transferred in 1933 to R. Bound and others. Later, lease 348P/M was taken up, comprising 176 acres, in the names of R., J. R., and C. A. Bound.

Operations began in 1903 and the mine was being worked on a small scale in 1911 (Twelvetrees, 1911, p. 108). Reid (1922) reported that operations had ceased with the extraction of coal to the edge of the lease. Production was resumed in 1924 (Reid, 1924a, p. 108) on an extended lease.

The coal was extracted from the initial lease by the step-longwall method from dip tunnels over 1000 feet long (Underground Plan 281 and Reid, 1922, p. 223). A compilation of the known workings is shown in Figure 83. Note that "old workings" north of 248P/M have not been identified, but may be the workings of a small mine surveyed 1.10.1907 (Underground Plan 257) and called there the "Spreyton Mine".

The mine was worked on tribute for the first half of 1918. Production was governed by demand, rising in 1919 and 1920 when Holymans took bunkering coal on contract, and again in 1929 during a mainland coal strike.

Production figures were:

	tons		tons
1903	20	1923	623
1904	590	1924	675
1905	121	1925	763
1906	Nil	1926	1240
1907	150	1927	1328
1908	60	1928	901
1909	Nil	1929	1817
1910	120	1930	2137
1911	128	1931	1066
1912	110	1932	940
1913	160	1933	849
1914	74	1934	1717
1915	188	1935	1668
1916	512	1936	1775
1917	463	1937	1590
1918	932	1938	949
1919	2139	1939	1259
1920	2538	1940	1276
1921	546	1941	903
1922	305	1942	757
		Total	33,398

ILLAMATHA NO. 2

This mine was situated north of Illamatha No. 1 on Lease 349P/M, 5 acres (Figure 80), in the name of R. Bound and Others, and the workings ran into Lease 348P/M, held by the same lessees.

After the closure of the Illamatha No. 1, the Bound brothers worked a small fault block further down the creek, between the Illamatha No. 1 and the old Don Colliery. This mine was the last on the Mersey Coalfield, and closed in 1961 when the market (the Ovaltine factory at Quoiba) was changed to fuel oil.

The coal was extracted by bord and pillar methods from a shaft 80 feet deep (Underground Plan 281). The brothers worked alternate shifts underground. It was necessary, owing to the two-foot seam, to use small hand tools, and work in a recumbent position. The surface worker operated the cage and loading of bins. The mine was subject to flooding, and much broken by faults.

Production figures recorded include the Aberdeen Colliery from 1947 to 1950. It is assumed that the Aberdeen contributed a total 3000 tons in that period, and the remainder is assigned to the Illamatha.

	tons		tons
1943	1554	1953	930
1944	1874	1954	917
1945	1651	1955	610
1946	1421	1956	587
1947–1950	5492	1957	736
		1958	647
1951	1018	1959	424
1952	876	1960	552
		Total	19,189

This figure agrees with a production of 20,000 tons calculated from planimetric measurements of the underground plans.

COVENTRY NO. 1

This mine was sited on Lease 167P/M of 20 acres, (Devon 33/2) granted in 1922 and still in force in 1931 (Devon 36/36) (Figure 80). Production had ceased by 1939 (Underground Plan No. 1). The mine was known as the Tarleton Coal Mine, or Tarleton No. 1 Pit, but on one plan is termed The Alfred. It was worked from a single adit (Figure 84). The Government built a tramway into the workings to connect with Allison's old tram (Figure 80). Output went to the Goliath Portland Cement Company. Production figures cannot be separated from those for the Coventry No. 2 Colliery.

COVENTRY NO. 2

This mine was situated east of Coventry No. 1 on lease 39M/43, of 5 acres (Devon 39/31) including a tunnel and roadway easement No. 13W/43 on the NW side (Devon 39/30).

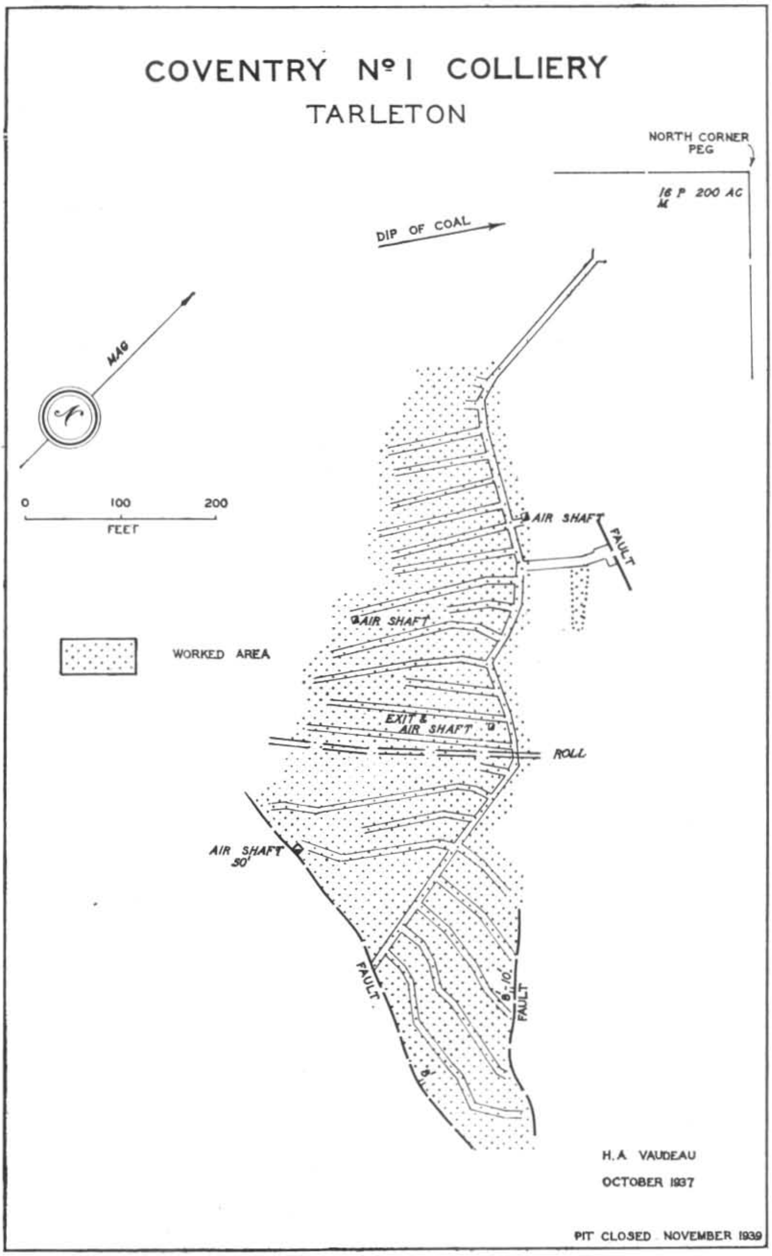


FIGURE 84.

5 cm

The lease was surveyed in 1944 but a plan dated November, 1939, of the Tarleton No. 2 Pit (Underground Plan No. 1) seems to apply to this mine. When the lease was surveyed, there was a shaft on the SE boundary reaching the coal at 35 feet depth, and other workings one chain south, part of an earlier colliery. The coal was removed through a tunnel driven south from the NW side. The Government provided assistance for a short tramway to join the Coventry No. 1 tram-route. Production went first to the Goliath Cement Company, thereafter to the Ovaltine Factory. Total production for Coventry Nos. 1 and 2 was—

	Tons
1931	207
1932	382
1933	290
1934	640
1935	1,276
1936	1,150
1937	1,001
1938	1,008
1939	1,070
1940	1,207
1941	1,252
1942	860
1943	558
1944	589
1945	521
1946	372
Total	12,383

TUGRAH COALFIELD

The Tugrah coalfield was located on the banks of the Don River between Eugenana and Don. The main workings adjoined the old River Don Tramway on the west side, under the high bluff between Tugrah settlement and Tugrah Siding. There is evidence of workings on the flats to the north and across the river to the south. This area is outside the detailed maps of the coalfield of the accompanying figures, but the mines are shown on Devonport Map Sheet.

Cummings, Raymond, and Company (later the River Don Trading Company) from their port at the Don Heads built a tramway up the Don River, as far south as Lower Barrington, to tap resources of timber and limestone. The present Melrose Line and the old Government Railway to Barrington follow a route close to the old tramway. In 1862 coal was discovered close to the tramway and considerable quantities were shipped to Launceston (Fenton, 1891, p. 113). The miners' settlement was on the west bank of the

Don opposite modern Tugrah on alluvial flats, now farmlands termed "Miners Row". The coal was worked from a series of adits driven into the hill.

Thureau (1883) reported that the Don Mining Company had raised 25,000 tons in the 18 years to 1883, which dates initial production in 1865. It may be noted that Reid (1922, p. 228) assigned this production to Dean and Williams's Don Colliery. The Tugrah Mines probably closed in 1888, so that at the rate reported by Thureau, production would have totalled 32,000 tons. This is only 10 percent of the estimated quantity in the fault block exploited.

Coal exports recorded at Port Sorell in this period were probably shipped from the Don Heads. Mr. B. Booth has kindly supplied the following figures:

	Tons
1875	2,491
1876	1,860
1877	3,072
1878	1,366
1879	960
1880	511
Total	10,260

These figures read very much as if the coal was shipped from a single declining mine, and shipments from the un-customed port of Don Heads would logically be recorded at Port Sorell during passage to Launceston just as earlier shipments to Melbourne were customed at Stanley.

SPREYTON AREA

The area north of the Spreyton Railway Station (north of Lot 281, 600 acres, A Nicholas, of Figure 78) was non-producing, but there were a number of exploratory workings.

Shafts 15 and 16 (Figure 78) were sunk either side of Flour Mill Bay (then "Swan Bay") but were too shallow to afford any results. Further NW, on Q. S. Button's 100 acres, near Spreyton Race Course, a bore was sunk to 100 feet without finding coal. Another bore was sunk by Crompton in the same area in 1861. The log of this bore was given by Gould (1861, p. 8). Reid (1922, p. 226) reproduced this log, but called the bore location Tarleton. At some later time a shaft was sunk in the same area and remnants of this haft still exist at 4314E 9235N, waterfilled, and with coal in the spoil. The minimum depth of the coal in this vicinity is estimated at 150 feet.

Production from the Mersey Coalfield

Thureau (1883) recorded a total production from Tugrah of 25,000 tons, and from the rest of the field about 60,000 tons. Johnston (1888, p. 134) recorded production as "recently fallen" to 6,000 tons per annum. Reid (1922, p. 222), using Thureau's estimate, calculated that if 85,000 tons had been raised in the period 1858-1883, the production for 1883-1922 would be, at the same rate, 136,000 tons. He therefore estimated for the field as a whole a total 211,000 tons for the period 1858-1922.

Production estimates given earlier in this volume are based on records, or on calculation from the probable area extracted (assuming 1 acre-foot of Mersey coal to weigh 1586 tons, and adjusting for seam thickness) or, as a final resort, from calculation over the life of the mine at an output not exceeding 2,500 tons per annum.

Estimates and recordings for the various mining areas are as follows:

Area		Estimated total Production (tons)
Tugrah		32,000
Denny Gorge		
Denny's	10,000	
Novelty	593	
	10,593	10,000
Bott Gorge		
Mersey Coal Co.	Six drayloads	—
Spreyton West		
Spreyton 2	1,150	
Aberdeen	25,199	
Illamatha 1	33,398	
Illamatha 2	19,189	
Don	32,000	
	110,936	110,000
Spreyton East		
Spreyton 1	2,091	
Spreyton 3	5,034	
Russell	100,000	
	107,125	110,000
Tarleton		
Denison	15,000	
Southern Star	1,837	
Riley 1	10,000	
Riley 2	20,000	
Coventry 1 & 2	11,313+	
Spreyton 4	8,696	
Spreyton 5	3,120	
	69,966+	70,000

Sherwood

Alfred	100,000	
Mersey	40,000	
	140,000	140,000

Total estimate (northern part of Mersey Coalfield with Dulverton and Nook omitted)	472,000

This figure agrees with Reid's estimate. The production rate is at 472,000 tons for 107 years (1855-1961), or about 4,400 tons per year.

Exports from the Mersey Coalfield

These figures were kindly supplied by Mr B. Booth.

Year	Port of Recording				Total
	Port Sorell	Ballahoo	Sherwood	Tarleton	Tonnage
1866					1,782
1867					2,075
1868					2,000
1869					3,000
1870					2,400
1871					2,810
1872					2,000
1873					3,180
1874					2,474
1875	2,491				2,491
1876	1,860				1,860
1877	3,072				3,072
1878	1,366		780	1,500	3,616
1879	960		250	1,800	3,010
1880	511			1,850	2,361
1881			360	300	660
1882		1,800	1,500		3,300
1883		1,200	900		2,100
1884		1,500	700		2,200
1885		500	1,200	414	2,114
1886					1,400
1887					1,050
1888					1,468
1889					2,445
1890					3,778
1891					9,304
1892					3,000
1893					4,930
Totals	10,260	5,000	5,690	5,864	75,880 (28 years)

It may be noted that Watts (1858) recorded total coal exports from the Mersey of 4,287 tons, valued at £4,548, in the period 30/9/1856 to 30/9/1858.

The rate of export for this period is close to 2,700 tons per annum. Approximately half the production was exported, the remainder consumed locally, including that used by a gas works which operated at Latrobe in 1881 (Bethell, 1955, p. 168). More recent local consumers have included the Goliath Portland Cement Company at Railton, Holymans Steamship Company, the Ovaltine Factory at Quoiba.

METALLIC MINERALS

There are a large number of showings of metallic minerals in Devonport Quadrangle (Figure 85), but although rich shoots have been found in some deposits, they are small and the mineable grades are uneconomic.

Prospecting was fairly intensive in the period 1880-1910 but very little has been done since that time. For many prospects nothing is known except brief reports dating from the last century. This summary is not intended to be in any way an assessment of the economic potential of the field or of any particular deposit, but is an attempt to relate the topography and geology as now known to the occurrences described in the older literature. It follows an earlier summary by Hughes (1953) who described the Dial Range deposits in detail. In addition to the prospects discussed here, manganiferous limonite, barite and pyrite with traces of other metals occur as showings throughout a wide area.

The deposits include replacements of Cambrian conglomerate and tuff, fissure fillings in a variety of host rocks, and impounded deposits at the base of the Barrington Chert and Duncan Conglomerate.

A number of fields, or mineral provinces, are recognizable. On the western basement of the Dial Range Trough are hematite deposits within the Precambrian Rocky Cape Group, and a related limonite deposit at the Iron Cliffs. On the eastern basement are quartz-hematite deposits carrying traces of gold, and quartz-pyrite deposits with traces of copper and gold.

Within the Cambrian rocks of the Dial Range Trough, there is a group of silver prospects near the western margin at Penguin, containing pyrrhotite, tennantite, and reportedly nickel and cobalt, which appear to be orthomagmatic deposits related to intrusive Cambrian keratophyre. Further south, in the Dial Range itself, there is a central field of pyrite deposits, one deposit containing traces of tin in the pyrite, and two deposits containing arsenic. An outer belt of deposits has barite as gangue, or else galena as the predominant sulphide. A southern belt of cupriferous pyrite has a quartz-hematite gangue. Small showings of manganiferous hematite occur throughout the area.

Prospecting of the small deposits is unlikely to yield metal in payable quantity. However, it is pointed out that the trough has a steep western wall, probably a fault active during the Cambrian (but blanketed by Ordovician sediments and not an important structure in the Devonian) which is analogous in some respects

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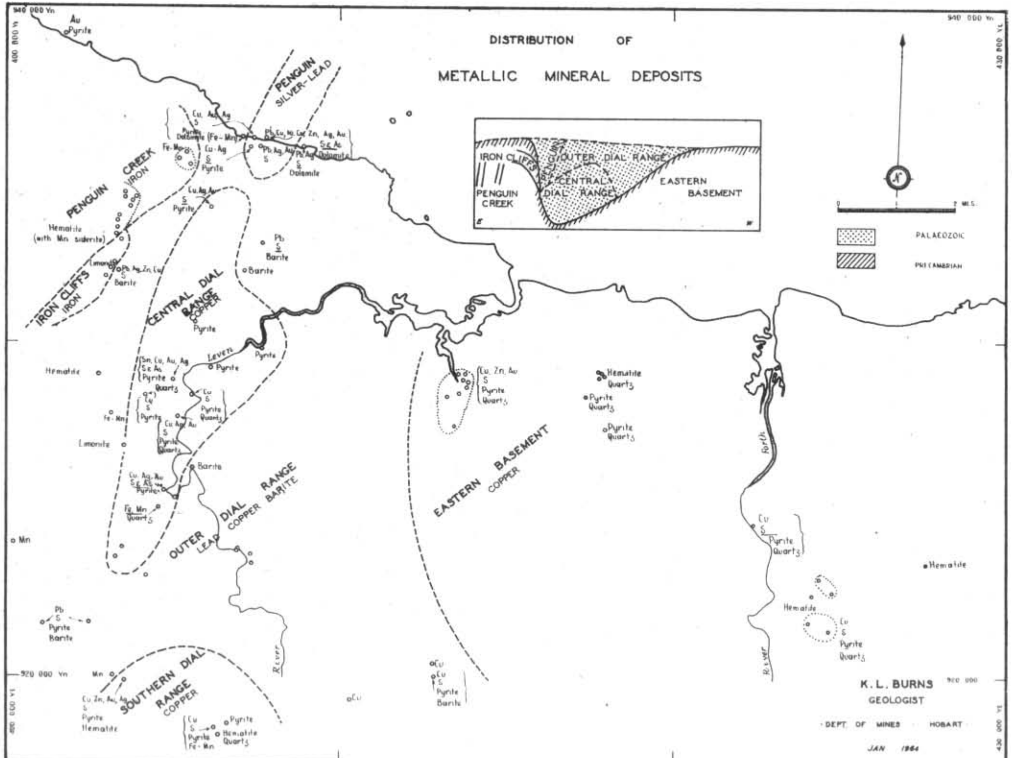

FIGURE 85.

to the graben-forming faults of the West Coast of Tasmania which Campana *et al.* (1958) regarded as major inhomogeneities controlling ore deposition. There is felt to be a real possibility of large replacement deposits occurring near the western margin of the trough, but at considerable depth in the Cambrian (as much as 5000 feet) and below the Ordovician cover—such a deposit would probably be undetectable with present prospecting techniques.

Iron

PENGUIN CREEK

Hematite and limonite occur in the valley of Penguin Creek between 40325E 9332N and 4035E 9344N.

The deposit is a foliated, friable, red hematite containing boulders of dense, blue, "hard hematite" weighing up to 25 tons. In the centre of the deposit, at creek level, some of the hematite has weathered to limonite. The country rock is mudstone and sandstone of the Precambrian Rocky Cape Group. The hematite may be a bedded deposit, but is more probably a fissure-filling—wherever a boundary is exposed of hematite against country rock, the boundary transgresses bedding in the country rock.

Following the discovery by "Philosopher" Smith (Fenton, 1884, p. 388) assays and trial shipments of iron ore were made by Messrs. Law, Brown, and others (Montgomery, 1896). The northern end of the deposit occurs on land owned by Messrs. Hudson, Good, Brown, and Crawford, and was worked by Mr. J. C. Ellis for a Sydney firm, the Tasmanian Iron Company. Between 1897 and 1909, ore was shipped to Cockle Creek for use as metallurgical flux. The southern end of the deposit has been exploited in only a limited fashion, apparently for road metal. The central (weathered) part of the deposit, at 40335E 93365N, has been operated by K. O. Atkins and A. Pearson for earthy iron ore. Limonite has been used as pigment and for scrubbing coal gas, and hematite has been used for cement manufacture.

Montgomery (1896), Twelvetrees (1903) and Twelvetrees and Reid (1919) reported assays of the hematite at the northern end of the deposit ranging from 65% to 69% iron with only small amounts of impurities. Longman (1962) sampled the weathered central portion of the deposit and estimated the available ore as 500 tons of grade 50%-60% iron and 40,000 tons of grade 40%-50% iron.

IRON CLIFFS

Limonite occurs in McBrides Creek about 400 yards above the Iron Cliffs Road at 40312E 93216N as a replacement body of saddle-reef form in sandstone and mudstone of the Rocky Cape Group within 20 feet of the boundary against Cambrian rocks. There is minor replacement of the Cambrian conglomerate. The main body is a nearly vertical sheet between 20 and 50 feet wide which mushrooms upwards into a body at least 400 feet wide and 50 feet thick. It contains relicts of hematite and Rocky Cape Group sandstone veined with siderite, and was considered by Reid (1923) and Burns (1961b) to be an alteration product of Precambrian hematite, the time of alteration being Upper Cambrian.

Workings include Ellis's tunnel, probably driven by the Tasmanian Iron Company, and the Lady Braddon Tunnel driven by the Lady Braddon Development Company. Hutton and Revell quarried some limonite from an open cut at the northern end of the outcrop. Barnes's Prospect is a deposit of manganiferous limonite containing quartz, barite, and traces of gold and silver, at 4033E 9334N. Ling's Prospect is a hematite outcrop at 4034E 9331N. Barnes's and Ling's outcrops were linked by Twelvetrees (1903) and Montgomery (1896) with the Iron Cliffs deposit, from which they are separated by a patch of basalt. Burns, (1961b) discussed this prospect in detail and quoted analyses by Twelvetrees (1903) (48%-59% iron) as well as those from samples from diamond drill cores obtained by the Department of Mines in 1959-60 (highest iron content: 48.4%).

MISCELLANEOUS IRON DEPOSITS

Twelvetrees (1903), Twelvetrees and Reid (1919), Hughes (1953) and others reported on occurrences of a hematite-pebble conglomerate interbedded with Duncan Conglomerate at several places in the Dial Range. Leases have been held on the western side of Mt Riana between 4016E 9264N and 4017E 9269N by W. Jones, F. S. Denney, E. Hobbs and J. O'Neill but no production has been recorded. Workings consist of a number of pits and a short tunnel. Another deposit, on the hillside above the Devon Consols Copper Mine at 4059E 9340N, was prospected by Henry Law and Company and some 300 tons of ore was shipped by the Tasmanian Iron Company for use as metallurgical flux. A similar deposit was prospected on Marsdens Hill at 40497E 93345N.

Ochre

SPALFORD DEPOSIT

On the east side of a by road joining the Clerkes Plains and Moreton Roads, at 4177E 9199N, weathered Tertiary tuff occurs at the level of the Lower Coastal Surface. It contains both limonite and hematite and has been worked of recent years for ochre. Blake (1928d) recorded three analyses as follows:

	1	2	3
SiO_2	28.18	27.40	43.60
Al_2O_3	30.31	30.80	6.15
Fe_2O_3	27.17	28.30	48.30
FeO	1.55	2.06	1.55
CaO	Nil	Nil	Nil
MgO	0.50	0.50	0.27
TiO_2	2.00	1.80	—
Ignition Loss	11.00	10.30	2.00

(1) Grab sample of first-grade yellow ochre.
(2) Grab sample of second-grade yellow ochre.
(3) Fine, earthy hematite.

Mr. A Pearson (Ulverstone Mineral Supplies) has worked the deposit by means of an open cut and exploratory pits.

Production

Year	Tons	Value
		£
1945	61	161
1955	6	18
1956	20	140
1957	22	148
1958	20.5	140
1959	51	304
1960	31	219
1961	75	509
1962	60	390

Pyrite

KEDDIE'S PROSPECT

Pyrite mineralization occurs along Dial Creek from near its junction with the Leven River to 4046E 9292N and at Davies Adit on the bank of the Leven River at 4055E 9284N. The deposit has been known as Keddies Copper and Dial Creek Pyrite. The principal adit was driven for 200 feet into the right bank of Dial Creek near 40505E 92885N. It was reported on by Montgomery (1896), Smith (1899), Twelvetrees (1903), Blake (1940b), Hughes and Everard (1952) and Hughes (1952a).

The mineralized zone is a "breccia" close to the margin of the Lobster Creek Volcanics. This may be a fault breccia within the volcanics or at its southern edge, but it is more likely to be a conglomerate or a pyroclastic interbedded within the volcanics.

The mineralization is quartz and pyrite with chalcopyrite, and siderite, and is oxidized in places. The pyrite contains traces of tin. The bulk composition is 50% pyrite, or 25% sulphur (Hughes, 1953).

Assays

	(1)	(2)	(3)	(4)
Gold	20 grn.	Trace	1 dwt. 15 grn.	Nil
Silver	6½ dwt.	3 dwt. 6 grn.	Nil	Nil to 18 grn.
Copper	Nil	—	Nil	Trace to 0.2%
Tin	—	—	—	Nil to 0.1%

(1) Pyrite } Montgomery (1896).
(2) Gossan }

(3) Pyrite (Smith 1899).
(4) Range of 8 samples (Hughes and Everard, 1952).

REVELL'S PROSPECT

Revells Prospect is located on the right bank of Revells Creek near 4042E 92845N. The deposit has also been known as "Sykes and Revells". It is a replacement deposit in beds of mudstone and conglomerate in the formation overlying the Lobster Creek Volcanics. Mineralization is pyrite with copper staining. Development is largely confined to a single adit.

Manganese

BLACK'S PROSPECT

On top of a spur on the north face of Mt Duncan at 40315E 9279N, there is a replacement by manganiferous hematite of flat-lying Cambrian conglomerate just beneath the Duncan Conglomerate, with surface enrichment and minor fissure fillings in underlying mudstone. The area has been held intermittently under leases since 1908, but the only record of production is a sample parcel of ore produced in 1941 by A. G. Black, weighing 0.581 tons and valued at £2 7s.

Rowe (1963) reported on the area and gave a detailed description of all work done there. He published a table of analyses taken by various people at various times with a manganese content ranging up to 43.8% for a picked sample taken by Blake (1940a), and estimated reserves tentatively at 30,000 tons of manganese ore.

Titanium

Anatase, brookite and rutile occur in the Clayton River, Little Clayton River, Orchard Creek, and surrounding country (Gould, 1867; Petterd, 1910; Blake, 1928c). Anatase also occurs in the Forth River near Forth and rutile in Penguin Creek (Petterd, 1910). A heavy-mineral layer in Tertiary sand at Parkers Ford carries 67% ilmenite and a small amount of rutile according to a sample received for investigation by the Department of Mines Laboratory (Reg. No. 117).

CLAYTON RIVER DEPOSITS

On the top of the hill west of where the Clayton River emerges onto the Marine Platform (4197E 9300N), a sub-basaltic quartzite (cemented wash) contains rutile, which "occurs in large quantities in grains and slightly waterworn crystals up to ½-inch in length . . . the crystals are usually well-formed, including angulated twins, but have mostly rough faces. The colour varies from light to dark reddish-brown. Metagenic twins are of frequent occurrence" (Petterd, 1910, p. 154).

In a gully on the eastern side of the Rifle Range Road (4198E 9279N), basalt overlies sub-basaltic wash which overlies Precambrian schist. Workings include a tunnel and a number of pits. From uncemented wash Blake (1928c) panned rutile at the rate of 1.07 and 1.12 lbs per cubic yard. From these workings half a ton of rutile was shipped, but the price was unsatisfactory.

Blake (1928c) recorded rutile in Quaternary deposits as listed in the table below:—

Locality	*Coordinates*	*Rutile lb./cu.yd.*	*Deposit*
Mouth of a small creek in the Clayton River	41845E 92790N	0.29	Stream bed
Clayton River, upstream from Little Clayton junction	41845E 92715N (approx.)	0.32	Creek bank
Little Clayton, upstream from Orchard Creek junction	41815E 92505N (approx.)	1.16	Stream bed
Orchard Creek	41720E 92545N	0.75	Stream bed
Orchard Creek	41720E 92500N	0.64	Creek bank
Orchard Creek	41735E 9244N	2.36	Creek bank
Orchard Creek Headwaters	41750E 9244N	2.04	Stream bed

Possibly there is a source in the divide between the Little Clayton River and Orchard Creek.

Silver-Lead

PENGUIN MINE

Silver-Lead was worked on the foreshore east of Penguin near 4077E 93605N at the Penguin Mine. The country rock is Beecraft Megabreccia intruded by stocks of Cambrian keratophyre. Near the mine the Beecraft Megabreccia has autochthonous (or "matrix") rock consisting of greywacke conglomerate with chert pebbles and spilitic debris. The allochthonous rocks are large slabs of "welded" spilitic tuff. The stock is crowded with xenoliths and pyrite is abundant in all rock types.

The mineralization is unusual and the deposit appears to be an orthomagmatic one related to the stock. The minerals occur in small veins, the pattern being variously described as veins running E-W (Gould, 1867), veins running in all directions (Thureau, 1882), a stock-work with a general north or NE trend (Montgomery, 1896) or a mesh of veinlets (Twelvetrees, 1906b).

Gould (1867) reported strings of copper with blue and green carbonates and "grey copper ore". Thureau (1882) reported cupriferous pyrite and native copper in hornstone (allochthonous welded tuff?), and a network of ferruginous veins and masses of iron pyrite in a dyke of hornblendic porphyry (probably the stock, which contains tremolite). Thureau collected fahlerz embedded in iron pyrite, quartz, calcite, and barite. He recorded lodes with galenite, fahlerz, and native silver beneath gossanous caps.

Fenton (1884, p. 360) wrote "The assay of J. Cosmo Newbery proved the ore to contain gold, silver, copper, lead, nickel, cobalt, manganese, and iron." Thureau (1884) recorded the presence of fahl-ore (argentiferous tetrahedrite). Montgomery (1896) recorded veins of quartz and dolomite containing chalcopyrite, pyrite, galena, blende, native silver, and arsenical grey copper ore. He thought the arsenical grey copper ore was epigenite, or possibly tennantite, and was told it carried 230 oz. silver per ton. Twelvetrees (1903) saw these assay returns, but apparently regarded them with suspicion. However, the assays were of selected mineral samples and not of run-of-mine ore.

Samples of second-class ore were collected by Montgomery and assayed:

Gold—1 dwt 15 grn/ton
Silver—27 oz 15 dwt 18 grn/ton
Copper—3.4%
Nickel—2.5%
Cobalt—0.8%
Lead—10.8%
Antimony—Trace
Zinc—Nil

Petterd (1910) recorded the following mineral assemblage:—galena, sphalerite, arsenopyrite, arsenolite, tetrahedrite, melaconite, native copper, azurite, annabergite, millerite, nickeliferous pyrrhotite, smaltite, cobaltite, erythrite, and native silver. He also recorded asbolite at the Penguin River.

Smith (1899) described a gangue of calcite, dolomite, steatite, bright green chlorite, magnesite, and pyrite containing chalcopyrite, tetrahedrite, galena, and sphalerite. He reported a prospect assay returning:—

Gold—15 grn/ton
Silver—1 oz 18 dwt/ton
Copper—0.5%
Lead—0.5%

Twelvetrees (1903) recorded a pyritic siliceous dolomite, the pyrite carrying 1½ oz silver per ton. He reported one assay of the ore, of 8 dwt silver per ton: a second of 4 oz silver per ton; and a third of 12 dwt silver, trace of gold, and 1% copper.

The ore appears to have been oxidized, the veins having well-developed gossans, despite their occurrence in the intertidal zone. In order of abundance, the principal minerals appear to have been: pyrite, galena, chalcopyrite, grey arsenical copper ore (probably tennantite, with high silver values in selected samples), nickeliferous pyrrhotite and millerite, cobaltite and smaltite, native silver (as frondose patches in gossan), and native copper (in scaly and hackly forms in spilitic tuff) (compare Carey and Scott, 1954).

This discovery of galena at Penguin in 1861 (the second in Tasmania according to Petterd, 1896, p. 39) is generally credited to "Philosopher" Smith (Fenton, 1891, p. 71; Skemp, 1963). The Penguin deposit was the first to be worked (in 1870 according to Petterd, 1896).

The Penguin Silver-Lead Mining Company commenced operations on the 7th June, 1871 with an elaborate treatment plant (Fenton, 1884, p. 360), but operations ceased soon after June, 1872 (Skemp, 1963). A Melbourne syndicate took over the mine shortly before 1899, unwatered the shaft, and cleared out the drives, but had ceased operations by 1903.

Although the workings were described by Thureau (1882), Montgomery (1896) and Twelvetrees (1903, 1906b), the only first-hand description of the underground workings was by Smith, (1899).

NEPTUNE MINE

This is on the foreshore east of Penguin on the western side of Teatree Point near 40885E 9358N. The location of the main shaft is shown in Figure 7.

The country rock is the Teatree Point Megabreccia, a correlate of the Beecraft Megabreccia, underlain by Motton Spilite at depth and intruded by dykes of Cambrian keratophyre.

The autochthonous, or matrix, rock is greywacke conglomerate with pebbles and boulders of spilite and chert and with some beds of mudstone, sandstone, and chert-granule conglomerate. The allochthonous rocks are large slabs, up to 30 feet long, of thin-bedded magnesian limestone, massive calcareous dolomite, and red and yellow chert.

The mineralization occurs in a wide vein which strikes between 320° and 330° and dips SW at 75° (Hughes, 1953) with smaller fissures. The lode was interrupted by a dyke of keratophyre, north of which the ore is sensibly more argentiferous (Thureau, 1882).

Gould (1867) described a galena vein one foot in thickness at Teatree Point. Thureau (1882) recorded galena, calcite and heavy spar, the galena carrying 25 oz silver per ton. Thureau (1884) recorded antimonial silver (dyscrasite). Montgomery (1896) recorded siderite, and galena carrying 29-45 oz silver per ton. Twelvetrees (1903) recorded galena and chalcopyrite, and assays as follows:—

Sample	*Silver* (oz/ton)	*Lead* (%)
Galena and cerussite	36	66
Galena (upper level)	24	67
Galena (lower level)	28	69
Lode matter	5½	a few
Bagged ore	24	60

Peart's Shaft was sunk alongside the lode by the Neptune Silver-Lead Mining Company, sometime after 1871, as it was sunk later than the Penguin Mine Shaft (Thureau, 1882; Twelvetrees, 1903). By 1873 the shaft was down 50 feet and the lode intersected in a cross-cut (Twelvetrees, 1903). Some ore was raised, and some was smelted on the beach (Montgomery, 1896).

The workings were deserted in 1895, but were re-opened in 1897 by Mr. Ellis, in an unsuccessful attempt to reach the main lode (Twelvetrees, 1903). The mine was operated for a short time during the 1914-18 war, by W. B. Revell (Hughes, 1953).

WATCOMBE PROSPECT

The Watcombe Prospecting Company followed the "hornstone" inland from the Penguin Mine, and at the foot of the hill opened up a lode containing native copper, and argentiferous auriferous pyrite carrying 3% copper and 5 oz silver per ton (Thureau, 1882, 1884). Montgomery (1896) found traces of gold and silver in spoil from an old shaft near General Wilson's house. The location is probably near 40735E 93585N.

MISCELLANEOUS ARGENTIFEROUS DEPOSITS

Hardy's Lode

Ten chains at 235° from the Penguin Mine, Montgomery (1896) reported galena and cerussite in clayey gossan, assaying 49.3% lead, traces of gold, and 8 oz 14 dwt 8 grn silver per ton. Twelvetrees (1903) reported Hall driving a new tunnel on the deposit. The location is probably near 4076E 9358N.

Sullocks Lode

Montgomery (1896) reported chert outcrops containing pyrite and magnetite, and lode material consisting of iron oxide, dolomite, pyrite, native copper, copper carbonates, and pyrrhotite, at high water mark near 4074E 9361N. A low angle fault intersects the Beecraft Megabreccia in this vicinity. Twelvetrees (1903) found siliceous dolomite with argentiferous auriferous pyrite, quartz, and magnetite. Montgomery (1896) recorded assays as follows:—

Sample No.	*Gold*	*Silver*
8	1 dwt 15 grn	8 dwt 4 grn
10	2 dwt 9 grn	8 dwt 4 grn
13	Traces	Traces

Sample 13 was magnetite-rich country rock; sample 8 was from a lode containing quartz, pyrite, pyrrhotite, magnetite and dolomite: and sample 10 was a lode containing quartz, iron oxide, pyrite and dolomite.

The mineralization is visible at the present time, although the main deposit appears to have been covered during railway construction.

Badgers Prospect

In McBrides Creek there are sulphide deposits, mainly in Cambrian rocks on the eastern side of the Iron Cliffs limonite deposits.

Montgomery (1896) recorded lead, zinc, iron and copper sulphides, occurring with dolomite. Smith (1899) recorded pyrite, green copper stainings, and rubbly quartz containing native copper. Twelvetrees (1903) recorded galena, native copper, zinc blende, chalcopyrite and pyrite. In the drilling of 1960, wide veins of barite were found at the footwall of the limonite body and in Cambrian mudstone. Twelvetrees (1903) recorded assays of lode-matter containing 44% lead and 13 oz silver per ton. Burns (1961b, p. 133) found traces of gold in barite veins and traces of silver in siderite veins in Rocky Cape Group rocks. In late faults intersecting the limonite he found traces of silver, lead, and copper.

The mineralization is a fissure-replacement type in Tabberabberan faults intersecting Cambrian mudstone and conglomerate.

The sulphides were discovered by Hall about 1895. Montgomery (1896) found cuttings and Smith (1899) found tunnels driven by Badger and Hall. The area was held by McKenna and Rogers and some work was in progress in 1903. There was a small production of galena, three tons carrying ½ oz silver being recorded by Twelvetrees (1903).

Hutton's Prospect

This was reported as being a "couple of miles south-west" of the Hardstaff Creek-Leven River junction (Twelvetrees, 1903). It is probably in the headwaters of Walloa Creek near 40245E 92165N (Hughes, 1953).

Small veins carrying quartz and galena were opened up by means of a shaft and adit between 1903 and 1953.

Heazlewood's Prospect

On the Leven River, 7 miles SW of Ulverstone, south of Griffin's 30 acres (Twelvetrees, 1909b, p. 23; see also 1904, p. 37), which is south of Allison's Road and north of Gunns Plains, galena was reported carrying 15% to 20% lead and 36 oz silver per ton.

The deposit was discovered in 1891 by Lines and Elliott. Galena from here was exhibited at the Launceston Exhibition of 1891. The deposit was idle for a time after 1891, then £300 to £400 was spent on it. Workings consist of shafts and tunnels.

Barite

SULLOCKS HILL

A barite deposit is located at 4079E 9328N on the eastern side of Sullocks Hill. Another adit occurs further south, near 4071E 9321N.

The barite occurs with galena. It is tabular, crystalline, pearly with an inherent grey colour, assaying as follows:—

	%
SiO_2	0.46
$BaSO_4$	96.40
Al_2O_3 plus Fe_2O_3	0.50
MgO	0.14
Ignition Loss	0.60

The southern adit is driven at 317° into black and white banded chert. Blake (1928e) located the northern adit on the 24-acre block purchased by T. E. Revell near 4077E 9330N. Barite occurred as hillside debris but trenches failed to find the lode. Hughes (1953) found a tunnel driven into the hillside near 4079E 9328N. A small galena lode was found, with a lode of barite 6 feet wide on the footwall of the galena lode.

KAINE'S PROSPECT

South-west of Mt Lorymer, on Kaines Creek, at 4011E 9216N, the barite occurs as fissure-fillings in Cambrian conglomerate. The bulk of the deposit is of good quality with specks and threads of chalcopyrite and pyrite. Recorded assays are as follows:—

	(1)	(2)	(3)
SiO_2	1.30	0.90	0.4
$BaSO_4$	93.50	95.9	98.6
Fe_2O_3 plus Al_2O_3	1.90	1.06	0.3
CaO	1.50	Tr.	—
MgO	0.39	0.25	—
Ignition Loss	0.98	0.50	—

(1) First grade } Blake (1928e).
(2) Ironstained }
(3) Chip sample (Hughes, 1953).

Copper

Devon Consols

This deposit is located on a branch of Myrtle Creek one and a half miles south of Penguin near 4061E 9340N. It had been opened up by surface cuttings and two prospecting shafts when Thureau (1882) gave a detailed description of the vein and a drawing of its appearance in the shaft. The gossan contained native copper. Below the gossan the country rock was porphyry, and the centre of the fissure was occupied by soft, black copper oxides mixed with native copper. Picked ore assayed 32% copper while the vein in bulk (over a width of 5 feet) assayed 19% copper.

Shafts and a tunnel were opened up between 1882 and 1896. As the drive went westward, the wall-rock became conglomerate with discontinuous veins of pyrite on the hanging wall (Montgomery, 1896). An assay of 32% copper was reported to Montgomery who was also told of " as much as 6 ounces of gold to the ton, and in one case 7 per cent (sic) of silver, which I hardly credit ". His own samples of pyrite yielded only traces of copper and gold, and silver at the rate of 1 oz 1 dwt 5 grn per ton.

The deposit occurs in a fault zone striking 312° and dipping at 80° to the NE. The occurrence is close to the contact between Ordovician and Cambrian rocks but is apparently below it, as the conglomerate is a mudstone-pellet type and is probably Cambrian. The varying descriptions of the lode suggest that there was surface enrichment at its eastern end, at the level of the valley floor.

Dial Copper

This prospect is located in Stanton Creek near 4051E 92785N. The mineralization is replacement of " breccia " at the edge of the Lobster Creek Volcanics. The " breccia " is probably Cambrian conglomerate in the formation overlying the volcanics.

The mineralization is pyrite, with bunches of chalcopyrite, tarnished with melaconite and coloured oxides. The pyrite carries no silver, and gold from traces to 1 dwt 15 grn; the chalcopyrite carries traces of gold, and silver from 15 dwt to 3 oz (Twelvetrees, 1906b).

Assays

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Copper	3.2%	1.6%	8.2%	9.1%	23.6%	3.5-17.6%	4.9%	7.2%
Silver	Tr	15 dwt	68 oz	Nil	2 oz	1-3 oz	Nil	1 oz
Gold	Tr	Tr	3 dwt	4 dwt	Nil	Nil-Tr	Tr	Tr

(1) "Fair average sample" across a width of 6 feet (Smith, 1899).
(2) Lode matter
(3) Selected ore
(4) Parcel of 6 cwt sent to Smelters
(5) Selected ore, Broken Hill assay
(6) Range of 9 pyrite samples, Stone's assay
(7) Assay for E. Braddon
(8) Assay for F. S. Denney
} Twelvetrees (1903).

Workings include tunnels, shafts and pits, sunk by the Dial Range Prospecting Association (c. 1898-1900) and P. H. Sams (c. 1903) among others.

RUSSELL'S PROSPECT

This is located near the mouth of Hardstaff Creek at 4047E 9256N. The workings have also been known as "Hardstaff and Rogers" and "Rogers and McKenna's". The deposit is apparently a fissure filling in the Kerrison Volcanics or in mudstone adjacent to it. There is some replacement along bedding in the mudstone. It was reported on by Twelvetrees (1903; 1906b) who recorded the following assays:—

	(1)	(2)	(3)	(4)	(5)
Copper	40.7%	—	—	19.48%	6.49%
Silver	2 oz	4 oz	Up to 20 oz	12 oz 15 dwt	17 oz 19 dwt
Gold	—	1 dwt	1-4 dwt	Nil	Tr.

(1) Two-inch vein of chalcopyrite and glance.
(2) Pyrite.
(3) Mine assays
(4) Lode as mined
(5) Across lode in winze.

Mineralization is barite, quartz, siderite, arsenical iron and copper pyrite and glance. Pyrite from the outcrop returned gold at the rate of 1 dwt and higher.

An adit was driven NW for 200 feet from a point 50 feet below the outcrop. It intersected a small lode at 108 feet containing copper and iron pyrite which was followed south for 20 feet.

Gold

There has been a considerable amount of prospecting for gold, especially in the Gawler district, but nothing of any importance has been found. Thureau (1882) inspected some prospects along the Castra Road, near Ulverstone, remarking that the rocks "have been included amongst the auriferous class because they are being prospected for gold, though such metal had not yet been discovered at the time of my inspection". Montgomery (1896) reported on a little work near the Gawler River about two miles from Ulverstone. Although "a little gold was seen", prospects generally were very poor.

A few colours have been reported from Buttons Creek and vicinity and some assays record small amounts of gold (see assays under "Copper" and "Silver-Lead").

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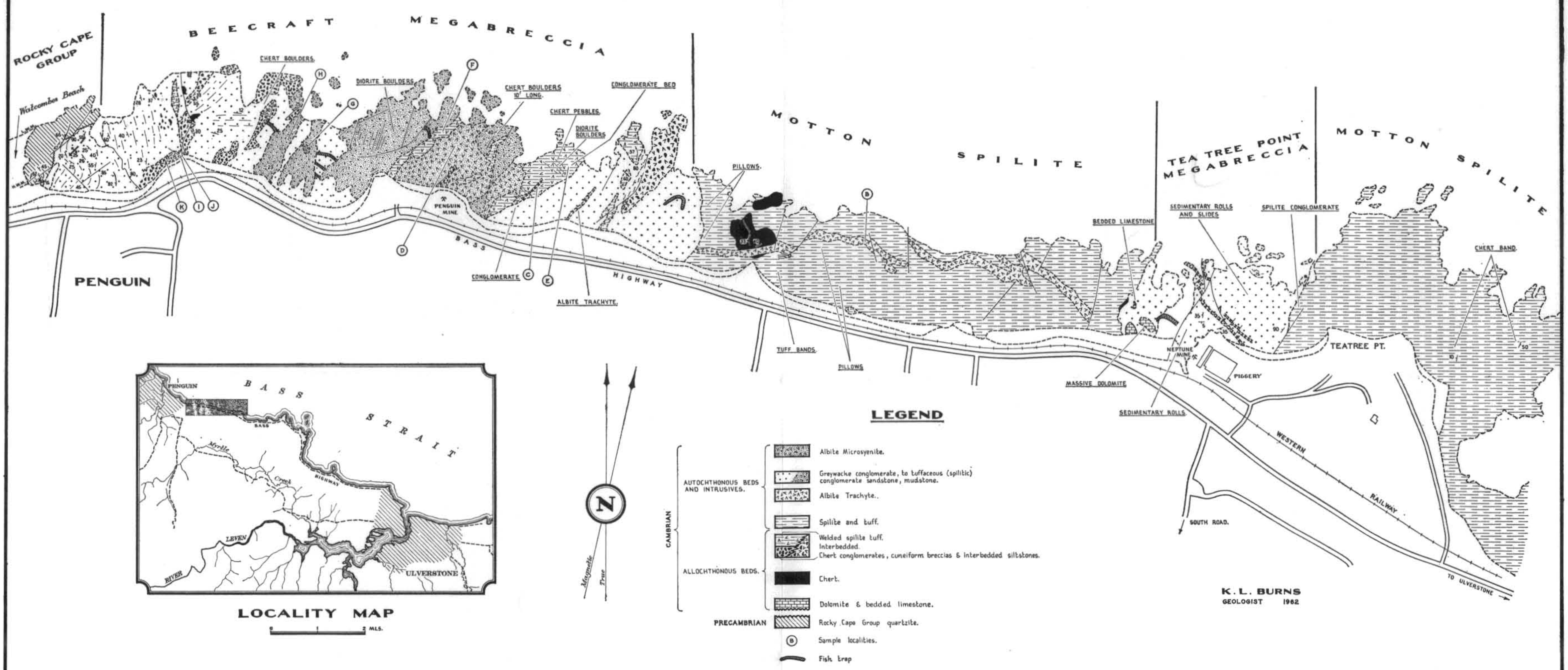
FIG. 7

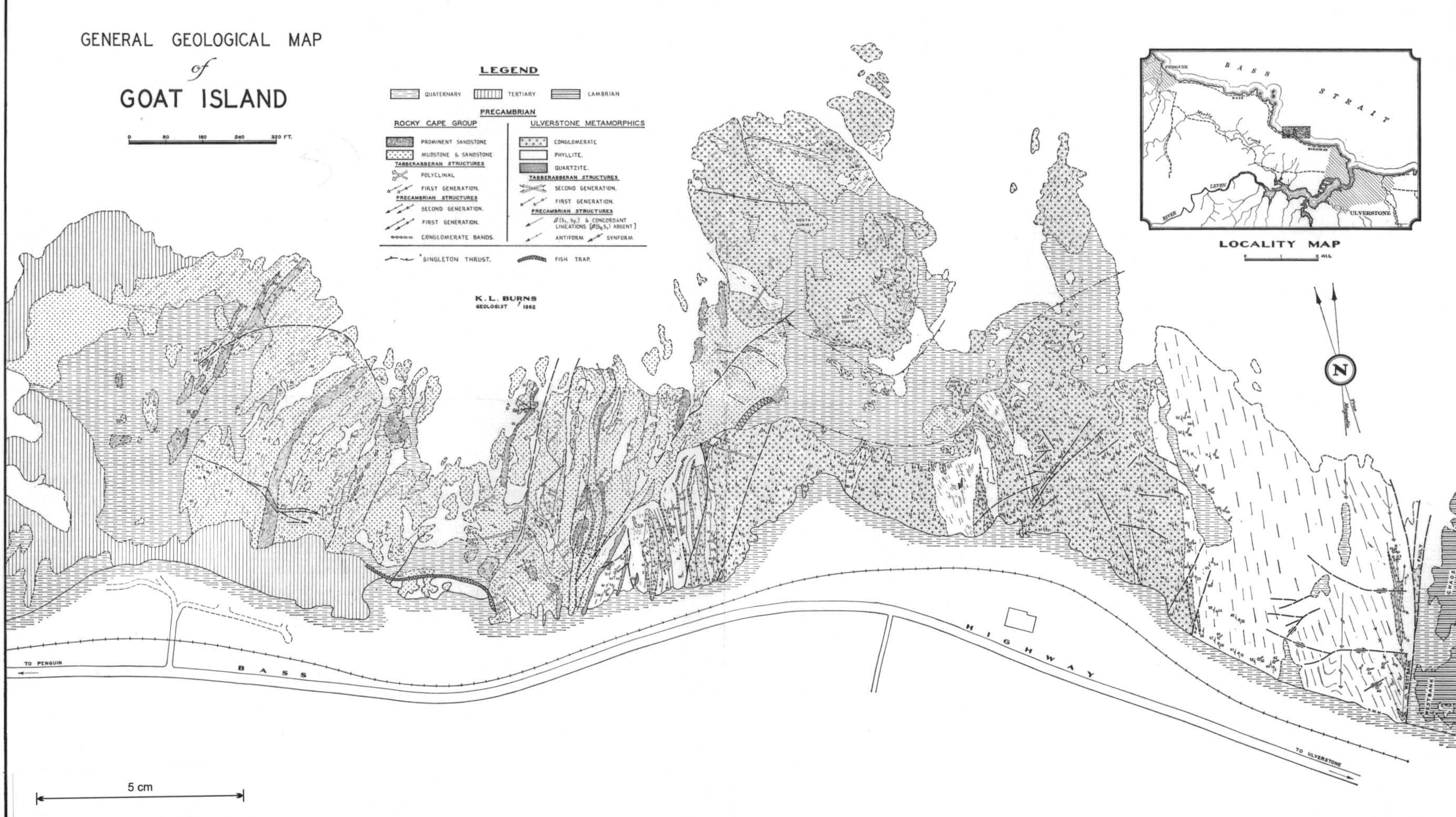


THE BEECRAFT MEGABRECCIA MAP

0 200 400 600 800 1000 1200 1400 1600 FEET.

5 cm

FIG. 27



GENERAL GEOLOGICAL MAP
of
GOAT ISLAND
0 80 160 240 320 FT.
LEGEND
QUATERNARY
TERTIARY
CAMBRIAN
PRECAMBRIAN
ROCKY CAPE GROUP
PROMINENT SANDSTONE
MUDSTONE & SANDSTONE
TABBERABBERAN STRUCTURES
POLYCLINAL
FIRST GENERATION.
PRECAMBRIAN STRUCTURES
SECOND GENERATION.
FIRST GENERATION.
CONGLOMERATE BANDS.
ULVERSTONE METAMORPHICS
CONGLOMERATE
PHYLLITE.
QUARTZITE.
TABBERABBERAN STRUCTURES
SECOND GENERATION.
FIRST GENERATION.
PRECAMBRIAN STRUCTURES
$\beta(S_1, S_2)$ & CONCORDANT LINEATIONS [$\beta(S_0 S_1)$ ABSENT]
ANTIFORM
SYNFORM
SINGLETON THRUST.
FISH TRAP.
K.L. BURNS
GEOLOGIST 1962
BASS STRAIT
ULVERSTONE
LOCALITY MAP
N
TO PENGUIN
BASS HIGHWAY
TO ULVERSTONE
5 cm

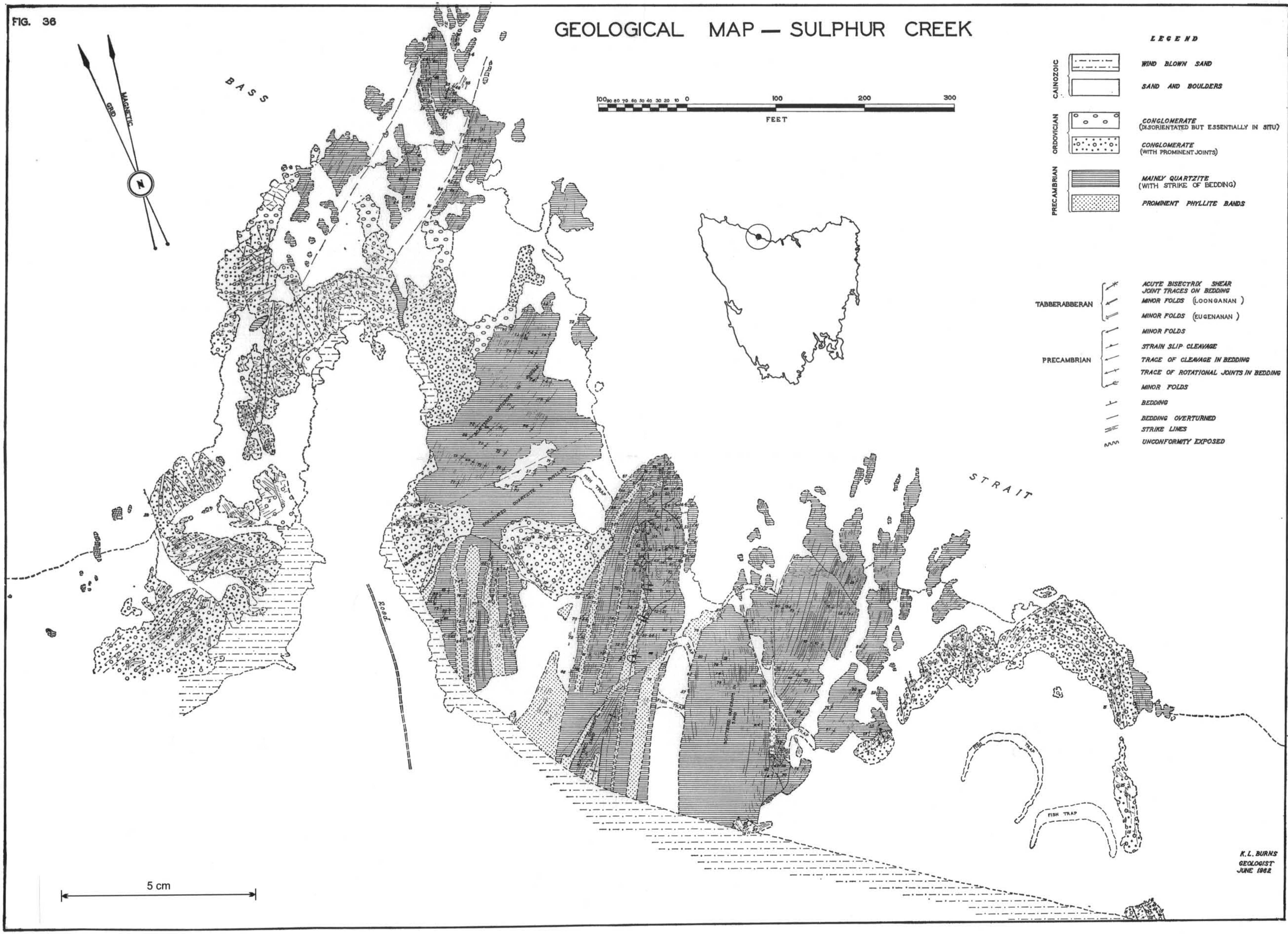


FIG. 36
GEOLOGICAL MAP — SULPHUR CREEK
LEGEND
CAINOZOIC
WIND BLOWN SAND
SAND AND BOULDERS
ORDOVICIAN
CONGLOMERATE (DISORIENTATED BUT ESSENTIALLY IN SITU)
CONGLOMERATE (WITH PROMINENT JOINTS)
PRECAMBRIAN
MAINLY QUARTZITE (WITH STRIKE OF BEDDING)
PROMINENT PHYLLITE BANDS
TABBERABBERAN
ACUTE BISECTRIX SHEAR JOINT TRACES ON BEDDING
MINOR FOLDS (LOONGANAN)
MINOR FOLDS (EUGENANAN)
PRECAMBRIAN
MINOR FOLDS
STRAIN SLIP CLEAVAGE
TRACE OF CLEAVAGE IN BEDDING
TRACE OF ROTATIONAL JOINTS IN BEDDING
MINOR FOLDS
BEDDING
BEDDING OVERTURNED
STRIKE LINES
UNCONFORMITY EXPOSED
100 90 80 70 60 50 40 30 20 10 0 100 200 300
FEET
MAGNETIC
GRID
N
BASS
STRAIT
Road
FISH TRAP
5 cm
K. L. BURNS
GEOLOGIST
JUNE 1962

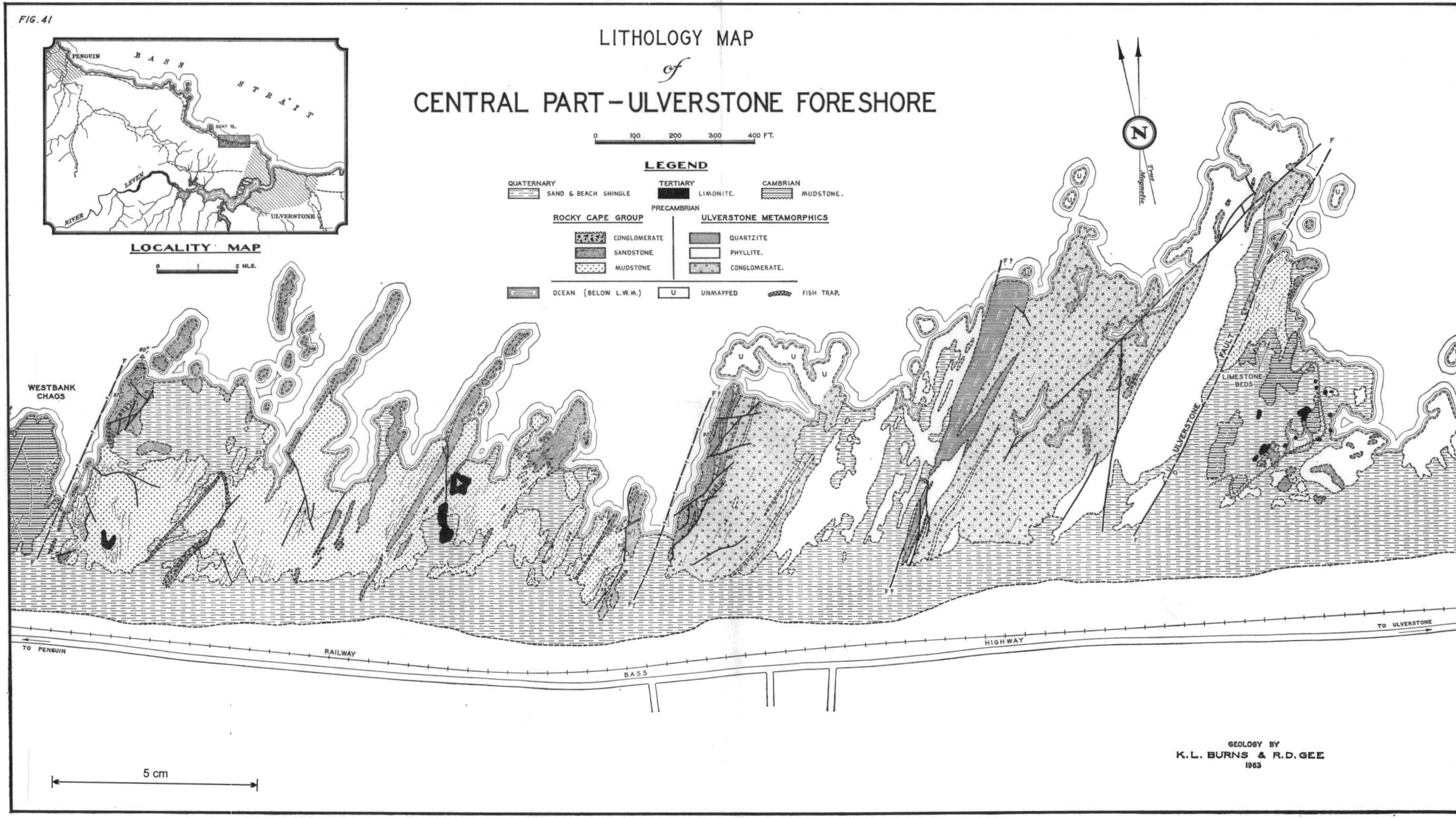


FIG. 41
LITHOLOGY MAP
of
CENTRAL PART - ULVERSTONE FORESHORE
0 100 200 300 400 FT.
LEGEND
QUATERNARY
SAND & BEACH SHINGLE
TERTIARY
LIMONITE.
CAMBRIAN
MUDSTONE.
PRECAMBRIAN
ROCKY CAPE GROUP
CONGLOMERATE
SANDSTONE
MUDSTONE
ULVERSTONE METAMORPHICS
QUARTZITE
PHYLLITE.
CONGLOMERATE.
OCEAN (BELOW L.W.M.)
U
UNMAPPED
FISH TRAP.
PENGUIN
BASS STRAIT
GOAT IS.
RIVER LEVEN
ULVERSTONE
LOCALITY MAP
0 1 2 MLS.
N
True
Magnetic
WESTBANK CHAOS
LIMESTONE BEDS
ULVERSTONE FAULT
TO PENGUIN
RAILWAY
BASS
HIGHWAY
TO ULVERSTONE
GEOLOGY BY
K.L. BURNS & R.D. GEE
1963
5 cm

ER8115N

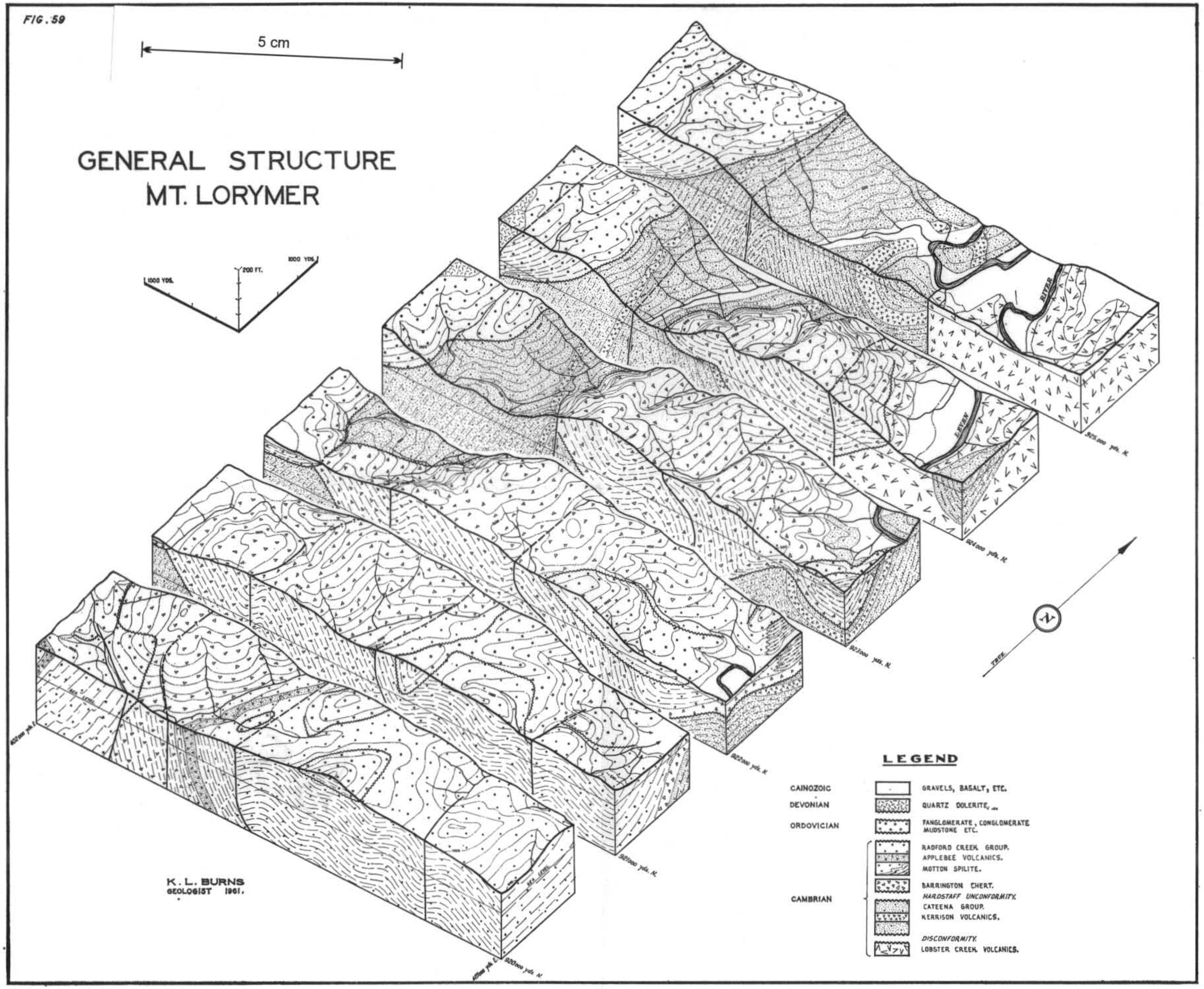


FIG. 59
5 cm
GENERAL STRUCTURE
MT. LORYMER
1000 YDS.
200 FT.
1000 YDS.
925,000 yds. N.
924,000 yds. N.
923,000 yds. N.
922,000 yds. N.
921,000 yds. N.
920,000 yds. N.
RIVER
LEVEN
SEA LEVEL
N
TRUE
LEGEND
CAINOZOIC
GRAVELS, BASALT, ETC.
DEVONIAN
QUARTZ DOLERITE, ..
ORDOVICIAN
FANGLOMERATE, CONGLOMERATE
MUDSTONE ETC.
CAMBRIAN
RADFORD CREEK GROUP.
APPLEBEE VOLCANICS.
MOTTON SPILITE.
BARRINGTON CHERT.
HARDSTAFF UNCONFORMITY.
CATEENA GROUP.
KERRISON VOLCANICS.
DISCONFORMITY.
LOBSTER CREEK VOLCANICS.
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GEOLOGIST 1961.

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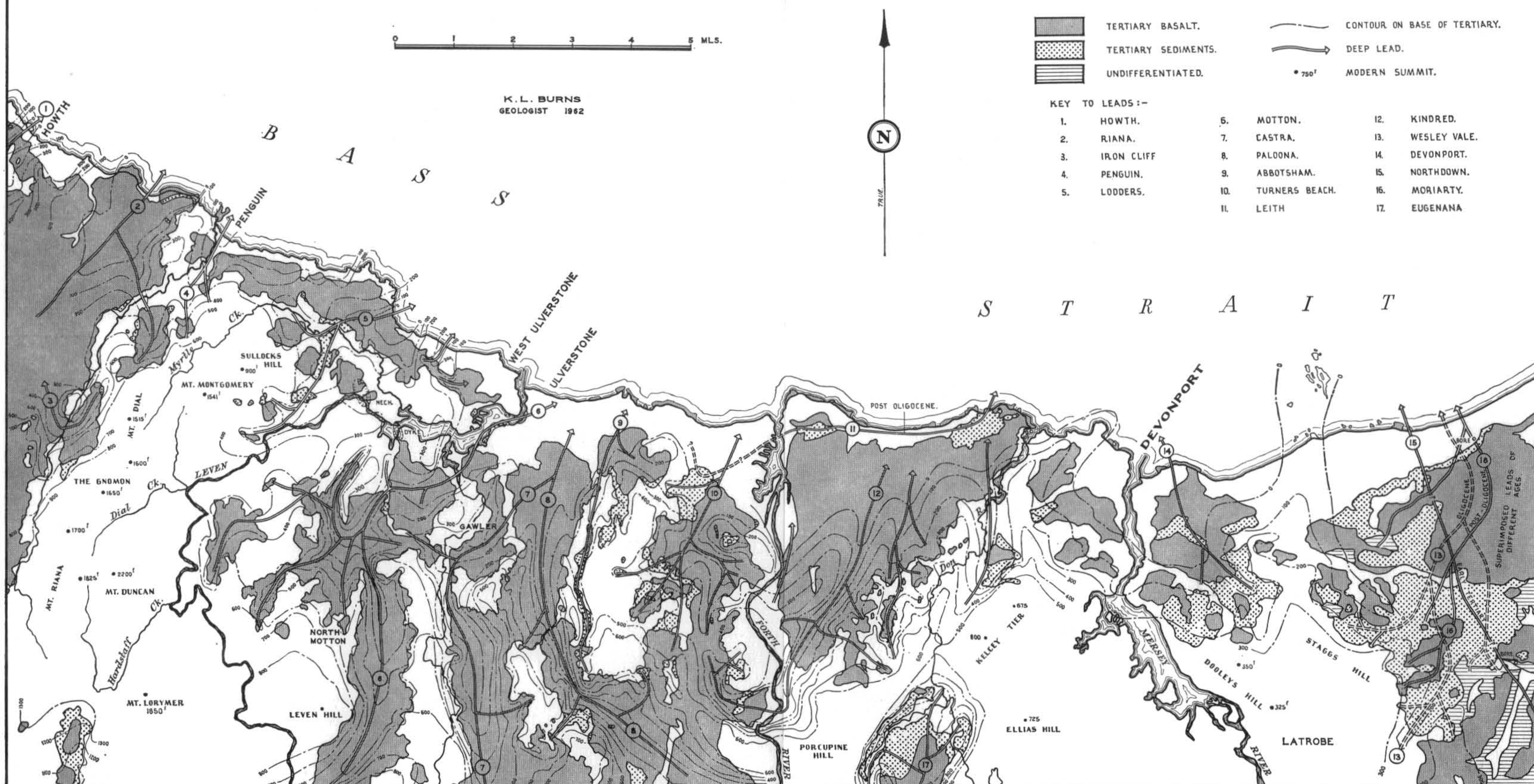
FIG. 76

DEEP LEADS – DEVONPORT QUADRANGLE



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