GEOLOGICAL SURVEY
EXPLANATORY REPORT

SHEET 44
MACKINTOSH

GEOLOGICAL SURVEY EXPLANATORY REPORT

GEOLOGICAL ATLAS 1 MILE SERIES

ZONE 7 SHEET 44 (8014N)

MACKINTOSH

compiled by P. L. F. COLLINS, B.Sc.(Hons),
A. B. GULLINE, B.Sc., and
E. WILLIAMS, B.Sc.(Hons.), Ph.D.

with contributions by T. G. SUMMONS, B.Sc.,
and V. M. THREADER, M.Sc.
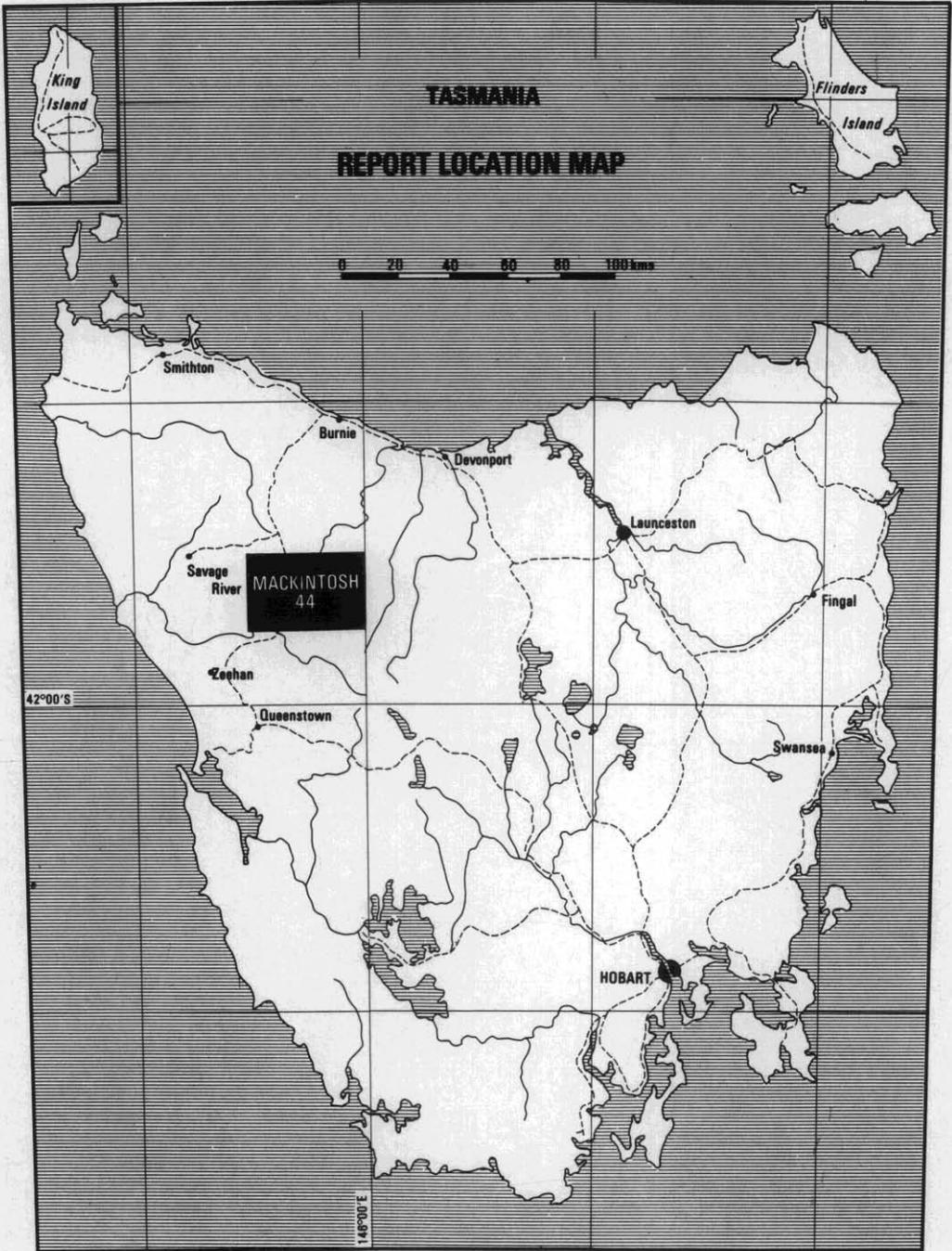
Figure 1. *Location of Mackintosh Quadrangle*

CONTENTS

LIST OF FIGURES

LIST OF PLATES

INTRODUCTION

The Mackintosh Quadrangle covers the region drained by the Mackintosh River system and lies between latitude 41°30' and 41°45'S and longitude 145°30' and 146°00'E (fig. 1). Previous geological surveys have been mainly reconnaissance in nature, and reference to these studies is given at appropriate places within this report.

Mapping was carried out mainly during periods from December to March inclusive, 1963 to 1966. A complete air photo cover was available and topographic maps on a scale of 20 chains to the inch, contoured at 50 foot intervals, were used as base maps. The following geologists took part in the geological survey; C.M. Barton, K.L. Burns, R.D. Gee, D.I. Groves, A.B. Gulline, D.J. Jennings, M.J. Longman, B. Marshall, W.L. Matthews, W.R. Moore, I.H. Naqvi, V.M. Threader and G. Urquhart. These studies were made under the supervision of E. Williams.

The following report has been compiled by P.L.F. Collins, A.B. Gulline and E. Williams from the notes of the geologists listed previously, unless stated otherwise. The individual geologists responsible for the information given are referred to wherever possible by their initials within brackets. Geological work done since the publication of the map is indicated.

The map sheet was published in 1966 on a scale of 1:63 360; a simplified map is given as Figure 2.

The only permanent settlement in the quadrangle is Tullah [660610]*, a village initially dependent on silver-lead mining which started in 1899. Tullah was linked to the Emu Bay Railway by a horse drawn tramway in 1902, this tramway being rebuilt as a 610 mm gauge steam tramway in 1907. The Murchison Highway was completed in 1963 and this affords Tullah access to towns on the north coast as well as to those to the south. There are some vehicular side-tracks along the highway extending a few kilometres to the east and the west. A number of vehicular tracks at the northern and eastern boundaries of the quadrangle provide access to extensive grassy plains. These plains are unsuitable for cultivation but have been used for the summer grazing of cattle and sheep. Some timber is cut from the surrounding forested areas.

Access to the eastern part of the quadrangle is by road from Wilmot to Cradle Valley [950727] in the Cradle Mountain - Lake St Clair National Park. Access to most of the areas between the Murchison Highway and the Cradle Mountain Road is mainly by walking tracks.

PHYSIOGRAPHY

The basalt plains on the northern and north-eastern margins of the quadrangle and the Cradle Mountain plateau on the eastern margin form major drainage divides between the rivers draining north to Bass Strait and the Pieman River system draining west to the Southern Ocean.

The Cradle Mountain plateau is part of the high area around Cradle Mountain [956669] and Barn Bluff [930622], where remnants of a flat-lying Permian succession cover portions of the Precambrian basement. The Permian succession has been intruded by a sill of dolerite, which caps the higher peaks (plate 6). Whereas the major landforms are related to the underlying geology, the details of the landscape were formed by Pleistocene glaciation

---

* All localities lie within the kiloyard grid square 38, Zone 7.

REFERENCE

Permian; glacio-marine and freshwater sequences.

Ordovician - Silurian dominantly siliceous clastic and limestone sequences.

Cambrian; dominantly volcanic rocks, volcani-clastic and turbidite sequences.

Precambrian; dominantly metaquartzite phyllite and schist.

Igneous Rocks

Tertiary basalt.

Jurassic dolerite.

Devonian granite.

Fault.

Geological boundary

Hinge line of major folds - syncline, anticline.

(Cross-sections in Figure 5)

5 cm

10 km

Figure 2. Bedrock geology, Mackintosh Quadrangle

(page 64). This highland area, which is greater than 1200 m in height, receives an annual average rainfall in excess of 2800 mm and patches of thick snow may persist well into the summer months. It is moorland of shrubbery, sedge, swamp and bog.

Grassland plains, including large areas of button-grass, extend north from the Cradle Mountain area and occupy much of the east and the north of the quadrangle. These extensive plains, which vary in height between 600 m in the north-west and 880 m in the east, are underlain by Tertiary basalt. Steps on the plains are related to margins of separate basalt lava flows and the plains are often bounded by impressive cliffs (D.J.J.). Shallowly incised creeks drain the plains, usually descending in pronounced waterfalls coinciding with the margins of the basalt sheets (D.J.J.).

The mountains in the remainder of the quadrangle tend to be ridge-like in character with individual peaks varying in height between approximately 520 m (Mt Sale, 627600) in the south-west to 1150 m (Granite Tor, 800605) in the east. The mountain ranges reflect the strike of the underlying folded rocks. The adapted river systems, which drain into the Pieman River in the south-west, form trellis patterns and many of the strike streams have developed comparatively wide valley plains with the aid of Pleistocene glacial activities. Where rivers and creeks cross the strike of the country rock they are usually deeply incised (e.g. Pieman River in the south-west of the quadrangle). The western area of the quadrangle receives an annual average rainfall in excess of 2280 mm and is mostly occupied by dense rain forest which commonly extends to altitudes of 1000 m.

11

SUMMARY OF GEOLOGICAL HISTORY

QUATERNARY	HOLOCENE	Modification of Pleistocene glacial forms and deposits with the formation of local flood plains in the major river valleys. Notable talus deposits developed around basalt, dolerite and Ordovician siliceous clastic occurrences.
	PLEISTOCENE	Widespread development of cirques, wide and deep valleys and small scale erosional features, such as roche moutonnées. Extensive deposition of glacial drift, including end moraines and hummocky moraines, glacio-fluvial and glaciolacustrine sediment. Erratic boulders distributed over most of the region.

TERTIARY   Outpourings of basalt, with total thicknesses in excess of 150 m, and local deposition of sediment with plant remains.

Extensive erosion resulting in a dissected plain at about 550 m above present mean sea level in the north of the region.

CRETACEOUS   *Extensive erosion and faulting*

JURASSIC   Intrusion of dolerite sheets and smaller bodies.

PERMIAN   Accumulation of dominantly glaciomarine deposits filling basement trough and covering surrounding margins.

Erosion of 300 m deep local trough in basement

Extensive erosion

DEVONIAN   Emplacement of granite.

Folding of Lower Palaeozoic rocks ≡ Tabberabberan Orogeny.

SILURIAN   Deposition of marine sandstone, siltstone and mudstone.

ORDOVICIAN   Deposition of marine limestone and a siliceous clastic sequence, which may be partly of terrestrial fans.

CAMBRIAN   Folding.

Accumulation of acid – intermediate volcanic and volcaniclastic sequences with deposition of dominantly greywacke sequences.

PRECAMBRIAN   Folding and metamorphism ≡ Frenchman Orogeny.
(PROTEROZOIC) Deposition of dominantly interbedded siltstone and orthoquartzite.

STRATIGRAPHY

Precambrian

*R.D. Gee**
B. Marshall
K.L. Burns

Precambrian rocks occur in the Cradle Mountain area in the south-west of the quadrangle, where they occupy the north-west portion of the central older metamorphic basement of Tasmania (the Tyennan nucleus). They consist of thick, sub-parallel belts of pelite and quartzite which generally dip steeply and trend ENE, parallel to the edge of the nucleus. These lithons show strong internal deformation due to multiple fold movements and contain mineral assemblages indicative of the lower and upper greenschist facies of regional metamorphism. The regional metamorphism reflects the Frenchman metamorphic period (Spry, 1963), which affected the entire Tyennan nucleus in Tasmania.

No stratigraphic section can be suggested within the basement because marker horizons are lacking and a major coherent structure is not revealed. Although the major lithological layering of pelite and quartzite probably reflects original sedimentary layering, there is much folding and transposition of surfaces and the pelite and quartzite interfaces are the loci of tectonism. Sedimentary features such as cross bedding and graded bedding are locally preserved. The original sedimentary pile was probably a thick sequence of siltstone and orthoquartzite.

The rocks of the Cradle Mountain area are equivalent to similar schist and quartzite in the adjacent Middlesex Quadrangle. Such rocks have been termed the Dove Group and the Fisher Group (Spry, 1958; Jennings, 1963). The Dove Schist is equivalent to the dominantly pelitic rocks of the northern portion of the Precambrian basement at Cradle Mountain and the Fisher Group to the southern, dominantly quartzite portion.

The Tyennan nucleus is flanked to the north and west by thick sequences of eugeosynclinal Cambrian rocks.

PETROLOGY

Low grade metasedimentary rocks

Scattered slices of indurated banded siltstone occur within the semi-pelitic belt between Lake Rodway and Granite Tor. These are generally black and grey banded, slightly glossy rocks which split preferentially along the lamination. The lighter laminae consist of angular quartz grains of medium silt grade, small detrital flakes of muscovite and chlorite and a fine sericitic matrix which shows little recrystallisation. The darker laminae consist of very fine quartz and sericite in dirty brown, stringy bundles which have an aggregate polarisation parallel to the bedding. Probable graded bedding is present in the thinly banded phyllite and quartzite. This is expressed by an increase in the frequency of the dark sericitic bundles toward the dark layer, or by oblique slaty cleavage curving toward parallelism with the darker laminae.

Restricted to the northernmost portion of the Precambrian outcrop [910807] are sequences of interbedded mudstone and quartzite (B.M.). The

---

* Extracted mainly from Gee *et al.*, 1970.

13

5 cm

Geology by K.L.Burns, B.Marshall, R.D.Gee

0 1 2 3 4 5kms

PERMIAN
Pm   Sedimentary rocks

DEVONIAN
+ + + +
+ + + +   Granite

CAMBRIAN
Єp   Porphyry
Єsp   Sediments and Porphyry

PRECAMBRIAN
pЄq   Quartzite
Pelite

N

Generalised trend S₂

Generalised trend S₃

Metamorphic "isograds"

Єsp

Єp

pЄq

Mt Kate

MT KATE ANTIFORM

Mt Remus

Єp

Єsp

pЄq

Єp

Anio

Creek

Rozina

Phyllite

Muscovite Chlorite Schist

Garnet Schist

Mountain

Road

WALDHEIM

pЄq

Creek

Devil's

Crisis

pЄq

Lake Dove

Hansons Peak

Crater Lake

pЄq

Cradle Mt

Lake Rodway

Fury   River

pЄq

pЄq

Pm

Mt Emmett

Pm

pЄq

Granite Tor

Pm

Mt Inglis

pЄq

Barn Bluff

Pm

pЄq

TASMANIA DEPARTMENT OF MINES

4486-44

14

Figure 3.   *Bedrock geology, Cradle Mountain area.*

quartzite, pale whitish-grey on the weathered surface but medium to dark grey when fresh, occurs in beds up to 225 mm thick. The quartzite layers commonly display convoluted laminae, cross-lamination and load-casted soles. The interbedded argillaceous horizons are dark grey when fresh and weather to a pale fawn colour.

Phyllite

Phyllite is common within the pelite layers and is the dominant rock in the western portion of the major pelitic belt to the north (fig. 3). This belt grades eastward into medium-grained schist and then into coarser grained garnet schist at Waldheim.

The phyllite is well foliated and is a glossy steel-grey colour. Mesoscopic lithological banding is visible only in large outcrops. The foliation is either planar or finely anastomosing and commonly displays a crenulation lineation. A fine mineralogical segregation parallel to the foliation is visible in hand specimen.

In thin section, the phyllite (*e.g.* 63-80, 63-81, 63-82, 63-87, 63-89* from the Crisis Creek area) consists of thin lenticles, up to 1 mm thick, alternately rich in quartz and muscovite. The quartz (0.1 mm in diameter) forms a fine-grained interlocking mosaic, and the muscovite is dirty and stringy and has a strong preferred orientation parallel to the segregation. Micro-porphyroblastic albite and tourmaline occur in the micaceous layers. Specimen 63-19 from Anio Creek contains albite grains, 0.08 mm in diameter, generally surrounded by a fringe of minute xenocrystalline clear chlorite (penninite?). The albite micro-porphyroblasts contain sigmoidal trails of fine, black, dusty inclusions which are continuous with the enclosing foliation. Specimen 63-81 is a coarser phyllite containing albite up to 0.2 mm and micro-porphyroblasts of cross-fibre chlorite (anomalous blue interference colours) in flakes up to 0.3 mm.

Schist

The pelitic rocks are mostly medium-grained quartz-muscovite schist, commonly with albite and less commonly with biotite. Coarser grained garnet schist occurs along the Cradle Mountain Road, north of Waldheim (fig. 3). The schists are glossy grey to brown in colour and possess a strong schistosity due to a metamorphic segregation up to 5 mm in thickness. A lithological banding 30-300 mm thick is commonly parallel or slightly oblique to the schistosity. This banding may represent original sedimentary layering.

Quartz generally occurs in xenoblastic grains up to 0.2 mm in dia-meter, having a weak dimensional orientation in the foliation. These form an interlocking mosaic which enclose scattered small individual flakes of muscovite. Some textural variations occur. Specimen 64-257 contains elongate quartz grains with straight parallel borders terminated against mica flakes. Specimen 54-247A has a fine-grained quartz mosaic with common triple intersections giving pseudo-hexagonal shapes. This is probably an annealed cataclastic texture.

Muscovite is the dominant micaceous material, forming bundles along the foliation. Such muscovite flakes generally tend to be ragged and dirty, due to abundant fine inclusions of ilmenite and leucoxene, and are probably the phengite variety. Muscovite also occurs as clean sub-idio-blastic flakes discordant to the main foliation. Another textural type occurs as small (0.8 mm in length) clean discrete flakes, defining remnants

* Specimen number, Department of Mines thin section catalogue

15

of a micro-folded surface, within the quartz-rich layers.

Chlorite occurs as sub-idioblastic flakes up to 0.3 mm, growing either across or along the main foliation. Chlorite also occurs as prismatic stacks aligned across the foliation with a porphyroblastic habit, and wrapped by the foliation.

Biotite, distinguished from stilpnomelane by X-ray diffraction, is a common but minor constituent in most schist. It is the dominant micaceous mineral in some schists from north of Mt Inglis (63-104) and Lake Rodway (63-34), where it occurs in small (<0.05 mm) ragged flakes commonly interleaved with muscovite in the mica-rich layers and defines the main schistosity. In the quartz-rich layers muscovite occurs to the exclusion of biotite.

Albite occurs as lozenge-shaped porphyroblasts within the mica-rich layers of the pelite. Inclusions within the porphyroblasts define an internal fabric (S_i) which can be planar, sigmoidal or strongly plicated in habit. Two types of inclusions are present; a fine, dusty black type of graphitic material, iron oxides, and possibly rutile, probably inherited from the muscovite during its replacement by albite; and a crystalline type of minute quartz, muscovite and, less frequently, tourmaline, zircon and epidote. Porphyroblasts with the dusty type of inclusions are rimmed by an opaque, earthy material. This is probably the residue from muscovite that could not be accommodated within the lattice of the growing albite. The crystalline type of inclusion is more common in the garnet schist near Waldheim.

Some of the plagioclase (n<balsam) is twinned (65-34) and this has been examined by the method of Slemmons (1962). Values indicate a nearly pure end member (An_0-An_2).

Garnet forms porphyroblastic dodecahedra varying in size from 0.05 mm up to 2.0 mm (64-254, 64-247, 64-29), which are wrapped around by the main foliation. The crystals generally contain a few randomly distributed quartz inclusions and are sometimes cracked and altered to chlorite. Some have a zonal arrangement in which a cloudy rim, often deeply altered to chlorite (64-254), contains abundant weakly orientated inclusions of quartz. This rim is generally more fractured than the clear core and shows a tendency to be drawn out along the foliation (64-256). Fine muscovite and quartz has grown between the core and the rim, especially in the 'eyes' of the garnet.

A chemical analysis of garnet separated from the coarse-grained garnet schist (64-254) from near Waldheim is shown in analysis 8 (Table 1). This material includes mainly idioblastic cores contaminated with earthy chloritic alteration material. The analysis does not balance structurally, due to an excess of ferric iron. Using the divalent ions, on the basis of 24 [O], a garnet containing 66% almandine, 14% spessartite and 20% grossular is indicated. These values are approximate but indicate a dominant almandine component.

Semi-pelite

Semi-pelite, or thinly interbedded phyllite, schist and quartzite, is the dominant rock type in the major pelitic belt at Lake Rodway. These rocks are petrologically similar to the phyllite and schist described previously. The semi-pelite consists of quartzite bands (30-150 mm thick) with regular alternation of either fine-grained, dark bluish-grey phyllite or quartz-muscovite-albite schist of a similar thickness.

16

Quartzite

Two main types of quartzite can be distinguished, a well-bedded platy quartzite, and a schistose quartzite. The platy quartzite occurs predominantly within the two major quartzite belts in the southern half of the area, as well as in the core of the antiform on Mt Kate and on Mt Remus. The schistose quartzite is more common in the thinner quartzite slabs within the major pelitic belt in the northern half of the area. This broad spatial distribution reflects partly the influence of argillaceous impurities, and partly the more intense folding and transposition associated with the pelitic belts. However, even the most massive quartzite has a microscopic foliation.

The least schistose quartzite occurs on Mt Remus at a shallow structural level. The quartzite occurs in planar slabs from 50 mm to one metre thick and is devoid of internal lamination. The units are defined by a plane of parting and not a penetrative schistosity, giving the appearance of a well-bedded orthoquartzite. A weak foliation parallel to the bedding (?) is defined (*e.g.* 63-79) by a planar orientation of small (0.3 mm) dispersed, clean, muscovite flakes. Ninety-eight per cent of the rock consists of quartz grains (0.03-0.1 mm) which form an interlocking mosaic. In places, the quartz grains have a near-hexagonal shape and triple-point intersections are common, suggesting post-kinematic or static re-crystallisation.

The typical platy quartzite varies from thinly bedded to thickly bedded. The slabby nature is defined by discrete planes of parting which in some cases are due to thin layers of schistose micaceous quartzite or pelitic material. Within the slabs is a weak colour-banding which is more apparent on weathered surfaces. This internal lamination is due to grain size differences, shreds of chlorite (64-217B), and trails of small hematite grains (64-249A). The lamination is mostly planar, but on Hansons Peak it forms a series of nested festoons within the planar slabs commonly showing tangential and truncated contacts. This internal lamination is almost certainly the original sedimentary lamination and cross lamination.

Despite the bedded appearance of the quartzite, a microscopic foliation is always visible, due to a preferred dimensional orientation of quartz and mica. In the more micaceous and schistose quartzite (*e.g.* 64-255), the foliation is expressed by stringy bundles of mica flakes, separated by one or two layers of tabulate quartz grains.

In general, the schistose quartzite is pure and was originally an orthoquartzite. In thin section, it consists dominantly of an interlocking mosaic of xenoblastic, undulose quartz grains (0.1-0.4 mm). Muscovite and chlorite occur as clean sub-idioblastic flakes and form up to 5% of the rock. The chlorite is pale green and weakly pleochroic, with an extinction of 8° and weak, but not anomalous, birefringence. It has the properties of clinochlore and appears to be a primary metamorphic mineral.

Secondary chlorite occurs in some quartzites (*e.g.* 64-258, 64-259 from Mt Kate). This mineral occurs as fine, ragged flakes or more commonly as alteration rims around the muscovite and primary chlorite and penetrating along the basal cleavage.

Garnet occurs in the schistose micaceous quartzite. It exhibits well developed sieve structures with up to 70% of square or rectangular shaped quartz grains, defining an internal surface (S_i) at an angle to the external foliation of the rock. Although the external foliation, defined

17

by the preferred orientation of mica and elongate quartz, is slightly deflected around the garnet, it is basically continuous with S_i.

Minor amounts of feldspar (albite?) occur in the less pure quartzite as scattered xenoblastic grains interlocked in the quartz mosaic. This is texturally distinct from the albite in the pelitic rocks which occurs as porphyroblasts confined to the micaceous layers. The xenoblastic type of feldspar was probably of detrital origin.

Green tourmaline is a common accessory in the quartzite (64-252, 64-225) and occurs as idiomorphic prisms with their long axes lying along the foliation. The tourmaline is generally fractured and wrapped around by the foliation.

Other accessory minerals in the quartzite include opaque oxides and zircon; these are probably of detrital origin.

Amphibole schist

Amphibole schist crops out at the 1220 m level in the south-west corner of the wall of Crater Lake. It occurs as slabs concordant with the main lithological layering.

The rock is a dense, dark green to black, well foliated and knotted schist with feldspar up to 2 mm in diameter. Specimen 64-30 consists of albite porphyroblasts (up to 40% of the rock) in a foliated matrix of green actinolite (0.15 mm in length) and biotite. Granular (0.05 mm) epidote forms trails along the foliation and small amounts of calcite, quartz and pyrite are present.

Abundant inclusions of clinozoisite(?), epidote and actinolite are arranged within the albite in sigmoidal trails (S_i) of varying degrees of curvature. In many porphyroblasts, S_i is perfectly continuous with the external foliation (S_e) and the actinolite needles penetrate the albite. However, there are microscopic zones of later deformation in which the early foliation is crumpled and S_i and S_e are discordant. In these domains, biotite and chlorite have recrystallised in random orientation and the albite porphyroblasts are fractured and penetrated by thin veinlets of calcite.

A chemical analysis of the rock is given in Table 1, analysis 3. This analysis gives a CIPW normative composition of orthoclase 10%, plagioclase (An$_{35}$) 43%, clinopyroxene (CaO$_{0.50}$, FeO$_{0.13}$, MgO$_{0.37}$) 10%, orthopyroxene (En$_{0.74}$, Fs$_{0.26}$) 16.5%, olivine (Fa$_{0.3}$, Fo$_{0.7}$) 10.3%, magnetite 4%, ilmenite 1.5%, calcite 0.5%. This suggests that the rock is an albitised olivine dolerite.

TEXTURAL SEQUENCE

Particularly in pelitic rocks, microfabric analysis of such features as grain shape, the relationships of grains to s-surfaces and lineations, and the relationships of the various s-surfaces provide a record of the metamorphic and structural development of the fabric.

Surfaces in the pelitic rocks

The basic pattern in the pelitic rocks of the Cradle Mountain area is one in which an older, microscopically visible foliation has been crenulated and almost obliterated by a main schistosity which, in turn, has been crumpled, but not obliterated, by a later cleavage. There is no evidence

that this sequence has been repeated, such that the main foliation in one area is transposed in another area by a later dominant foliation.

The oldest surface (S_1), which is found in both the phyllite and schist, occurs as curved or sigmoidal trails of small single muscovite flakes between the mica foliae of the main schistosity (S_2). The S_2 surface is a crenulation foliation derived by mechanical rotation of pre-existing S_1 micaceous minerals into a new position. In the schist, S_2 is accentuated by syn-kinematic and post-kinematic recrystallisation of muscovite.

S_3 is present only in certain structural belts characterised by mesoscopic refolding. It has the characteristics of a strain-slip cleavage and may be seen as a finely-spaced discrete planar parting that cuts across S_2 at a high angle.

Surfaces in the quartzites

The correlation of the various surfaces in the pelite and quartzite can be made in field exposures. The platy parting, which is the most conspicuous surface in the quartzite, is parallel to the faint internal colour lamination and is considered to be a bedding foliation analogous to S_1 in the pelite.

In thin section, there is a conspicuous foliation expressed by a dimensional orientation of muscovite, chlorite and, in some places, tabulate quartz. It is parallel to S_1 on the limbs of isoclinal folds, but is oblique to S_1 in the crests and holds an axial-plane relationship. On the mesoscopic scale this foliation occurs as a faint 'grain' on glassy surfaces, or as feathery indentations of more schistose material in the cores of folds. It is analogous to the main schistosity S_2 in the schist, which is also oblique to the lithological layering.

In the quartzite at Hansons Peak, Mt Kate and Lake Rodway, S_2 is cut by a surface parallel to, and continuous with, the S_3 strain-slip cleavage of the pelite. This surface is a flaggy parting spaced from 6 to 20 mm apart and is parallel to the axial planes of the later folds.

DEFORMATION PHASE →		F_1			F_2		
SURFACE →	S_1	S_2			S_3		
MINERAL ↓		Pre	Syn	Post	Pre	Syn	Post
QUARTZ	▬▬▬	▬▬▬				▬▬	
MUSCOVITE	▬▬▬	◀▬				▬ ▬	
BIOTITE		▬▬					
CHLORITE	▬▬▬	▬▬▬				▬	
GARNET		◀▬▬					
ALBITE		◀▬▬▬					

Figure 4. *Relationship between tectonic surfaces and metamorphic crystallisation in the pelitic rocks.*

Crystalloblastic sequence

The petrographic features allow mineral species to be divided into textural types that define different growth periods. These are summarised in Figure 4.

METAMORPHISM

The following metamorphic assemblages occur consistent with petrographic observation; chlorite-muscovite, chlorite-muscovite-biotite, and almandine-chlorite-muscovite, all with albite (An_0) and quartz. The amphibole schist occurs in the epidote-tremolite-biotite field and also contains albite and calcite. Chemical analyses of selected schists are listed in Table 1. The assemblages indicate a middle greenschist facies of regional metamorphism, which with the incoming of almandine garnet was transitional to the upper greenschist facies. This represents a small part of what is commonly called the Barrovian metamorphic series.

Table 1. CHEMICAL ANALYSES OF PRECAMBRIAN SCHIST FROM THE CRADLE MOUNTAIN AREA

Analysis	1	2	3	4	5	6	7	8
SiO_2	66.6	66.1	50.8	68.3	63.3	76.2	76.0	32.8
Al_2O_3	13.7	17.5	12.7	13.5	18.9	11.5	14.1	19.2
Fe_2O_3	1.1	1.7	2.9	4.3	1.5	1.4	0.68	11.6
FeO	5.5	3.9	7.0	2.6	4.9	2.1	0.74	24.4
MnO	0.22	0.34	0.16	Trace	0.14	Trace	Trace	4.9
TiO_2	0.49	0.35	0.85	0.37	0.51	0.20	0.50	0.35
P_2O_5	0.08	0.10	0.09	0.10	0.08	Trace	Trace	Trace
CaO	1.5	0.19	5.9	0.21	0.21	–	–	3.0
MgO	3.6	1.6	10.6	3.0	1.6	1.4	0.71	1.1
Na_2O	2.0	0.69	3.3	1.2	0.83	2.3	1.1	0.10
K_2O	3.5	3.4	1.7	3.3	4.1	2.4	4.3	0.38
H_2O+	1.9	3.6	3.1	3.2	3.7	1.9	2.1	2.0
H_2O-	0.12	0.23	0.26	0.31	0.21	0.29	0.20	Trace
CO_2	–	–	0.23	–	–	–	–	Trace

1. Biotite-albite schist, plateau north of Mt Inglis (63-104).
2. Quartz-muscovite-albite-garnet-chlorite schist, Smithies Peak (64-29).
3. Amphibole schist (igneous), south-west wall of Crater Lake (64-30).
4. Quartz-chlorite-biotite-albite schist, Lake Rodway (63-105).
5. Quartz-muscovite-albite-garnet-chlorite schist, Cradle Mountain Road, 1 km north of Waldheim (64-254).
6. Quartz-albite-chlorite schist, Twisted Lakes (69-13).
7. Low-grade quartz-muscovite-chlorite metasediment, Artists Pool, 1.5 km south of Lake Dove (69-16).
8. Garnet separated from 64-254 (analysis 5).

The present distribution of pockets of differential metamorphism is more related to post-metamorphic deformation than to the metamorphic series. The highest grade, indicated by the garnet schist, occurs in the core of the Mt Kate antiform (fig. 3). Further west, in the crest of the antiform, the schist grades into muscovite-chlorite schist and then to chlorite phyllite. The Mt Kate antiform plunges about 30° in a general south-west direction and this zonation appears to be correlated with depth.

Garnet does not occur in the schist south of a major dislocation that marks the southern edge of the Mt Kate antiform. This schist contains

biotite, muscovite and chlorite and in many places is strongly transposed
by the late S_3 strain-slip cleavage. In the area between Lake Dove and
Lake Rodway, and on the plateau north of Mt Inglis, biotite-muscovite-
chlorite schist occurs in immediate juxtaposition to chlorite schist and
low grade metasediments with no metamorphic recrystallisation. These
areas are also characterised by the S_3 cleavage.

<div align="center">STRUCTURE</div>

Polyphase folding is recognisable on the mesoscopic scale, and can
be related to the textural sequence. The early phase of folding, character-
ised by the S_2 schistosity, is common throughout the area, but the later
structures are restricted to certain belts. Thus it is not possible to
correlate or differentiate accurately all of the post S_2 structures, and
it is possible that they represent genetically unrelated phases of deforma-
tion. For the purpose of this report, all the later penetrative surfaces
are termed S_3 and are assigned to the F_2 fold sequence.

The structures recorded in the interbedded mudstone and quartzite at
910807 (B.M.) may be related to those appearing in the Precambrian rocks.
The rocks have been deformed by folding that pre-dates the accumulation of
the Cambrian rocks, but they lack the structures resulting from the earliest
Precambrian movement.

F_1 fold sequence

Mesoscopic folds of the F_1 sequence occur abundantly throughout the
area especially in the quartzite. They are difficult to detect in the
pelite, but are commonly revealed by thin layers of quartzite forming
detached fold cores. The mesoscopic folds vary in half-wavelengths from
1 mm – 200 m. They vary in style from open and rounded, to highly-flattened
flexural-slip folds. The folds are commonly bounded on one limb by a thrust
plane which is parallel to the axial plane schistosity. The axial-plane
schistosity (S_2) is generally visible only in the fold cores, although it
is fully penetrative in thin section. The S_2 schistosity is commonly
accentuated by the penetration of schistose leaves of pelitic material in
the core of folds.

A lineation resulting from the intersection of S_1 and S_2 parallels
the hinge line, but is usually seen only in the hinge areas, giving way to
a lineation of different style and orientation on the limbs of the folds.
This is a strong quartz fibre lineation and is generally oblique to the F_1
hinge line; parallelism is rare and is considered to be fortuitous. It is
not parallel to any known mesoscopic set of folds and appears to be a
regionally pervasive fabric element in the quartzite.

Recumbent or reclined mesoscopic F_1 folds occur in the crest of the
Mt Kate antiform. Elsewhere axial planes are essentially co-planar with
the ENE trend of the steeply dipping basement slabs. The plunge of the
hinges varies tremendously within the axial planes of the folds. The
departure in plunge of hinges in closely adjacent folds is up to 60°.

F_2 fold sequence

The F_2 fold sequence involves those penetrative structures that
deform the S_2 schistosity (along with the S_1 bedding foliation) and produce
the S_3 strain-slip cleavage. The angular kinks and many of the late folds
along the Cambrian-Precambrian border are specifically excluded from this
classification. The F_2 structures vary in intensity and occur only in
certain zones, for example, at Lake Rodway, Hansons Peak and Mt Kate.

<div align="center">21</div>

F_2 folding is most intensely developed 3.5 km south of Mt Emmett (fig. 3), where an east-west trending belt of gently undulating and shallowly plunging quartzite, containing a few recumbent mesoscopic (F_1) folds, is truncated to the north and south by belts of thinly interbedded quartzite and schist containing an intense near-vertical transposition foliation. Within these belts, the form-surface is only recognisable in small detached fold cores, quartz rods and contorted and sliced shreds of the quartzite. The fold axes vary markedly in plunge, but have constantly orientated east-west axial planes.

In a sequence of quartzite, pelite and semi-pelite at Lake Rodway, abundant folds in S_1 (and S_2) have developed an axial-plane strain-slip cleavage (S_3). Detached fold cores of quartzite occur within pelite and folded mesoscopic folds are exposed at Flynns Tarn (500 m north-west of Lake Rodway).

At Twisted Lakes (2 km north of Lake Rodway) a group of rather open folds with wavelengths of up to 200 m have S_2 as the form surface and have developed a strain-slip cleavage with an axial surface orientation. These folds have variable but generally sub-horizontal plunges and steeply dipping east-west trending axial planes.

Hansons Peak, 400 m further north, is an antiformal mullion zone which plunges steeply to the WSW within a near-vertical axial plane (S_3). The mullions are bounded by S_1 (with S_2 co-planar) and the newly-generated, coarsely-spaced strain-slip cleavage S_3. Further evidence of refolding is visible in the schistose quartzite between the quartzite slabs. Minor folds with an axial surface schistosity (S_2) are discordant to and maintain a constant vergence relationship with the layering of the main slabs around the antiform.

The major pelitic belt to the north of Waldheim, which includes the Mt Kate antiform, does not exhibit the intense transposition structures found further to the south. The S_2 foliation which defined the crest of the antiform is bent into broad open mesoscopic folds. Garnet schist at lower structural levels possesses a widespread but weak strain-slip cleavage, usually only visible microscopically. The S_3 cleavage in the garnet schist has a general east-west trend and is approximately vertical. In the phyllite at higher structural levels S_2, itself an axial plane schistosity, is the form surface of open or moderately tight folds with an axial plane strain-slip cleavage. These folds generally plunge at less than 30° to the WSW.

Late structures

Regular accordian folds are common in the platy quartzite and semi-pelite in certain narrow NNW-SSE trending zones between Lake Rodway and Crater Lake. The folds are angular and symmetrical, with regularly spaced parallel axial planes averaging 400 mm apart. The axial planes trend NNW-SSE and the axes plunge steeply in the near-vertical foliation. They are entirely post-metamorphic, and deform all the structures previously described. In the Lake Rodway area, especially at the overflow lip of Flynns Tarn, the folds occur in belts up to 30 m wide, in which the folding increases in intensity toward NNW-SSE trending faults. These faults, which are common in the Lake Rodway area, generally have a small displacement with a dextral strike-slip component. A similar trending fault at Granite Tor cuts and displaces Devonian granite; it is therefore possible that kinks are related to the Middle Devonian Tabberabberan Orogeny which affected the Lower Palaeozoic rocks about 16 km to the north-west.

Regional structure

The regional structure (fig. 3) consists of a series of approximately vertical belts of pelite and quartzite with abundant internal folding. The only unit structure on this scale is the Mt Kate antiform.

The major lithological boundaries are variable in nature. The boundary between the schist belt at Waldheim and the thinner quartzite slab to the north is parallel to the S_1 bedding foliation. However, this same quartzite slab truncates the folded S_2 surface in the pelite to its north on the limb of the Mt Kate antiform. The lithological layering within the semi-pelite belt that extends from Granite Tor to Lake Rodway is truncated acutely by the major dislocation which, in the Lake Rodway area, appears to post-date both the F_1 and F_2 Precambrian folds. To the west of Lake Dove, the boundary between a thin pelite bed and major quartzite slabs on either side can be related to the thrusting out of the limbs of the F_2 folds. Similar types of dislocation, clearly related to F_2 folds, occur in the area between Lake Dove and Twisted Lakes. In the south-east corner of the quadrangle (fig. 3) gently folded massive quartzite abuts a zone of intensely transposed vertically dipping schistose quartzite.

The Mt Kate antiform is an asymmetrical structure, with an approximate south-west plunge of 30°, a gentle northerly limb which tends to become synformal, and a steep southern limb. The southern limb is marked by a major dislocation which truncates abruptly the metamorphic zoning and the S_2 foliation. The Mt Kate antiform may therefore be thought of as an undeformed remnant of an early, more or less flat-lying basement, rather than as a late antiform formed by rotation of the steeply dipping foliation to horizontal.

CONCLUSIONS

The sequence of events in the evolution of the Precambrian basement in the Cradle Mountain area may be summarised as follows. The earliest recorded event was the growth of muscovite and chlorite along the bedding of orthoquartzite and siltstone to produce a bedding foliation. This event culminated in the growth of pre-kinematic almandine garnet, although garnet did extend into the early syn-kinematic phase of F_1. The main period of F_1 folding was accompanied by the formation of a widespread axial plane schistosity in the pelite due to the syn-kinematic growth of muscovite, biotite and chlorite. A basic dyke was intruded at about this stage and appears to have undergone syn-kinematic retrogressive metamorphism. Muscovite and chlorite continued to grow in the post-tectonic interval. Albite was the last metamorphic mineral to crystallise in the inter-kinematic period between F_1 and F_2.

The F_2 movement was essentially a post-metamorphic slicing of the basement along near vertical, east-west trending shear zones. The more strongly transposed zones may have been controlled by the distribution of pelitic belts, but the nature of the F_1 structure, and consequently its influence on the F_2 structures, is not known. The F_2 movement and the S_2 cleavage was not accompanied by the formation of any new metamorphic minerals, but was merely associated with the recrystallisation of quartz and the minor growth of muscovite and chlorite.

The Mt Kate antiform is interpreted as a flat-lying remnant of the metamorphic basement in which is preserved a zonal sequence grading from low-grade metasediments to upper greenschist facies. Using a plunge correction of 30° west for the antiform, the vertical tectonic thickness

5 cm
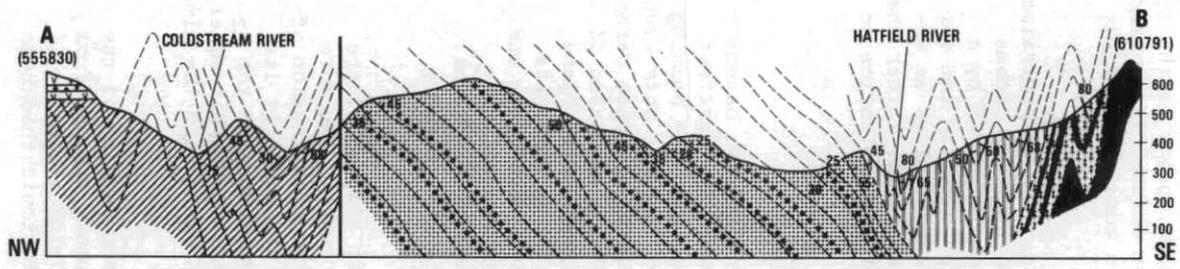
Folding is diagrammatic but includes all possible data. Way-up established in greywacke –conglomerate only.
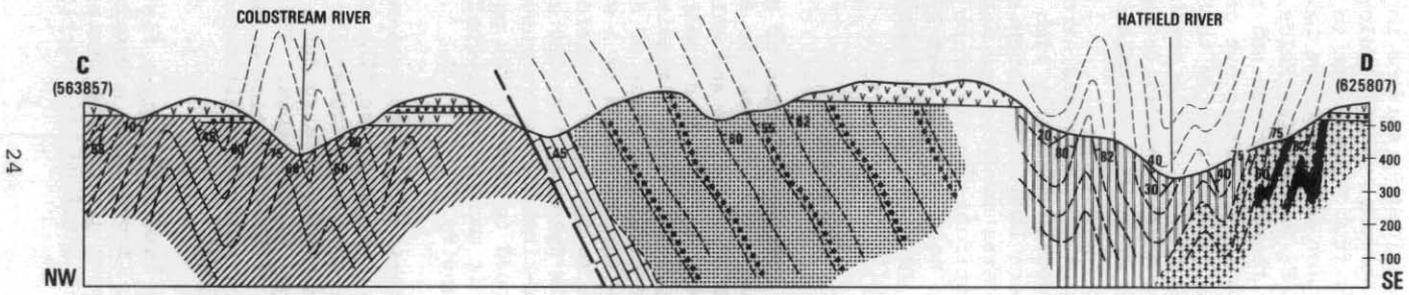
TERTIARY — Basalt/non-marine sediment

Greywacke, mudstone sequence of the Coldstream River

Limestone conglomerate

CAMBRIAN — Greywacke – conglomerate, sandstone and mudstone sequence

Mudstone and greywacke sequence of the Hatfield River

Black shale and quartzite sequence with quartz conglomerate horizons

0   1000m   2000m

V:H – 1.65:1

D.J. JENNINGS.

For location of sections see Figure 2.

Figure 5. *Diagrammatic north-west – south-east geological sections across the Coldstream – Hatfield area.*

exposed is in the order of 7 km. This would correspond approximately with a pressure of two kilobars, a figure compatible with the pressure range of the greenschist facies (Turner, 1968).

Cambrian*

Rocks assigned to the Cambrian system rest unconformably(?) on Precambrian rocks of the Tyennan region and are unconformably overlain by correlates of the siliceous conglomerate and sandstone sequence of the Jukes Breccia and Owen Conglomerate, which range in age into the Ordovician.

Cambrian rocks dominate the western half of the Mackintosh Quadrangle and also occur as a NE-SW trending belt along the southern slopes of the Sophia, Mackintosh, Vale and Lea River valleys, between the Ordovician and Precambrian sequences (fig. 2). The Cambrian rocks on the northern margin of the quadrangle are blanketed by an extensive cover of Tertiary olivine basalt and non-marine sediment. Pleistocene glacial and glacio-fluvial deposits cover vast areas of Cambrian rocks (plate 7), notably in the headwaters of Farm Creek and Bulgobac River, and in parts of the Que, Sophia and Mackintosh River valleys.

These explanatory notes have been compiled from the field notes of several geologists who mapped the Cambrian rocks, and where possible they have been supplemented by thin section descriptions of specimens collected during the course of the mapping. Many of the petrological descriptions were made by G.B. Everard. The notes have been compiled, and are also presented, for various physiographic areas, each area generally being dominated by either sedimentary or volcanic rock.

More recent mapping of much of the area underlain by volcanic rocks in the western half of the Mackintosh Quadrangle, between the Pieman River and the Que River, is described by P.L.F. Collins (Appendix 1).

COLDSTREAM - HATFIELD - QUE SEDIMENTARY SEQUENCE

The sedimentary sequences exposed in the Coldstream - Hatfield - Que area, in the north-west corner of the quadrangle west of the volcanic sequences, may be divided into four main units (D.J.J., G.U.):-

West A Highly folded micaceous greywacke and mudstone sequence with minor sandstone, quartzite and limestone of the Coldstream valley.

       B Uniformly dipping and east-facing sequence of predominantly plum coloured greywacke-conglomerate, sandstone and mudstone with subsidiary limestone nodule conglomerate of the Coldstream - Hatfield interfluve.

       C Highly folded greywacke, siltstone and mudstone sequence of the middle Hatfield valley.

East D Highly folded mudstone (black shale), quartzite and greywacke sequence with prominent quartz conglomerate of the upper Hatfield valley and the Que valley.

The gross structure of the four main units in this area is illustrated in the two diagrammatic NW-SE cross sections (fig. 5). The location of these cross sections is indicated on Figure 2. The junctions between the

---

* Compiled by P.L.F. Collins from notes by C.M. Barton, D.I. Groves, A.B. Gulline, D.J. Jennings, B. Marshall, W.L. Matthews and G. Urquhart.

units are not well exposed, but there is fair evidence of faulting in the middle and lower Coldstream valley between unit A and unit B. The contrast in folding is not easily accountable, except by evoking gross differences in physical properties in unit B on the one hand and units A and C-D on the other. The only persistent facing information is supplied by unit B, which apparently overlies unit A and is overlain by units C-D. The lithostratigraphy of units A and C-D are similar and may possibly be correlated, but no quartz conglomerate is known in the Coldstream valley (D.J.J.).

Probably intrusive into the sedimentary sequence in the Coldstream valley (unit A) is an altered feldspar porphyry [562806] and altered basic to ultrabasic rock [553770 and 554793]. The grey feldspar porphyry (65-86) consists of altered feldspar phenocrysts up to 2 mm long in a fine-grained felted matrix with minor granular pyrite and abundant dispersed iron oxide. About 25% of the rock is altered and replaced by calcite. The medium- to coarse-grained, green basic to ultrabasic rock (65-93, 65-100) is composed of biotite plates up to 2 mm long, subhedral pyroxene up to 2 mm across, skeletal iron oxide, apatite and sphene and large pods of calcite in a matrix of chlorite, biotite and feldspar. At 556793 is a fine-grained, dark green, altered porphyritic basalt (65-99) consisting of feldspar phenocrysts up to 2 mm long in a fine-grained loose lattice of plagioclase laths and granular pyroxene, with interstitial chlorite. Calcite occurs in patches up to 10 mm across and in veinlets up to one millimetre thick (D.J.J.).

Greywacke and mudstone sequence of the Coldstream River

The sedimentary rocks exposed in the valley of the Coldstream River consist predominantly of grey, but occasionally green or brown greywacke and mudstone with minor sandstone, quartzite, siltstone and limestone in a well-bedded and banded succession. The sequence is characterised by the presence of mica (muscovite) in most units (D.J.J.).

Brief descriptions of the salient features of the main rock types follow (D.J.J.).

Greywacke (65-57, 65-61, 65-73, 65-98). The greywacke is generally poorly sorted, with up to 50% matrix, is fine- to medium-grained and pale to dark grey colour, commonly with red and black flecks. The rock consists of angular quartz grains (some embayed) up to 0.8 mm, altered feldspar fragments up to 0.4 mm, muscovite flakes generally 0.3 mm long but up to one millimetre in coarser grained units, subrounded quartzite fragments up to 0.5 mm, occasional subrounded basic fragments up to 0.6 mm, chloritic patches, iron oxide segregations up to 0.3 mm and occasional clusters of fine pyrite up to 0.2 mm.

Shale (65-58, 65-72, 65-84, 65-85, 65-92, 65-96). Generally grey-black, though occasionally plum or green shale is interbedded with the greywacke. The shale is often contorted, some of which is possibly soft sediment folding and brecciation, and usually contains muscovite wisps up to 0.1 mm, most evident on cleavage surfaces. Carbonate veins up to 2 mm thick are common and contain calcite, quartz and pyrite. Pyrite occasionally occurs on bedding surfaces.

Siltstone (65-63, 65-66, 65-97). Grey, laminated siltstone with minor granular pyrite up to 0.05 mm occasionally containing erosional washout features consisting of quartz grains up to 0.4 mm and grading upwards to 0.1 mm, muscovite laths up to 0.4 mm, and rare feldspar and pyrite.

Quartzite (65-62). Fine-grained, pale green quartzite consisting of quartz grains averaging 0.04 mm in a fine-grained quartz matrix and containing rare muscovite laths up to 0.1 mm long.

Sandstone (65-66, 65-70, 65-94). Uniform, well-sorted, fine-grained to poorly sorted, coarse-grained pale grey sandstone consisting of about 50% angular to subrounded quartz grains typically 0.4 mm with minor quartzite fragments, and rare muscovite flakes up to 0.4 mm long and feldspar fragments to 0.3 mm set in a carbonate cement. Quartzite fragments up to 1.5 mm long occur in the coarser sandstone units.

Limestone (65-87). A grey-black, well-bedded and banded (2 - 40 mm thick) coarse to finely crystalline stylolitic limestone occurs at 562809.

Limestone conglomerate

Cropping out in Hay Creek, the major north-east tributary of the Coldstream River at 580835 is a limestone nodular conglomerate, possibly the basal member of the greywacke-conglomerate suite to the east (D.J.J.).

The pale pink to pale green-grey, banded limestone conglomerate (63-79, 63-101) consists of well-rounded limestone and quartzite pebbles, generally about 5 mm in diameter but up to 25 mm, and sub-angular quartz grains up to 0.5 mm in a calcareous matrix also containing fine-grained (0.05 mm) quartz and minor muscovite flakes up to 0.05 mm long. The rock is poorly sorted and veined by calcite and quartz. Marginal replacement of the limestone fragments by the matrix is common. Also within the unit is a medium- to coarse-grained, poorly sorted, pale grey calcareous greywacke with rare rounded pebbles to 8 mm in diameter. The greywacke (65-80) consists of subrounded to ovoid pebbles of fine-grained quartzite and limestone and abundant angular, coarse- to fine-grained quartz in a calcareous matrix (D.J.J.).

Greywacke-conglomerate, sandstone and mudstone sequence

The sedimentary rocks in the lower portion of the Hatfield valley and on the Hatfield - Coldstream interfluve are predominantly massive, bedded, coarse-grained, graded, plum-coloured greywacke-conglomerate with limestone pebbles. The conglomerate locally forms up to 80% of the succession, forming cliffs and gorges in the river and weathering to large monoliths. Interbedded with the conglomerate is abundant greywacke-grit and compact purple mudstone with discontinuous, lensoid sandy horizons which are invariably graded. The sequence trends uniformly N-S to NNE-SSW and dips and faces east (D.J.J.).

In the lower reaches of the Que River is a monotonously uniform and rhythmic succession of interbedded maroon shale and welded greywacke beds. The alternating beds are variable in thickness, with the shale partings commonly 10-25 mm thick and separate maroon and dull red bands of greywacke up to 300 mm thick (G.U.).

Brief descriptions of the salient features of the main rock types follow (D.J.J.).

Conglomerate (65-75, 65-76, 65-83). The dark red to occasionally dark grey conglomerate consists of rounded to subrounded limestone pebbles and sub-angular pebbles of quartzite and chert commonly 10 mm but up to 25 mm in diameter, in a sandstone/grit matrix. The quartzite pebbles often consist of recrystallised quartz up to 2 mm across and are veined by coarse, cryst-

alline euhedral quartz and calcite. The limestone pebbles are usually composed of dirty, very fine-grained (0.03 mm) calcite. In addition, there are occasional basic lava(?) fragments up to 7 mm across. The pebbles are often dispersed in layers within the greywacke matrix, which consists of abundant medium-grained (0.5 - 1 mm) angular to subrounded quartz and quartzite and minor muscovite with interstitial chlorite, carbonate and black iron oxide.

Greywacke (65-77, 65-82, 65-91). The medium- to coarse-grained, poorly sorted, bedded and graded, plum-grey greywacke consists of shale slivers up to 10 mm long, angular quartz and quartzite up to 2 mm across, abundant granular black iron oxide and minor feldspar and rare muscovite. Minor chlorite occurs interstitialy.

Mudstone (65-81, 65-88). The plum coloured, banded mudstone characteristic-ally contains lenticular graded layers of orange sandstone 2 mm to 10 mm thick. The mudstone occasionally grades into banded and laminated silt-stone (65-78).

Greywacke and mudstone sequence of the Hatfield River

In the middle reaches of the Hatfield River is a well banded sequence of greywacke-sandstone, siltstone, shale and mudstone, commonly grey with occasional purple and dark green bands and weathering to khaki. The sequence also contains occasional clean fine-grained quartzitic sandstone (65-89) and fine-grained micaceous sandstone (65-69) units, and rare well-cleaved laminated slate (65-68). The grey, fine- to medium-grained grey-wacke-sandstone (65-67, 65-90) consists of abundant angular to subrounded quartz, whisps of chlorite, muscovite and biotite, and rare pyrite in a fine-grained matrix of quartz and sericite. Iron oxide and carbonate are characteristically absent (D.J.J.).

Mudstone, quartzite, greywacke sequence

This sequence consists predominantly of sooty and rusty blue to black shale and slate with occasional thin clean quartzite and greywacke beds and coarse, grey to white quartz conglomerate, which consists of rounded quartz pebbles in a siliceous matrix. The thickness of individual slate beds attains 30 m but is generally less. The greywacke ranges from fine-grained to gritty texture, is dark coloured and in places appears recrystallised (G.U., D.J.J.).

Forming the ridge between the Hatfield and Que valleys is one of the quartz conglomerate beds (65-102), consisting of moderately close-packed pebbles of abundant rounded to subrounded cleaved quartzite and rounded greywacke in a speckled grit/sandstone base containing whisps of sericite/muscovite. In specimen 65-102 [612795] is a subrounded pebble, 6 mm in diameter, of quartz porphyry consisting of embayed, euhedral quartz pheno-crysts up to 2 mm across in a mottled cellular base (D.J.J.). The quartzite pebbles are generally less than 25 mm in diameter but are up to 300 mm in places (G.U.).

BURNS PEAK - BULGOBAC SEDIMENTARY AND VOLCANIC SEQUENCES

Rocks of probable Cambrian age in the vicinity of Mt Kershaw - Burns Peak - Boco Siding - Bulgobac may be subdivided into predominantly sodic volcanic rocks and predominantly sedimentary rocks. The sedimentary rocks are distributed west of Mt Kershaw - Burns Peak and also in a narrow NE-SW trending zone immediately east of Tullah. North of Burns Peak, the major

28

contact between the two subdivisions swings east to trend approximately NE-SW. A transitional zone of predominant porphyry with interbedded slate and sandstone flanks the eastern margin of the main area of sedimentary rocks north of the Burns Peak track. The distinct sedimentary band, marking the eastern margin of the transitional zone, gives way eastwards to pre-dominant quartz and feldspar porphyries. An eastward dipping linear band of siliceous porphyry, which extends northwards from Burns Peak along The Pinnacles, is limited on both sides by sedimentary rock. The structural implications of the NW-SE trending off-shoot from the Burns Peak siliceous porphyry are not clear (C.M.B.).

In Boco Creek, south of the Burns Peak track, is a succession of fine-grained to porphyritic massive Cambrian volcanic rock, ranging from a feldspar porphyry with a pale green to grey groundmass and coarse pink feldspar phenocrysts to a fine pink to green, fine-grained rock with occasional small glassy phenocrysts of quartz. Quartz spherulites and amygdales are present in patches, and clots of albite and chlorite are rare. Possible pyroclastic rocks also occur but are difficult to dis-tinguish from porphyries. About 750 m along the Burns Peak track west of the railway is a crudely banded, possibly sedimentary, green-grey rock. About 750 m south of the track is a strong 'shatter' zone striking 005° and dipping 70° W with well developed slickensiding and alteration of the porphyries (D.I.G.).

West of Boco Siding, sediments and porphyries are closely inter-mingled, causing widespread induration of the sediments. The porphyries vary in grain size and generally seem conformable with the sediments, occurring as both intrusions and extrusions. In some intrusions, fragments of sediment have been included in the porphyry. For example, at 624707 and to the west, there is a thin intrusion dipping at a shallow angle with baked sediments above and below and sediment fragments within the porphyry. The sediments consist of dark to light brown banded siltstone and micaceous greywacke and tuffaceous sandstone (65-117 to 65-124). Cleavage is variably developed and sometimes masks bedding completely (W.L.M.). The fine- to medium-grained, grey to brown greywacke (65-117, 65-119, 65-121 to 124) consists predominantly of angular to subrounded fragments and grains of quartz, quartzite, quartz-mica schist and muscovite, and minor feldspar, chlorite, biotite, carbonaceous schist and basic volcanic rock set in a sericitic matrix. The fine-grained, grey-brown sandstone (65-118, 65-120B) is similar in composition to the greywacke, but lacks feldspar and basic volcanic fragments and exhibits a preferred orientation or platy arrangement of the grains and sericitic matrix. Occasional beds of grit (65-120A) con-sist of angular to subrounded grains of quartz, quartzite and quartz schist, about 1 mm across, in a yellow clay matrix (G.B.E.).

About 500 m north of Boco Siding a logging track extends to the west and exposes a sequence of sedimentary rocks with a regional strike of approximately 030° and dipping 65-80° W. This sequence comprises slate, siltstone and volcanic sandstone which are foliated in part, although small convolute folds and flame structures are well preserved in one horizon on the western extremity of the sequence. Volcanic sandstone with the same trend is also exposed on the flank of the next hill to the north and is well foliated (foliation 025°/70°E). North of this sedimentary sequence is a sequence of porphyries with coarse phenocrysts of quartz and feldspar. Cropping out on the Emu Bay Railway approximately 100 m south of Bulgobac is a grey coloured quartz-feldspar porphyry which encloses small, more leucocratic and fine-grained angular to subrounded fragments of quartz-feldspar porphyry. Fragments vary in size up to 225 mm in maximum diameter. Apart from the variation between fragments, the rocks are apparently homogeneous. Within this fragmental rock, roughly concentric 'joints' outline 'boulders' which

vary in size from less than 300 mm to more than 2.5 m in maximum diameter
(D.I.G.).

Along the Murchison Highway, north of Animal Creek, is an extensive
sequence of slate, siltstone and volcanic sandstone (weakly foliated) with
a regional trend of 030°-040° and dipping 40°-65°W. Small bands of pyro-
clastic or volcanic rock are enclosed within the sedimentary sequence,
particularly in the western margin of the sequence. Sedimentary structures
(e.g. convolute folds, grading) are common in places and indicate correct
way up for the beds. A small fold in the sequence plunges 4° towards 176°
with an axial plane 178°/88°E (D.I.G.).

RELATIONSHIP BETWEEN THE VOLCANIC AND SEDIMENTARY SEQUENCES

Sedimentary rocks within the predominantly volcanic sequence at Boco
Siding are, in part, gently dipping and rest upon quartz porphyry. To the
west of this point, the sedimentary bands are interbedded with quartz and
feldspar porphyries. A similar relationship is apparent at Tullah and at
several localities south of Farrell Junction (C.M.B.).

The main area of sedimentary rock exposed in the Pieman River gorge
is apparently up-faulted to the west and possibly unconformably against
predominant volcanic rock. The trend of this contact is at variance with
the general NE-SW trend of quartz porphyry ridges and sedimentary bands in
the Burns Peak, Farrell Junction and Tullah areas. However, between
Farrell Junction and the contact, the steep easterly dipping sedimentary
layers within the quartz and feldspar porphyries show a progressive west-
ward strike change to progressively parallel the contact. Sedimentary
rocks of the Pieman River gorge, approximately 1.5 km west of the contact,
are separated from the underlying (?) Crimson Creek Formation beds by a
thin fuchsitic conglomerate band (C.M.B.).

Both along the Pieman River and west of Boco Siding to the Burns
Peak ridge, the overall ratio of sedimentary rock to volcanic rock increases
westwards towards the major contact, a relationship which is not clear in
other less well exposed areas. Scree and rock detritus cover the flanks
of Burns Peak ridge and obscure field relationships of the siliceous
porphyry (C.M.B.).

STRUCTURE

In general, a NE-SW strike is common in the predominant porphyries,
and a NNW-SSE strike in the areas of predominant sedimentary rock near the
western margin of the quadrangle. Minor, steeply plunging asymmetrical
'drag' type folds occur within a zone of stratigraphic inversions west of
the main porphyry/sediment contact in the Pieman River. The plunge of
these folds varies from 85° to vertical with traces of axial planes,
measured at two localities, at 010° and 100°. The sequence inversions
and associated folding may possibly be significant expressions of large
scale overfolds. Minor flat lying, open folds have been recorded at
several localities (C.M.B.).

A steeply inclined NW-SE trending fault crosses the Pieman River
approximately 400 m west of the old Emu Bay Railway bridge. This fault
brings Cambrian sedimentary rock to the west against predominant porphyries
to the east. A roughly parallel fault, with a possible downthrow to the
north-east, offsets the quartz porphyry ridge north of Burns Peak (C.M.B.).

VOLCANIC AND SEDIMENTARY ROCKS IN THE TULLAH AREA *

Along the western margin of the Farrell Range, an extensive westerly dipping belt of slate and volcanic sandstone occurs between Cambrian porphyries, which are in places strongly foliated (foliation generally between 005° and 030°). There has been much controversy concerning the orientation of this succession, the majority of authors considering it overturned. Brooks (1962) reported overturning of sedimentary structures, current bedding and ripple marks near the Murchison River bridge. However no conclusive example of current bedding was found at this locality, although features structurally similar to current bedding are present. These are apparently produced by modification of bedding by cleavage at an acute angle to bedding. The Cambrian sequence is unconformably overlain by Owen Conglomerate, ranging in age into the Ordovician, occurring to the east of the area.

STRATIGRAPHY

Volcanic suite

The most westerly belt of rocks exposed at Tullah consist of soda-rich basic and intermediate volcanic rocks, including lava, tuff and breccia. The predominant rock type is sodic lava comprised of phenocrysts of pyroxene, feldspar, quartz and leucoxene in a fine groundmass of dominantly chlorite and sericite. Augite phenocrysts have ragged boundaries rimmed by secondary actinolite-tremolite and chlorite. The feldspar appears to be predominantly albite with a little oligoclase. In places, the augite phenocrysts are altered to an aggregate of epidote grains enclosed in chlorite, and hornblende occurs rarely as a minor constituent. Some coarse-grained aggregates of calcite, quartz and albite may represent amygdales.

Farrell Slate

Structurally underlying the volcanic rocks is a sequence of approximately 600 m of slate and volcanic sandstone. These sediments have been termed the Farrell Slates (Hills, 1915), Farrell Slate series (Henderson, 1945b), "bedded series" (Hall et al., 1953), Farrell Slates and Breccias (Carey, 1953) and Tullah Slates (Solomon, 1958). They apparently crop out over a distance of some 16 km from the Sterling valley to north of the Farrell Range. The slate sequence generally strikes 360° to 030° and dips 75-80° W, with a strong foliation at a small angle to the bedding. A strong shear subparallel to the porphyry-slate contact occurs on the western margin of the slate and the main Farrell ore bodies are contained within this shear.

The slate, which is predominant in this succession, is grey to black in colour and is finely laminated in places. It is composed of elongate undulose quartz grains, in places severely crushed, in a fine-grained matrix of sericite, chlorite and calcite. Small rock fragments and veinlets of calcite comprise the remainder of the rock, all constituents being commonly oriented parallel to the strong cleavage.

The volcanic sandstone appears discontinuous along its strike and is probably made up of lenticular units up to 30 m in width. Thin bands of alternating volcanic sandstone and slate are also common. The sandstone is green-grey, granular and contains irregular grains of quartz, albite, volcanic rock fragments, slate fragments and muscovite in a fine matrix.

---

* Compiled from Groves and Noldart (1965) and notes by D.I. Groves and
  C.M. Barton.

The rocks are characterised mainly by their granular texture.

Conglomerate

A lens of conglomerate occurs to the east of the slate and volcanic sandstone, reaching a maximum thickness of 152 m east of Tullah and thinning rapidly towards the south. It is poorly sorted, with an open framework and contains fragments of slate, quartz and feldspar porphyry, quartz and hematite in a fine matrix of sericitised and chloritised quartz and feldspar.

<div align="center">STRUCTURE</div>

The Cambrian rocks are extensively cleaved, while the overlying Owen Conglomerate is relatively less cleaved, probably due to greater competency. In places, the cleavage or schistosity is so strong within the Cambrian beds that the rocks may be termed cataclasites (plate 1). Pebbles of Cambrian rocks within the Lower Owen Conglomerate are cleaved, the cleavage being aligned parallel to that within the Cambrian rocks, suggesting that the cleavage is post-Ordovician and probably a Tabberabberan structure. There is no direct evidence for pre-Ordovician folding, although it is suggested by shallow residual dips in the Cambrian rocks upon unfolding of the Ordovician sequence (Brooks, 1962). Rose diagrams of cleavages indicate the occurrence of two acutely transgressing cleavages, the predominant cleavage, varying in strike from 005° to 015°, and the minor cleavage 020° to 030°. Both cleavages generally dip steeply west throughout the area, although vertical and easterly dipping examples occur.

Variations between isoclinal and shallow concentric folds are common within the Farrell Slate. The axial planes of small folds exposed in the area generally subparallel cleavage, with a N-S trend. The folds generally plunge to the north at 10° to 40°, although several plunge south at similar angles. Kink bands are common and strongly developed in places. More intense deformation appears to have occurred between the western boundary of the slate and volcanic rocks and the main Farrell shear zone, some 75 to 135 m to the east of this boundary. This is probably due to extensive relative movement between the two adjacent surfaces.

Joint directions were recorded at twenty-one localities in the vicinity of Tullah. Eleven of these localities are situated on the Murchison Highway to the south of Bulgobac River, five are on the Emu Bay Railway south of Boco and the remainder are on the north bank of the Pieman River between Farrell Junction and Tullah. Stereographic plots of poles to joints reveals that the greatest concentration of poles does not exceed 6% in any 1% area of the stereographic net. The difference between maximum and minimum concentrations is not sufficiently well marked for any conclusive interpretation of regional trends. Nevertheless, out of the 100 measured joints, those which strike 020°-025° with a dip of 80° to 90° W, and those which strike 165°-170° with a dip of approximately 80° S are relatively common. Other common directions strike 090°-150° and 160°-170° with dips of 5°-25° E and 45° N respectively.

<div align="center">MT BLOCK - MT CHARTER AREA</div>

The Cambrian rocks in the vicinity of Mt Block and Mt Charter are predominantly volcanic rocks, with the probable north-easterly extension of Farrell Slate lining the western slopes of the Mackintosh-Southwell valley.

On the western foothills of Mt Block is a monotonous sequence of light fawn or cream weathering, occasionally banded feldspar porphyry (*e.g.* 65-19), consisting of altered feldspar phenocrysts up to 3 mm long and scarce embayed

quartz phenocrysts in a fine-grained quartzo-feldspathic groundmass containing some sericite. Colour bands are about 5 mm thick. On the summit of Mt Block is a red-brown weathering, aphanitic quartz-feldspar porphyry (65-18), consisting of phenocrysts of feldspar (orthoclase) up to 3 mm long and sparse quartz, and stringers and patches of chlorite in a fine-grained (0.03 mm) granular quartzo-feldspathic groundmass in which irregular masses of chlorite and magnetite occur (A.B.G., G.B.E.).

Cropping out on the Murchison Highway, south-west of Mt Block and west of Farm Creek, are fine-grained, irregularly flow banded, grey and green feldspar porphyry lavas (e.g. 64-185), some trachytic in composition (64-183), and fine-grained, leucocratic, columnar jointed ignimbrite(?) (64-187). On the east bank of Farm Creek is a band of flowglomerate which can be traced north for about one kilometre from just east of the Farm Creek road bridge. Intrusive into these rocks are diabase dykes [639672 and 640647]. These fine- to medium-grained green dykes (e.g. 64-186) consist of partly altered (epidote, zoisite) feldspar laths, ragged hornblende crystals largely altered to chlorite, large and skeletal crystals of ilmenite and common irregular grains of fresh secondary albite (A.B.G., G.B.E.).

Cropping out along the Murchison Highway, west and north from Mt Charter, is a NNE-SSW trending sequence of fissile black mudstone, slate and shale. The sequence is terminated in the south by a NW-SE trending fault west of Mt Charter, and in the north, disappears beneath Tertiary basalt and sediment. East of the black shale sequence is an assemblage of melanocratic feldspar porphyry and fine-grained acid volcanic rocks, and intimately associated hornfelsed sediments. Along the ridge of Mt Charter is a NNE-SSW trending mottled grey, aphanitic, sheared and altered volcanic rock containing disseminated pyrite over a width of at least 30 m (G.U.).

East of Tullabardine Creek and north of Hanging Rock, the Cambrian rocks consist of the Farrell Slate and a variety of feldspar porphyries (A.B.G.). Intrusive(?) into the porphyry at 686673 is a fine- to medium-grained green diabase (64-190) consisting of feldspar laths (largely altered to microcrystalline calcite, zoisite and epidote), hornblende (largely altered to chlorite), skeletal magnetite and fresh secondary albite (A.B.G., G.B.E.).

Further to the north-east and underlying the Ordovician Owen Conglomerate correlate on the western slopes of the Mackintosh - Southwell valley are predominantly grey and brown bedded mudstone (64-46, 64-48), fine-grained grey micaceous sandstone (64-49, 64-51), medium-grained grey greywacke (64-55) and carbonate altered lithic tuff (64-50), with cataclasite and scarce feldspar porphyry (64-47) horizons. However further to the west the proportion of cataclasite and porphyry increases until the sedimentary rocks give way entirely to generally sheared porphyritic rocks (W.L.M., B.M.). Included in the porphyritic rocks west of the dominantly sedimentary sequence [716727] is a fine-grained light and dark mottled grey hybridised lava(?) (64-54) consisting of augite phenocrysts, isolated or as groups of phenocrysts up to 3 mm across, sub-angular recrystallised quartz, usually accompanied by irregular patches of chlorite, and a little epidote in a groundmass of feldspar laths, largely altered to carbonate, together with small grains and patches of quartz, feldspar, carbonate, chlorite and epidote (G.B.E.).

VOLCANIC AND SEDIMENTARY ROCKS OF THE EASTERN BELT

Trending north-east from the Sophia River valley through Mt Remus

Plate 1. *Cataclasite derived from Cambrian quartz-feldspar porphyry, Mackintosh River.*

Plate 2. *Contact between Cambrian porphyry and Ordovician siliceous clastic rocks, Black Bluff Range* [W.R. Moore].

and Back Peak, on the south-eastern slopes of the Mackintosh valley, to the head-waters of the Iris and Lea Rivers is a 2-4 km wide belt, broadening towards the north-east, of sedimentary and volcanic rock of probable Cambrian age. The rocks overly Precambrian rock to the south and south-east, and to the north and north-east are unconformably overlain by correlates of the Owen Conglomerate. The erosional contact between the Cambrian rocks and the overlying siliceous clastic deposits is most evident near the confluence of Speeler Creek, Fleece Creek and Vale River [875795] (B.M.). Similar erosional contacts between the windows of Cambrian porphyry and overlying correlates of the Owen Conglomerate have been noted on the north-western flank of Black Bluff Range (plate 2) (W.R.M.). The nature of the Cambrian/Precambrian boundary has not been established.

The Cambrian and Precambrian sequences are intruded by quartz porphyry bodies (B.M.) and in the Brougham River is a possible granite porphyry (A.B.G.).

STRATIGRAPHY

Overlying the Precambrian rocks to the north-east of Mt Remus and at Courtney Hill is a narrow belt of dominantly sedimentary rock overlain to the north and north-east by predominantly porphyritic volcanic rock.

Sedimentary rocks

East of Mt Remus and along Sumer Spur to Back Peak is a dominantly sedimentary sequence of conglomerate, coarse-grained quartzite, fine-grained quartzite and siltstone, and mudstone. Sedimentary structures suggest the bedding is upright and facing north to north-west. The base of the sequence has not been observed but quartzite and conglomeratic grits occur in out-crops south of Back Peak [875746] and on the southern side of Sumer Spur, closest to the base. These pass upwards via a transitional zone of thinly bedded mudstone and siltstone into predominantly pale grey siltstone. Over-lying this are thinly interbedded siltstone and fine-grained quartzite horizons. One quartzite bed about 230 mm thick contains sedimentary slump-ing or convolute folding in close proximity to an horizon of sedimentary brecciation. The top of the sequence has not been observed. Due to the presence of sill-like porphyry intrusive bodies within the sequence and the lack of outcrop to the north, away from the plateau margin, it is not possible to give a cogent estimate of the thickness of the sequence (B.M.).

Conglomerate horizons. These are confined in their distribution to Sumer Spur and are of two types, conglomeratic grit and pebble conglomerate. The grit beds are pale grey to dirty white on the immediate weathered surface and have an underlying reddish-brown weathered layer approximately 10 mm thick. On a fresh surface, the rock is grey-white but frequently has a faint pinkish tinge due to incipient weathering. Quartz fragments range up to 2 mm across and are distinctly angular. The feldspathic content is probably high and in this respect the rock could be termed an arkosic grit. The conglomerate horizons are similar in appearance to the grit on both weathered and fresh surfaces. The pebbles, which are either angular or sub-angular, range in size from 3 mm up to 30 mm but are predominantly 10 mm across. Four different rock types appear to comprise the pebble fraction; glassy (vein) quartz, quartzite, thinly bedded siltstone and micaceous schist. The matrix is probably argillaceous and feldspathic.

Quartzite. This rock is typically developed on the north face of Sumer Spur, where it occurs in beds ranging from 150 to 760 mm in thickness.

Poorly developed cross-bedding occurs in some of these horizons. The quartzite is grey-white in colour with varying shades of yellow, brown and purple on weathered surfaces.

Fine-grained quartzite and siltstone. With decrease in grain size and, possibly, an increase in the proportion of argillaceous detritus, the coarse-grained quartzite changes to pale grey, fine-grained quartzite interbedded with pale-medium grey siltstone. Unless banding is encountered in these rocks, bedding is not easily discernible.

Mudstone. Interbedded with the siltstone are horizons of dark grey mudstone (*e.g.* 63-62) occurring in bands ranging from a few millimetres to more than one metre in thickness. Occasionally, evidence of grading from siltstone into mudstone horizons is observed. At 841723 is a thinly laminated rock unique to the sedimentary sequence of this area. The laminae, generally less than 3 mm thick, comprise alternating argillaceous and siliceous horizons and exhibit cross-bedding (63-75).

Sedimentary breccia horizons. Beds of sedimentary breccia are developed at 849741, 856732 and 842723 from which specimens 63-72, 63-69 and 63-76 have been collected, respectively. The first of these horizons lies between undisturbed beds of fine-grained quartzite and siltstone and consists of fragments of quartzite or siltstone in a dark green-grey matrix. The included angular fragments, though very irregular in shape, are markedly equidimensional. The second horizon is closely associated with siltstone to the north and undisturbed quartzite to the south. It combines characteristics both of the previous breccia with those of the conglomerate horizons described previously on Sumer Spur, for although possessing a dark argillaceous matrix in which are embedded angular siltstone fragments, it also contains angular quartzite and schistose fragments. This horizon could be termed either a conglomerate or a sedimentary breccia. The third horizon is closely associated with the laminated mudstone (63-75) described in the previous paragraph and is underlain by a medium-grained quartzite. This breccia comprises angular fragments of quartzite (similar to 63-86) and laminated siltstone (similar to 63-75) within a dark grey argillaceous matrix. The platy fragments vary from 1 mm to 60 mm in both length and breadth and are up to 10 mm thick. The larger plates are slightly flexed but show no signs of balling.

From north-east of Back Peak to the Iris River, thin horizons of thinly bedded mudstone and quartzite and minor quartz sandstone are occasionally encountered within the porphyritic rock near the Precambrian boundary (B.M.).

Bedded clean quartzite is in contact with porphyritic rocks at Courtney Hill and again about 2 km along to the east. Fragments of quartzite occur within the porphyry along the contact (W.L.M.).

Porphyritic rocks

Rocks of probable volcanogenic origin have been mapped and recorded as predominantly quartz and quartz-feldspar porphyries, occasionally with sedimentary units being indicated. Flow banding in probable lavas has been occasionally recognised and recorded.

Along the western edge of the Precambrian rock, on the eastern slopes of the Sophia River valley and north-east towards Mt Romulus, is a mixed porphyry sequence dipping steeply west. The western extent of this Cambrian unit is probably restricted by a north-east trending fault, paralleling the outcropping porphyritic rock. The porphyry varies in macroscopic appearance; for example in one area it contains brecciated schist(?) fragments,

in another area rounded quartzite(?) pebbles up to 75 mm in diameter and in another area, a lens of siltstone and mudstone is enclosed by porphyry (A.B.G.).

North of Mt Romulus massive quartz-feldspar-chlorite porphyry, characteristically containing feldspar ovoids, is overlain concordantly by Ordovician quartzite [754704] (B.M.).

On the western slopes of the Fury River valley, near its confluence with the Mackintosh River, is a chloritic quartz-feldspar porphyry (W.L.M.). The purple coloured porphyry (64-53) consists of a fine-grained matrix crowded with phenocrysts of quartz and ferromagnesium minerals from 2 - 3 mm across and of pink and white feldspar crystals 5 - 6 mm long. The matrix is an even-grained mosaic of quartz and feldspar grains (averaging 0.05 mm) with minor chlorite and iron oxide. The phenocrysts comprise quartz in clear, rounded grains, often deeply embayed and shattered pseudomorphs of chlorite after hornblende, partially carbonated, and sericitised plagioclase and orthoclase (G.B.E.).

South-east of Mayday Mount, on the southern slopes of the Vale River valley between Tumbling Creek and Speeler Creek, is a sequence of quartz and quartz-feldspar porphyry rocks in which definite sedimentary rocks have not been observed. The porphyritic rocks contain phenocrysts of quartz, feldspar and chlorite (probably after amphibole) set in a fine-grained matrix. Quartz phenocrysts are always present, ranging from approximately one millimetre in a grey to green-grey 'cherty' to very fine-grained quartzite-like matrix, usually bereft of feldspar and mafic constituents, to 7.5 mm in a dark grey-green to blue-green coarser grained matrix, when they are frequently accompanied by phenocrysts of feldspar and chlorite. Original igneous banding or layering is infrequently observed on the weathered surfaces. Deformation is evident in most outcrops, ranging in its expression from zones of closely spaced platy joints to well developed schistosity enclosing lozenges and lenticles of less schistose rock of distinctly igneous origin. These rocks are transitional into highly schistose porphyritic rock in which original textures have been destroyed, but quartz phenocrysts are always present and commonly 3 mm in diameter. The schistosity apparently penetrates the area in belts independent of the original rock type (B.M.).

From north-east of Back Peak to the Iris River, the Cambrian rocks are predominantly massive porphyries, similar to the porphyritic rocks south-east of Mayday Mount, with occasional thin horizons of mudstone, quartzite and quartz sandstone. The porphyries range from coarse-grained melanocratic rocks to fine-grained 'cherty' leucocratic rocks with rare phenocrysts. Some of the more schistose quartz porphyries are probably originally tuffs and sediments of bimodal origin. In addition to the massive porphyries are composite rocks, generally with a porphyritic matrix, and of two main types. One type consists of angular 'cherty' fragments which may contain pin-head sized phenocrysts, in a porphyry-like matrix, while the other type [at 915805 and 923809] is a conglomerate consisting of angular 'cherty' blocks, well-rounded pebbles and cobbles of meta-quartzite, and coarse-grained porphyry also of high sphericity. This rock is probably derived from an admixture of volcanic and sedimentary material. Also within the sequence are fine-grained colour banded, possibly bedded, 'cherty' rocks of indeterminate origin. These rocks are typically enclosed by massive porphyry, the sheeting in which parallels the banding (or bedding). These rocks occasionally exhibit convolute folding [916808] suggestive of a sedimentary origin (B.M.).

To the north and north-east of Courtney Hill is a sequence of quartz-feldspar porphyries (*e.g.* 65-112, 65-113), devitrified tuff (65-115), silt-

stone (65-114) and greywacke (65-111). Interbedded with these rocks are beds of banded dark quartzite containing pyrite (W.L.M.).

Specimen 65-112 [991817] is a fine-grained green porphyry containing phenocrysts of quartz and feldspar and irregular rock fragments. The quartz crystals show embayment and corrosion and the feldspar crystals are completely sericitised but show indications of zoning and contain inclusions of quartz and greenish brown biotite. Other fragments consist of bright green chlorite associated with masses of sericite, the boundaries between the two often being sharp and straight and suggestive of crystal forms. The groundmass is a fine-grained non-uniform mass of sericite, chlorite and quartz (G.B.E.).

Specimen 65-113 [964810] is a pale grey, medium-grained porphyry containing irregular grains of quartz and·feldspar up to 3 mm long and a few dark irregular patches of opaque iron oxides up to 5 mm long. The rock consists of anhedral to subhedral quartz and subhedral feldspar in a fine-grained matrix, containing quartz, feldspar, sericite, and opaque white clay minerals sometimes stained by iron oxides. The feldspar is probably albite and is considerably altered, so that crystals may be difficult to distinguish from the matrix. The quartz is fractural and shows corrosion and embayment, but some grains show peripheral granulation (G.B.E.).

Specimen 65-115 [982821] is a pale coloured fine-grained devitrified acid tuff with some irregular banding and a few granular aggregates 0.5 - 2 mm across. In thin section, the rock is a mass of fine-grained quartz and sericite. Patches of fine-grained sericite up to 2 mm across occur sparingly and may represent original crystals of feldspar. Quartz occurs as grains up to 0.5 mm across and also occurs in small curved fragments and shard-like shapes (G.B.E.).

Specimen 65-114 [966815] is a fine-grained, brown, iron-stained indurated siltstone consisting of sharp angular quartz grains and opaque angular masses of kaolin derived from feldspar in a fine matrix of quartz, sericite and kaolin. There are a few scattered crystals of magnetite. Specimen 65-111 [988814] is a pale brown to grey coloured, partially metamorphosed fine-grained greywacke consisting of angular grains of quartz and a little fresh feldspar set in a fine-grained matrix of muscovite, biotite, quartz, feldspar and opaque clay minerals and iron oxides (G.B.E.).

INTRUSIVE PORPHYRITIC ROCKS

Intrusive quartz porphyry bodies have been mapped in the vicinity of Mt Remus - Back Peak and in Crisis Creek, intruding both the Precambrian rocks and the Cambrian sequence.

To the east of Mt Remus are pale grey-green to green-black porphyry bodies which weather to shades of pale yellow-brown to dark brown colour. They are characterised by glassy phenocrysts of quartz, ranging from less than 1 mm to 7 mm in diameter and frequently exhibit phenocrysts of a mafic constituent. When feldspar phenocrysts are present, the weathered surface is generally pitted. The contacts of the porphyry bodies vary with the host rock. In the Precambrian sequence, they appear to trend N-S to NNE-SSW and may possibly be controlled by fracture surfaces that denote the axial planes of a period of folding which crumples the schistosity. However in the Cambrian sedimentary sequence, the porphyry horizons trend parallel (or sub-parallel) to the bedding. They may be transgressive but confirming evidence is lacking. Therefore, it is tentatively concluded

that the porphyry bodies occur as dykes in the Precambrian rocks and as sills in the Cambrian sequence (B.M.).

In Crisis Creek, the only major tributary of Devils Ravine, pale green to green-black quartz porphyry dykes intrude Precambrian rocks up to 3 km from the Cambrian/Precambrian boundary. The rocks are characterised by glassy quartz phenocrysts ranging from less than 1 mm to 5 mm in diameter. The pale yellow-brown to dark brown weathered surface is frequently pitted, probably due to the weathering out of euhedral feldspar phenocrysts. Some of the pits may also have been formed from the weathering out of a mafic constituent, possibly amphibole. Disseminated pyrite and pyrrhotite are also present (B.M.). Specimen 63-64, for example, [840695] is of a green porphyry dyke containing phenocrysts of embayed and euhedral quartz and sericitised feldspar and irregular masses of chlorite with accompanying pyrite in an aphanitic matrix (G.B.E.). Although the relationship between the porphyry bodies and the country rock is not easily discernible, the porphyries appear to be dyke-like and trend 10° to 20° east of north, sub-parallel to the dominant schistosity. However the contacts are not markedly chilled and where observed [e.g. at 840695] are not simple but are frequently offset by small fractures and transgress the schistosity both along the strike and down the dip. The surfaces which bound the dykes are not planar but veer around the schistosity. In the porphyry dyke at 840695, adjacent to its contact with the Precambrian schist, are small xenoliths or rafts of the country rock. The xenoliths usually possess sharp margins, are bounded by concave surfaces, show no signs of assimilation, or exhibit much evidence of thermal metamorphism either in the xenoliths or the schist contiguous with the contact (B.M.).

Upstream from the Ordovician rocks in the Brougham River near its confluence with White Hawk Creek to about 732660 is a coarsely crystalline pink feldspathic porphyry with green crystals of chlorite. The coarse nature suggests it is intrusive, possibly a chloritic granite porphyry, but the contact between this and the finer grained porphyry to the east is not exposed (A.B.G.).

STRUCTURE

Bedding in the Cambrian sedimentary sequences is generally conformable with the dominant schistosity in the underlying Precambrian rock. Folds have not been recorded and separate intersecting foliations have not been observed. The present disposition is probably controlled by NNE-SSW trending folds. The Cambrian rocks were apparently not folded before the deposition of the Ordovician sedimentary sequences, since no pre-Ordovician period of deformation has been established (B.M.).

No schistosity is visible in the Cambrian sedimentary rocks in the Mt Remus - Back Peak area, the dominant form-surface being the original bedding. Lineation is restricted to thinly bedded (<10 mm) argillaceous horizons occurring at 869745, 856732 and 862787, whilst mesoscopic folding is confined to a small area immediately south of Back Peak [871746]. On a macroscopic scale, the bedding strikes from NNE-SSW in the region of Back Peak to E-W or NNW-SSE on the slopes of Sumer Spur, and dips predominantly to the north and north-west. This suggests large wavelength folding which, in view of the comparatively unmetamorphosed state of the rocks, is probably mainly flexural. It is likely that the fold axis plunges steeply north. Due to a lack of evidence, a structural sequence cannot be erected for these rocks and consequently a correlation or comparison of structures recorded in this and the Precambrian sequence is not feasible (B.M.).

Along the eastern edge of the Sophia River valley, the Cambrian porphyry/Precambrian schist contact possibly reflects a fault line along the edge of the Tyennan block and may be a fossilised fault scarp against which early Cambrian lavas and sediments were extruded and deposited, whilst deeper down the coarse porphyries were intrusive. In most places, the contact is not visible, but in one area to the south where it is exposed over a short distance the contact appears igneous, with anastomosing hematite veins penetrating the schist and porphyry across the contact (A.B.G.).

The actual boundary between the Cambrian and Precambrian sequence has not been observed in the Mt Remus - Back Peak area. The present divisional surface is probably tectonic, but whether it is wholly dislocational or has resulted from slight movement along a depositional unconformity is not known. Between Back Peak and Sumer Spur the boundary trends north-east and follows the strike of the bedding in the Cambrian sequences. It is reasonable to suggest that the boundary here is at least sub-parallel to the bedding along this section. North of Sumer Spur the boundary trends north-west and appears to truncate the bedding, indicating here it is at least partly tectonic. Further speculation on the mode of formation of these contacts with the little evidence available is hardly justified; however any hypothesis that is postulated must also account for the small outcrop of Cambrian rock at 842723 (B.M.).

The NNE-SSW trending section north-east of Back Peak appears to transect the Precambrian quartzite and has a similar relationship with the strike of the Cambrian sedimentary rocks, the Cambrian perhaps being conformable with the pre-Cambrian topography. The E-W trending section of the boundary north of Speeler Creek cannot be explained by this process, nor is there sufficient data in the Cambrian to ascertain its relationship with bedding. It would, however, appear unconformable with the dominant Cambrian schistosity (B.M.).

Ordovician and Silurian*

JUKES CONGLOMERATE CORRELATE

The oldest unit of the dominantly Ordovician sequence is the correlate of the probable Late Cambrian Jukes Conglomerate, which crops out on the western flank of Mt Farrell [672623] with structural discontinuity between it and the underlying Cambrian rocks. The conglomerate consists of boulders of quartz, quartzite, schist, chert and volcanic rocks contained in a quartzo feldspathic matrix with alteration to chlorite and sericite.

This basal formation is massive and always sheared and altered and is generally red to purplish-brown in colour. The composition of the matrix is very similar to the underlying Cambrian rocks from which it is partly derived. Consequently, shearing during the Devonian deformation resulted in segments of Cambrian rock tectonically interdigitating into the basal conglomerate.

OWEN CONGLOMERATE CORRELATE

Conformably overlying the Jukes Conglomerate correlate on Mt Farrell is the correlate of the Owen Conglomerate. This consists of hard prominent

---

* Compiled by A.B. Gulline from notes by B. Marshall, W.R. Moore, W.L.
  Matthews and A.B. Gulline.

beds of small boulder to cobble conglomerate, fine- to coarse-grained sandstone and fine- to coarse-grained shale. The basal siliceous conglomerate of this sequence contains boulders of quartzite, quartz, chert, jasper, occasional pebbles of sheared porphyry and uncommonly pebbles of hematite quartzite. Toward the north end of Mt Farrell the sedimentary rocks become finer, consisting of thinly bedded pink sandstone with subordinate pebble conglomerate and some coarse pebble to cobble conglomerate at the base (plate 3,4).

East of these beds but faulted against them are the youngest beds of the Mt Farrell sequence; these consist of well bedded fine pebble to small cobble conglomerate, fine to very coarse sandstone, pebbly sandstone and fine to coarse shale. This sequence fines northwards into better sorted fine to coarse sandstone and rare pebble conglomerate and pebbly sandstone. No fossils, bioturbation or tubicles have been found in the sandstone.

The progressive fining of the constituents of the siliceous clastic rocks continues northwards to the confluence of Speeler Creek, Fleece Creek and the Vale River [873798]. Here the unconformity between Cambrian rocks and the siliceous clastic sequence occurs in two outcrops (B.M.). The rock types overlying the Cambrian vary in thickness and lateral extent. In particular, the conglomerate beds are frequently lenticular. At the Vale River a siliceous quartz sandstone with infrequent small lenses of quartz pebble conglomerate rests unconformably on Cambrian rocks passing upwards over two metres into worm cast sandstone.

Basal beds of the siliceous clastic sequence from the Vale River are marked by a purplish-brown quartzite pebble and quartzite cobble conglomerate containing stringers and disseminations of specular hematite. The base of this conglomerate is very irregular with big embayments (possibly lens shaped) up to two metres deep into the underlying Cambrian.

The section down Fleece Creek from the Vale River is 60 - 76 m thick with a dip of 18 - 20° (B.M.). A syncline extends north-east from Fleece Creek toward Lake Lea in which conglomerate is subordinate and generally thin and fine in the eastern and western limbs. In the north-east corner of the quadrangle coarse siliceous conglomerate interbedded with granule conglomerate and hard siliceous red sandstone is found over a 16 m vertical interval (fig. 6,7). This is overlain by 150 m of red and pink sandstone siltstone and grey sandstone, with bioturbation becoming more common as grain size decreases. The top nine metres of the section consists of fine-grained massive light-grey sandstone (W.R.M.).

To the west of this syncline, the siliceous clastic sequence forms an anticline with some inliers of Cambrian rock exposed along the axis at Black Bluff [880860]. The rocks are fine-grained compared with the basal conglomerate seen to the south at Mt Farrell and comprise bioturbated and cross-bedded red and grey sandstone with poorly exposed red granule conglomerate (plate 5).

Further outcrops of siliceous sedimentary rocks occur at and east of Mt Pearse [647893]. These exposures are limited by overlying Tertiary basalt and Quaternary deposits. A cobble conglomerate bed occurs in coarse pink quartz sandstone on Mt Pearse (P.R. Williams, *pers. comm.*) but in the nearby exposure east of the Waratah Road there is only coarse- to fine-grained pink sandstone. Bioturbation and worm borings are abundant in both localities.

ORDOVICIAN SECTION – LEA RIVER
VICINITY OF VALE OF BELVOIR

GEOLOGIST W.R.MOORE

TASMANIA DEPARTMENT OF MINES

4484-44

Figure 6.

5 cm

STATION NUMBER DIP/STRIKE FORMATION AND TOTAL THICKNESS

THICKNESS (in metres)

Grey, calcareous, fine sandstone and limestone
interbedded with grey, muddy limestone
9m fine – grained, muddy limestone with fine,
calcareous sandstone beds and concretionary limestone
with pebble and fossil impressions
3m fine – grained, dark – grey, limestone
with stylolitic bedding
3m no exposure, contact not exposed
9m light – grey, non – calcareous, massive,
fine – grained sandstone with small quartz veins
Lithologically similar and correlated with massive,
fine – grained sandstone with quartz veins
and geodes at Station 12

No outcrop
Probably Moina Sandstone

65/070

Light – grey, tabular sandstone with
frequently abundant borings
Sandstone sorted, medium – grained
and bedded

65/070
65/070

0.9m – 1.2m bedded, medium – grained,
highly – bored sandstone minor fine sandstone
beds and siltstone less than 25mm thick present

Sandstone becoming better bedded, dark – grey
and medium – grained, occasionally bored
Strongly – jointed poorly – bedded, bored,
coarse – grained hard, pink sandstone

82/085

Banded, hard, red, coarse – grained
quartzitic poorly – bedded, sandstone

85/080

15m coarse conglomerate interbedded
with grit and hard, red sandstone, massive to
poorly – bedded, often quartzitic with minor shale
Sandstone highly jointed near contact in three directions
(260°, 140°, 90°) Quartz veins abundant at base
Unconformity not exposed 3m of no outcrop
separating good quartz porphyry and base of
cliff wall of Owen Conglomerate
9m dark – grey, strongly foliated schistose
– quartz – porphyry becoming less strongly
foliated away from contact
Coarse porphyroblastic quartz feldspar porphyry
at base of outcrop

GORDON LIMESTONE (17m)

OWEN CONGLOMERATE MAXIMUM 168m MINIMUM 127m

CAMBRIAN QUARTZ PORPHYRY

ORDOVICIAN SECTION
LEA RIVER
VICINITY OF VALE OF BELVOIR

GEOLOGIST W.R.MOORE

TASMANIA DEPARTMENT OF MINES

4485–44

Figure 7.

43

5 cm

Plate 3. *Kink bands developed in well bedded quartz sandstone, correlate of Owen Conglomerate, Sophia River.*

Plate 4. *Siliceous cobble conglomerate, correlate of Owen Conglomerate, Mackintosh River.*

Plate 5. *Cross-bedding in grey sandstone, correlate of Owen Conglomerate, Black Bluff Range* [W.R. Moore].

GORDON LIMESTONE CORRELATE

Limestone occurs in the valleys of the Sophia River, Mackintosh River, Brougham River, Mayday Creek, Southwell River and Vale River. In all cases only small stratigraphic thicknesses can be measured and the sequence cannot therefore be given accurately.

North from Fury Flats [790737] the sequence grades upward from bluish-grey calcareous quartz sandstone into interbedded, pure limestone with calcite nodules, siltstone and occasional fossiliferous sandstone (B.M.). Bedding is thin, ranging up to 250 mm. This lithology passes upward into thinly bedded limestone with filmy argillaceous partings beneath thinly bedded calcareous siltstone.

In the Vale River limestone occurs in a 17 m section near the base of the sequence (W.R.M.). The lowest outcrop consists of three metres of fine-grained grey limestone with stylolites followed by 10 m of fine-grained muddy limestone with fine calcareous sandstone beds and limestone with concretions, pebbles and fossils. The top of this section consists of grey calcareous fine sandstone and limestone with interbedded muddy limestone (fig. 7).

On the Brougham River, limestone is found near the top of the sequence and consists of dark blue-grey massive limestone containing fossils including *Maclurites* and *Favosites*. A section of unknown stratigraphic position occurs at the north end of Mt Farrell in the Mackintosh River. Generally dark blue-grey in colour, the limestone is fine to thickly bedded and contains beds of greyish calcarenite. These show current bedding that indicate that the beds are right way up. Some beds are fossiliferous, containing rugose and colonial corals.

From the various sections, it appears that the limestone has a con-formable gradation of boundaries between the underlying Ordovician siliceous rocks and the overlying siliceous Silurian rocks.

ELDON GROUP CORRELATE

The area between the Southwell River and its confluence with the Mackintosh River south-westerly to Brougham Creek contains rocks identifiable as Ordovician and Silurian in age.

In an overturned synclinal structure, white quartz sandstone pre-dominates at the northern end, overlying the Gordon Limestone correlate along its eastern boundary and at 720690 is overlain by slaty siltstone. A few fossils were found north of this point but at 725687 the sandstone becomes richly fossiliferous, being made up almost entirely of casts of *Cyrtia tasmaniensis* Gill which has a faunal range from the top of the Early Silurian into the Devonian. The sandstone is medium- to coarse-grained.

A major north-easterly trending fault cuts off the Ordovician and Silurian sequences from the Cambrian rocks to the west of 710680. The succession is probably equivalent to the Crotty Quartzite and is overlain by slaty siltstone of Amber Slate lithology. This siltstone contained unidentifiable corals and *Tentaculites*. A thin, hard siliceous quartz sandstone about three metres in thickness occurs in this slaty siltstone sequence and may be the Keel Quartzite equivalent. If so, the overlying beds are the equivalent of the Austral Creek Siltstone. Dips on this syn-cline range from 60° W on the western limb, becoming near vertical a short distance east and on the eastern side are shallow to 50° W, indicating

that overturning has occurred.

South-west of Mt Cripps [785795] between the Southwell and Mackintosh
Rivers is an area of predominantly siliceous quartz sandstone with inter-
bedded cleaved siltstone and slate (B.M., W.L.M.). The sandstone horizons
are sometimes fossiliferous and as these beds overly the Gordon Limestone
correlate, they are considered to be Ordovician to Lowermost Silurian (B.M.).
The fossiliferous quartz sandstone above the limestone suggests that it may
be equivalent to the Crotty Quartzite. Similar beds occur to the north-
west in the headwaters of the Hatfield River [760860].

The Silurian and Ordovician rocks have been folded and eroded and
therefore occur mainly in synclinal structures, with the exception of the
Ordovician rocks in the Black Bluff anticline.

Structure of Lower Palaeozoic rocks

The basal beds of the dominantly siliceous clastic correlate of the
Owen Conglomerate and its associated conformable strata appear to rest
with an erosional contact on underlying Cambrian rocks. On the western
flank of Mt Farrell [672623] the basal beds of the overlying conglomerate
reflect the composition of the eroded underlying acid and intermediate
Cambrian volcanic rocks (A.B.G.). Near the confluence of Speeler Creek,
Fleece Creek and Vale River [873798] an irregular erosional contact occurs
between underlying Cambrian rocks and overlying siliceous clastic deposits
(B.M.). Similar contacts between Cambrian rocks and the overlying correlate
of the Owen Conglomerate have been noted in the Black Bluff Range (plate 2;
W.R.M.).

Despite the occurrences of erosional contacts, there is no evidence
of angular unconformity to demonstrate deformation of the Cambrian rocks by
folding or faulting before the deposition of the overlying transgressive
siliceous clastic beds, which are followed conformably by a sedimentary
sequence ranging in age from Ordovician to Silurian.

FOLDS

The Cambrian, Ordovician and Silurian rocks are extensively deformed
by flattened parallel folds which are believed to be of Middle Devonian
age (Balme, 1960; Burns, 1965; Williams, 1976).

The hinges of the folds affecting the Lower Palaeozoic rocks are
usually either horizontal or gently plunging, so that the strike of the
various rock-units reflect the dominant fold trends. In general, the rock
units strike north-east, except for the areas in the south-west corner
of the region where they strike NNE and in the north-east corner where they
strike ENE.

The Cambrian rocks have behaved more incompetently during deformation
than the younger sedimentary rocks and the tight folds they display contrast
with the large open folds of the Ordovician and Silurian sequences. Slaty
cleavage in the Cambrian rocks is usually sub-parallel to the bedding in the
limbs of folds (C.M.B.) and is particularly well developed in some areas,
such as in a NNE trending zone near Tullah [655610]. The most complicated
fold structures noted in the Lower Palaeozoic rocks occur in a zone of
stratigraphic inversion of Cambrian beds west of the main porphyry/sediment-
ary rock contact in the Pieman River [570610], where minor asymmetrical
folds plunge at 85° to vertical and axial surfaces trend north (C.M.B.).
The sequence inversions and associated folding may possibly be significant

47

expressions of relatively large-scale overfolds.

First order folds in the Lower Palaeozoic rocks are most readily determined by examining the distribution of the Ordovician-Silurian rock units. The most continuous first order fold is a faulted syncline which extends south-west from Mt Cripps [785795], where it emerges from beneath a cover of Tertiary basalt, to the Sophia River [690630]. At the Sophia River, the synclinal trough is occupied by Ordovician Gordon Limestone. The eastern limb has probably been faulted out, whereas the western limb comprises siliceous clastic beds which become overturned at the western margin of the Farrell Range (A.B.G.). Further north, the synclinal trough is occupied by Silurian and Ordovician rocks. South of the Mackintosh River, the Sophia River - Mt Cripps syncline plunges gently to the north-east (A.B.G.), whereas north of the Mackintosh River the syncline plunges gently to the south-west (B.M.; W.L.M.).

South-east of the Sophia River - Mt Cripps syncline, the parallel trending folds, which have a half wavelength of approximately 2 km, are the Black Bluff Range anticline [860850], Vale of Belvoir syncline [900850] and the Bonds Range anticline [930860]. Along the crests of both the north-easterly and ENE trending anticlines of Black Bluff Range and Bonds Range are basin and dome structures, and inliers of Cambrian rocks amongst the overlying correlate of the Owen Conglomerate are common (W.R.M.; B.M.). The basin and dome structures may have been formed during a single fold phase, although the development of more than one cleavage in the area and the local divergence of the axial trends of the domes from the regional trend [e.g. 890870] suggests that they are the result of the interference of folds of two phases (B.M.). The dominant cleavage in the Lower Palaeozoic rocks in the north-east corner of the quadrangle is steeply dipping and is parallel to the north-easterly trending axial surface of the regional folds. Another steeply dipping cleavage, which is probably earlier, varies in trend from NNE [880870] to NNW [900810].

North-west of the Sophia River - Mt Cripps syncline, first order folds are difficult to determine because erosion has removed the Ordovician and Silurian beds and exposed Cambrian rocks. However, at Mt Pearse [657893], which rises above a plateau of Tertiary basalt, Ordovician siliceous clastic beds form a trough of a syncline gently plunging to the north-east (M.J.L.).

FAULTS

The faults indicated on the map sheet have either been proved or the mapped distribution of various rock-units has necessitated their presence. Many more faults may be present, but such possible faults have been omitted.

All faults are pre-Tertiary in age and most, if not all, are post-Jurassic. Faults developed in the central area of the region, however, are associated with zones of sheared rocks, which is an unusual relationship for those of post-Jurassic age. On the western side and adjacent to the fault along the Mackintosh River (A.B.G.), between 710690 and 730720, occur Cambrian cataclasites which grade to the west through a 800 m wide zone of less sheared Cambrian sedimentary and volcaniclastic rocks into unsheared feldspar porphyry. East of the fault is an associated zone of sheared and highly disturbed Ordovician and Silurian sedimentary rocks, the eastern boundary of which is concealed beneath Tertiary basalt and Quaternary deposits [730680].

Devonian granite

A grey coarse-grained, muscovite-biotite granite forms an intrusion within Precambrian rocks at Granite Tor [800605]. The granite is fine-grained near the contact and contains stoped xenoliths of the country rock along the northern boundary. Aplite dykes and veins of greisen and quartz also occur, while tourmaline nodules have been noted within the granite. The age of the granite has long been considered to be Devonian (Ward, 1908; Campana and King, 1963) and this has been substantiated by K-Ar dates of 355 ± 6 Ma for biotite and muscovite samples (McDougall and Leggo, 1965).

Permian

R.D. Gee *
K.L. Burns

Remnants of the Permian succession that covered much of Tasmania are exposed in the Mt Inglis-Barn Bluff-Cradle Mountain area in the south-west of the quadrangle. The section is incomplete, but there is a maximum of 360 m extending from the basal conglomerate up to at least the correlate of the Ferntree Group. The main interest in this area is in the lower con- glomeratic units which were deposited in a small trough. Deep dissection of the plateau allows the use of structure contours and isopachs to show the geometrical relationships between the individual units.

GEOLOGICAL SETTING

The flat lying Permian rocks were deposited on a basement of Pre- cambrian quartzite and schist on an erosional surface of considerable relief. Cambrian porphyry, Ordovician conglomerate and Devonian granite formed the basement immediately west at Granite Tor, where the Permian rocks have since been removed. The Permian succession was intruded by a sheet of Jurassic dolerite, which now occurs as remnants capping the higher peaks above the 1370 m level. There has been considerable erosion of the Permian and Jurassic rocks, with the development of a well marked plateau at a level of 1210 m. This plateau is now deeply dissected. Much of the area is covered by Pleistocene moraine and periglacial material, however the benched nature of the peaks allows the more resistant formations of the Permian succession to be traced between outcrops.

MT INGLIS TYPE SECTION

The type section of the formations are in the creek that flows south- east from the summit of Mt Inglis [889602]. The details of this section are given below and in Figure 8.

Basal pebbly siltstone

This unit extends from the unconformity at 857587 which is at 930 m to an altitude of 994 m. It consists mainly of pebbly siltstone and con- glomerate with thinner beds of limestone and sandstone. The composition of this unit is;

---

* Extracted mainly from Gee and Burns, 1968; Gee, 1964

Left column (stratigraphic section):

SUMMIT

1280

FELDSPATHIC SANDSTONE.

MT. INGLIS SANDSTONE 43m+

INTERBEDDED ARGILLACEOUS SILTSTONE.

1250

?
?

1220

FOSSILIFEROUS (CALCAREOUS) SILTSTONE.

WATERFALL VALLEY SILTSTONE 90m

1190

1160

SANDSTONE. BENSON PEAK SANDSTONE 5m

1130

FOSSILIFEROUS (CALCAREOUS) SILTSTONE WITH MINOR LIMESTONE BANDS.

CRADLE CIRQUE SILTSTONE 82m

1100

FOSSILIFEROUS (CALCAREOUS) SILTSTONE.

1070m

CARBONACEOUS SILTSTONE.

LAKE HOLMES COAL MEASURES 21m

LEVEL
SEA
ABOVE
METRES

Right column (stratigraphic section):

1070

FLAGGY SILTSTONE AND SANDSTONE.
FELDSPATHIC SANDSTONE.
CARBONACEOUS SILTSTONE.
WELL-BEDDED, FLAGGY SILTSTONE AND SANDSTONE.
CARBONACEOUS SILTSTONE.

LAMINATED PEBBLY SILTSTONE AND CONGLOMERATE WITH (CALCAREOUS) SILTSTONE, SANDSTONE AND MUDSTONE BANDS.

1040

LAKE WILL PEBBLY SILTSTONE 27m

POORLY SORTED, UNBEDDED, COBBLE AND BOULDER CONGLOMERATE.

1010

BARN BLUFF CONGLOMERATE 30m

BLACK (CALCAREOUS) SILTSTONE.

980

WELL-BEDDED COBBLE CONGLOMERATE.

BASAL PEBBLY SILTSTONE 80m

BLACK SILTSTONE.

CONGLOMERATE WITH THIN SILTSTONE AND SANDSTONE BANDS.

950

PEBBLY SILTSTONE.
LIMESTONE.
PEBBLY SILTSTONE.
CONGLOMERATE WITH SILTSTONE LENSES.

PRECAMBRIAN QUARTZITE.

920m

PERMIAN SECTION
MT INGLIS

R. D. GEE GEOLOGIST

Figure 8.

50

|← 5 cm →|

Altitude (m a.s.l.)	Description	Thickness (m)

Unconformity

930 *Member a* 3

Poorly sorted conglomerate with a perceptible
but non-persistent stratification. The layer-
ing is defined by lenses (600 mm thick and 1.2 –
1.5 m long) of brown argillaceous and micaceous
siltstone and also by boulder beds of varying
boulder size. The boulders occupy upward of 50%
of the conglomerate and are mostly of quartzite
with occasional schist. The quartzite boulders
are subangular, equant and tabular, the last being
oriented flat in the bedding. Schist boulders are
discus shaped and subrounded. Mean size of the
boulders is 50 mm and the maximum size is 305 mm.
Although a large mass of granite occurs 5 km west,
only one boulder of granite, 75 mm in diameter,
well rounded and spherical, was found. The matrix
is a quartzose and argillaceous siltstone with sub-
ordinate quartz granules and clastic mica flakes up
to 2 mm in diameter. The matrix in the conglomerate
has the same composition as the siltstone lenses, so
that there is no compositional change in matrix
between lithologies. The unconformity surface is
flat and smooth over the observed distance of 2.5 m.

933 *Member b* 9

Brown, micaceous, argillaceous, pebbly siltstone
with 10% of pebbles of quartzite which range
between 12 and 600 mm in diameter, have low
sphericity and are subrounded. In the middle of
this member is a one metre thick bed of weakly
laminated grey-blue unfossiliferous limestone.

942 *Member c* 14

Well-bedded conglomerate and conglomeratic silt-
stone beds, 1.2 – 2.1 m thick and regularly inter-
bedded with sandstone and siltstone beds averaging
300 mm thick. The conglomerate itself is fairly
well stratified by variations in the size of the
boulders. It consists of 40% or more of rounded to
subrounded, equant quartzite boulders with sub-
ordinate discoid schist boulders. Average size is
50 mm and the range is 12 to 130 mm. Both sand-
stone and siltstone contain up to 40% of rounded
pebbles.

956 Black micaceous pebbly siltstone with about 10% 1
subrounded quartzite boulders ranging from 6 to
12 mm.

Altitude (m a.s.l.)	Description	Thickness (m)

957   *Member d*   24

            Well-bedded pebble and cobble conglomerate with scarce siltstone bands. Pebbles are mostly of quartzite, average size 150 mm and range from 6 - 900 mm. The small pebbles are rounded and have a high sphericity. The matrix is micaceous, fine sand size, with about 20% of small pellets of clay mineral, 1 mm in diameter.

981   *Member e*   13

            Black, micaceous, calcareous, laminated siltstone with a coarse conchoidal fissility. It contains up to 50% of subrounded to rounded quartzite pebbles (average diameter 25 mm) with a high sphericity and ellipsoidal clay pellets (12 mm diameter). It is interlaminated with siltstone and fine sandstone bands 60 mm thick. Internal and external moulds of small conispiral gastropods 12 mm long are found

994   in this siltstone

Barn Bluff Conglomerate

This is one of the most topographically prominent formations in the area. It consists of a resistant boulder bed 30 m thick extending from 994 m to 1024 m a.s.l. This unit is generally the locus of large waterfalls and forms a conspicuous ledge which can be traced all round the southern and eastern part of Mt Inglis and up to 10 km to the east to Lake Will, Lake Agnew and Lake McRae. Stratification in the conglomerate is poor and discontinuous, being defined by a poor sorting of boulders of different size into rudimentary layers. Pebbles are mostly of quartzite with some schist. Quartzite boulders vary from sharply angular to subrounded and range in size from 12 mm to 1.2 m. The quartzite boulders are both equant and tabular, the latter being arranged at all angles to the horizontal. Matrix amounts to about 20% and is a coarse quartzose argillaceous silt with angular quartz granules and mica flakes. Siltstone bands are absent. The Barn Bluff Conglomerate is distinguished from the underlying and overlying conglomeratic units by its massive, unbedded appearance, the poor sorting of both matrix and pebbles and the angularity and disorientation of boulders.

In this section, the top siltstone member of the basal pebbly siltstone grades upward into the Barn Bluff Conglomerate. This transition takes place over a height of 1.8 m. Elsewhere, the base of the Barn Bluff Conglomerate is quite sharply defined. On this stratigraphic horizon in a large waterfall one kilometre north of the summit of Mt Inglis is a 300 mm thick bed of fossiliferous pebbly limestone. The fossils are calcite shell fragments of gastropods (*Keeneia?*), brachiopods and *Stenopora*.

Lake Will Pebbly Siltstone

This formation (1024-1052 m a.s.l.) is a well stratified sequence of siltstone and conglomerate beds averaging 3.6 m thick, with thinner beds of calcareous siltstone, mudstone and sandstone bands. Pebbles in the conglomerate vary in size between 6 and 150 mm, are rounded to subrounded and

elliptical in shape. All the siltstone beds are fossiliferous and the basal siltstone at 1024 m is exceedingly rich in gastropods, brachiopods, fenestellids, pectenids and stenoporids.

The siltstone bands in the upper portion contain worm tubules arranged parallel to the bedding, and infrequent structures of uncertain origin. These appear like plant or bark fragments, are up to 450 mm long and 50 mm wide, and striated with symmetrical, evenly spaced round top ridges, 2 mm high and 5 mm apart. They are terminated by structures which appear like nodes.

Lake Holmes Coal Measures

This unit (21 m thick) consists of black carbonaceous siltstone, quartzose siltstone and quartzo-feldspathic sandstone. It is a topographic-ally prominent unit, is pyritic and may be a freshwater deposit. It is made up as follows:-

Altitude (m a.s.l.)	Description	Thickness (m)
1052	*Member a*	1.5

Black carbonaceous fissile siltstone with small films of pyrite on bedding surfaces. Contains about 1% pebbles.

1053.5	*Member b*	6

Alternations of coarse fissile siltstone and medium-grained flaggy sandstone. Bedding surfaces (surfaces of lithological change) are undulating places of parting coated with large flakes of muscovite (0.5-3 mm in dia.). The sandstone is hard, light buff in colour, fairly well sorted and dominantly quartzose, containing 20% clay mineral and 10% mica. There are occasional rounded pebbles and cobbles of quartzite. The siltstone has a similar composition. Cross bedding and slump structures are common in the siltstone. Profiles of these slump folds are clearly visible on NW-SE vertical faces. They are confined to certain beds and each bed retains its uniform thickness. A structure resembling a plant stem was found near the top of this member. It was 230 mm long, 25 mm in diameter, ellipsoidal in cross section and completly replaced by pyrite.

1059.5	*Member c*	3

Well bedded, black, micaceous, fissile siltstone. A coal seam occurs in this unit in the Barn Bluff area but it was not found in the Mt Inglis area.

1062.5	*Member d*	1

Hard, buff-coloured massive, quartzo-feldspathic, micaceous, medium-grained, well-sorted sandstone. This is characteristic of the Lake Holmes Coal Measures and is easily recognisable in the field.

Altitude (m a.s.l.)	Description	Thickness (m)

It retains its thickness in all parts of the
area. In the northern sector of the area it is
coarsely cross-bedded and the bottom 150 mm is
quite gritty, containing angular granules of
clear quartz.

1063.5   *Member e*   3.5

Well bedded, coarse, fissile siltstone and medium-
grained flaggy sandstone.

1067   *Member f*   6

Hard, black micaceous siltstone. It is non-
fissile, has a conchoidal fracture and contains
1073   abundant small black plant fragments.

Cradle Cirque Siltstone

A black, calcareous, well-bedded siltstone, containing brachiopod
shell fragments at 1073 m a.s.l., marks the end of the freshwater deposit.
This formation extends from 1073 to 1155 m a.s.l. The exposure of the
lower portion is not good, as it occurs on the ledge created by the Lake
Holmes Coal Measures. The lower portion appears to be a well-bedded
micaceous siltstone with 5-10% pebbles. Spiriferids, strophomenids and
fenestellids are abundant. The upper portion is better exposed. It is
mainly a well-bedded, brown coloured argillaceous siltstone with bedding
units 150 - 300 mm thick. The pebbles are well rounded and vary in size
from 6 - 100 mm. Beds of fine quartzose siltstone, calcareous siltstone
and limestone averaging 300 mm in thickness are found within the top nine
metres. Brachiopod fragments are common, and some bands of siltstone have
a pseudo-stratification due to the profusion of bryozoa.

Benson Peak Sandstone

The Benson Peak Sandstone (1155 - 1160 m a.s.l.) is a green greywacke
sandstone five metres thick which forms a prominent bench at this altitude
around the greater part of Mt Inglis. It is composed of quartz (varying in
size from 2 mm down to silt size), disoriented muscovite flakes and small
clay pellets (1 mm in diameter). It contains about 15% of fragments of
calcite, angular quartzite, siltstone and quartz-mica schist. In addition
to these rock fragments, there is about 20% of subrounded quartzite granules
of medium sphericity and average size of 6 mm in the matrix. Thin round-
stone conglomeratic bands (50 - 75 mm thick) also occur. It is massive and
thickly bedded in 900 mm units, some being rich in bryozoal fragments.

Waterfall Valley Siltstone

This formation is also not well exposed, being covered by a thin
blanket of moraine. Immediately above the Benson Peak Sandstone at 1160 m
a.s.l. is two metres of an argillaceous thickly bedded siltstone containing
2% of quartzite pebbles. This is interbedded with a 300 mm thick band of
pebbly siltstone (up to 30% pebbles). The pebbles are well-rounded,
ellipsoidal and mostly of quartzite. One well-rounded, elongate cobble of
(Cambrian?) quartz-porphyry was found.

Commencing at an altitude of 1220 m is about 6 m of poorly sorted grey-blue calcareous fissile siltstone with abundant sub-rounded quartz granules and large clastic mica flakes, 2 mm in diameter. At 1245 m is a one metre thick exposure of brown, well-bedded siltstone with 5% quartzite pebbles. The base of the next formation is not exposed here but occurs at an altitude of about 1250 m. The Waterfall Valley Siltstone therefore extends from 1160 m to about 1250 m and is about 90 m thick.

Mt Inglis Sandstone

This unit consists of feldspathic siltstone passing upward into sand-stone. The altitude of the base is not known precisely but it occurs at approximately 1250 m. The lower half consists of regularly-bedded greenish-grey siltstone (600 - 900 mm thick units) with thinner sandstone bands. The sandstone has a weak colour lamination parallel to the bedding. It contains small globular and discoid clay pellets 0.5 to 2 mm in diameter. It is unfossiliferous, but contains abundant small black carbonaceous plant fragments. Pebbles are rare.

The upper half is a well-bedded, otherwise massive, quartzo-feldspathic sandstone, interbedded with thin siltstone bands. The individual sandstone beds average one metre in thickness. The sandstone is a creamy-brown colour with a green tinge. It is well sorted and contains small amounts of fine mica.

PRE-PERMIAN RELIEF

The deeply dissected present-day topography allows the altitude of the base of the Permian succession to be determined at a sufficient number of points to draw form lines on the surface of deposition. The basin (fig. 9) is at least 10 km long and 3 km wide. It is elongated in a north-east direction, parallel to the strike of the basement schist and quartzite and is actually carved out of a major schist belt. There is no evidence on the cause of this erosion, but glacial action may have been a cause.

The basin is closed to the north-east but is open to the south-west by an area of low relief with an incised deep gorge-like outlet. Flanking the basin to the north-west is a high ridge of quartzite, generally 275 m above the basin floor. To the south-east is a broad area of low relief 180 m above the basin floor. Still higher ground is found to the north at Cradle Mountain. The total relief in the area is 425 m.

A small NNE trending pre-Permian fault cuts the north-east end of the basin. The Barn Bluff Conglomerate was deposited against the low scarp of this fault.

BLUFF RIVER PEBBLY SILTSTONE

In its type section (Gee, 1964) this formation consists of five members. These correspond to members *a* to *e* of the basal pebbly siltstone (page 49).

The pebbles within these members are rounded and consist of mainly Precambrian quartzite and schist with small amounts of Lower Palaeozoic granite, conglomerate and porphyry. Members *e* and *a* are laterally persistent throughout the Mt Inglis area.

RELIEF OF SUB-PERMIAN SURFACE
STRUCTURE CONTOURS DRAWN THROUGH SPOT
HEIGHTS ON UNCONFORMITY SURFACE
UNITS IN METRES ABOVE PRESENT SEA LEVEL

Figure 9.

The lowest bed of member *a* in the Mt Inglis section contains both angular and rounded boulders between 12 and 300 mm in diameter. Many of the quartzite boulders occur as slabs which are lying flat in the bedding plane. The matrix is poorly sorted and dominantly quartz of coarse silt grade, with subordinate quartz granules and clastic mica flakes. The surface of deposition is smooth, but with no evidence of striae.

In the gorge of a tributary of the Fury River [894615], 1.5 km north of the summit of Mt Inglis, the basal bed consists of 1.2 m of conglomerate with a rudimentary sorting due to larger more angular fragments at the base and smaller rounded fragments at the top. Overlying this is a one metre thick bed of siltstone with about 5% pebbles. In this tributary, member *b* contains at least three thin limestone beds.

In the bottom of a deep cirque [875597] 1.5 km west of the summit of Mt Inglis, member *b* contains beds of poorly sorted quartzo-feldspathic sandstone about 450 mm thick. Also in the cirque is an angular unconformity within member *c*. One sandstone bed is tilted at 12° south-west. The upper surface of this bed contains asymmetrical ripple marks indicating a current direction from the south-east. This is overlain by a poorly sorted, un-stratified, wedge-shaped cobble bed, which is in turn overlain by a flat-lying, stratified conglomerate with siltstone lenses.

The Bluff River Formation is confined to the deeper parts of the basin and at higher levels is transgressed by the overlying Barn Bluff Conglomerate which then lies directly on the basement. The established limits of Bluff River sedimentation are shown in Figure 9. The wedging-out against basement rises is seen on the plateau 2.5 km north of Mt Inglis [895628], on the eastern wall of the Fury Gorge 1.5 km north of Barn Bluff where the basement rises sharply at an angle of 25° [926635] and also on the southern edge of Lake Will [926595].

A marine environment is indicated by gastropods in the top unit and the presence of bedded limestone. The appearance of ripple marked sand-stone close to the higher ground to the north may indicate the proximity of the strand line. The ripple axes are directed along the axis of the basin. The significance of the angular unconformity associated with the sandstone beds is uncertain, but may be due to littoral slumping.

Most of the boulders and pebbles are of Precambrian rock and probably of a local origin. The exotic pebbles are rare and well-rounded. The common occurrence of well-rounded and sharply angular fragments suggests that some contribution to the rudite fraction may have come from scree material shed from the high ground to the north-west. There is no evidence to indicate deposition by mudflows or glaciers. However, it is possible that some of the isolated pebbles in the siltstone are ice rafted.

BARN BLUFF CONGLOMERATE

The Barn Bluff Conglomerate covers the underlying Bluff River Pebbly Siltstone in the lower parts of the basin of deposition and at higher levels is draped directly onto the basement. It averages 30 m in thickness. It is the most prominent topographic unit in the area and forms a well marked bench on the sides of mountains throughout the area.

The Barn Bluff Conglomerate is different from the underlying and over-lying pebbly siltstone because of its massive or poorly bedded appearance, the poor sorting of both matrix and fragments which form a continuous frame-work and the angularity and disorientation of the fragments. It consists of

two fragment types, one type rounded and ellipsoidal, the other angular and tabular. In the deep part of the basin the minor rounded type is more evenly distributed throughout the formation and the fragment size is usually larger.

In the Mt Inglis section, the top siltstone member of the Bluff River Formation grades upward over an interval of two metres into the conglomerate. Both angular and rounded fragments occur, varying in size from 12 mm to 1.2 m. Schist fragments are uncommon. The large slabs of quartzite are inclined at all angles.

West of Mt Inglis, where the conglomerate laps onto the Precambrian basement, schist fragments are more abundant. At the small outlier 4 km west of Mt Inglis [847610], it consists of 60% boulders of angular fragments of schist, minor amounts of rounded quartzite and rare granite cobbles. The tabular slabs are not lying flat in the bedding plane but stand at all angles. The matrix is a poorly sorted quartz sandstone with abundant angular quartz granules.

On the edge of the plateau north of Mt Inglis, overlooking the Fury Gorge [892628], the Barn Bluff Conglomerate is underlain by inter-foliated, vertically dipping quartzite and schist, with the rudite fraction consisting of equal portions of angular to sub-angular quartzite slabs and sub-angular slabs of schist. There is no indication of an oriented boulder bed at the base. The fragments vary in size from 50 to 900 mm and average 250 mm in diameter. The matrix generally occupies 10% of the rock and is composed of angular granules of locally derived quartzite and schist in about equal proportions. Silt is generally absent from the matrix.

On the south edge of Fury Gorge [936650], just west of a northerly flowing tributary, the lower portion of the formation consists dominantly of sub-spherical angular quartzite ranging in size from 75 - 450 mm. The rounded type, consisting of ellipsoidal quartzite pebbles up to 100 mm, is dominant toward the top. At this locality there is a lateral diminution in pebble size to the north-east. This round-pebbly conglomerate at the top of the Barn Bluff Conglomerate is a characteristic feature in the area from Little Horn to Hartnett Rivulet.

On the north bank of the Fury River, immediately under the summit of Cradle Mountain [952668], is a basal boulder bed two metres thick draped over the basement quartzite. This contains sub-rounded quartzite boulders up to two metres and averaging 150 mm, forming 60% of the rock. There are occasional angular boulders up to 600 mm at the base derived from the immediately underlying basement. The matrix is composed of angular quartzite chips of coarse-sand grade. The overlying granule conglomerate consists of angular fragments of quartzite, with scattered pebbles of rounded quartzite, averaging 25 mm. These rounded pebbles are ellipsoidal with their long axes parallel to bedding. Bedding is marked by discontinuous bands of coarser conglomerate.

At Little Horn [967680] the angular fragments comprise 80% of the rudite fraction and average 100 mm in length, although they may occur up to 600 mm. The tabular fragments average 50 mm with some up to 100 mm. The matrix is composed of schist and quartzite flakes averaging 12 mm, with interstitial granules of quartzite. Bedding is from 1.5 to 3 m thick and is marked by variations in the quantity of matrix.

On the north face of Benson Peak [965650], the conglomerate con-sists of sub-angular, equant quartzite and discoidal schist particles rang-ing in size from 25 - 150 mm. Some rare pebbles of Lower Palaeozoic con-

glomerate occur. The round-pebbly conglomerate contains ellipsoidal
pebbles 12 - 75 mm in diameter. The matrix is a fine quartz sandstone.

Oriented boulder beds at the base of the Barn Bluff Conglomerate
are developed on the flat pre-Permian surface south-east of the basin, in
the Lake Agnew-McRae-Ellen area.

At Lake Ellen [983596], the dominant foliation in the basement is
sub-horizontal. The basement is overlain by a boulder bed in which the
foliation and mullions in the detached slabs are nearly parallel to those in
the quartzite. This grades upward into a disorientated boulder bed and
then into the normal conglomerate. The transition zone is lenticular,
varying from 1.5 to 4.5 m in thickness. The detached slabs in the oriented
boulder bed vary from 50 - 600 mm and appear to be controlled by the
spacing of joints in the quartzite. The matrix in this basal bed is a
fine argillaceous sand containing angular chips of quartzite of coarse-
sand size.

The Barn Bluff Conglomerate is draped like a thin blanket over the
partly filled trough in a manner shown diagrammatically in Figure 10.
The shape of the top of the conglomerate still reflects the shape of the
initial basin, but with markedly reduced relief. Basinward dips of 6° are
common on the north-west flank and more gentle basinward slopes occur on
the south-east flank. The overlying formations wedge out against the
rising Barn Bluff Conglomerate. In the Hartnett Rivulet and the Mt Inglis
area it is overlain by the Lake Will Pebbly Siltstone. At the head of Fury
Gorge it is overlain by the Lake Holmes Coal Measures and at Little Horn
it is overlain by the Cradle Cirque Siltstone.

The unusual features of the Barn Bluff Conglomerate suggest that it
is neither a glacial nor marine deposit. It is considered to be dominantly
a terrestrial scree breccia or periglacial deposit, which formed during a
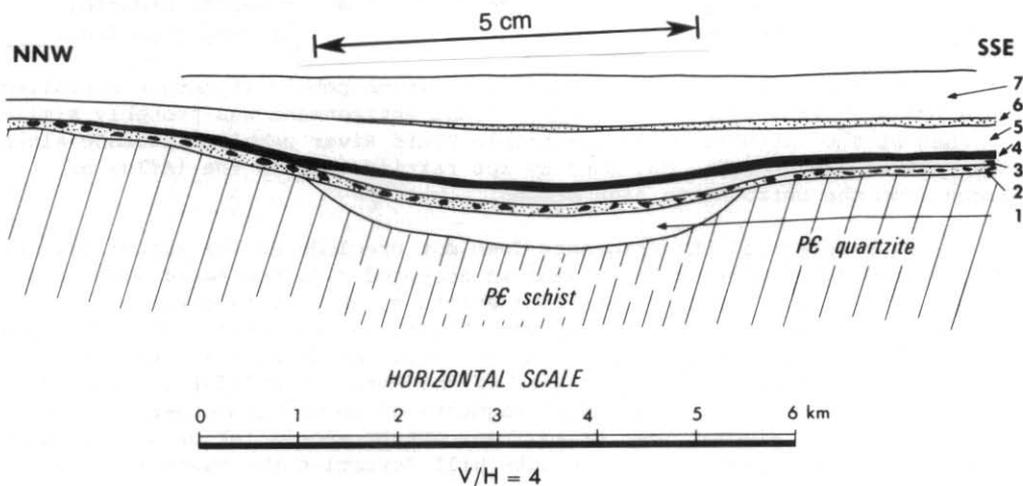
1. Bluff River Pebbly Siltstone
2. Barn Bluff Conglomerate
3. Lake Will Pebbly Siltstone
4. Lake Holmes Coal Measures
5. Cradle Cirque Siltstone
6. Benson Peak Sandstone
7. Waterfall Valley Siltstone

Figure 10. *Diagrammatic cross-section of the Permian basin*

specific interval of time when the basin had partly filled. A derivation predominantly from the local basement is certain and some of the material on the flat pre-Permian surface has undergone no transport. There is an overall fall on the top of the conglomerate from north to south of 240 m in 6.5 km. This confirms the suggestion of Banks (1962, p. 200) that much of the material was shed from a high ridge to the north-west. Remnants of this high ground exist on the northern end of the north-west flank of the basin.

LAKE WILL PEBBLY SILTSTONE

The Lake Will Pebbly Siltstone is a well-stratified sequence of dominantly siltstone with conglomerate layers and beds of calcareous siltstone, fossiliferous limestone and sandstone. It is about 27 m thick and is more conglomeratic in the deeper part of the basin.

In the type section at Mt Inglis, the conglomeratic layers vary from 1.5 - 4.5 m thick. The fragments vary in size up to 150 mm and are sub-rounded. The matrix is generally poorly sorted, consisting of both silt and sand.

The siltstone layers contain scattered rounded to sub-rounded pebbles in varied proportions. The pebbly layers within the siltstone are rich in fossil fragments and in places are calcirudites. The lower-most siltstone lying directly on the conglomerate at 888616 is rich in *Trigonotreta stokesi* Koeing, *Martiniopsis, Keeneia platyschismoides* Etheridge Fil., *Keeneia* [*Platyschisma*] *ocula* (J. de C. Sowerby) and *Peruvispira* sp. The siltstone beds toward the top contain worm tubules arranged parallel to the bedding. These structures have been observed in the Mt Inglis section and in the wall of the Barn Bluff cirque.

On one bedding plane in the wall of the Barn Bluff cirque [948623] is a zone of nested rectilinear grooves up to 25 mm in depth, trending 040°. These may be the result of glacial sliding or iceberg grounding.

The Lake Will Pebbly Siltstone is a marine pebbly siltstone deposited in a broad shallow basin. The depositional environment was probably similar to that of the lithologically comparable Bluff River Pebbly Siltstone although the pebbles are probably due more to ice rafting than to the influx of scree from the surrounding high ground.

The rounding of the fragments does not preclude an ice-rafted origin, because rounded fragments are common in accepted tillites found elsewhere in Tasmania (*e.g.* rounded quartzite erratics, showing faceted and striated surfaces, occur in the Wynyard Tillite at Wynyard). This rounding in a glacigene environment may be due to recycling of erratics within multi-glacial and interglacial phases of the Permo-Carboniferous glaciation, incorporation of initially rounded fragments of Lower Palaeozoic conglomerate pebbles into the glacial ice, or to transport by subglacial or supraglacial streams. After deposition of the Lake Will Formation the basin was almost completely filled.

LAKE HOLMES COAL MEASURES

In the Mt Inglis section, this formation consists of six members (see p.53). The Lake Holmes Coal Measures is 21 m thick in the Mt Inglis section, thins to 15 m east of Barn Bluff and appears to wedge out against the underlying Lake Will Pebbly Siltstone further east.

The coal seam that is reported in the early reports (Montgomery, 1893*a*, 1893*b*) was not observed in the Mt Inglis area and is thought not to exist there. In the Barn Bluff area its outcrop is limited by the extensive periglacial and moraine material and was not seen at the time of this mapping. It has been observed previously by one of the authors (K.L.B.) on the Overland Track, on the spur north of Waterfall Valley. The coal seam is a clastic deposit 200 mm thick and occurs at the top of unit *c*. Fragments of coal are abundant in the glacial moraine on the spur between Lake Holmes and Barn Bluff [952604]. Montgomery (1893*a*) records the plant fossils *Neoggerathiopsis* and *Glossopteris* in the shale which is probably unit *c*.

South of Cradle Mountain the overlying Cradle Cirque Siltstone lies directly on the Barn Bluff Conglomerate. This is an area of slightly higher ground upon which the coal measures were probably never deposited.

The lithological features indicate the environment was non-marine, shallow water, at times with free current action and at other times with restricted circulation.

CRADLE CIRQUE SILTSTONE

The Cradle Cirque Siltstone is a well-bedded micaceous and argillaceous siltstone which is 80 m thick in the Mt Inglis area. It contains up to 10% pebbles of rounded quartzite in certain bands. Spiriferids, strophomenids and fenestellids are abundant and in places the siltstone is calcareous. At least two beds of blue-grey limestone occur near the top of the formation.

Many more limestone beds are exposed at the same stratigraphic interval at Barn Bluff. These beds are 75-600 mm in thickness and are interbedded with thin calcareous siltstone beds. The limestone beds are richly fossiliferous, containing spiriferids, stenoporids, strophomenids and crinoids.

BENSON PEAK SANDSTONE

The Benson Peak Sandstone forms a prominent bench at the 1158 m level around Mt Inglis, on the north slopes of Barn Bluff and at Benson Peak. It is a light cream coloured quartzo-feldspathic sandstone, in bedding units averaging one metre thick and contains angular quartz grains of very coarse-sand and coarse-silt grade, disorientated muscovite flakes, clay pellets of coarse-sand grade and probably glauconite. Some of the beds contain up to 15% of angular fragments of quartzite, siltstone, mica schist and fossil shell fragments.

The sandstone is 45 m thick at Mt Inglis and the lower beds contain thin conglomerate bands 50 to 75 mm thick. These have a continuous framework and are composed of rounded quartz and quartzite up to 50 mm.

Five kilometres to the north-east at Barn Bluff it is only 2.5 m thick. The lowermost bed is 1.8 m thick and is a massive white feldspathic, medium-grained sandstone. The lowest 75 mm of this bed is a conglomerate composed of rounded and spherical quartzite and schist granules up to 25 mm. Minor amounts of pebbles of Devonian granite and Cambrian quartz porphyry are present three kilometres further to the north-east at Benson Peak, where it is only one metre thick and is a conglomeratic sandstone with rounded quartzite pebbles up to 50 mm.

WATERFALL VALLEY SILTSTONE

The Waterfall Valley Siltstone consists of 75-90 m of blue-grey siltstone which weathers to a light brown colour. It is poorly exposed and is incompletely known.

At Mt Inglis, immediately above the Benson Peak Sandstone, is 12 m of thickly bedded argillaceous siltstone containing isolated pebbles. These pebbles are well rounded and dominantly of quartzite with rare Cambrian quartz porphyry.

Thirty metres above the base is 6 m of grey-blue mudstone with a conchoidal fracture. This mudstone contains abundant sub-angular to sub-rounded quartz granules and clastic mica flakes 2 mm in diameter. Rare fenestellids occur at Mt Inglis and Barn Bluff.

This formation is outwardly similar to the Cradle Cirque Siltstone, but differs by its finer grain size, paucity of fossils and pebbles and lack of limestone.

MT INGLIS SANDSTONE

The Mt Inglis Sandstone forms the capping of Mt Inglis. Its base is not clearly exposed and it has a minimum thickness of 43 m.

At Barn Bluff, the Mt Inglis Sandstone is similar to that at Mt Inglis. The lower 30 m is dominantly a yellow argillaceous mudstone with abundant worm casts and mud pellets. This passes upward into a feldspathic sandstone which contains angular quartz fragments varying from 2 to 10 mm.

Between this sandstone and the base of the dolerite at Barn Bluff are scattered outcrops of a black carbonaceous shale with sandstone bands up to 12 mm thick, commonly as cross-bedded lenses. This sandstone contains black carbonaceous fragments. The section at Mt Inglis is not high enough to include this rock type.

CORRELATION OF THE PERMIAN SECTION

The general sequence of pebbly siltstone with limestone containing Lower Permian fossils, followed by a coal measures horizon and then siltstone with strophomenid limestone beds forms a basis for correlation in nearby areas. The Lake Holmes Coal Measures can be correlated confidently with the Liffey Group (McKellar, 1957), as suggested by Banks (1962, p. 192).

The succession above the Lake Holmes Coal Measures has broad lithological similarities with other areas in the central highlands. The Cradle Cirque Siltstone and the Waterfall Valley Siltstone correspond respectively to the 'Woodbridge Group' and Ferntree Group as used by Jennings (1963), MacLeod et al. (1961) and McKellar (1957).

The Benson Peak Sandstone is lithologically similar to the 9 m thick resistant sandstone between the Woodbridge and Ferntree Groups in the Du Cane Quadrangle. MacLeod et al. (1961, p. 23) considered this to be the Garcia Sandstone, at the base of the Ferntree Group in the Poatina section, but Banks (1962, p. 208) suggested correlation with the Malbina Formation in the Hobart area.

The Mt Inglis Sandstone, consisting dominantly of massive cream feldspathic and carbonaceous sandstone, appears to equate with the correlate

of the Cygnet Coal Measures in the Du Cane Quadrangle and the Poatina section.

The Lake Will Pebbly Siltstone, immediately below the coal measures, is correlated on lithological and stratigraphical grounds with the Wallace River Group of MacLeod *et al.* (1961) and the Kansas Creek Beds of Jennings (1963). Both of these units have been correlated with the Golden Valley Group of McKellar (1957) and Wells (1957).

CONCLUSIONS

The Cradle Mountain-Barn Bluff area provides an example of a local and complete basin, where the mutual relations between the rock units of the Lower Permian can be examined. Of particular interest is the influence of the shape of the basin on the sedimentary history of the lower pebbly formations. The basin is 10 km long and 3 km wide and 300 m deep. Not until the deposition of the Lake Holmes Coal Measures did the basin cease to be an effective restriction on sedimentation.

The basal Bluff River Pebbly Siltstone is marine and is confined to the buried valley beneath Mt Inglis. The overlying Barn Bluff Conglomerate is draped over the pre-Permian surface on the flanks of the basin. The succeeding Lower Permian formations wedge out against the Barn Bluff Conglomerate which rises onto high ground on the north-west flank of the basin.

The Barn Bluff Conglomerate exhibits unusual features. It is an unstratified blanket deposit composed dominantly of angular, unsorted fragments of Precambrian quartzite and schist, in a silty and sandy matrix. In places it has a considerable depositional slope and where it directly overlies Precambrian basement, parts of the deposit can be shown to be un-transported.

The conglomerate was probably continuous across the basement high in central Tasmania, covering a region extending from Barn Bluff to Cathedral Mountain and Western Bluff.

Banks (1962, p. 196-197) has advanced the picture of this central region as an ice-covered island in the Permian sea at the time of initial sedimentation, with tillite accumulating in the major basins to south and east. Following this, the ice retreated, allowing Quamby Mudstone to form in the major basins and a more pebbly variant in the smaller basin beneath Mt Inglis.

At a specific interval of time, probably while Quamby sedimentation was continuing, climatic conditions were such that an extensive periglacial scree blanket formed on the central island. This was followed by a marine transgression onto the island, as a result of which the top layer of the scree was reworked to form the top round-stone conglomerate. Some of the debris may have been washed away and incorporated as conglomeratic lenses in the Quamby Mudstone.

The deposition of the Lake Will Pebbly Siltstone (Golden Valley) marks a complete transgression and a sandy, shelly environment. The gradual warm-up culminated in the formation of the coal measures in a shallow-water, free-circulating, non-marine environment.

Jurassic dolerite

In the south-east of the quadrangle the Permian succession has been intruded by a sill of dolerite which caps the higher peaks of Cradle Mountain [955669] (plate 6), Barn Bluff [929622] and Mt Emmett [981642]. The medium-grained, well-jointed sheet of dolerite is a continuation of the dolerite bodies underlying the Central Plateau, which have been K-Ar dated as 170.5 ± 8.0 Ma (Schmidt and McDougall, 1977). A small body of dolerite which crops out on the western flank of Mt Charter [699748] and a smaller body indicated by dolerite float at 750810 are probably Jurassic in age.

Tertiary

In the north-west of the quadrangle the pre-Tertiary surface was generally a plain at about 550 m above present mean sea level (D.J.J.). Locally, the plain was deeply dissected with remnant topographic highs (e.g. Mt Pearse, 647893). Basalt flows inundated much of the area, filling the major valleys and obliterating the drainage patterns, but leaving a few Palaeozoic inliers with intervening lava flats. The basalt is olivine rich and comprises a series of flows, the total thickness of which is frequently in excess of 150 m. The flows form several distinct topographic steps and the margins of multiple sheets form step-like features on the valley sides. The basalt occasionally preserves ropy, vesicular and zeolite-rich soles.

Vesicular basalt underlies the plateau in the north-east of the quadrangle (B.M.). The base of the basalt flow tends to conform with the 550 m contour.

Sediment has been recorded beneath the basalt and between basalt flows at a number of localities. Areas of quartz sand, siliceous sandstone, siliceous conglomerate with rounded pebbles and mudstone with plant remains occur in the headwaters of the Coldstream (D.J.J.), Hatfield (D.J.J.) and Que Rivers (W.R.M.). A grey micaceous siltstone occurs in a cutting on the Cradle Mountain Road near the landing ground and boulders of Tertiary siliceous breccia and conglomerate, considered to have been derived locally, occur in glacial deposits in the drainage area of the Iris River (W.L.M.).

Pleistocene

E. Derbyshire*

GLACIAL MORPHOLOGY

Glacial erosion

The widespread development of cirques has resulted in the dissection of the upper slopes of most of the ranges to produce a fretted upland. The growth of cirques on the eastern slopes has given a marked asymmetry to the mountains. The mean orientation of all cirques, including over-ridden cirques, on and about the Cradle Mountain - Barn Bluff plateau is a little north of east. Nivation cirques, which are the product of perennial snow or firn patches, occur at Mayday Mount [851806]. In terms of glaciation, cirques provide an indication of parts of the former transition zone from glacial to non-glacial environments. Valley-head rock thresholds, which are best developed on the Cradle Mountain - Barn Bluff plateau, are complex in that they were associated with piedmont and plateau ice-sheets rather

---

* Extracted mainly from Derbyshire, 1968.

64

than with valley glaciers.

The lakes on the Precambrian basement about Cradle Mountain and Barn Bluff vary from lakes occupying hollows gouged out by the plateau ice-sheet, to substantial rock basins in cirques (e.g. Lake Will at 930605, which is approximately 30 m deep), over-ridden cirques (e.g. Crater Lake at 950700 which is approximately 60 m deep) and over-ridden trough ends (e.g. Lake Dove at 965700, approximately 60 m deep). Lake Rodway [970660], which occupies the large complex cirque on the east side of Cradle Mountain, is approximately 36 m deep.

The considerable amount of valley widening and deepening effected by glacial erosion is obvious only in the source area of glaciers, as in the areas of Cradle Mountain - Barn Bluff and High Tor - Mt Romulus [760670] (A.B.G.). Elsewhere, large scale signs of glacial erosion are either absent or require detailed investigations of the type used in drilling and geo-physical studies by the Hydro-Electric Commission to establish a catenary valley cross-profile of the Mackintosh Valley at 690660. Many of the major glacial outlet valleys (e.g. Fury River) have v-shaped cross profiles, which suggest that the agents of modification include post-glacial river erosion.

Small scale erosional effects

Small scale effects of ice abrasion and plucking, such as roche moutonnées, fluting, gouging and striation are best seen on the Precambrian rocks, notably about Lake Dove [965700]. The varying resistance of different members, such as massive quartzite and schist, is reflected in the details of several glacial pavements, where the directions derived from glacial striae are consistent with those obtained from roche moutonnées (Derbyshire, 1968).

Glacial depositional landforms

Glacial deposits are widely distributed and they are generally thicker and least modified on gentler slopes. On steep slopes, glacial drift may be covered or mixed with talus in which broken dolerite columns are the major component.

The most important landforms of glacial drift in terms of former ice extent and movement are the end moraines, such as the low, discontinuous and sometimes hummocky examples north-west of Lake Dove and a thick arcuate moraine mound, which is concave to the west, at 730645 (A.B.G.). Hummocky moraines occur in tributary valleys as well as on some plateau surfaces (e.g. Dove River and Barn Bluff plateau) and they indicate thin, motionless ice.

GLACIAL SEDIMENTS

Till

Areally, the most important category of drift is the glacial till or ground moraine. In the Cradle Mountain area fragments of Precambrian meta-morphics predominate. The till is usually rather poor in the silt-clay fraction, clasts are more angular, texture loose and the degree of chemical weathering less than in the drifts consisting dominantly of dolerite. Some 24 m of a possible till has been recorded by the Hydro-Electric Commission in a drill hole at 690660, while further west near 650730, 3.6 m of compact till has been exposed in cuttings on the Murchison Highway (A.B.G.).
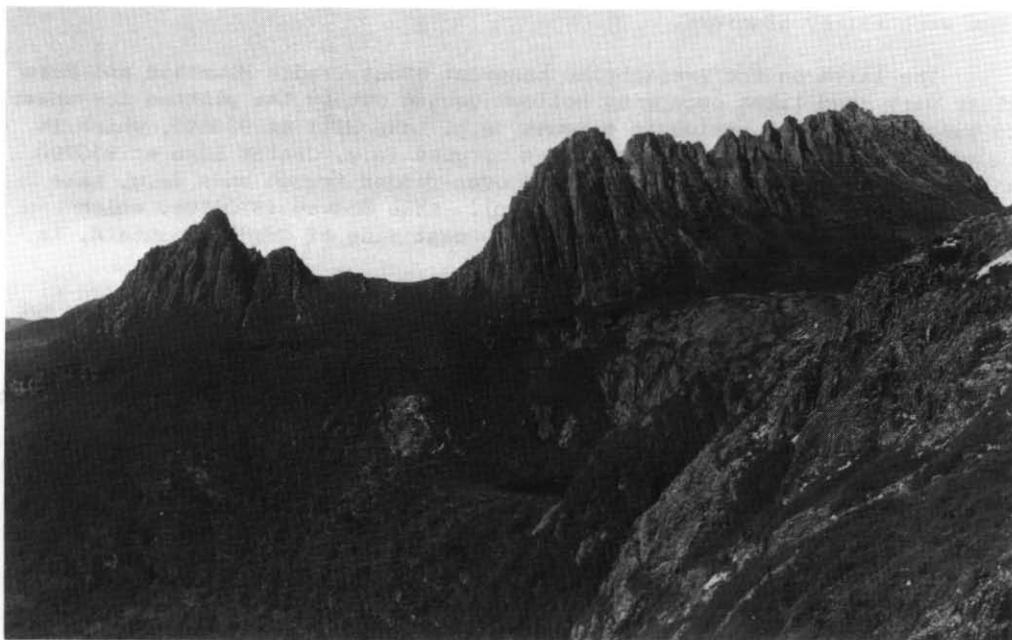
Plate 6. *Dolerite peaks of Little Horn and Cradle Mountain overlying gently dipping Permian sediments which unconformably overly Precambrian basement rocks.*

Plate 7. *Channel developed in Cambrian acid volcanic rocks infilled with Quaternary gravel of probable glaciofluvial origin, Pieman Road.*

Plate 8. *Bedded scree derived from correlate of Owen Conglomerate,
Sophia River.*
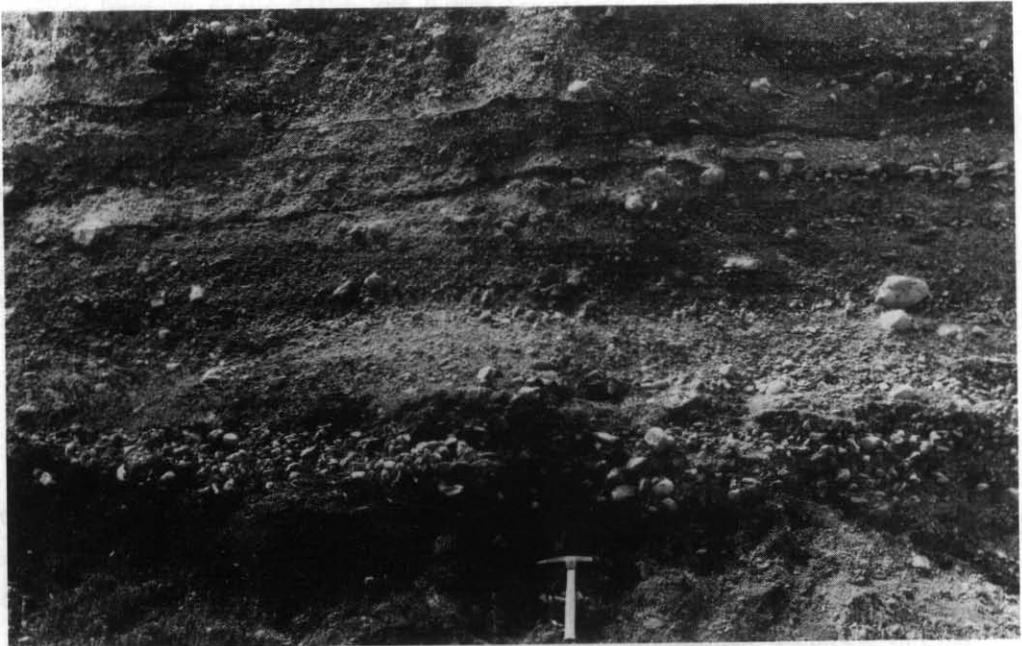
Plate 9. *Well bedded gravel of probable glaciofluvial origin, Murchison
Highway.*

Erratic boulders have been found well beyond the limits of glacial till. These include the large dolerite erratics on the surface of the Vale of Belvoir near Lake Lea [925875] and a variety of erratic pebbles and cobbles upon and within the soils on the Middlesex Plains [980770]. Erratic boulders of granite, dolerite, Owen Conglomerate, Cambrian porphyry and Precambrian quartzite are common in the High Tor - Mt Romulus area (A.B.G.; B.M.). Erratic boulders have also been recorded at the confluence of the Southwell River and Mackintosh River [742730] and as far west as 630700, where they consist of dolerite, Owen Conglomerate, Cambrian porphyry and Precambrian quartzite (W.L.M.).

Glaciofluvial deposits

Glaciofluvial deposits have been noted by the Hydro-Electric Commission in drill core from 690660 and are exposed along the Mackintosh River up-stream from the drill site (B.M.). Glacial and glaciofluvial deposits occur in the area between the Murchison Highway (plate 9) and Burns Peak [579674] (C.M.B.; D.I.G.). Further to the south-west, glaciofluvial and resorted glacial material form extensive deposits in the flat-lying plains near the headwaters of the Marionoak River and along the Pieman River (C.M.B.).

Glaciolacustrine deposits

Deposits laid down in ponded glacial melt waters occur in minor undulations in the regions of hummocky moraines. The deposits are light grey and consist of unconsolidated, pliable clay-silt with occasional sandy layers as at Lake Rodway.

Rhythmites up to 2.5 m thick are exposed in a western tributary of the Southwell River at 720740 (B.M.) and a two metre thick section occurs in a creek draining the western slopes of Observation Spur at 720720 (W.L.M.).

Holocene

Pleistocene glacial forms and deposits have recently been modified. Many of the major glacial outlet valleys (*e.g.* Fury River 900640) have v-shaped cross profiles, and narrow strips of alluvium, which parallel the larger creeks and rivers, merge imperceptibly with glaciofluvial and glacial deposits from which they are derived by re-sorting (B.M.; A.B.G.). Difficulties have been noted in distinguishing the older glaciofluvial deposits from the derived shingle banks, sand bars and alluvium associated with the flood plains of the Mackintosh River and Southwell Creek (B.M.). Pre-existing creek bed levels are marked by terrace deposits, as in Crisis Creek near its confluence with the Devils Ravine [837695], where the top surface of gravel deposits is approximately one metre above the present creek level, which approximates the lower surface of the gravel deposits (B.M.).

Swamp deposits underlie valley plains to the west of Mt Block [670705]. The deposits consist of sand and clay derived from Pleistocene glacial deposits and peat formed from buried vegetation of dominantly buttongrass (A.B.G.). Similar deposits underlie the Sophia River plain [700650], which is bounded to the west and east by recent talus deposits of sandstone and Cambrian porphyry respectively (A.B.G.).

Notable talus deposits occur of basalt [730680, 995790], dolerite [925620; 980635; 950660] and sandstone [640880; flanking Bonds Range at 930870; flanking Black Bluff at 890855]. Stratified scree deposits derived from the Owen Conglomerate correlate at Hanging Rock have been exposed by

quarrying at 690650 (plate 8).

ECONOMIC GEOLOGY

Metallic minerals

P.L.F. Collins

The area covered by the Mackintosh Quadrangle contains a variety of metallic mineral occurrences, the most significant of which are the silver-lead(-zinc) deposits of the Mt Farrell mining district and the stratiform, massive pyrite deposit at the Chester mine. Mining activity has been centred in the Mt Farrell area, particularly at the North Mt Farrell and New North Mt Farrell mines which, between them, operated continuously from 1899-1973.

Current mineral exploration is concentrated in areas underlain by Cambrian rocks of volcanogenic affinity and in areas of potential carbonate bearing sequences, for possible volcanogenic massive sulphide deposits and for metasomatic replacement (skarn) deposits respectively. Exploration in the quadrangle has been stimulated by the recent discovery of the Que River prospect, a volcanogenic Zn-Pb-Cu massive sulphide deposit.

The majority of the metallic mineral deposits in the quadrangle occur within areas underlain by Cambrian rock, and in particular those sedimentary and extrusive/intrusive igneous rocks of volcanogenic origin. These deposits can be generalised into four groups; two groups syngenetic with volcanism, one group later than the host volcanic rock but possibly related to the volcanism, and the Mt Farrell deposits of probable mixed origin.

The first group includes the massive pyrite deposit at Chester, the Pinnacles Cu-Pb-Zn mineralisation, and the recently discovered Que River deposit, which are all probably stratiform massive sulphide deposits formed by exhalative processes syngenetic with the volcanism. The mineralisation at Chester and the Pinnacles has also suffered intensive post-depositional deformation with accompanying remobilisation and recrystallisation of the metallic sulphides.

In the second group are several small prospects (*e.g.* Silver Falls, Cutty Sark, Hawkesbury, Gold Hill) at which disseminated metallic sulphides of probable volcanogenic origin have been remobilised(?) into shear zones within volcanic rock during post-volcanism deformation.

In the third group, several small prospects have been established on cross-cutting veins within the Cambrian volcanic sequence (*e.g.* Home Rule, Langdon). The restriction of these veins to Cambrian volcanic rock indicates that they are probably associated with late stage volcanic activity, rather than related to Late Devonian granitic plutons.

The Mt Farrell deposits, including the Tullibardine deposit, occur in a sedimentary sequence of volcanogenic origin within the volcanic pile and exhibit characteristics of syngenetic massive sulphide mineralisation, and also features indicating epigenetic fissure veins. The most likely explanation of the origin of these deposits is that they were partially deposited during accumulation of the volcanic pile, and were later remobilised and emplaced, together with additional epithermal mineralisation, in their present position, filling fissures formed during deformation in the Early-Middle Devonian (correlated with the Tabberabberan orogeny).

THE MOUNT FARRELL MINING FIELD

0 — 1 — 2 km

BUTTRESS HILL

NEW NORTH
MT FARRELL MINE

Line of section, Figure 13

CENTRAL MACKINTOSH MINE

SOUTH MACKINTOSH MINE

NORTH MT FARRELL MINE

MT FARRELL MINE

MT FARRELL

MT FARRELL MINE
(SOUTH WORKINGS)

DUTTONS WORKINGS

CENTRAL FARRELL   MINE

TULLAH

NORTH MURCHISON
(MURCHISON EXTENDED)

MACKINTOSH
MURCHISON

Lake Herbert

MURCHISON RIVER
MINE

SOUTH MURCHISON

GREEN AND KING
WORKINGS

REUNION
RIDGE

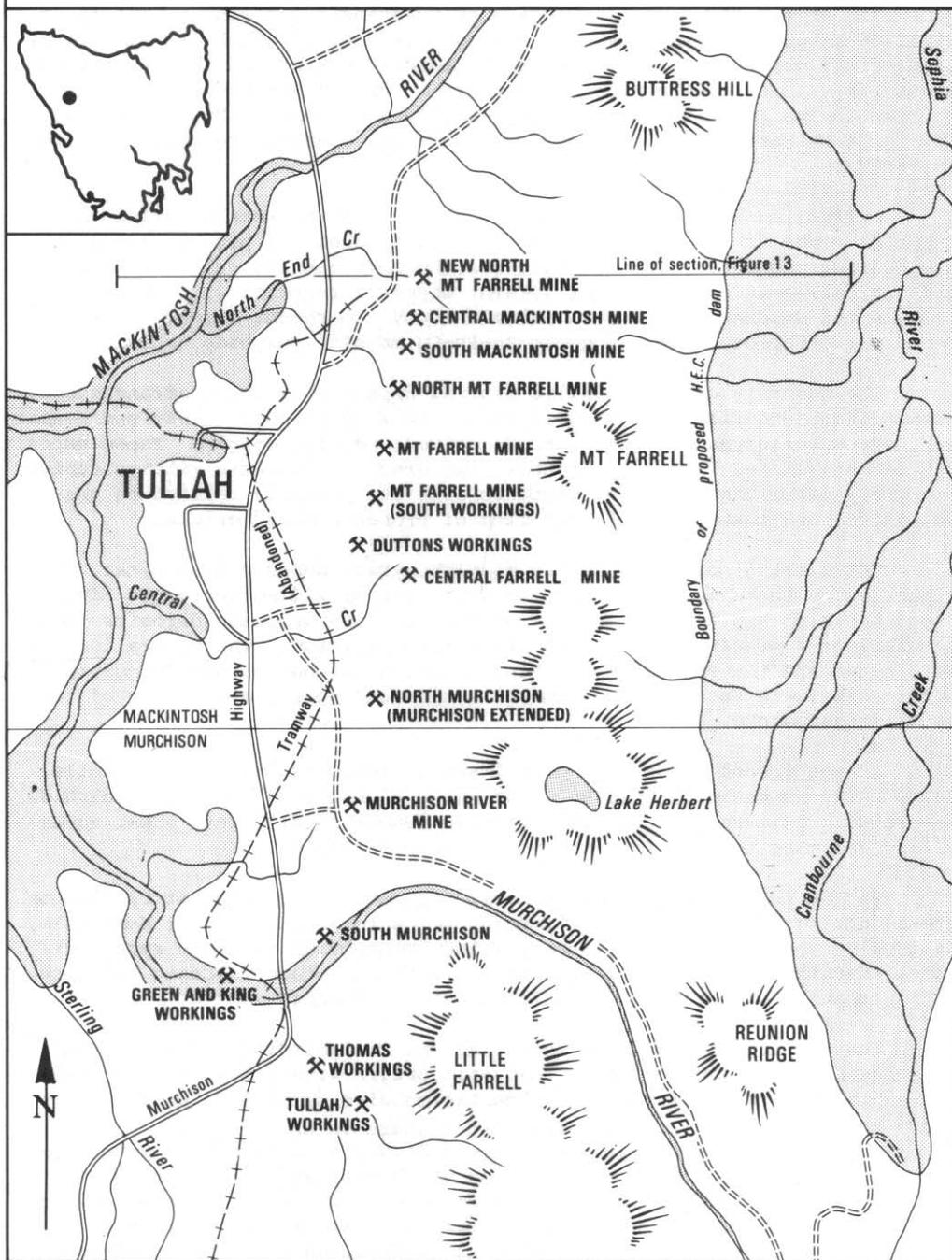THOMAS
WORKINGS

LITTLE
FARRELL

TULLAH
WORKINGS

N

Figure 11.

5 cm

Deposits probably genetically associated with the emplacement of Late Devonian granitic plutons are minor in number and include the White Hawk Ag-Pb-Zn deposit in Gordon Limestone, quartz-pyrite-molybdenite veins at the Mt Remus prospect, and the Fleece Creek Ag-Pb deposit. In addition, there is a small tin prospect on Granite Tor.

The only significant occurrence of alluvial gold is at Strongs workings, adjacent to the Pinnacles mine.

SILVER-LEAD-ZINC

Silver and lead are the only metals in the quadrangle which have been mined continuously and in significant economic quantities. Most production has come from the North Mt Farrell and New North Mt Farrell mines on the Mt Farrell mining field. Although always known to contain sphalerite, the majority of these deposits were mined for their silver and lead content only. In addition to the deposits described below, Henderson (1945a) reports the occurrence of barite and galena in limestone near the junction of the Que and Huskisson Rivers.

MT FARRELL MINING FIELD

The Mt Farrell mining field comprises several small silver-lead-zinc deposits situated along the western flank of Mt Farrell, between the Murchison and Mackintosh Rivers (fig. 11). Although any general observations apply to the entire field, only those workings north of, and including the North Murchison (Murchison Extended) mine are described here. In addition to the mines and prospects described below, numerous other small prospects scattered throughout the Mt Farrell area are described by Ward (1908) and Brooks (1962). These are mostly on veins exposed in creeks.

Between 1899 and 1973, the total recorded production from the Mt Farrell deposits was 735 064 t of ore containing 96 092 t of lead and 319 695 kg of silver. Most of this was mined from the North Mt Farrell mine and later from the New North Mt Farrell mine. Annual production graphs for these two mines are shown in Figure 12. Recorded production from some of the mines on the field was;

Mine	Ore mined (t)	Pb (t)	Ag (kg)
North Mt Farrell (1899-1933)	est. 432 000	49 340	159 714
New North Mt Farrell (1934-1973)	298 682	44 610	151 274
Murchison (1904-1909)	2 727	1 112	4 541
Mt Farrell (1906-1911)	1 305	829	3 428
Mackintosh (1906-1911)	350	201	738

History

Silver-lead mineralisation was discovered near Mt Farrell in 1897 (Hall *et al.*, 1953) and by 1900 at least ten mining companies were operating (Foley, 1901). Mining activity reached a peak following the completion of the Tullah Tramway in 1902, but by 1911 all mines except the North Mt Farrell mine were abandoned. A detailed history of mining in the Mt Farrell field is given by Henderson (1945b). The following description of the two main producers on the field (North Mt Farrell and New North Mt Farrell mines) is taken from Groves and Noldart (1965).

"Galena was discovered on the North Mt Farrell leases in 1899 and mining was commenced by driving adits at successive levels on this lode.
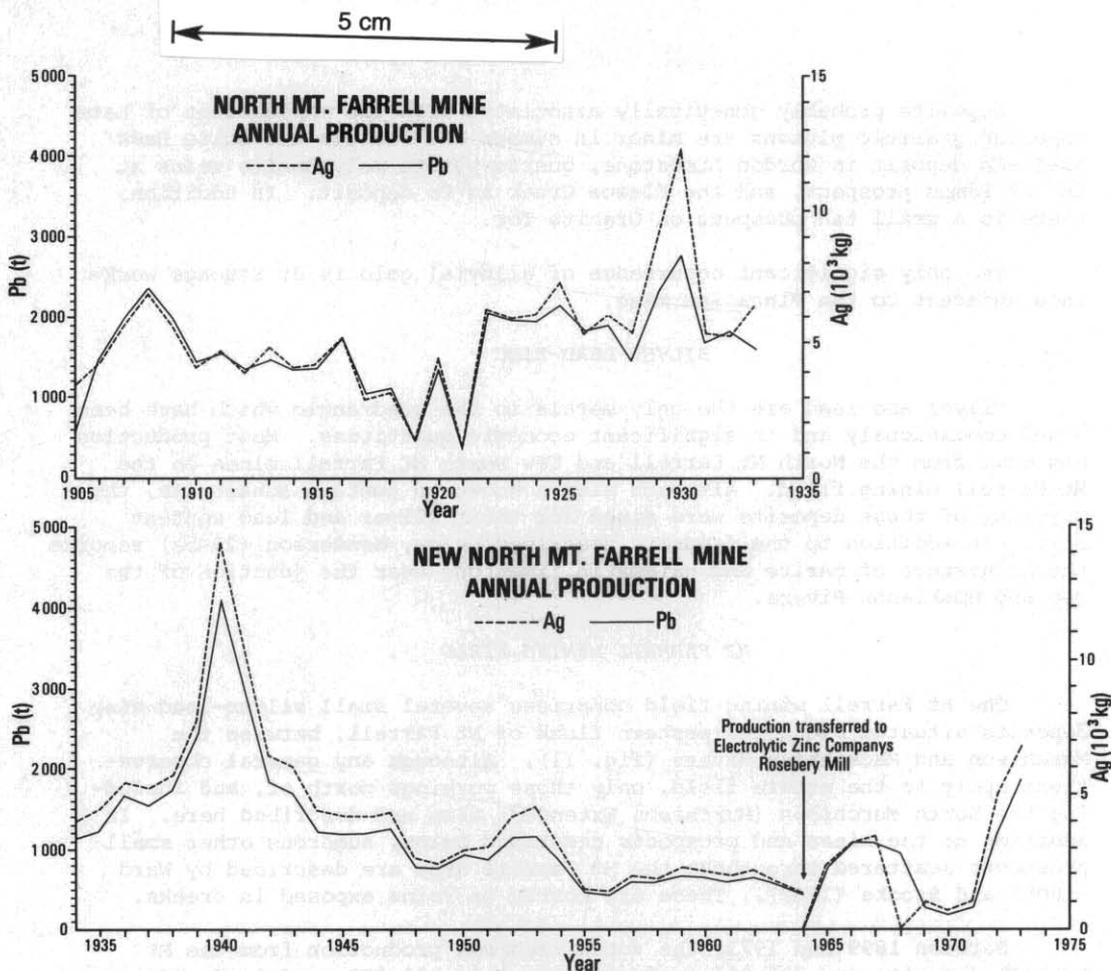
Figure 12. *Annual production, North Mt Farrell and New North Mt Farrell mines.*

The North Mt Farrell mine was worked on four adit and ten underground levels until its closure in 1932. The reason for closure is obscure, but it appears that it may have been due to a combination of low metal prices and poor management rather than poor values in the winzes below 10 level.

Following closure of the mine, the men were employed prospecting north of the Company's leases under Government Relief Fund subsidy. Early in March 1933, a lode of galena, 150 mm wide, was discovered on the abandoned Mackintosh Lease and a shaft was sunk on the lode in 1934. This was the beginning of the New North Mt Farrell mine which was worked continuously from 1934 to 1973. The main three compartment shaft was sunk to 7 level and an internal two compartment shaft sunk from this level to 9 level."

In December 1964, the New North Mt Farrell mining lease was secured by the Electrolytic Zinc Company. The main shaft has since been sunk to 11 level with development to 10 level. However, due to the relatively low zinc grade and increased production requirements at the E.Z. Company's mine at Rosebery, mining at the New North Mt Farrell mine ceased in December 1973, the mine being placed on care and maintenance.

Previous literature

The first report on the silver-lead mineralisation at Mt Farrell was

by Twelvetrees (1901), when the North Mt Farrell lode was being worked from an open cut and four adit levels. Ward (1908) included inspections of the North Mt Farrell lode and of the Mackintosh mine workings, commenting on the potential of the lodes on this prospect, now in the vicinity of the present New North Mt Farrell mine. Reid (1927), Nye (1931) and Henderson (1945b) have reported on various aspects of the field.

Detailed investigations of the geology, structure and mineralisation of the Mt Farrell area have been undertaken by Brooks (1962) and Groves and Noldart (1965). Summaries of the geology and mineralisation are given by Hall *et al*. (1953), Hall and Solomon (1962), Solomon (1965) and Burton (1976).

Investigations have also been undertaken by several mining companies interested in further development of the New North Mt Farrell mine (*e.g.* Richardson, 1951; Drew, 1957; Jensen, 1959) and by the Bureau of Mineral Resources (Tate, 1958).

Geology

The lode deposits occur close to the western margin of an approximately 600 m thick NNE trending band of unaltered shale, tuff and grey-wacke (the Farrell Slate) within Cambrian(?) lava, agglomerate and pyroclastic rocks of the Mount Read Volcanics (fig. 13). Structurally underlying the Farrell Slate along its eastern edge is a lens of conglomerate, up to 150 m thick, containing fragments of shale and volcanic rocks. The western contact between the Cambrian volcanic sequence and the Farrell Slate is strongly faulted, striking 020° and dipping 65° W. The main lode fractures parallel this contact (Drew, 1957). Quaternary gravel, sand and clay, probably of fluvioglacial origin, blanket much of the low lying area.

Mineralisation

The lodes. The silver-lead-zinc deposits of the Mt Farrell field occur almost entirely within the Farrell Slate, along two distinct lode zones; the Farrell lode, which includes the North Mt Farrell and New North Mt Farrell mines and, to the south-east, the Murchison lode, which includes the Central Farrell and North Murchison mines (fig. 11).

The ore deposits occur as a series of sub-parallel lenticular fissure lodes filling shear zones (of probable Tabberabberan age) which acutely transgress bedding in the host rocks. The lodes strike NNW to NNE, dip steeply west and plunge to the south. They are up to 125 m wide and over 300 m long, with subsidiary branch lodes and local bifurcations. At the New North Mt Farrell mine, for example, the ore occurs in two sub-parallel fissures 30 m apart. These are the main lode and the quartz - footwall lode. The main lode occurs as a series of lenticular shoots up to 65 m wide, dipping 60° - 65° W and plunging at 70° S over a length of 120 - 300 m. The average thickness is 1.0 - 1.5 m, but may be up to 7.5 m.

Mineralisation along the shear zones is not continuous, but is locally intensified at the intersection of the main and branching lodes, and particularly where the fissures intersect tuffaceous horizons within the Farrell Slate. This is probably due to development of continuous discrete fractures formed in the tuffaceous horizons during deformation, in contrast to anastomosing fractures in the shale. The ore grade is similar in both host rocks (Groves and Noldart, 1965).

The lodes are characterised by a well-defined footwall, but in the

73

MACKINTOSH RIVER

NEW NORTH
MT. FARRELL LODES

MT. FARRELL RANGE

SOPHIA RIVER
VALLEY

W

E
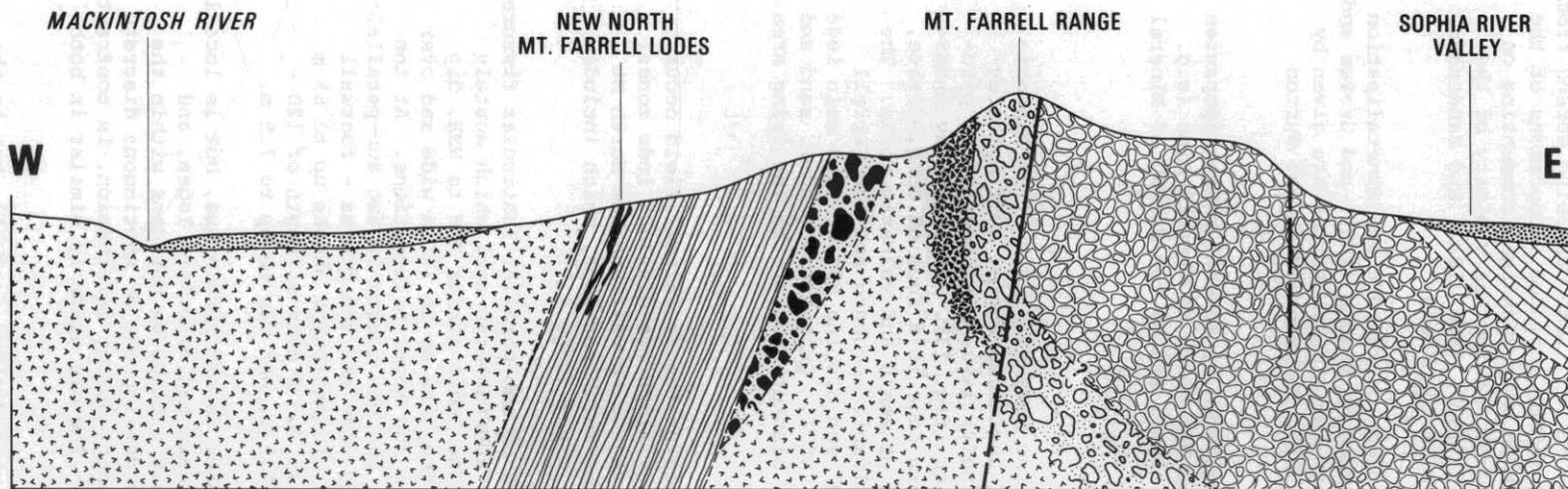
QUATERNARY

Fluvioglacial deposits

ORDOVICIAN

Gordon Limestone

Middle-Upper Owen Conglomerate
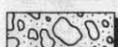
Lower Owen Conglomerate

Jukes Breccia

CAMBRIAN

Lava and pyroclastic rocks

Conglomerate

Farrell Slate

SECTION THROUGH MT. FARRELL SHOWING
GEOLOGICAL SETTING OF MT. FARRELL LODES

COMPILED AFTER BROOKS (1962)
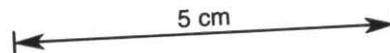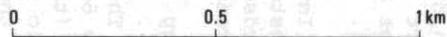
For location of section see Figure 11

Figure 13.

0   0.5   1 km

5 cm

hanging wall, the ore may work out into fractured rock beyond the fissure (Hall *et al.*, 1953).

Mineralogy. The mineralogy of the ore is consistent along each of the two lode zones but differs between them. The Farrell lodes consist of early quartz and late siderite with argentiferous galena, sphalerite, chalcopyrite and pyrite and minor tetrahedrite, jamesonite, arsenopyrite and argentite. The Murchison lodes contain more arsenopyrite, pyrite and sphalerite and less galena and siderite. Brooks (1962) describes chalcocite replacing chalcopyrite, and marcasite replacing pyrrhotite in the Murchison lode and hematite in siderite in both lode zones. Much of the galena is brecciated and sheared, indicating post sulphide mineralisation movement. Barite, fluorite and chlorite are minor constituents of the Murchison lodes (Ward, 1908; Brooks, 1962).

Banding of coarse-grained siderite and galena is common, with individual bands up to 20 mm thick. Laminated shale and fine-grained sulphides (galena and chalcopyrite) occur locally.

The wall rocks exhibit little alteration, with only disseminated fine-grained pyrite occurring near the lodes. This pyrite is distinct from coarser-grained syngenetic pyrite occurring along bedding planes in the shale (Hall *et al.*, 1953).

Genesis. The mineralisation has previously been described as being of hydrothermal origin, genetically associated with emplacement of Late Devonian granite, and deposited during the Tabberabberan Orogeny (*e.g.* Solomon, 1965). The strongest evidence in favour of this hypothesis is the morphology of the mineralisation (*i.e.* filling fissures of probable Devonian age). Such an origin is also supported by the similarity of the cadmium content of sphalerite, and of cobalt and nickel in pyrite from the New North Mt Farrell mine to other Devonian deposits (Groves and Loftus-Hills, 1968).

However, the association of the mineralisation with volcanic rocks, the lack of an obvious granitic source (the nearest igneous rock, the Murchison Granite, is of Cambrian age), and the similarity of $\delta^{34}S$ values of the sulphides to the Rosebery massive sulphide deposit indicates the sulphide mineralisation is possibly of a volcanic origin and was later remobilised (Solomon *et al.*, 1969). This is also supported by the lack of extensive wallrock alteration, by the widespread deformation of the galena, and local occurrences of laminated sulphides and shale.

New North Mt Farrell mine [664619]

The lodes of the New North Mt Farrell mine are described by Groves and Noldart (1965) from which the following is taken, with appropriate alterations and additions for development to 1973.

The New North Mt Farrell lode has been worked from ten underground levels to approximately the same depth as the North Mt Farrell workings. A main three compartment shaft extends from the surface to 11 level and an internal two compartment shaft between 7 level and 9 level. The main lode, striking 010° - 020° and dipping 65° - 80° W, comprises three main ore shoots which, although patchy, contain abundant argentiferous galena in places. Most of the lead produced has been obtained from this lode, although two additional lodes have been productive.

The most extensive ore shoot, with a maximum level length of 150 m and plunge length of 275 m, was located on the north side of the main shaft.

75

The ore shoot had a relatively consistent level length between 1 level and 5 level and an average thickness of about 1.5 m. Below 5 level the ore shoot narrowed to a maximum level length of 27 m beneath the most northern section of the shoot in the higher levels, and an average thickness of about 600 mm. The balance of the lode north of the shaft appears barren below 5 level apart from a small shoot of ore stoped close to the main shaft on 7 level. Below 7 level the ore shoot widens to attain a maximum level length of 150 m on 10 level. The most productive sector of the ore shoot occurred between 1 level and 2 level where the lode was up to 14 m thick for a length of some 6 m at the intersection of main and branch lodes. The overall plunge of the ore shoot is about 75°S.

Two further ore shoots are situated to the south of the main shaft. The uppermost shoot has been stoped from the surface to 7 level over a plunge length of some 330 m with a maximum level length of 105 m. The average thickness of the shoot is about 0.6 - 1.0 m and the plunge 35° to the south. This ore shoot has not been worked on 8 level and 9 level because extensive driving is required to intersect the shoot which is pitching away from the shaft with depth, although about 45 m of drive had been completed south of the shaft on 10 level by December 1973. The third shoot has been stoped adjacent to the shaft on the southern side from above 5 level to 9 level. The shoot plunges steeply south and has been stoped over a plunge length of 150 m and a maximum level length of 85 m.

The quartz-footwall lode sub-parallels the main lode and dips at 45°W between the surface and 4 level, steepening to 75°W to 9 level. It comprises predominantly barren quartz, although three discrete ore shoots have been stoped to a maximum height of 9 m over a stope length of 45 m on various levels. A single branch lode has been stoped between 3 level and 4 level over a level length of about 90 m.

The ore grade in the New North Mt Farrell mine has averaged 9 - 12mass% Pb and approximately 28 g silver to each 1% of lead. Ore grade in 1956 approximated 12mass% Pb and 390 g/t Ag (Drew, 1957) and in 1963 was about 10.4mass% Pb and 305 g/t Ag. The ore treated generally averaged 1 - 2 mass% Zn, care being taken to exclude excessive sphalerite from the treatment plant. Since 1964, the ore has been treated at the Rosebery mill for extraction of sphalerite as well as the argentiferous galena. The average ore grade in 1973 was 11.2mass% Pb, 4.8mass% Zn, 0.22mass% Cu, 9.8mass% Fe and 402 g/t Ag.

North Mt Farrell mine [661612]

Although little is known about the North Mt Farrell ore body due to inaccessibility of the workings, the ore apparently occurred as a single, discontinuous, N-S trending lode (1 - 1.5 m thick) with several branch lodes in the upper levels. The mineralisation was intensified locally at fracture intersections, attaining a thickness of 10 m in 4 adit level (Ward, 1908).

Groves and Noldart (1965) adequately describe the North Mt Farrell mine and their description is reproduced below.

"The lodes at the North Mt Farrell mine have been worked from four adit levels and ten underground levels. An internal three compartment shaft connects 4 adit level and all levels to 9 level and a three compartment shaft connects 8 level and 10 level to the surface. The surface shaft was sunk just prior to closure of the mine.

76

The No. 3 lode is the principal of four lodes worked in the North Mt Farrell mine and is considered by most authors to be a continuation of the quartz-footwall lode of the New North Mt Farrell mine. It strikes approximately magnetic north and dips 60°W, the ore shoot pitching about 70°S. It has been continuously stoped from the surface to 10 level south. The latter proved uneconomic, but may not be a true indication of ore grade as the ore shoots are reported to be patchy. The average width of the lode on 10 level was 1.2 m.

Apart from the main lode, three branch lodes have been worked in the North Mt Farrell mine, the deepest joining No. 3 lode at 6 level. No. 1 lode strikes at 045° and dips 60°W and has been driven on at 3 adit level, 4 adit level and 1 level. Ward (1908) reported an overall lode thickness of 10.5 m on 4 adit level with a payable length of 73 m. No. 2 lode strikes 030° and dips 50°W from 4 adit level to 2 level and then 85°W to 6 level where it joins No. 3 lode with a south pitching intersection. The lode has been stoped to the surface from 2 adit level over a length of 228 m, from 3 adit level to 2 adit level over a length of 122 m and between 4 adit level and 3 adit level over a length of 76 m. No. 2A lode strikes 020° and dips 75°W with stoping between 3 level and 1 level.

From mine plans of the North Mt Farrell mine, it appears probable that enrichment occurred at the intersection of main and branching lodes, a feature consistent with smaller-scale enrichment in the New North Mt Farrell mine. The ore grade determined from tonneages given by Drew (1957) averaged 11.5mass% Pb and 320 g/t Ag, figures from the Department of Mines indicating an average of 9mass% Pb and 251 g/t Ag between 1922 and 1927."

Mt Farrell mine [660609]

The lodes of the Mt Farrell mine have been mined from two separate workings, approximately 400 m apart. In both workings there is a well-defined western lode, considered by Ward (1908) to be the southern extension of the No. 3 lode in the North Mt Farrell mine, and to the east is a quartz lode (sub-parallel to the western lode) from which most of the ore produced was recovered.

North Workings [660609]. These were the main workings of the Mt Farrell mine, the lodes being worked from three adit levels and a small open cut. In the main 3 adit level Ward (1908) described a well-defined western lode striking 022°-025° and dipping 60°W, containing patches of galena in a quartz-siderite gangue and averaging 0.75 m in thickness over a level length of about 60 m. The quartz lode, about 27 m east of the western lode, consists of predominantly barren quartz, 15 m in thickness and dipping 70°W. Irregularly distributed along the footwall of the quartz lode are a series of vugs partially filled with galena, sphalerite and siderite.

South Workings [658605]. The lodes here were worked from two adit levels, with only the lower adit level intersecting both the western lode and the quartz lode. A well-defined western lode averaged one metre in thickness over a level length of 150 m, with the strike of the lode alternating between 009° and 023°-026° for distances of 15 - 50 m. A 21 m thick quartz lode, intersected approximately 65 m east of the western lode in 2 adit level, contains predominantly barren quartz with minor galena and siderite towards the footwall of the lode (Ward, 1908).

Mackintosh mine

The Mackintosh mine includes several small workings extending linearly

for about 500 m north of the North Mt Farrell mine. The most northerly workings are possibly the surface expression of some lodes of the New North Mt Farrell mine.

South Mackintosh [661613]. The lodes here are approximately 45 m north of the North Mt Farrell mine and are clearly a continuation of the North Mt Farrell lodes (Ward, 1908). The main lode, striking 009° and dipping west, and three NW-SE trending branch lodes all occur in shale, and have been mined from one adit level. The main lode varies between 1.2 - 2.7 m in thickness over a level length of 60 m and occurs as a brecciated zone of quartz and argentiferous galena and fragments of shale scattered through pug. In 1907, 49.2 t of ore mined averaged 55.5mass% Pb and 68.8 g/t Ag (Ward, 1908).

Central Mackintosh [662615]. Two lodes are exposed in trenches in a creek and in an adit, 74 m in length and about 26 m below the creek intersection (Ward, 1908). The main west lode has been stoped out nearly to the surface over a distance of 33 m. This near vertical lode strikes about 010° and attains a maximum thickness of 2.4 m. Most of the galena, with minor tetrahedrite - tennanite (fahlore), is within 150 mm of the footwall and adjacent to a band of pug containing brecciated galena. The occurrence of brecciated ore in pug here and at the South Mackintosh mine indicates post-mineralisation movement. The eastern lode was intersected in the adit 12.8 m to the east of the main lode and is probably a branch of the main lode.

North Mackintosh workings. Ward (1908) described two occurrences (2.4 m and 0.9 m wide and 19.5 m apart) of quartz veins with siderite, pyrite and chalcopyrite in a siliceous schist exposed in the bed of a creek. Further north, on the Farrell Blocks prospect and along the banks of the Mackintosh River, Ward (1908) described several occurrences of quartz veins with minor siderite, pyrite, chalcopyrite and galena.

Duttons workings [657601]

This was the most southerly of the mines on the Farrell line of lodes and was located on the edge of the glaciofluvial deposits to the south. The lode has been worked on two adit levels. Whitten (1948) described a well-defined lode 1.5 - 1.8 m thick, striking 010°-015° and dipping 65°W, within shale and tuffaceous sediments striking 000°-010° and dipping west parallel to the lode. The lode consists of quartz and carbonate veins containing narrow veinlets and bunches of galena, with some disseminated galena in the footwall.

Drilling by the Farrell Mining Co. Ltd to test the lode at depth intersected 0.4 m of 28mass% Pb and 25 g/t Ag and 1.8 m of 5.3mass% Pb and 65 g/t Ag at about 30 m below the mine, and 0.6 m of 5.8mass% Pb at a depth of about 60 m. Further drilling to test far deeper mineralisation and to the south, failed to intersect significant mineralisation (Drew, 1957).

Central Farrell mine [661599]

At this, the northernmost occurrence of mineralisation on the Murchison line of lodes, two sub-parallel lodes about six metres apart have been prospected from two adit levels and surface trenching. The lodes strike 356° - 360° and dip 60° - 65°W, parallel to the host shale, and are separated by a three metre thick porphyritic unit (Ward, 1908). The lodes vary from 1.0 - 1.5 m in thickness and consist of veins of quartz and siderite with galena, sphalerite, tetrahedrite-tennanite (fahlore) and

chalcopyrite. Twelvetrees (1901) reports stannite detected in galena from this mine. The ore at this deposit also contains a high, but variable silver content with assays of up to 407 g/t Ag in ore containing 64.5mass% Pb (Twelvetrees, 1901).

North Murchison (Murchison Extended) mine [660592]

The workings, apparently abandoned at the time of Ward's (1908) inspection, consist of one adit 43 m in length, which intersected a zone of brecciated shale containing siderite veins with minor galena, pyrite and fahlore. Surface trenching indicated the lode is about two metres thick (Twelvetrees, 1901). Further prospecting south and east of the mine located several quartz and siderite veins with minor pyrite and galena.

OTHER SILVER-LEAD DEPOSITS

Silver Falls prospect [564728]

This prospect is situated at the base of a 30 m waterfall in Ross Creek, approximately 5 km north of Burns Peak. Silver-lead mineralisation was discovered in 1891, but only limited exploration by small open cuts and trenching has been undertaken (Reid, 1918). In the first report on the prospect, Montgomery (1892) concluded that the scattered galena in the lode was not in payable proportions.

The mineralisation occurs along the faulted(?) contact (striking 010° and dipping 65°-75°E) between quartz-feldspar porphyry to the east and mudstone to the west. Fine-grained galena, sphalerite and minor chalcopyrite and pyrite occur as disseminations and as veinlets sporadically distributed throughout silicified dolomite (or limestone) over a thickness of some 15 m (Reid, 1918). Gangue minerals include calcite, barite, talc and pyrophyllite. A sample of galena-bearing dolomitic rock collected by Reid contained 9.4mass% Pb, 1.7mass% Zn and 22 g/t Ag.

Reid (1918) concluded that brecciation and silicification of the host rocks occurred prior to precipitation of calcite, barite and sulphide from hydrothermal solutions.

White Hawk mine [724664]

The White Hawk mine is situated on the steep slopes on the west bank of White Hawk Creek, near its confluence with the Brougham River, where the occurrence of galena in limestone was discovered by T.H. Farrell in 1891 (Montgomery, 1892). The mine was first inspected by Montgomery (1895), but the only detailed description of the deposit is that given by Ward (1908), who reported a gossanous lode dipping 35° - 40° SE and striking 340° within limestone dipping 40° due west. Two tunnels driven into the west bank of the creek intersected limited oxidised and semi-oxidised mineralisation at a depth of approximately 25 m below the surface gossan.

Ward (1908) described veins of galena and sphalerite with minor cerussite and calcite filling joints in the limestone and occasionally veinlets of calcite with galena, sphalerite and chalcopyrite, parallel to bedding. Analyses of samples collected by Ward (1908) indicate a high silver content associated with the galena (e.g. 1.625 kg/t Ag in a sample containing 77.2mass% Pb).

Fury mine [892778]

Located in Fleece Creek, at the boundary between the Cambrian and Precambrian sequences, are the workings (pits, trenches and adit) of the Fury mine. Krummei (1970) described small, irregular patches of galena with minor pyrite, sphalerite and chalcopyrite and secondary cerussite and malachite in north-west trending faults in Cambrian quartz-feldspar porphyry and volcanic breccia, and in Precambrian(?) quartz-chlorite schist occurring in the north bank of Fleece Creek. This is possibly the same mineralisation as that prospected by R.W. Carter in the north-west corner of E.L. 14/74, and known as the Fleece Creek prospect. A 2 kg sample collected by Carter indicated 35.0mass% Pb, 1.3mass% Zn, <0.01mass% Cu, <0.01mass% As, 60 g/t Ag and trace Au. In polished section the only sulphide mineral visible is galena, occurring as regularly shaped grains <1 mm across and averaging 0.2 - 0.4 mm in a siliceous gangue. There is no evidence of deformation of the galena.

Boco Creek prospects

Reid (1918) described a discontinuous linear lode (also known as Samuel Smith's lode), 0.5 - 1.5 m thick, extending from near Farrell Siding along the western bank of Boco Creek to the Boco Plain. Quartz, limonite and siderite with minor chlorite, pyrite and calcite occurring within a steep west dipping fracture in quartz-feldspar porphyry is exposed in cuttings along the Emu Bay Railway line. Reid reported the presence of very small quantities of silver in a number of samples, but disputed a reported occurrence of tin in the lode. The quartz-pyrite-carbonate mineralisation is probably associated with development of a major fracture in the porphyry.

Lynch Creek prospect [552707]

Reid (1918) reported the discovery of a siliceous cellular limonite gossan carrying abundant barite, pyrite and occasional blebs of galena in the bed of John Lynch Creek. A sample of the gossan assayed at 1.7mass% Pb and 5 g/t Ag. Reid suggests this deposit formed by metasomatic replacement of a thin bed of limestone within breccia-conglomerate, but the presence of limestone is only inferred from the structure of the siliceous gossan.

<center>COPPER</center>

Small copper deposits occur within Precambrian rocks (Welcome Home prospect) and within Cambrian volcanogenic sequences (Tullibardine mine, Cutty Sark and Hawkesbury prospects). The Tullibardine deposit exhibits a genetic affinity to the Mt Farrell mineralisation, but is included in this section as copper was the dominant metal apparently prospected and exposed in the workings.

Welcome Home prospect [964792]

This prospect (also known as the Cataract Creek prospect) is situated on the north bank of the Dove River, approximately one kilometre north-east of its confluence with Pencil Pine Creek and is within the Cradle Mountain - Lake St Clair National Park. Exploration of the prospect is limited to one small open cut in the north bank of the Dove River and several small trenches.

Henderson (1941) described discontinuous, dispersed, lenticular veins, up to 250 mm thick, of pyrite and quartz with minor pyrrhotite, hematite,

chalcopyrite and covellite(?) and with a chlorite selvage, filling fractures in an apparently conformable, east-west trending sequence of phyllite, micaceous schist and quartzite. The veins, striking N-S to NE-SW and dipping steeply east, are most persistent in the quartzite beds. On the hanging wall is a chloritic shear zone, up to 4.6 m wide, containing veinlets of sulphides.

Vein mineralisation is also exposed in the banks of the Dove River over about 500 m to the east toward Rifle Creek [967796]. Here a quartz-sulphide vein, about 50 mm thick, also has a chloritic shear zone on the hanging wall. This zone is 1.2 m wide and contains disseminated sulphides.

Chip samples of the lode material collected by Larsen (1939) reflect the variable nature and inconsistency of the mineralisation with a range in copper content from 0.40 - 10.60mass% and 0.96 - 3.32 g/t Au. One bulk sample of 4.444 t assayed at 4.21mass% Cu, 44.2 g/t Ag and 0.57 g/t Au (Henderson, 1941).

Tullibardine mine [698680]

Discovered in 1894 by T.H. Farrell, and originally known as Pearce's Copper Reward, the Tullibardine mine is situated on the west bank of the Mackintosh River, in the bed of a creek draining the eastern slopes of Mt Block. The workings comprise several small cuts in the banks of the creek, a 2.1 m deep winze in one of the cuts, a six metre deep shaft, and two cross cut adits about 30 m apart and driven 36.5 m and 10.8 m into the south and north banks of the creek respectively (Henderson, 1943).

Unconsolidated river gravel blankets much of the surrounding area, but the main creeks have dissected the wash, exposing intercalated sheared porphyry, slate and sandstone, of a similar nature to the host rocks of the Mt Farrell lodes 6 - 7 km to the south (Henderson, 1943).

The mineralisation occurs as irregular, discontinuous quartz veins, 10 - 300 mm thick, with ankerite, disseminated chalcopyrite and minor galena and secondary malachite and bornite. Although the complex vein system generally parallels the regional 020° strike, individually, the veins dip steeply east and west and vary in strike from 005° - 040° (Ward, 1908; Henderson, 1943). Channel samples collected by Henderson indicate up to 1.64mass% Cu and 6.57 g/t Ag. The northern adit, adjacent to the shaft, also exposed siderite filling fractures in slate (Ward, 1908).

Approximately 500 m south-west of the Tullibardine mine, Ward (1908) described an outcrop of quartz with minor ankerite, chalcopyrite and pyrite and fragments of slate, similar to the quartz reef at the Mt Farrell mines. Siderite-pyrite veins and quartz veins are also exposed in a trench to the south-east of the outcrop.

On the east bank of a creek, approximately 600 m south-west of the Tullibardine mine, Ward (1908) also described veins up to 250 mm thick of carbonate containing galena and sphalerite, either disseminated through the gangue or in bands up to 25 mm thick. These veins dip west and strike 010° - 012°, and resemble the mineralisation in vughs in the quartz reefs at the Mt Farrell mine (Ward, 1908).

The resemblance of the mineralisation and its mode of occurrence to the Mt Farrell lodes, particularly the carbonate-galena-sphalerite veins exposed at the southern prospect, indicate the vein mineralisation at the Tullibardine mine is probably genetically associated with the Mt Farrell

mineralisation.

Cutty Sark and Hawkesbury prospects

Several small prospects occur south of the Pieman River, in the vicinity of the old Emu Bay Railway bridge, and in Boco Creek near its junction with the Pieman River. The deposits were discovered in 1896 and first reported on by Smith (1898) and then Twelvetrees (1901), but apparently abandoned soon after.

Reid (1918) reported exploration at the Cutty Sark mine consisted of a deep surface trench above a 91.5 m long adit in the west bank of Robbie Creek [587604]; at the Cutty Sark consols a 30 m long adit is located in the east bank of Boco Creek [594627] and several trenches and a 17 m deep shaft with a 12 m long cross cut at the bottom are located at the Hawkesbury mine [about 582598].

The deposits occur in an altered volcanic sequence of chloritised pyroclastic rock and chloritised and sericitised dacitic crystal tuff and lava. The mineralisation occurs predominantly within the chloritic pyroclastic units as short lenses and stringers of disseminated pyrite and minor chalcopyrite with secondary azurite and malachite in association with chlorite, quartz, calcite and minor hematite (Reid, 1918). Smith (1898) also recorded chalcocite and native copper from the Cutty Sark consols. The lenses strike 340° - 345° and dip 65° - 75°E, subparallel to cleavage in the pyroclastic rocks.

Reid (1918) concluded that the chlorite, pyrite and chalcopyrite have a secondary, hydrothermal alteration origin and that cleavage in the pyroclastic unit is post-mineralisation. In view of this, a Cambrian age and possible volcanogenic origin for the alteration and copper mineralisation must be considered.

Other copper deposits

A small un-named prospect is situated south of the Lea River [997892]. Several quartz veins up to one metre thick and filling fractures in quartz porphyry lava have been prospected by means of trenches, two adits and a shallow shaft. Only one of the veins contains significant quantities of pyrite, chalcopyrite and possibly cobaltite (Collins, 1975a).

A group of claims were pegged on Bonds Range late last century for copper and silver-lead but no production is recorded.

COPPER-LEAD-ZINC

Copper-lead-zinc mineralisation is confined to the Cambrian volcanic sequences and includes the recently discovered volcanogenic massive sulphide deposit located to the north of Mt Charter, and the mineralisation at the Pinnacles mine, which is also of probable volcanogenic origin. Several small prospects have also been established on east-west trending veins within the Cambrian volcanic and sedimentary sequences.

Pinnacles mine

The group of workings collectively known as the Pinnacles mine are located on the western flank of Burns Peak. The Cu-Pb-Zn mineralisation was discovered in 1896, and the deposits were developed by means of small open cuts, deep trenches, shafts and adits (Reid, 1918). In 1950, the

82

Electrolytic Zinc Company tested for depth and lateral extensions of the
deposits by diamond drilling (Hall, 1950). Recently, Comstaff Pty Ltd have
undertaken detailed exploration of the area, including several diamond drill
holes and a detailed study of the mineralisation at the southern workings
has been undertaken by Stevens (1974).

The workings of the Pinnacles mine are divided into three sections:

(i)   The northern workings [571674], consisting of a small open
      cut with a 9 m deep shaft in the floor, a 40.5 m long adit
      (Brown's tunnel), and numerous trenches.

(ii) The central workings [571672], consisting of a 177.1 m long
      adit (Thomas' tunnel), a 9.1 m deep shaft (McGuinness' shaft)
      and several trenches; and

(iii) The southern workings [568667], consisting of a 34.7 m long
      trench up to 5.2 m deep, with parallel trenches on either side.

During the period prior to Reid's (1918) visit, the total production
was 453.4 t of ore, of which 395.5 t was produced from the northern workings,
at an average grade of about 5.8mass% Fe, 2mass% Zn, 0.8mass% Pb, 0.4mass%
Cu, 4 g/t Au, and 44.3 g/t Ag.

Geology. The deposits occur on the western margin of the Mt Read Volcanics
within a north-south trending acid volcanic sequence of flow banded and
autobrecciated rhyolitic lava, ignimbrite and rhyolitic tuff with inter-
calated chert, black shale and siltstone. The mineralisation is associated
with predominantly sedimentary units within the acid volcanic sequence
(Stevens, 1974). To the west, in the Marionoak River, are interbedded grey
mudstone, siltstone and greywacke.

The mineralisation exposed in the trench at the southern workings occurs
within a vertical sequence of ignimbrite and vitric tuff to the west of the
lode and chert/rhyolite to the east (fig. 14). The sequence strikes 010°,
with a dominant cleavage striking 015° and dipping 85° - 90°E. Despite
extensive deformation and brecciation of the chert, hydrothermal alteration
of these rocks is not readily apparent, although Stevens (1974) suggests
some primary textures in the volcanic rocks may have been erased by hydro-
thermal alteration.

Mineralisation. The Cu-Pb-Zn mineralisation at the Pinnacles mine occurs
as several small deposits of massive sulphide bodies, stringer veins, and
disseminated sulphides. The ore consists dominantly of pyrite, sphalerite,
galena and chalcopyrite, with barite common in the northern and central
workings. Native gold occurs as inclusions in pyrite and sphalerite
(Stevens, 1974). The silver content of the ore is variable, depending on
the proportion of galena (Table 2), but gold is very erratic in its dis-
tribution, with up to 189.8 g/t in pug on the footwall of the lode at the
north open cut (Reid, 1918).

The mineralisation has suffered intensive deformation, and in polished
section the dominant texture of the sulphide minerals is that of annealed
intergrowths. Stevens (1974) also describes deformation twins in sphalerite,
bent cleavage traces in galena, preferred orientation of galena stringers
parallel to the cleavage, and brecciated pyrite healed with chalcopyrite
and pyrite. The ore often exhibits poorly preserved primary compositional
banding approximately parallel to the bedding in the enclosing rock, and
also an additional parallel banding due to variation in grain size of the

PINNACLES MINE — SOUTH OPEN CUT

5   0   5   10 metres

P.L.F. COLLINS, 1979

N

PLAN

Entrance

Top of cut

Bottom of cut
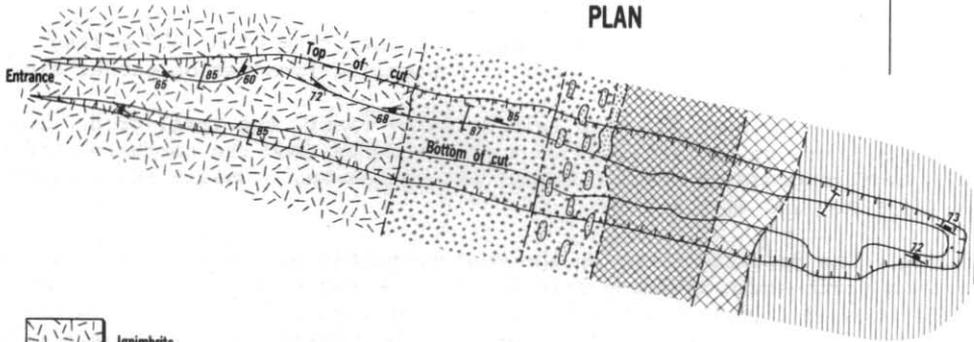
Ignimbrite

Litho-vitric tuff

Chert

Chert boudins

Cu-Pb-Zn sulphide mineralisation
(massive and as veins in chert)

Chert/rhyolite-pyrite (massive, disseminated
and vein pyrite)

Chert/rhyolite (partly as large pods in
highly schistose rock)

Joint; dipping, vertical

Cleavage; dipping, vertical

Geological boundary

NORTH FACE
V/H = 1

W   E

Top of cut

Bottom of cut

5 cm
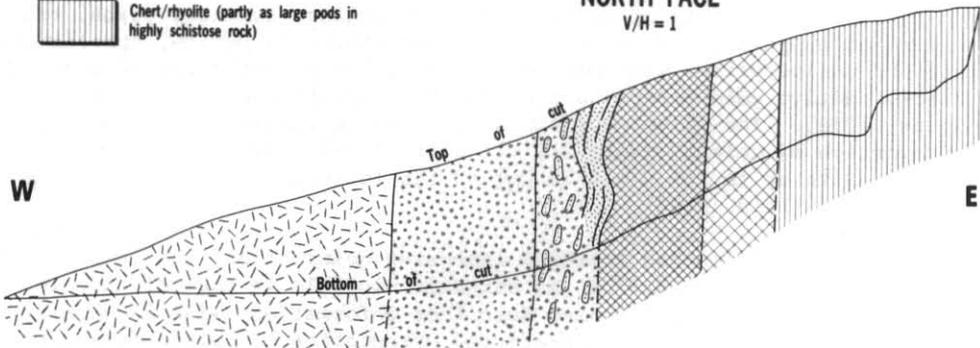
Figure 14.

84

sulphide minerals. In addition to the compositional banding, the only other primary feature of the ore is relict colloform textures in pyrite (Stevens, 1974).

The Pinnacles mineralisation is characterised by an apparent association of the Cu-Pb-Zn mineralisation to bands of brecciated chert. For example, in the north open cut and shaft, Reid (1918) described a 300 mm thick lode of sphalerite, galena, chalcopyrite and barite encased in brecciated chert and below, in Brown's tunnel, brecciated chert contains disseminated sulphides and veins and lenses of galena, sphalerite, quartz and pyrite. In Thomas' tunnel a one metre thick lode of barite with pyrite, galena, sphalerite, chalcopyrite, pyrophyllite and chlorite is encased in banded(?) cherty quartz, whereas in nearby McGuinness' shaft brecciated chert is cemented by chalcopyrite, pyrite and sphalerite (Reid, 1918).

At the south trench, the 3.7 - 4.6 m thick lode occurs between sheared vitric tuff containing chert boudins to the west, and brecciated chert/ rhyolite to the east. On the north face of the trench and interbedded(?) between the sheared vitric tuff and the lode is a one metre thick unit of banded chert (fig. 14). The brecciated chert immediately east of the main lode consists of fragments of banded chert separated by sheared pyrite and sericite. The chert contains disseminated euhedral pyrite, and tension gashes within the chert contain pyrite and chalcopyrite. The main lode consists of massive, banded ore as lenses up to 0.6 m thick, and as disseminated sulphides and stringer veins in chert. Reid (1918) also described a banded arrangement of the sulphides in the lode in Thomas' tunnel.

Genesis. Reid (1918) considered the mineralisation was precipitated out of solutions permeating through parallel fissures, arranged *en echelon* and striking obliquely to the general trend of the schist, additional deposition being associated with later brecciation. However, the stratabound nature of the ore, within a volcanic environment, and the relict banding of the massive sulphide ore indicate the mineralisation was probably syngenetic with the volcanism. The mineralisation was remobilised and recrystallised during later deformation with some of the sulphides being remobilised into fractures formed during brecciation of the chert.

The association between the sulphide mineralisation and the chert indicates that there may be a genetic association between the Pinnacles mineralisation and the massive pyrite mineralisation at the Chester mine.

Que River prospect [736772]

The Que River prospect, situated 3 km north-east of Mt Charter, was discovered in 1974 by Cominco Exploration Pty Ltd. As the prospect is still in a development stage, there is only limited information available on the deposit, but a few brief comments follow.

The deposit was initially located as a result of the coincidence of an airborne electromagnetic anomaly over an area of anomalous stream sediment geochemistry, and further defined by soil geochemistry and ground electromagnetic techniques (Webster and Skey, 1977). Outcropping sulphide mineralisation is minimal, and the immediate area is devoid of prospectors pits, despite the workings of the Gold Hill prospect being less than one kilometre to the north-west.

The initial diamond drill holes encountered significant intersections of sulphide mineralisation, assays of which were most encouraging (Table 3). Since then, the prospect has been explored by an intensive diamond drilling

Table 2. ANALYSES OF Cu-Pb-Zn ORE, PINNACLES MINE

Sample	Location	Fe (%)	Zn (%)	Pb (%)	Cu (%)	S (%)	Au (g/t)	Ag (g/t)
1	North open cut	4.80	34.5	29.4	1.5	-	36.7	324.5
2	North shaft at 3.35 m	9.22	17.8	19.74	4.31	-	70.4	235.8
3	West trenches	5.56	3.15	0.00	2.19	-	Tr	18.7
4	West trenches	0.95	4.26	13.56	0.25	-	1.84	255.5
5	South open cut	13.74	29.8	15.19	0.93	32.21	-	-
734306	South open cut	5.8	24.0	11.0	1.9	18.3	Tr	Tr
734307	South open cut	23.9	6.7	2.5	1.0	19.4	0.13	21.4
734308	Dump, Thomas' tunnel	5.4	14.8	5.6	0.19	15.4	Tr	27.6

Analyses: 1-5 after Reid (1918)

734306-8 by Department of Mines Assay Laboratories, Launceston

Table 3. MINERALISED INTERSECTION ASSAYS, DIAMOND DRILL HOLES, QUE RIVER PROSPECT

Hole	Depth (m)	Cu (mass%)	Pb (mass%)	Zn (mass%)	Ag (g/t)	Au (g/t)
DDH QR1	107.9-112.4	0.21	0.24	1.34	-	-
	112.4-121.2	2.63	6.07	7.39	122.94	3.32
	121.2-123.8	0.31	1.71	7.34	-	-
	123.8-135.9	0.09	0.80	2.42	-	-
	150.9-154.9	0.04	0.64	2.66	-	-
DDH QR2	78.4- 83.2	0.29	11.00	17.68	299.71	5.07
	93.2- 99.1	0.06	1.32	2.40	-	-
	99.1-100.7	0.14	4.41	7.55	-	-

Table 4. ESTIMATED ORE RESERVES (1977), QUE RIVER PROSPECT

Category	Lens	Tonnes	Cu (%)	Pb (%)	Zn (%)	Ag (g/t)	Au (g/t)
Indicated	P South	2 322 791	0.33	6.42	11.84	130.96	3.15
	Q	1 168 039	0.25	4.60	7.31	88.63	1.76
	S (Cu Lens)	870 711	1.05	1.89	3.86	41.66	-
	Total	4 361 541	0.45	5.03	9.03	101.8	2.15
Inferred	P West	748 833	0.20	3.86	6.97	52.10	0.94
	P North	633 160	0.23	3.50	6.77	60.70	1.21
	N	421 290	0.18	2.68	5.43	54.51	0.76
	Total	1 803 283	0.21	3.46	6.54	55.68	0.99
Indicated and Inferred	Total	6 164 824	0.38	4.57	8.30	88.31	1.81

programme. The estimated 'geological' ore reserves at the end of 1977 are given in Table 4.

During 1976 an exploration decline intersected P South lens at about 30 m below the surface. However, this decline was abandoned after driving along the lens for 52 m, and a shaft has since been sunk, from which levels have been driven on the lenses. Further exploration, development and assessment of the prospect is continuing.

The deposit consists of five small, north-south trending sulphide lenses (S, P South, P North, Q, N) occurring within a near vertical sequence

of dominantly andesitic volcanic rock.

The host rocks comprise massive vesicular and fragmented andesite bodies with disseminated pyrite and chalcopyrite, massive pyritic dacitic lava/intrusive, and feldspar phyric dacitic lava(?) occasionally fragmented and containing disseminated and stringer mineralisation. The immediate host rock to the mineralisation is a series of pyroclastic and massive dacitic units and adjacent to the ore lenses is a shaly tuff. Sericite and pyrite and minor carbonate, silica and chlorite alteration of the host volcanic sequence is widespread (Duggan, 1980).

The mineralisation occurs as a series of sub-parallel lenses of massive and banded sulphide, over a strike length of about 700 m and as minor stringer mineralisation. The lenses are near vertical, with a shallow northerly plunge, and average 9 m in thickness and up to 450 m in length. No significant ore grade mineralisation has been intersected below a depth of 260 m (Duggan, 1980). The ore lenses are subdivided into two groups on the basis of their copper content. The easternmost cupriferous S lens is dominated by pyrite and chalcopyrite, with sphalerite and galena, and is apparently zoned, containing dominantly pyrite and chalcopyrite in the southern end, and pyrite, galena and sphalerite in the northern end. The four remaining Pb-Zn lenses are predominantly fine-grained, massive and banded sphalerite and galena with chalcopyrite and pyrite.

The ore lenses are composed of sphalerite, galena, pyrite, chalcopyrite and tetrahedrite, with minor tennanite, arsenopyrite, bournonite and gold. Silver occurs in tetrahedite. The dominant gangue mineral is barite, with sericite, quartz and carbonate.

Langdon prospect [about 603609]

This prospect is situated approximately 5 km west of Tullah, and south of the Pieman River. Ward (1908) described sphalerite and galena occurring in a series of narrow east-west trending veins, dipping steeply north, in dacitic quartz-feldspar porphyry. The veins, up to 150 mm thick, consist predominantly of sphalerite with variable proportions of galena. Several other similar trending veins, up to 80 mm thick, of sphalerite with minor galena occur in gossanous formations in the vicinity of the prospect. The host dacitic quartz-feldspar porphyry is slightly altered adjacent to the veins (Ward, 1908).

Other copper-lead-zinc vein deposits

Reid (1918) described a 50-100 mm thick vein of galena, sphalerite, pyrite, hematite and calcite filling a fracture within massive dacitic feldspar porphyry, exposed on the north bank of the Pieman River, approximately 500 m upstream from its confluence with Boco Creek (the Home Rule prospect) [597626]. The vein strikes east-west and dips steeply south.

A similar parallel vein of galena, sphalerite and pyrite in dacitic feldspar porphyry, which is slightly altered adjacent to the vein, is situated approximately one kilometre south-east of the above prospect, on the south bank of the Pieman River [603615].

Chalcopyrite, sphalerite and galena vein(?) mineralisation also occurs in pyroclastic rock on the north bank of the Pieman River at the old Emu Bay Railway bridge [580608] and further west in sedimentary rocks [563602].

Near the South Chester prospect, approximately 0.5 km south-south-west of the Chester mine, a sphalerite vein with intergranular pyrite, galena, quartz and minor chalcopyrite, loellingite and native silver was intersected in diamond drill core. The vein is later than the alteration and deformation of the host sericitised rhyolitic quartz porphyry, but there is also evidence of postmineralisation deformation of the sulphides (Collins, 1975b).

Galena is also reported to be present in volcanic rock exposed in the north bank of the Pieman River [572607].

<div align="center">SULPHUR</div>

Pyrite, as a source of sulphur, was one of the minerals commercially extracted from mines in the Mackintosh Quadrangle, all production being from the Chester mine.

Chester mine [581634]

The Chester mine, originally known as Kershaws Iron Blow, is situated on Mt Kershaw approximately 8 km north of Rosebery and 7 km west of Tullah.

History and previous literature. The first report on pyrite mineralisation at Mt Kershaw is in a brief note by Smith (1898), who inspected the prospect soon after its discovery by F. Kershaw and H. Sanderson in 1896. Although originally considered to have a promising future as a source of copper, Smith predicted the pyritic ore, then exposed in limited surface workings, was too low grade in copper to be economic.

Further exploration proved a significant pyrite deposit which, although containing minor chalcopyrite, sphalerite and galena, was of value only as a source of sulphur. In 1908, the Mt Lyell Mining and Railway Company secured the mining lease and during the period 1909-1913 produced 36 804 t of pyrite ore averaging 37.25mass% sulphur (Reid, 1918). During the same period 61 516 t of second grade ore averaging 21.08mass% sulphur was dumped at the mine. Between 1918-1920 a further 6935 t of pyrite were extracted by Cumming Smith and Company.

Following these two brief periods of production the mine has lain dormant, although sporadic interest has been shown in the deposit (Nye, 1928a; Nye, 1932; Blake, 1939; Hughes 1951; Muceniekas and Boniwell, 1959). Recently, Comstaff Pty Ltd have undertaken geological, geochemical and geophysical investigations in the vicinity of the Chester deposit, including several diamond drill holes. A detailed investigation of the geology and mineralisation (and associated hydrothermal alteration) has been undertaken by Stevens (1974).

Exploration and development. The pyritic ore is exposed in several small open cuts on the steep eastern slopes of Mt Kershaw. The ore body has also been systematically tested at shallow depths by diamond drilling, and by a 30.5 m long exploration adit (Twelvetrees, 1901; Reid, 1918). This work and additional exploratory trenching to the west of and above the open cuts was undertaken by the Mt Lyell Mining and Railway Company.

Mining was undertaken on 7 bench levels 10-12 m apart, with each level connected to a haulage at the north end of the mine (fig. 15). The open cuts extend vertically over 72 m and cover an area of about 1.2 ha. To the east and below the open cuts, a tunnel was driven west on a bearing of 280° for a distance of 106.5 m (fig. 15). This tunnel is not described

STEREOGRAPHIC PLOTS
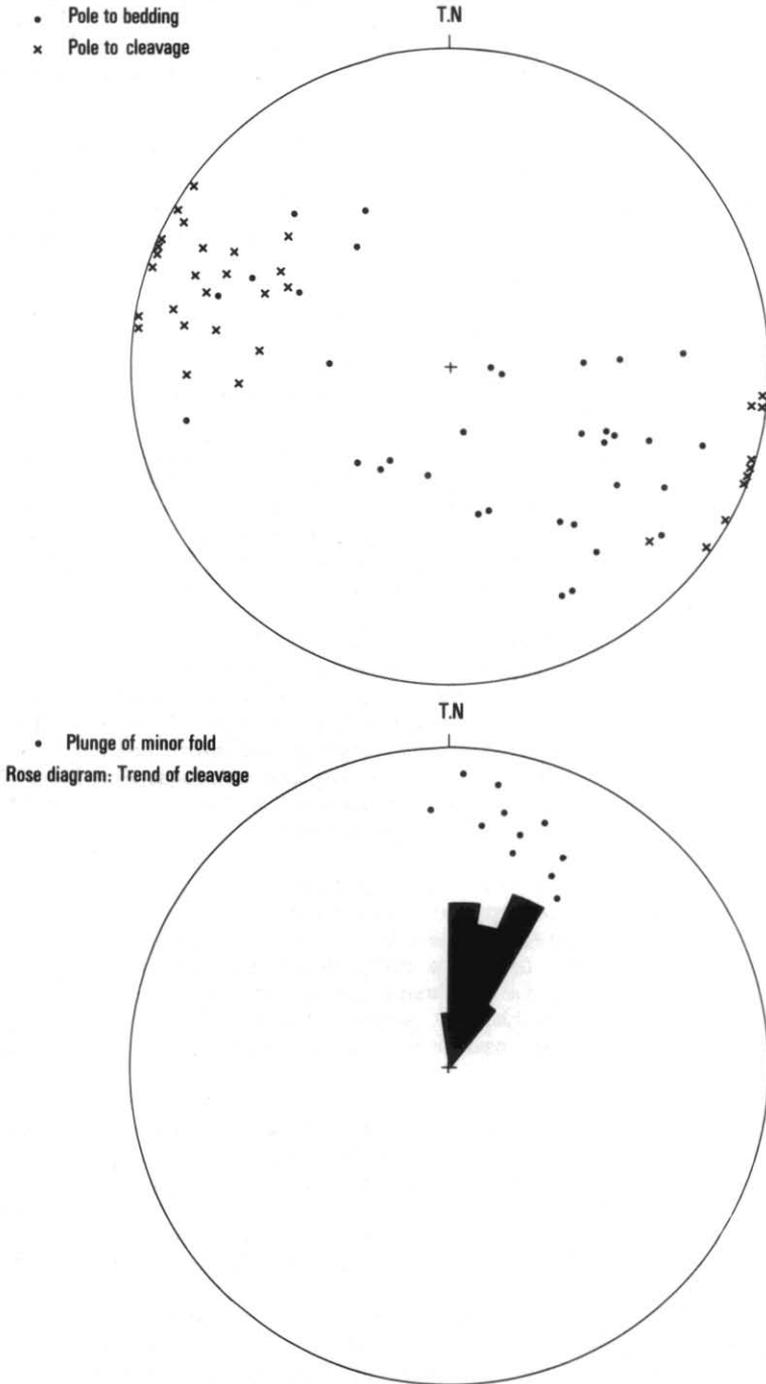
Figure 16. *Structural analysis, Chester mine*

5 cm

CONTOURED DIAGRAMS
2-4-6-8-10% per 1% area

BEDDING

T.N

T.N

CLEAVAGE

5 cm

(a) Basic dyke intersecting massive pyrite-chert
(-tuff) and bed of banded chert.
Inset (b): Fold in chert bed.
Location: On the bend in Bench "F"

(b)

(c) Folded wisps of chert in pyrite
Location: Large joint face between Bench "D"
and north end of Bench "E".

(d) Minor folding in thinly interbedded pyrite and chert.
Location: Ledge at end of open cut on Bench "G".

(e) Minor folding in banded and bedded chert/acid tuff.
Location: Northern most edge of the workings.

(f) Part of 7 m long lens of pyrite, bounded by chert,
within massive fine grained pyrite-chert.
Location: West face at end of small cut on bench "A".

SKETCHES OF OUTCROP — CHESTER MINE

P.L.F. COLLINS, 1979

Figure 17.

in Reid's (1918) report, but coincides with a recommended modification to the mining method. To the west and above the open cuts are numerous parallel trenches, 30 m apart, in glacial deposits but reported by Reid to expose pyrite mineralisation.

Mining of the deposit was hampered by the variability in pyrite content. This is exemplified by the mineralisation log of bore hole 7 (drilled by the Mt Lyell Mining and Railway Company) in which the following pyritic intersections were encountered; 18.3 m of 20.23mass% S, 9.1 m of 9.0% S, 27.4 m of 24.3% S, 12.2 m of 15.3% S and 2.4 m of 40.0% S (Reid, 1918).

Probable ore reserves estimated by Reid (1918) were 2.84×10^6 t of over 20% sulphur. A gravity survey over the Chester deposit indicated 2.29×10^6 t of 40mass% sulphides located approximately 240 m to the west (Muceniekas and Boniwell, 1959). The western deposit coincides with the pyrite mineralisation described by Reid (1918) in the trenched area west of the Chester mine.

Descriptions of the mining practice, and of the concentration and milling of the pyrite ore, are given in Reid's (1918) report.

Geology. The Chester pyrite deposit occurs within a north-south trending Cambrian volcanic sequence. In the mine area this comprises altered massive, flow-banded, autobrecciated rhyolitic lava and rhyolitic tuff with minor ignimbrite, dacitic lava and tuff, and trachyte. The mineralisation occurs within a dominantly pyroclastic sequence which is flanked to the west by a sequence of rhyolitic lava and to the east by a dacitic lava and tuff sequence (Stevens, 1974).

The mineralisation exposed in the open cuts occurs within an altered (sericite - quartz - pyrite) sequence of tuff and chert, with minor lavas, dipping predominantly 60° - 80° W-NW (fig. 16). Original textures in the tuff and lava are usually destroyed by alteration. Beds, up to 200 mm thick but usually less than 50 mm of massive, fine-grained pyrite occur interbedded with chert.

Intruding the sequence are at least three altered (chlorite-carbonate) basic dykes, decomposed at the surface but also intersected in the main tunnel (fig. 15). The dykes, up to 0.5 m wide, truncate interbedded chert and pyrite (fig. 17a), have narrow chilled margins, and do not contain visible sulphides.

The rocks have been subjected to at least one, and possibly two, phases of deformation with a dominant cleavage striking 000° - 030° and dipping steeply east (fig. 16). In some areas of the mine, particularly in areas where the pyroclastic units are common, the cleavage has obliterated primary structures (*i.e.* bedding). This cleavage also penetrates the basic dykes. The cleavage is commonly more prominent than the bedding, imparting a steep east dipping foliation which was probably recognised by Reid (1918) when describing the mineralisation as being typically lenticular in form and dipping steeply east, parallel with the planes of schistosity.

Small scale folds in thinly interbedded chert/pyrite units have axial surfaces paralleling the dominant cleavage (fig. 16). Vergence of cleavage within the less competent pyrite beds is towards the axial surface of these minor folds, indicating the bedded pyrite has a predeformational origin (fig. 17b, c, d).

Hydrothermal alteration. The Chester deposit occurs at the northern end of a lenticular hydrothermal alteration zone which parallels the regional trend of the volcanic rocks over a distance of one kilometre to the south of the mine. Stevens (1974) defines three concentric zones of hydro-thermal alteration:

(i)   an inner zone of quartz-sericite (pyrophyllite) - pyrite - (±carbonate), which includes both the Chester deposit and the South Chester prospect;

(ii)   a narrow zone of quartz-sericite (pyrophyllite) - chlorite - (±carbonate); and

(iii)   an outer weakly altered zone.

Carbonate as an alteration product is probably more intensively developed, particularly within the inner zone, than previously recognised by Stevens (1974). This is most evident in the section exposed in the tunnel below the open cut workings. The rocks here contain up to 10mass% carbonate (as calcite) and are cut by later calcite veins.

Mineralisation. The pyrite mineralisation exposed in the open cuts occurs as massive pyrite, interbedded pyrite and chert, disseminated pyrite, and remobilised pyrite and quartz. There is also one occurrence of colloform pyrite in the northern end of the mine; pyrite veins(?) intersect chert beds and euhedral pyrite, quartz and barite are developed along faults and joints. In the north-west corner of the mine is a chert breccia consisting of angular and lenticular fragments of chert, banded chert/rhyolite, pyritic chert, and pyritic pyroclastic rock, which are cemented in a siliceous pyrite matrix. This breccia is probably a pre-consolidation slump feature, possibly associated with extrusion of overlying lava. A foliation in the breccia is probably due to later deformation.

The massive pyrite consists of fine-medium grained anhedral pyrite containing minutely folded wisps of chert and occasionally angular blocks of banded chert, and patches of medium grained sphalerite, quartz and euhedral pyrite. Modal composition is approximately 70% pyrite and 30% quartz. The analyses in Table 5 indicate the metallic content of the massive pyrite ore, which would have been the bulk of the ore mined. The gossan overlying the massive pyrite is up to 3 - 4 m deep.

Table 5.   ANALYSES OF MASSIVE PYRITE ORE, CHESTER MINE

Reg. No.	S (mass%)	Fe (mass%)	Cu (mass%)	Zn (mass%)	Pb (mass%)	Ag (g/t)	Au (g/t)	SiO2 (mass%)
734304	23.5	30.7	0.05	0.03	0.02	12.7	<0.02	34.1
734305	28.4	27.1	0.06	0.06	0.04	11.5	<0.02	22.1

Analyses: Department of Mines Laboratories, Launceston

Interbedded pyrite and chert occurs in several localities in the open cuts and consists of 5 - 50 mm thick bands of chert interbedded with bands up to 100 mm thick of fine-grained pyrite (fig. 17f).

Disseminated pyrite occurs in massive chert beds as very fine grains, and in the pyroclastic beds as medium to coarse anhedral and euhedral grains. Where the cleavage is strongly developed in the pyroclastic units,

pyrite and quartz appear to have been remobilised into lenses of equigranular pyrite and quartz up to 200 mm long and paralleling the cleavage.

In polished section, the ore consists predominantly of pyrite with minor intergranular sphalerite and traces of tetrahedrite, enargite, covellite, chalcocite, galena, digenite and chalcopyrite, all occurring as inclusions in the pyrite. Sphalerite also occurs as inclusions in quartz. Pyrite occurs predominantly as anhedral broken and fractured angular - subrounded grains averaging 0.2 - 0.5 mm diameter, but up to 1.5 mm. Recrystallisation and annealing of the pyrite in the massive pyrite ore is common. Stevens (1974) also describes quartz beards on disseminated pyrite grains in the hydrothermally altered quartz-sericite-pyrite schist.

Genesis. Reid (1918) concluded that ore deposition resulted from hydrothermal solutions circulating through premineralisation fractures and metasomatically replacing the schistose rocks which originally contained calcite.

However, the pyrite mineralisation at the Chester mine is characterised by;

(i)   parallelism of the mineralisation with the host volcanic rocks,

(ii)   interbedded pyrite and chert,

(iii)   a pyritic slump breccia,

(iv)   a dominant cleavage penetrating the mineralisation and also post-mineralisation basic dykes,

(v)   remobilisation of disseminated pyrite into lenses parallel to cleavage,

(vi)   vergence of cleavage in pyrite thinly interbedded with chert towards the axial surface of small scale folds and

(vii)   parallelism of the alteration zone to the host volcanic sequences.

All of the above indicate a predeformation, syngenetic origin for the pyrite mineralisation, probably formed by exhalative processes genetically related to the volcanism.

OTHER PYRITE DEPOSITS

Several other occurrences of pyrite mineralisation are reported in the vicinity of Mt Kershaw, in addition to the massive pyrite deposit at the Chester mine (Reid, 1918). Most of these deposits were considered at the time to have promising futures as sources of copper, lead or gold, but all failed to realise the expectations of their discoverers.

Reid (1918) records the reported discovery of galena in a 'heavily pyritised formation ... near the junction of pyroclastic schist and slate' high on the western slopes of Mt Kershaw [about 566628] and of coarsely crystallised pyrite in tuffaceous rock in Hollway Rivulet [about 578655].

At the South Chester prospect, situated approximately 0.5 km south of the Chester mine [578629], a small open cut exposed disseminated pyrite
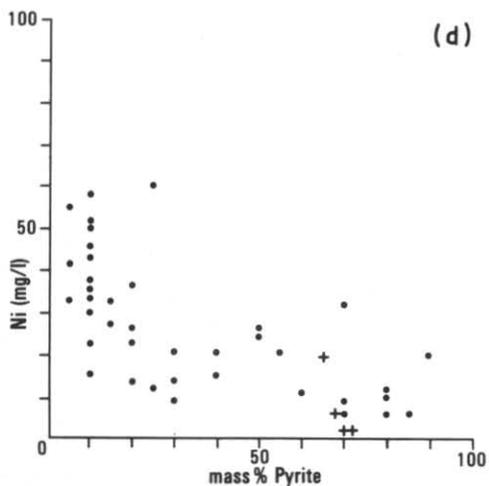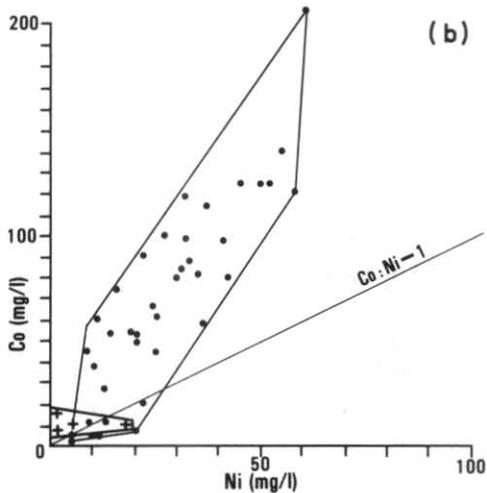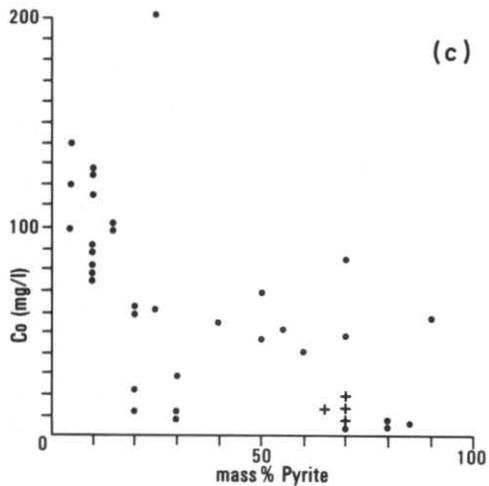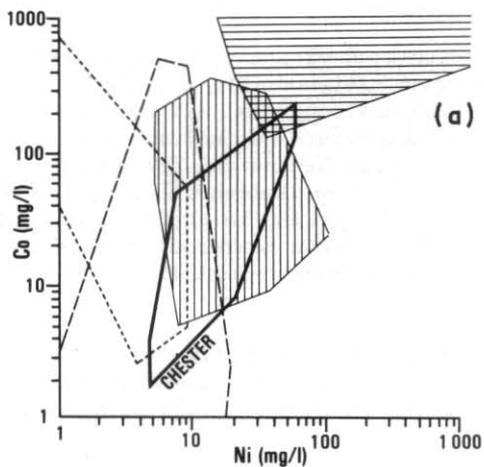
**COBALT AND NICKEL
IN PYRITE, CHESTER MINE**

- Massive and disseminated pyrite.
- Pyrite - quartz vein.

Mt Lyell copper ore.

Rosebery zinc - lead - copper ore.

Co, Ni in pyrite
(from Loftus-
Hills, 1968)

— — — Rosebery footwall.

- - - - - Rosebery hanging wall.

Figure 18.

96

5 cm
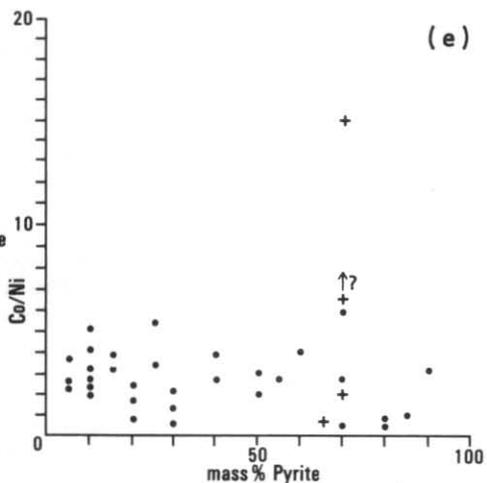
in altered rhyolitic lava and tuff. The pyrite is coarser grained and
Reid (1918) reports more chalcopyrite than at the Chester mine. In
polished section, the ore consists of disseminated, anhedral and often
broken pyrite, although occasionally as euhedral pyrite, with minor
intergranular sphalerite and rare sphalerite and enargite inclusions in
pyrite.

Disseminated pyrite is also reported on the west bank of Boco Creek
[595635 and 596643].

TRACE ELEMENTS IN PYRITE

Previous investigations of trace elements in sulphides from ore
deposits in western Tasmania (*e.g.* Loftus-Hills and Solomon, 1967; Groves
and Loftus-Hills, 1968; Loftus-Hills, 1968; Loftus-Hills *et al.*, 1969)
and in north-east Tasmania (Groves and Baker, 1971) have shown that, pro-
vided local controls are taken into consideration, the trace element dis-
tribution may be used as a genetic discriminant.

An attempt has been made to define the genetic association of the
pyrite mineralisation on Mt Kershaw (Chester mine and South Chester pros-
pect) using the cobalt and nickel content of the pyrite. The analytical
guidance of W.E. Baker and the co-operation of Comstaff Pty Ltd are
acknowledged.

Sample preparation and analysis

Twenty-one samples were collected *in situ* from the open cuts and main
tunnel of the Chester mine, and from the South Chester prospect. Twenty-
two drill core samples were supplied by Comstaff Pty Ltd from two drill
holes (DDH CP3 and CP4) collared near the South Chester prospect. All
samples are from within the alteration zones defined by Stevens (1974)
and include four samples of pyrite in veins. The amount of pyrite in each
sample was estimated from the specific gravity of the sample, obtained by
comparing the mass of the sample in air with its mass when immersed in
water, and using a density of 5.00 for pyrite and 2.65 for the non-sulphide
component.

A pyrite concentrate was provided by the Department of Mines Metallur-
gical Laboratories, and a slightly acid solution was prepared from this
concentrate for analysis by atomic absorption spectrophotometry, in a
manner similar to that described by Loftus-Hills (1968). The purity of
the concentrate, as determined from the acid insoluble residue, ranged be-
tween 93.9-99.9mass% pyrite, with most samples containing more than
95mass% pyrite and over half of the samples in excess of 98mass% pyrite.

Cobalt and nickel in pyrite

The analytical data are presented in Table 6, which also includes a
description of each sample and its location.

Although the cobalt and nickel content of all samples range from
2-140 ppm (one at 205 ppm Co) and 5-60 ppm respectively, pyrite from the
Chester mine generally has a lower trace element concentration with 2-83 ppm
Co and 5-36 ppm Ni. For most of the samples, the cobalt content is greater
than nickel, with 80% of the pyrite having a Co:Ni>1. Loftus-Hills and
Solomon (1967) regarded pyrite with a Co:Ni>1 as being associated with
deposits of probable volcanic origin, without accompanying lead and zinc
minerals. Pyrite-quartz veins contain 5-15 ppm Co and <1-18 ppm Ni.

Table 6. *COBALT AND NICKEL IN PYRITE FROM THE CHESTER MINE*

Reg. No.	Serial No.	Location	Description	S.G.	Pyrite (mass%)	Co (ppm)	Ni (ppm)	Co/Ni
740746		Bench B, north open cut	Interbedded pyrite and chert	2.95	20	11	13	0.85
740747		Bench B, north open cut	Interbedded pyrite and chert	3.11	30	8	20	0.40
740748	74-291	Bench B, north open cut	Massive pyrite with wisps of chert and minor sphalerite	4.37	85	4	5	0.80
740749	74-292	Bench B, north open cut	Massive pyrite with intergranular quartz and chert	4.22	80	5	10	0.50
740750		North end of mine	Chert-pyrite agglomerate	3.11	30	10	9	1.11
740751	74-293	Small north open cut, approx. bench A	Massive pyrite with intergranular quartz	4.24	80	5	11	0.45
740752	74-294	Small north open cut, approx. bench A	Colloform pyrite	4.30	80	3	5	0.60
740753	74-295	Haulage cut	Massive pyrite with intergranular quartz	4.00	70	2	5	0.40
740754	74-296	Bench C, north end	Massive pyrite with chert fragments	3.71	60	38	10	3.80
740755		Bench C, middle	Disseminated pyrite	2.94	20	20	22	0.91
740756		Bench B, south open cut	Chert with disseminated pyrite and lenses of pyrite	3.25	40	53	14	3.79
740757	74-297	Bench C, entrance to south open cut	Intergranular quartz and pyrite	3.98	70	45	8	5.63

Table 6. (continued)

Reg. No.	Serial No.	Location	Description	S.G.	Pyrite (mass%)	Co (ppm)	Ni (ppm)	Co/Ni
740758		Bench F, open cut	Intergranular quartz and pyrite	3.47	50	44	25	1.76
740759	74-298	Bench F, open cut	Intergranular quartz and pyrite	4.03	70	83	31	2.68
740760	74-299	Bench F, open cut	Disseminated pyrite in chert	3.44	50	67	24	2.79
740761		Bench F, west end of open cut	Intergranular quartz and pyrite with chert fragments	3.58	55	50	20	2.50
740762		Dump outside main adit	Disseminated pyrite in quartz-sericite schist	3.16	30	27	13	2.08
740763		Main adit, 104 m from entrance	Disseminated pyrite in quartz-sericite schist	2.95	20	58	36	1.61
740764		End of main adit 106.5 m	Disseminated pyrite in quartz-sericite schist	2.95	20	61	25	2.44
740765	74-300	South Chester prospect	Coarse grained disseminated pyrite in quartz-sericite schist	3.33	40	53	20	2.65
740766	73-28	Bench B, north open cut	Massive pyrite	4.60	90	54	19	2.84
741521		DDH CP3 24.40-25.00 m	Disseminated pyrite in quartz-sericite schist	2.75	5	140	55	2.55
741522		DDH CP3 30.90-31.35 m	Coarse grained pyrite disseminated in quartz-sericite schist	2.75	5	98	41	2.39
741523		DDH CP3 50.80-51.40 m	Patches of medium grained pyrite in quartz-sericite schist	2.83	10	125	51	2.45
741524		DDH CP3 57.55-57.95 m	Disseminated pyrite in quartz-sericite schist	2.80	10	88	33	2.67

Table 6. (continued)

Reg. No.	Serial No.	Location	Description	S.G.	Pyrite (mass%)	Co (ppm)	Ni (ppm)	Co/Ni
741525		DDH CP3 58.70-59.10 m	Disseminated pyrite in quartz-sericite schist	2.80	10	115	37	3.10
741526		DDH CP3 60.55 m	Vein of coarse grained pyrite	3.76	65	10	18	0.56
741527		DDH CP3 93.25-93.75 m	Disseminated pyrite in quartz-sericite schist	2.80	10	125	50	2.50
741528		DDH CP3 110.15-110.50 m	Disseminated pyrite in quartz-sericite schist	2.81	10	80	35	2.29
741529		DDH CP3 122.30-122.60 m	Medium grained pyrite disseminated in quartz-sericite schist	2.83	10	80	42	1.91
741530		DDH CP3 143.85-144.35 m	Disseminated pyrite in quartz-sericite schist	2.88	15	100	27	3.70
741531		DDH CP3 151.55-151.95 m	Disseminated pyrite in quartz-sericite schist	2.81	10	125	45	2.78
741532		DDH CP3 166.90-167.40 m	Disseminated pyrite in quartz-sericite schist	3.07	25	205	60	3.42
741533		DDH CP3 174.30-174.95 m	Disseminated pyrite in sheared quartz porphyry	2.82	10	80	30	2.67
741534		DDH CP3 182.40-182.85 m	Disseminated pyrite in quartz sericite schist	2.83	10	122	58	2.10
741535		DDH CP3 205.95-206.35 m	Patches of fine grained pyrite disseminated in quartz-sericite schist	2.77	5	119	32	3.72
741536		DDH CP3 242.60-243.15 m	Disseminated pyrite in quartz-sericite schist	2.87	15	99	32	3.09

Table 6. (continued)

Reg. No.	Serial No.	Location	Description	S.G.	Pyrite (mass%)	Co (ppm)	Ni (ppm)	Co/Ni
741537		DDH CP4 134.3-135.0 m	Fine grained disseminated pyrite in quartz-sericite schist	2.80	10	75	15	5.00
741538		DDH CP4 135.9-136.5 m	Disseminated pyrite in quartz-sericite schist	3.05	25	60	11	5.46
741539		DDH CP4 165.8-169.0 m	Fine grained pyrite-quartz vein	4.01	70	5	<1	>5.00
741540		DDH CP4 166.1-166.3 m	Fine grained pyrite-quartz vein	-	70(?)	9	5	1.80
741541		DDH CP4 168.2-168.4 m	Fine grained pyrite-quartz vein	-	70(?)	15	1	15.00
741542		DDH CP4 178.9-179.5 m	Fine grained pyrite disseminated in quartz-sericite schist	2.80	10	90	22	4.09

Analyses by P.L.F. Collins and C. Saunders, Department of Mines, Hobart

The analytical data are presented graphically in Figure 18, which illustrates the relationship between cobalt and nickel (fig. 18b), and between these elements and the amount of pyrite in each sample (fig. 18c, d). It is apparent from an examination of these graphs that there exists:

(i)   A distinct linear relationship between cobalt and nickel in pyrite from the Chester mine area. Linear regression analysis of the distribution of the points plotted in Figure 18b results in the expression Co = 2.64 Ni - 2.33 (i.e. Co:Ni = 2.6:1), and a correlation coefficient of 0.89, which indicates that there exists a significant linear relationship between the cobalt and the nickel content of the pyrite.

(ii) A definite decrease in the cobalt and nickel content of pyrite as the amount of pyrite in each sample increases. A similar trend is not obvious for the Co/Ni ratio (fig. 18e).

Discussion

Pyrite from the Chester mine area contains relatively low concentrations of cobalt and nickel. As pyrite is effectively the only sulphide mineral to be deposited at the Chester mine, there being no partitioning of cobalt and nickel between pyrite and other sulphide minerals, then the cobalt and nickel content of the pyrite should reflect the availability of these two elements. Thus it is considered that the solutions from which the pyrite was precipitated contained very low concentrations of both cobalt and nickel, with cobalt being in slightly greater concentration than nickel, in the ratio of approximately 3:1.

The decrease in both cobalt and nickel in pyrite with increasing pyrite in the rock indicates the availability of cobalt and nickel remained at a relatively constant level during deposition of varying proportions of pyrite within the alteration zone. The same amount of cobalt and nickel was apparently available during deposition of the massive pyrite, which has relatively low cobalt and nickel concentrations, as there was during deposition of the disseminated pyrite containing relatively high concentrations of cobalt and nickel. The similarity of the cobalt and nickel content of the vein pyrite to massive pyrite ore indicates they are probably both part of the same hydrothermal process.

In Figure 18a, the cobalt and nickel content of pyrite from the Chester mine is compared with analyses by Loftus-Hills (1968) of cobalt and nickel in pyrite from other volcanogenic massive sulphide deposits in western Tasmania, in particular the Rosebery zinc-lead-copper deposit and the Mt Lyell copper deposit. There exists a marked similarity in the cobalt and nickel content of pyrite from the Chester mine to pyrite from the nearby Rosebery deposit, and it is concluded that the massive pyrite mineralisation at the Chester mine exhibits a genetic affinity towards pyrite-sphalerite-galena-chalcopyrite mineralisation (e.g. Rosebery) rather than to pyrite-chalcopyrite mineralisation (e.g. Mt Lyell).

The presence of chert interbedded with massive sulphide mineralisation at both the Chester and the Pinnacles deposits, and the genetic affinity of the Chester mineralisation to Cu-Pb-Zn type mineralisation, as indicated by the cobalt and nickel content of pyrite, suggests that there may be a genetic relationship between these two deposits.

Mount Remus prospect [833727]

The Mount Remus prospect (Nichols' reward claim) is situated 500 m
south-east of Mt Remus, on the banks of Anio Creek (fig. 19) and is within
the Cradle Mountain - Lake St Clair National Park. The prospect has been
examined and sampled by Nye (1928b) and Burns (1963), followed by a prelim-
inary geochemical survey by Threader (1965). The workings consist of
several trenches and small open cuts and one shaft sunk to a depth of
3.5 m.

The deposit consists of numerous irregular, narrow pyrite veins and
quartz veins occurring at several localities in this vicinity (Nye, 1928b).
The veins penetrate Precambrian chloritic and micaceous schist, but do not
appear to penetrate Cambrian(?) quartz porphyry dykes intruding the Pre-
cambrian rock (Nye, 1928b).

The majority of the veins apparently form a 0.5 - 1 m wide NE-SW
trending lode zone exposed over a strike length of at least 200 m
(Threader, 1965). The lode, which consists of numerous quartz and pyrite
veins up to 150 mm thick but mostly less than 10 mm in thickness, is in
contact with a porphyry dyke at its north-eastern end (fig. 19). At the
south-western end, the lode occurs predominantly as quartz stockwork veins
with molybdenite generally occurring along joint planes in the footwall.
In the more pyritic north-eastern end, the veins forming the lode are
capped with limonitic gossan covering friable pyrite and then solid pyrite
at depth. The molybdenite here occurs as veinlets within the pyrite veins
or on the hanging wall (Nye, 1928b).

Stillwell (1932) described pyrite and molybdenite as the only sulphides,
with hematite and possibly magnetite, chlorite, epidote, zoisite, mica and
quartz. The molybdenite is later than some of the pyrite, which is coge-
netic with the remaining minerals.

Analyses of the ore (Table 7) indicate a high cobalt and vanadium
content in addition to molybdenum. The cobalt is probably contained in
cobalt-bearing pyrite, as indicated by analyses 12-14 (Table 7) in which
the cobalt content of pyrite is approximately the same as the ore samples.
There may also have been two generations of pyrite; an early pure pyrite
and a later cobalt-bearing pyrite associated with the molybdenite. Still-
well (1932) concluded that the vanadium probably occurs in chlorite derived
from alteration of vanadium-bearing mica (*e.g.* roscoelite).

Results of the stream sediment sampling by Threader (1965) indicate
other lodes probably occur to the south and east of the present prospect
(fig. 19).

The origin of the mineralisation is not known. The veins appear to
be older than the quartz porphyry intrusives, but the molybdenite and
cobalt-bearing pyrite may have been emplaced much later and are possibly
genetically associated with late Devonian granitoids.
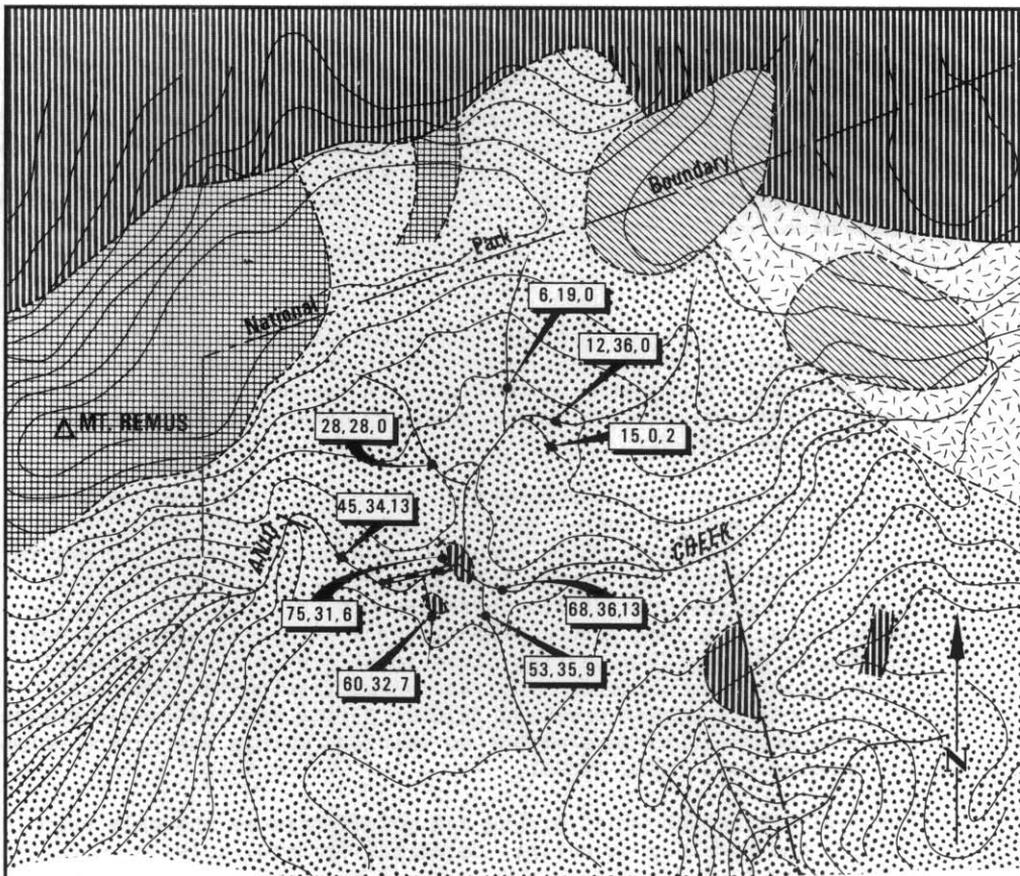
QUATERNARY

Glacial deposits.

CAMBRIAN

Quartz and quartz-feldspar porphyry.
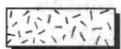
Undifferentiated sedimentary and igneous rocks.

PRECAMBRIAN
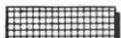
Quartzite.

Micaceous schist.

Lode

Fault

36,0,24   Stream sediment sample (Mo, V, Co (mg/l) indicated)

MT. REMUS PROSPECT

GEOLOGIST: P.L.F. COLLINS

Compiled from Barton et al. (1966) Threader (1965)

0   1   2 km

Figure 19.

5 cm
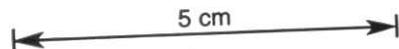
Table 7.   ANALYSES OF PYRITE – MOLYBDENITE ORE, MT REMUS PROSPECT

Analysis	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Mo (%)	1.57	0.20	1.33	0.65	45.67	0.47	0.48	0.48	0.43	0.49	0.48			
V (%)	0.33	0.22	0.39	0.19	4.38	0.35	0.49	1.57	Tr	Tr	Tr			
Co (%)	0.33	0.30	0.31	0.18	0.63	0.54	1.49	0.50	0.26	0.18	0.29			
Cu (%)	0.00	0.00	0.00	0.00				0.00						
Fe (%)					8.20			39.08						
S (%)					38.24			49.70	47.1	46.5	36.8			
Co (ppm)												3030	3034	3042
Ni (ppm)												19	21	19

1, 2, 3	150 mm pyrite vein (Nye, 1928b).
4	Stockwork ore in schist (Nye, 1928b).
5	Molybdenite, hand picked (Nye, 1928b).
6, 7	Pyritic ore, collected by Nye (Stillwell, 1932).
8	Bulk sample, collected by Nye (Stillwell, 1932). Also contains traces of As, Ni, Zn.
9, 10	150 mm and 200 mm pyrite veins respectively (Burns, 1963).
11	Molybdenite, hand picked(?) (Burns, 1963).
12-14	Pyrite (Loftus-Hills, 1968).

GOLD

Alluvial gold deposits are confined to the eastern side of the Marianoak River valley, in the vicinity of Burns Peak. The main workings, the Strong Creek gold diggings, are located approximately 250 m west of the south open cut at the Pinnacles mine [565668]. Reid (1918) described fine flakes and rounded particles of gold weighing up to 0.3 g occurring in detrital material which also contained galena, pyrite, chalcopyrite and chromite. The gold and sulphides probably originate from the Pinnacles mineralisation, which contains up to 190 g/t Au, but the origin of the chromite is not known.

Old sluice workings, probably established for alluvial gold, are located in the headwaters of Mayday Creek [853832]. Gold is also reported from the Gold Hill prospect, situated about 3.5 km north of Mt Charter [727778]. The mineralisation here occurs as disseminated pyrite and traces of secondary copper in NE-SW trending shear zones, up to three metres wide, within a volcanic sequence of acid - intermediate lava and pyroclastic rocks (Henderson, 1937; 1938). Samples of the mineralisation collected by Henderson assayed up to 1.8 g/t Au and 29.8 g/t Ag, although one sample assayed at 188.9 g/t Ag.

OTHER METALLIC MINERAL DEPOSITS

Ward (1908) refers to tin being recovered from Granite Tor [about 770626].

Anomalous radioactivity attributed to secondary enrichment of uranium in sheared crystallo-lithic tuff within Cambrian quartz porphyry lava is reported from the Lea River area [997892] (Collins, 1975a).

Industrial minerals and rocks

T.G. Summons

CHROMITE

Reid (1918) reported the occurrence of chromite in the auriferous alluvium at Strongs Creek, a tributary of the Marionoak River, and proposed the Coldstream River serpentine dykes, north of the area, as the probable source rocks.

The chromite potential of this area is influenced by;

(i)   The paucity of sufficiently extensive ultramafic source rocks;

(ii)   The thin, discontinuous nature of the alluvial material in Strongs Creek, and

(iii)   The lack of subsequent reports describing positive chromite prospecting results in the area.

BARITE

Barite is an ubiquitous mineral associated with the Zn-Pb-Cu mineralisation in the quadrangle (*e.g.* Pinnacles, Que River mines), the genetically related massive pyrite deposit enclosing the Chester mine (p. 89), and several of the Ag-Pb-Zn deposits (*e.g.* Murchison mine, Silver Falls and

Lynch Creek prospects).

Ward (1908), in describing the Mt Farrell mining field, referred to a barite vein flecked with galena, approximately 1 - 2 m wide, and exposed for approximately 100 m between Mt Murchison and the Murchison River.

Reid (1918) recorded a one metre thick barite lode with pyrite, galena, sphalerite, chalcopyrite, pyrophyllite and chlorite located in chert/quartz in the Pinnacles mine (Thomas' tunnel). Reid also refers to barite as being the dominant mineral in certain parts of the Pinnacles lodes. Hills (1919) recorded 1.5vol% barite in the average Zn-Pb-Cu ore of the Read-Rosebery district.

Blake (1928) described extensive deposits of 'low grade' barite in the Mt Block area, but does not elaborate in terms of mass and quality. A rapid reconnaissance stream sediment sampling programme by Comstaff Pty Ltd in 1968/69, apparently failed to locate any anomalous concentrations of barite in a restricted area of Mt Block (Comstaff, 1969).

Geochemical investigation for Comstaff Pty Ltd in 1976 of the Fury Plains prospect (consisting of galena, pyrite and sphalerite) revealed a coincident Pb-Zn-Ba anomaly (Rugless, 1976); the high Ba value is presumably due to a nearby concentration of barite in the host rocks.

Barite potential in the Mackintosh Quadrangle appears high because of:

(i)   The close association of the barite with the numerous Zn-Pb-Cu deposits, where further work should reveal the presence of massive barite ore-bodies, similar to the one at Rosebery.

(ii)   The lack of exploration effort to properly evaluate the full physical extent and chemical variations of the vein type barite deposits associated with minor Zn-Pb-Cu mineralisation.

GRAPHITE

Ward (1908) described a 'notable development of graphite where the lodes occur in dark coloured slate' at the North Mt Farrell mine. He also described highly contorted graphitic slate exposed in trenches on the north-west flank of Mt Farrell.

Reid (1918) suggests that the graphite present in the Silver Falls Ag-Pb-Zn prospect is derived from, and hosted by, bluish coloured fissile slate, similar to that seen in the railway cutting immediately south of the old Pieman River bridge. Reid also described graphite in the slate near the Pinnacles and Chester mines.

It would appear that carbonaceous argillaceous sediments, under the influence of hydrothermal solutions, are the source/host rocks for the graphite, and that the potential for locating further graphite occurrences lies in these altered carbonaceous sediments.

LIMESTONE

The only limestone occurrence investigated in the Mackintosh Quadrangle appears to be the exposure of Gordon Limestone in the Vale of Belvoir.

Threader (1963) mapped a north-east striking syncline axis in Gordon Limestone, underlain by Moina Sandstone/Roland Conglomerate; this axis parallels the long axis of the Vale, the floor and sides of which are mainly limestone. Based on cross sections normal to the axis of the valley, Threader calculated a probable ore reserve of 300×10^6 t, at an approximate grade of 82.50% $CaCO_3$. However, this grade should be examined closely with regard to its usefulness, because:

(i)   The extent to which the samples were taken from the same horizon (from one side of the syncline valley to the other) cannot be readily resolved, and

(ii) The method of sample collection only provides adequate information with regard to the quality of the limestone at shallow depth.

Thus the grade of limestone quoted by Threader (1963) should be considered only as a broad guide to the quality of a small proportion of the limestone in the Vale of Belvoir.

PYROPHYLLITE

Reid (1918) reported pyrophyllite as an abundant constituent of the mineralised zone between the Chester mine and the Silver Falls prospect, and that outside the ore channel pinite (sericite) was more common. Pyrophyllite was further described as constituting the greater portion of the gangue in the lodes at the Chester (pyrite) and Pinnacles (Zn-Pb-Cu) mines. Reid (1918) also referred to minor pyrophyllite in the gangue assemblage at the Silver Falls prospect.

Stevens (1974), in his study of the Chester-Pinnacles area, described the Chester mine as being at the northern end of a lenticular zone of hydro-thermal alteration, paralleling the regional trend of the country rocks for a distance of one kilometre south of the mine.

Stevens recognised three concentric zones of hydrothermal alteration;

(i)   An inner zone of quartz-sericite (pyrophyllite)-pyrite (±carbonate).

(ii) An intermediate zone of quartz-sericite (pyrophyllite)-chlorite (±carbonate).

(iii) An outer weakly altered zone.

(Stevens determined pyrophyllite by using X-ray diffraction).

The close physical similarities of pyrophyllite, sericite and talc makes the field recognition of pyrophyllite difficult, a fact affirmed by Deer, Howie and Zussman (1965, p. 14) who cite the example of the name sericite being wrongly used to describe pyrophyllite.

However, both Reid (1918) and Stevens (1974) have confirmed the

presence of pyrophyllite at the Chester mine (Table 8).

Table 8.   ANALYSES OF PYROPHYLLITES

Analysis	1	2	3
SiO_2	64.39	59.80	71.76
Al_2O_3	28.64	33.80	23.73
TiO_2	0.40		0.84
Fe_2O_3	0.43		0.37
FeO	0.02		
MnO	-		-
MgO	0.12		0.25
CaO	0.14		0.27
Na_2O	0.23		-
H_2O	0.07		0.58
P_2O_5	tr		0.15
H_2O	5.23	6.50	
Loss on ignition	-	-	1.13
	99.65	100.10	99.48

1. Average of seven pyrophyllites in the world (Deer, Howie and Zussman, 1965).

2. Reid, 1918.

3. Stevens, 1974.

PYRITE

See previous discussion under Sulphur.

Construction materials

V.M. Threader

As the Mackintosh Quadrangle is poorly developed, there is little demand for construction materials. Consequently little is known of its resources. Ten pits are listed in Table 9. Of these two are frequently worked, four are occasionally worked and four are disused.

The information available comes from three road making authorities; Department of Main Roads, Hydro-electric Commission and Australian Forest Holdings. The main access routes are the Cradle Mountain Road and the Murchison Highway.

There is no major road building activity in this quadrangle at present but there is a large inferred reserve of Tertiary basalt, Lower Palaeozoic quartzite and conglomerate, Quaternary fluvioglacial sediments and Devonian granite, all of which are potential sources of construction material. It can be anticipated therefore that no difficulty would be experienced in meeting any future demand.

Table 9. *SIZING ANALYSIS AND PHYSICAL PROPERTIES OF CONSTRUCTION MATERIALS, MACKINTOSH QUADRANGLE*

No.	AMG Reference	ANG Reference	Sizing Analysis Cumulative % passing (mm)														Status
			75	53	37.5	26.5	19	9.53	4.76	2.36	1.18	0.60	0.425	0.3	0.15	0.075	
1	CP863813	38/667638			100	98	92	76	63	55			39			28	Occasionally worked
2	CP843862	38/646692	100	89	88	84	80	70	54	32			8			6	Occasionally worked
3	CP849895	38/643728					92	79	70	62	56	52	50	49	45	41	Disused
4	CQ884044	38/693890	100	94	91	82	74	60	48	41			37			16	Frequently worked
5	CQ881018	38/690861		100	88	79	71	63	58	54			49			39	Disused
6	CP895985	38/704824															Disused
7	CP899960	38/709799															Disused
8a	CP840820	38/642645					93	82	68	54	41	32	28	25	20	15	Disused
8b	CP838824	38/640649			98		92	79	64	50	34	22	15	11	7	5	Occasionally worked
9	DP109937	38/938770			90		83	72	61	52	44	37	35	32	27	19	Occasionally worked
10	DQ144004	38/977843			97		85	73	64	55	46	39	36	33	27	20	Frequently worked

Table 9. (continued)

No.	Name	Locality	Dust Ratio	Liquid Limit	Plast. Index	Linear Shrink.	Classi-fication*	Material	Age#	Est.Prod. (m³)	Res.
1	H.E.C.	Hanging Rock	0.72	21	3	2	SMD	Quartzite/sandy silt	Q	10 000+	Large
2	D.M.R.	Murchison Highway	0.70	32	2	2	SW-SM	Clayey siltstone	Q	4 000	Small
3	D.M.R.	Murchison Highway	0.80	40	9	6.4	GMU	Mudstone	C	2 000	Small
4	A.F.H.	Moory Mount	0.44		Non-plastic		GMD	Siltstone and quartz	O	100 000	Very large
5	A.F.H.	Hatfield	0.79	40	0	1	GMD	Basalt	T	2 500	Small
6	D.M.R.	Murchison Highway						Basalt	T	2 000	Small
7	D.M.R.	Murchison Highway						Mudstone	C	4 000	Small
8a	D.M.R.	Murchison Highway	0.55		Non-plastic		GMD	Glacial sediments	Q	7 000	Small
8b	D.M.R.	Murchison Highway	0.32		Non-plastic		GMD	Glacial sediments	Q	5 000	Moderate
9	D.M.R.	Cradle Mount-ain Road	0.56		Non-plastic		GMD	Quartz and schist	E	2 000	Small
10	D.M.R.	Cradle Mount-ain Road	0.57	45	5	6	GC	Basalt	T	2 000	Moderate

* S = sand, C = clay, G = gravel, W = well graded, M = mixed non-clay fines, D = suitable plasticity, U = unsuitable plasticity.

E = Precambrian, C = Cambrian, O = Ordovician, T = Tertiary, Q = Quaternary

111

REFERENCES

BALME, B.E. 1960. Palynology of a sediment from Halletts Quarry, Melrose, Tasmania. *Palynol.Rep.Dep.Geol.Univ.W.Aust.* 62.

BANKS, M.R. 1962. Permian, *in* SPRY, A.H.; BANKS, M.R. (ed.). The geology of Tasmania. *J.geol.Soc.Aust.* 9(2):189-215.

BARTON, C.M., *et al.* 1966. Geological atlas 1 mile series. Zone 7 sheet 44(8014N). Mackintosh. *Department of Mines, Tasmania.*

BLAKE, F. 1928. Preliminary report on barite in Tasmania. *Unpubl.Rep. Dep.Mines Tasm.* 1928(1):102-114.

BLAKE, F. 1939. Sulphide deposits in Tasmania suitable for the production of elemental sulphur. *Unpubl.Rep.Dep.Mines Tasm.* 1939:69-74.

BROOKS, C. 1962. *Geology of the Tullah area.* B.Sc. Hons. thesis, University of Tasmania : Hobart.

BURNS, K.L. 1963. The geology of the Mt Remus area. *Unpubl.Rep.Dep.Mines Tasm.* 1891-1969:244-249.

BURNS, K.L. 1965. One mile geological map series. K/55-6-29. Devonport. *Explan.Rep.Dep.Mines Tasm.*

BURTON, C.C.J. 1976. Hercules and Farrell orebodies, Rosebery district. *Monogr.Ser.australas.Inst.Min.Metall.* 5:626-628.

CAMPANA, B.; KING, D. 1963. Palaeozoic tectonism, sedimentation and mineralisation in west Tasmania. *J.geol.Soc.Aust.* 10:1-53.

CAREY, S.W. 1953. Geological structures of Tasmania in relation to mineralisation. *Publs. 5th emp.min.metall.Congr.* 1:1108-1128.

COLLINS, P.L.F. 1975a. A radioactive anomaly in central northern Tasmania (E.L. 14/73). *Tech.Rep.Dep.Mines Tasm.* 18:28-31.

COLLINS, P.L.F. 1975b. Mineragraphy of Zn-Pb sulphide mineralisation intersected in diamond drill core from near the Chester mine, western Tasmania. *Tech.Rep.Dep.Mines Tasm.* 19:34-36.

COMSTAFF, 1969. Review of summer exploration programme, Exploration Licence E.L. 5/63, 1968-1969. *Unpubl.Rep.Comstaff Pty Ltd.*

DEER, W.A.; HOWIE, R.A.; ZUSSMAN, J. 1962. *Rock-forming minerals. Volume 3. Sheet silicates.* Longman : London.

DERBYSHIRE, E. 1968. Glacial map of north-west central Tasmania. *Rec. geol.Surv.Tasm.* 6.

DREW, B.J. 1957. Appraisal of the Farrell mining field, Tullah, Tasmania. *Unpubl.Rep.Rio Australian Exploration Pty Ltd.* 2/1957.

DUGGAN, N.T. 1980. The Que River deposit - a zinc-lead-copper occurrence in western Tasmania, *in* GEOLOGICAL SOCIETY OF AUSTRALIA. *Fourth Australian Geological Convention. Programmes and abstracts.* p.50.

FOLEY, J.L. 1901. *Notes on the Mount Farrell mining district*. Launceston. (compiled by a Committee appointed at a conference of the Mount Farrell and North Mount Farrell Companies' directorates).

GEE, R.D. 1964. Permian rocks of the Mt Inglis area. *Tech.Rep.Dep.Mines Tasm.* 8:57-63.

GEE, R.D.; MARSHALL, B.; BURNS, K.L. 1970. The metamorphic and structural sequence in the Precambrian of the Cradle Mountain area. *Rep.geol.Surv. Tasm.* 11.

GEE, R.D.; BURNS, K.L. 1968. Permian stratigraphy and sedimentation in the Barn Bluff area, central Tasmania. *Rep.geol.Surv.Tasm.* 10.

GROVES, D.I.; BAKER, W.E. 1971. The cobalt and nickel content of some sulphides from ore deposits in eastern Tasmania. *Tech.Rep.Dep.Mines Tasm.* 14:27-35.

GROVES, D.I.; LOFTUS-HILLS, G. 1968. Cadmium in Tasmanian sphalerites. *Proc.australas.Inst.Min.Metall.* 228:43-51.

GROVES, D.I.; NOLDART, A.J. 1965. Geology of the Tullah mining field. *Tech.Rep.Dep.Mines Tasm.* 9:43-54.

HALL, G. 1950. Pinnacles area (Progress report No. 12 covering S.P.L. 201) *Unpubl.Rep.Electrolytic Zinc Co.australas.Ltd.*

HALL, G.; SOLOMON, M. 1962. Metallic mineral deposits, *in* SPRY, A.H.; BANKS, M.R. The geology of Tasmania. *J.geol.Soc.Aust.* 9(2):285-309.

HALL, G.; COTTLE, V.M.; ROSENHAIN, P.B.; McGHIE, R.R. 1953. The lead-zinc deposits of Read-Rosebery and Mount Farrell. *Publs.5th emp.min.metall. Congr.* 1:1145-1159.

HENDERSON, Q.J. 1937. Notes on proposed operations at Gold Hill in vicinity of the Que River. *Unpubl.Rep.Dep.Mines Tasm.* 1937:18-19.

HENDERSON, Q.J. 1938. Geological survey of the Gold Hill area, vicinity of the Que River. *Unpubl.Rep.Dep.Mines Tasm.* 1938:49-53.

HENDERSON, Q.J. 1941. The Welcome Home copper area, vicinity of the Que River. *Unpubl.Rep.Dep.Mines Tasm.* 1941:1-4.

HENDERSON, Q.J. 1943. Notes on the copper prospects north of Farrell. *Unpubl.Rep.Dep.Mines Tasm.* 1943:27-29.

HENDERSON, Q.J. 1945a. The mineral prospects of the Pieman River area. *Unpubl.Rep.Dep.Mines Tasm.* 1945:28-30.

HENDERSON, Q.J. 1945b. The Farrell Mining Co. Ltd mines, Tullah. *Unpubl. Rep.Dep.Mines Tasm.* 1945:64-85.

HILLS, C.L. 1915. The zinc-lead-sulphide deposits of the Read-Rosebery district, Part II. Rosebery Group. *Bull.geol.Surv.Tasm.* 23.

HILLS, C.L. 1919. The zinc-lead-sulphide deposits of the Read-Rosebery district, Part III. Metallurgy and general review. *Bull.geol.Surv. Tasm.* 31.

HUGHES, T.D. 1951. Sulphur resources of Tasmania. *Unpubl.Rep.Dep.Mines Tasm.* 1951:29-31.

JENNINGS, I.B. 1963. One mile geological map series. K/55-6-45. Middle-sex. *Explan.Rep.geol.Surv.Tasm.*

JENSEN, H.E. 1959. Examination of Farrell Mining Company's properties at Tullah, Tasmania. *Unpubl.Rep.Rio Tinto Aust.Expl.Pty Ltd.* 20/1959.

KRUMMEI, G. 1972. Progress report on the Mackintosh area, E.L. 2/70, Tasmania 1971/72. *Unpubl.Rep.Aberfoyle Management Pty Ltd.*

LARSEN, R.J. 1939. [Report on mining propositions 'Welcome Home' and 'Cataract Creek' to Cataract mining syndicate].

LOFTUS-HILLS, G. 1968. *Cobalt, nickel and selenium in Tasmanian ore minerals.* Ph.D. Thesis, University of Tasmania : Hobart.

LOFTUS-HILLS, G.; GROVES, D.I.; SOLOMON, M. 1969. The selenium content of some Tasmanian sulphides. *Proc.australas.Inst.Min.Metall.* 232:55-65.

LOFTUS-HILLS, G.; SOLOMON, M. 1967. Cobalt, nickel and selenium in sul-phides as indicators of ore genesis. *Miner.Deposita.* 2:228-242.

MACLEOD, W.N.; JACK, R.H.; THREADER, V.M. 1961. One mile geological map series. K/55-11-52. Du Cane. *Explan.Rep.geol.Surv.Tasm.*

McDOUGALL, I.; LEGGO, P.J. 1965. Isotopic age determinations on granitic rocks from Tasmania. *J.geol.Soc.Aust.* 12:295-332.

McKELLAR, J.B.A. 1957. Geology of portion of the Western Tiers. *Rec.Qn Vict.Mus.* N.S. 7.

MONTGOMERY, A. 1892. Report on the country traversed by the route of the proposed Waratah-Zeehan railway. *Rep.Secr.Mines Tasm.* 1891-2:22-25.

MONTGOMERY, A. 1893a. *Interim report on the discoveries of coal at Barn Bluff, and on the progress of the mineral fields of the County of Montagu, Mount Zeehan, Mount Dundas, Mount Reid, Mount Heemskirk, Mount Lyell, &c.* Mines Department, Tasmania.

MONTGOMERY, A. 1893b. Report on the country between Mole Creek and Mount Dundas silver field and on the discovery of coal at Barn Bluff. *Rep. Secr.Mines Tasm.* 1892-3.

MONTGOMERY, A. 1895. Report on the progress of the mineral field in the neighbourhood of Zeehan; viz:- Mackintosh River, Mount Black, Mount Read, Mount Dundas, Mount Zeehan, Stanley River and Mt Heemskirk. *Rep. Secr.Mines Tasm.* 1894-5:vii-xxxviii.

MUCENIEKAS, E.; BONIWELL, J. 1959. The Pinnacles - Chester area, Tasmania, geochemical and geophysical surveys. *Unpubl.Rep.Rio Tinto Aust.Expl. Pty Ltd.*

NYE, P.B. 1928a. Sulphide deposits suitable for the production of sulphur or sulphuric acid. *Unpubl.Rep.Dep.Mines Tasm.* 1928(2):98-103.

NYE, P.B. 1928b. Report on the molybdenite prospect at Mt Remus. *Unpubl. Rep.Dep.Mines Tasm.* 1928(1):28-33.

NYE, P.B. 1931. Report on tribute at North Mount Farrel mine. *Unpubl.Rep. Dep.Mines Tasm.* 1931:51-53.

NYE, P.B. 1932. Sulphide deposits suitable for the production of sulphur or sulphuric acid. *Unpubl.Rep.Dep.Mines Tasm.* 1932(1):56-61.

REID, A.M. 1918. The North Pieman and Huskisson, and Sterling Valley mining fields. *Bull.geol.Surv.Tasm.* 28.

REID, A.M. 1927. Supplementary report on some mines in Mt Farrell district. *Unpubl.Rep.Dep.Mines Tasm.* 1927B:115-120.

RICHARDSON, L.A. 1951. Geophysical survey of Mackintosh area, Tullah. *Unpubl.Rep.Electrolytic Zinc Co.Aust.Ltd.*

RUGLESS, C.S. 1976. Final report on Fury Plains prospect, Exploration Licence 14/74. *Unpubl.Rep.Australian Anglo American Ltd.*

SCHMIDT, P.W.; McDOUGALL, I. 1977. Palaeomagnetic and potassium-argon dating studies of the Tasmanian dolerites. *J.geol.Soc.Aust.* 24:321-328.

SLEMMONS, D.B. 1962. Determination of volcanic and plutonic plagioclases using a three- or four-axis universal stage. *Spec.Pap.geol.Soc.Am.* 69.

SMITH, J.H. 1898. Report on the mineral fields in the neighbourhood of Mt Black, Ringville, Mt Read and Lake Dora. *Rep.Secr.Mines Tasm.* 1897-8:i-xxiv.

SOLOMON, M. 1958. Report on regional mapping, western Tasmania. *Unpubl. Rep.Rio Tinto Aust.Expl.Pty Ltd.* 80/20.

SOLOMON, M. 1965. Lead-silver-zinc ore deposits of Mt Farrell. *Publs. 8th commonw.min.metall.Congr.* 1:464-477.

SOLOMON, M.; RAFTER, T.A.; JENSEN, M.L. 1969. Isotope studies on the Rosebery, Mount Farrell and Mount Lyell ores, Tasmania. *Miner.Deposita.* 4:172-199.

SPRY, A.H. 1958. The Precambrian rocks of Tasmania. Part III, Mersey-Forth area. *Pap.Proc.R.Soc.Tasm.* 92:117-137.

SPRY, A.H. 1963. The Precambrian rocks of Tasmania. Part V, Petrology and structure of the Frenchman's Cap area. *Pap.Proc.R.Soc.Tasm.* 97:105-127.

STEVENS, A.G. 1974. *The geology and mineralisation of the Chester-Pinnacles area, W. Tasmania.* B.Sc. Hons. thesis, University of Tasmania : Hobart.

STILLWELL, F.L. 1932. The occurrence of cobalt and vanadium in Mt Remus pyritic ore. [Unpubl.Rep.; Dep.Mines Tasm.]

TATE, K.H. 1958. Geophysical survey at the Mt Farrell mine, Tullah, Tasmania. *Rec.Bur.Miner.Resour.Geol.Geophys.Aust.* 1958/35.

THREADER, V.M. 1963. Limestone in the Vale of Belvoir. *Tech.Rep.Dep. Mines Tasm.* 7:63-66.

THREADER, V.M. 1965. The Mount Remus prospect. [memorandum, Tasmania Department of Mines, Hobart].

TURNER, F.J. 1968. *Metamorphic petrology*. McGraw-Hill : New York.

TWELVETREES, W.H. 1901. Report on the Mount Farrell district. *Rep.Secr. Mines Tasm.* 1900-01:145-170.

WARD, L.K. 1908. The Mount Farrell mining field. *Bull.geol.Surv.Tasm.* 3.

WEBSTER, S.S.; SKEY, E.H. 1977. Geophysical and geochemical case study of the Que River deposit, Tasmania, Australia, *in : Mineral exploration with particular reference to western Tasmanian-type orebodies and terrain. Abstracts of a symposium, Queenstown, October 22, 1977.*

WHITTEN, G.F. 1948. First report on Dutton's workings, silver lead, Mount Farrell. *Unpubl.Rep.Electrolytic Zinc Co.australas.Ltd.*

WELLS, A.T. 1957. Geology of the Deloraine - Golden Valley area, Tasmania. *Rec.Qn Vict.Mus.* N.S. 8.

WILLIAMS, E. 1976. Tasman Fold Belt system in Tasmania. Explanatory notes for the 1:500 000 structural map of pre-Carboniferous rocks of Tasmania. *Department of Mines, Tasmania.*

APPENDIX 1

The Mount Read Volcanics and associated rocks in The Pinnacles - Que River area

P.L.F. Collins

Abstract

The Mt Read Volcanics in The Pinnacles - Que River area are subdivided into two major sequences. The western volcano-sedimentary sequence is dominantly marine and includes micaceous greywacke, shale, vitric tuff, quartz- and feldspar-phyric crystal-vitric tuff, and tuffaceous greywacke, with intercalated quartz- and feldspar-phyric lava and quartz-feldspar porphyry intrusive bodies. The Que River Beds (late Middle Cambrian) are interpreted as the basal sediments of the western sequence.
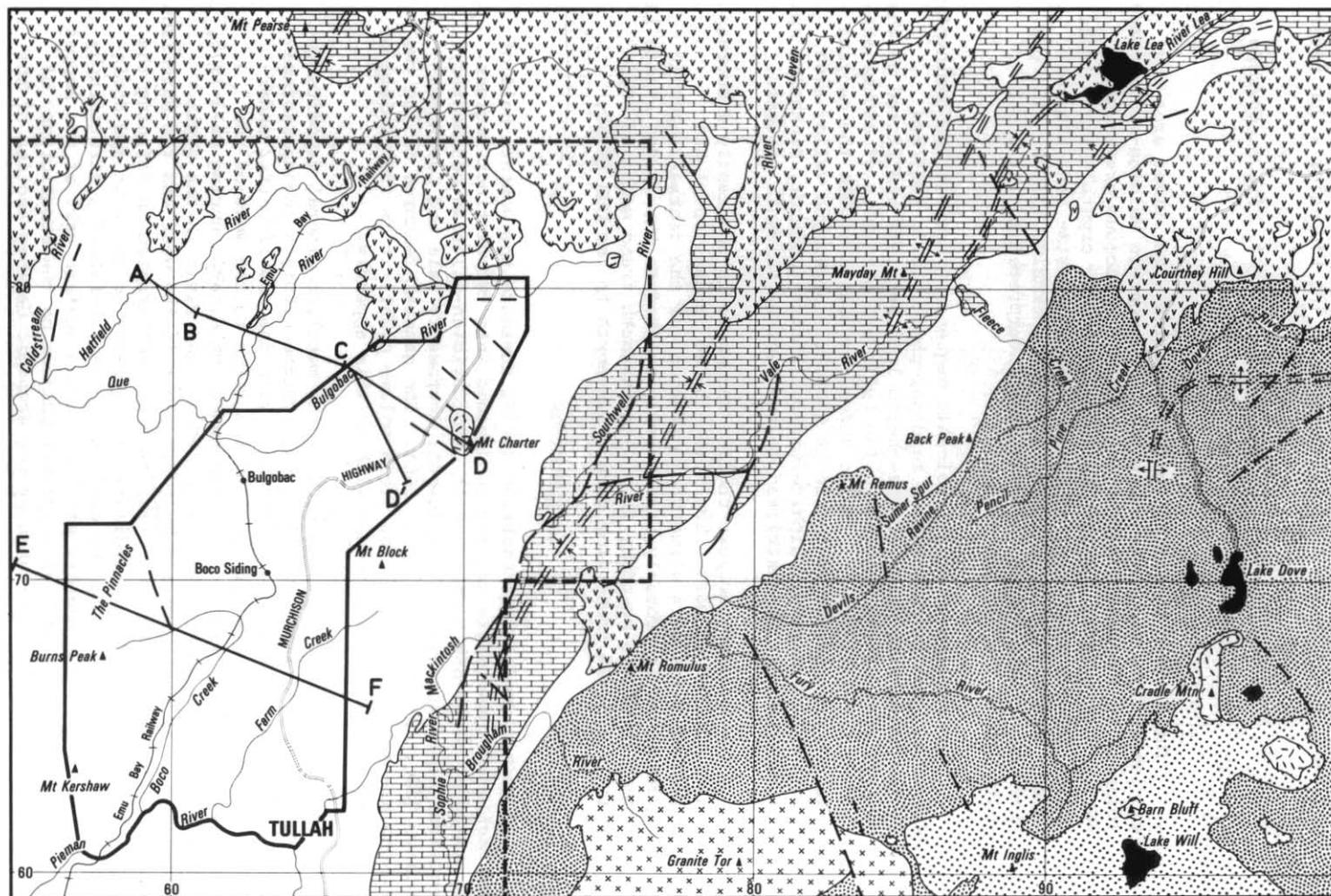
The eastern (central) volcanic sequence appears to be dominantly subaerial, and is composed of feldspar-phyric lava, tuff and agglomerate, with minor quartz-phyric lava and tuff restricted to the western edge of the sequence. The tuffs are generally of either ash-flow or air-fall origin. Mafic andesitic bodies within the central sequence are restricted to the Mt Charter - upper Que valley area. Volcanogenic, massive sulphide mineralisation (Chester, Pinnacles and Que River mines) is restricted to the central volcanic sequence.

The boundary between the two sequences is apparently discordant, and is faulted in part. The thumb-shaped projection of The Pinnacles lavas is a structural off-shoot of the central volcanic sequence and is probably structurally related to the abrupt change in direction of the boundary from a north-south trend south of Burns Peak to a NE-SW trend from Burns Peak north to the Que River.

INTRODUCTION

Rocks assigned to the Cambrian System dominate the western half of the Mackintosh Quadrangle and may be divided into two distinct regions separated by a NNE-SSW trending belt of Ordovician-Silurian sedimentary sequences along the Sophia, Mackintosh, Southwell, Vale and Lea River valleys (fig. 20; Barton et al., 1966). The general features of the two regions are described by Collins (this volume p.25); it is the geology of the western region which is dealt with in this appendix.

During a summary investigation of the metallic mineral deposits in the Mackintosh Quadrangle (Collins, this volume p.69), a reconnaissance geological mapping project was initiated with the aim of better under-standing the stratigraphy of the Cambrian rocks to the west of the Ordovician-Silurian divide. The mapping was undertaken during 1973-1975, principally within an area bounded by the Pieman River in the south, Mt Kershaw - The Pinnacles and Bulgobac River in the west and the Murchison Highway in the east (fig. 20). The mapping concentrated on defining the boundary between dominantly sedimentary sequences to the west and domin-antly volcanic sequences to the east, and on establishing a stratigraphy within the volcano-sedimentary sequence in the western part of the mapped area. The work forms part of a special project on the stratigraphy of the Mt Read Volcanics undertaken by the Economic Geology section of the Geological Survey of Tasmania.

5 cm

10 km

5

0

REFERENCE

Permian; glacio-marine and freshwater sequences.

Ordovician - Silurian dominantly siliceous clastic and limestone sequences.

Cambrian; dominantly volcanic rocks, volcani-clastic and turbidite sequences.

Precambrian; dominantly metaquartzite phyllite and schist.

Igneous Rocks

Tertiary basalt.

Jurassic dolerite.

Devonian granite.

Geological boundary

Fault.

Hinge line of major folds - syncline, anticline.

Geology shown in Figure 21

Area of reconnaissance mapping 1973-1974

A ———— D, D'

E ———— F

(Cross-sections in Figure 22)

Figure 20. *Bedrock geology, Mackintosh Quadrangle, showing the mapped area and the location of the sections shown in Figure 22.*

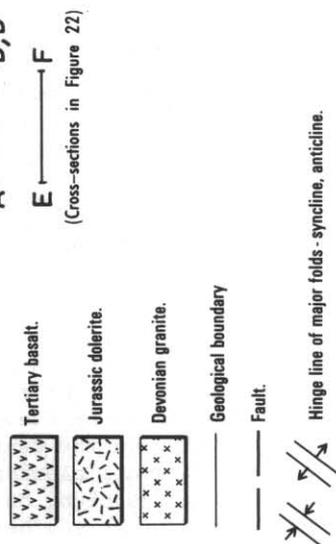The results of the mapping project are presented in Figure 21, which is a compilation of the work reported here superimposed on the Mackintosh map sheet (Barton *et al.*, 1966), together with additional unpublished mapping carried out during the Mackintosh regional mapping programme but not included on the map sheet. The previously unpublished information collected during the Mackintosh regional geological survey is referred to by individual geologists' initials within brackets, as in the main part of these explanatory notes. Schematic geological NW-SE cross-sections of the Que River - Mt Charter area and The Pinnacles - Farm Creek area are illustrated in Figure 22.

It is essential that the Mackintosh explanatory notes be read in con-junction with this appendix, and particularly the Cambrian section of those notes (pp.25-40). In the period since the mapping reported here was under-taken there has been, in addition to mapping by companies involved in mineral exploration, a detailed study of the geology and mineralisation of The Pinnacles - Mt Kershaw area (Stevens, 1974) and of the Mt Farrell area (Rivers, 1975). Anderson (1972) includes data on traverses of the Pieman River, Farrell Tramway and Emu Bay Railway. Only the results of the mapping reported here and interpretations based thereon are discussed in this appendix.

Specimens of the volcanic and sedimentary rocks collected in the course of the mapping and referred to in this appendix are referenced in the text by a serial number prefixed by the letter M. A catalogue of these

specimens is included in this appendix (table 11).

STRATIGRAPHY AND PETROLOGY

The Cambrian rocks to the west of the Sophia - Mackintosh - Southwell River valleys (fig. 21) may be conveniently divided into the following two sequences:-

(1) a dominantly sedimentary sequence with volcanic rocks and
     felsic intrusive bodies to the west, and;

(2) a dominantly volcanic sequence to the east.

To conserve a uniformity in terminology within the Mount Read Volcanics, the two sequences are here referred to as the western volcano-sedimentary sequence and the central volcanic sequence as previously used by Corbett (1979). The boundary between the two sequences trends north-south from the Pieman River to Burns Peak, then changes to a NE-SW trend from Burns Peak to the headwaters of the Que River. North of Burns Peak is a thumb-shaped projection of volcanic rock along The Pinnacles. The nature of the boundary between the two sequences is discussed in the section on structural relationships (p.138).

The Cambrian rocks are blanketed by large areas of Pleistocene glacial and glaciofluvial deposits and recent alluvium throughout much of the mapped area (fig. 21). The largest of the Pleistocene deposits forms the north-south trending Bulgobac Plain in the centre of the mapped area. This valley may have contained a small glacier, as the valley head has a cirque-like shape, transverse moraines occur on the eastern side of the valley south of Animal Creek, and at the southern end of the Plain are bedrock structures of similar shape to roche moutonnées [641680, 643684]. Varved sediments are common at the edges of many of the glacial deposits [e.g. 565682, 649753, 639645].

Allogenic, rounded boulders, up to 5 m in diameter, of medium grained biotite-muscovite granite rest upon a quartz-feldspar porphyry intrusive body at 671765. The granite is similar to Devonian granite. The boulders occur at similar elevations to nearby glacial deposits, and are located approximately midway between the Meredith Granite to the west and Granite Tor to the south-east. Granite boulders (up to 5 m square), together with boulders of dolerite, conglomerate and quartzite, are known to occur on Observation Spur [e.g. 736707, 744703] (B.M., W.L.M.).

The most likely origin of the granite boulders is that they are derived from Granite Tor, which is a muscovite-biotite granite (see p.49) and were transported to their present position during periods of Pleistocene glacial activity.

WESTERN VOLCANO-SEDIMENTARY SEQUENCE

An apparently conformable sequence of greywacke, mudstone, shale, tuff and agglomerate with intercalated felsic lava is exposed west of the central volcanic sequence in The Pinnacles, Bulgobac and upper Que River areas. At least two elongate, sub-conformable quartz-feldspar porphyry bodies, up to 1.5 km wide and 12-14 km in length, intrude the western part of the sequence.

The western volcano-sedimentary sequence within the Mackintosh Quadrangle may be divided into several units (fig. 21; Barton et al., 1966):-

West A Micaceous greywacke and mudstone sequence with minor sandstone, quartzite and limestone of the Coldstream valley.

B Plum coloured greywacke-conglomerate, sandstone and mudstone with subsidiary nodular limestone of the Coldstream - Hatfield interfluve.

C Greywacke, siltstone and mudstone sequence of the middle Hatfield valley.

D Mudstone (black shale), quartzite and greywacke sequence with prominent quartz conglomerate of the upper Hatfield valley and the middle Que valley.

E Tuffaceous greywacke and shale (brown-black) with crystal tuff beds of The Pinnacles - Bulgobac area.

F Felsic lavas at Bulgobac.

G Tuff and shale sequence of Boco Creek and Bulgobac River.

H Felsic lavas on the interfluve between the Bulgobac River and Animal Creek.

I Greywacke, mudstone and vitric tuff sequence of the Animal Creek Greywacke.

J Tuff and agglomerate of the upper Bulgobac River.

East K Que River Beds.

Descriptions of units E-K only are given in this appendix. Units A-D are described by Collins (this volume, p.25). The westernmost tuffaceous greywacke and shale sequence (unit E) in the Bulgobac area appears to grade into the mudstone, quartzite and greywacke sequence (unit D) of the middle Que valley further to the west.

Units E-K have a general NE-SW trend, sub-paralleling the boundary with the central volcanic sequence north-east of Burns Peak, and dip and face consistently west to north-west. The sedimentary sequence is apparently conformable, in which case the Que River Beds would be the oldest sediments within the mapped area.

Que River Beds

The Que River Beds (Gee *et al.*, 1970) are the easternmost sedimentary unit in the mapped area. They crop out along the Murchison Highway from west of Mt Charter for approximately 5 km north to the Que River bridge and in the headwaters of the Que River (fig. 21). The beds have not been located south of Mt Charter. The Que River Beds are bounded to the east by the central volcanic sequence and to the west are overlain with apparent conformity by a tuffaceous unit in the north and by the Animal Creek Greywacke towards the south (fig. 21).

The sediments consist of black mudstone and siltstone and subordinate shale. The carbonaceous shale is composed of about 15% subangular quartz grains (up to 0.1 mm) and about 30% muscovite flakes (up to 0.2 mm) in a matrix of chlorite and carbonaceous matter. Pyrite occurs as lenticular nodules, framboids, and cubes, and replaces sponge spicules (Gee *et al.*, 1970).

121

Exposed in a quarry [710783] on the eastern boundary of the Que River Beds is an agglomerate, 20-25 m thick, with interbedded grey-black silt-stone. The agglomerate (sample M1) is composed of irregularly shaped, grey-cream lava and tuff fragments (up to 150 mm), pumice fragments (up to 25 mm), massive pyrite fragments (up to 10 mm), irregular lithic fragments and rare angular quartz grains in a dark grey, argillaceous and glassy matrix exhibiting flow textures. Many of the lava and tuff fragments are strongly and irregularly fractured and these fractures are healed with pyrite. Some alteration of the fragments is associated with the fracturing but there is also an apparent syn-sedimentary alteration of the lava and tuff occurring as a cream-pink reaction rim surrounding a light grey core. The source area of the lava and tuff fragments obviously contained significant pyrite mineralisation but sphalerite, galena and chalcopyrite have not been observed in the agglomerate.

Agnostid trilobite fossils from these sediments at the Que River bridge [711803] indicate a late Middle Cambrian age (*Ptychagnostus nathorsti* and *P. punctuosos* Zones) (Gee *et al.*, 1970). This is a similar age to the Hodge Slate near the base of the Dundas Group in the Dundas area (Jago, 1979), and to the Comstock Tuff at the base of the Tyndall Group in the Queenstown area (Jago *et al.*, 1972; Corbett *et al.*, 1974).

Tuff-agglomerate sequence above Que River Beds

Apparently conformably overlying the Que River Beds is a sequence of vitric tuff and agglomerate with minor interbedded siltstone and sand-stone. The agglomerate occurs at the base of the unit as beds up to 10 m thick [*e.g.* 707796] and contains blocks up to 0.5 m in length of the under-lying black shale and siltstone in a matrix of embayed quartz crystals, partially sericitised albite crystals, lithic fragments and volcanic fragments in a vitro-clastic groundmass in which shard-like outlines are preserved (Gee *et al.*, 1970).

The vitric to crystal-vitric tuff (M2-M5) is composed of embayed and rounded quartz crystals (0.5-1.0 mm), tabular plagioclase crystals (up to 2 mm), clumps of crystals of plagioclase (up to 2 mm) and platy to irregular lithic (shale) and vitric (pumice?) fragments (up to 20 mm) in a vitro-clastic groundmass in which shard shapes are preserved. The quartz and plagioclase (albite-oligoclase) crystals are randomly orientated and comprise 5-30% of the rock. The shard-like outlines exhibit parallelism to a crudely developed bedding.

The lack of lamination and generally random orientation of the crystal fragments in the tuff suggests that much of the unit may have been deposited subaerially by air-fall deposition. However, the presence of large shale clasts in the basal agglomerate and siltstone horizons inter-bedded with the tuff indicate that the sequence was deposited in an aqueous rather than a subaerial environment, probably by deposition from subaqueous density flows.

Animal Creek greywacke-mudstone-tuff sequence

A distinctive sequence of greywacke, mudstone and vitric tuff is well exposed on the Murchison Highway north of the bridge over Animal Creek. The unit is sufficiently distinctive to warrant formal definition as a formation and is here defined as the Animal Creek Greywacke, which comprises that sequence of light to dark grey greywacke, siltstone, mudstone and very fine grained vitric tuff cropping out along the Murchison Highway for about four kilometres north of Animal Creek from 648730 to 684746. The NE-SW trending sequence is blanketed by the glacial and alluvial sediments of

Bulgobac Plain south-west of Animal Creek but crops out again to the west of Boco and on The Pinnacles track [at 610683].

The Animal Creek Greywacke is bounded to the south-east by the central volcanic sequence, except at the north-eastern end west of Mt Charter, where it is bounded by the Que River Beds. To the north-west it is bounded by felsic lava on the eastern side of Bulgobac Plain, and by a tuff and shale sequence on the western side of the plain. The out-crop on The Pinnacles track appears to be located within the central volcanic sequence.

The unit is approximately 500 m thick and is composed of interbedded, grey coloured greywacke and mudstone, minor black shale and siltstone, and thick (in excess of 20 m) grey coloured beds of very fine grained vitric tuff. The greywacke and mudstone comprise a probable turbidite sequence, with graded beds indicating consistent west to north-west facing. Grey-wacke beds range from 100 mm to in excess of one metre in thickness.

The greywacke (M6-M10) varies from quartzwacke to lithic wacke and is composed of angular to sub-rounded grains of quartz, minor quartzite, siltstone, quartz-sericite-muscovite schist and rare feldspar, generally 0.1 mm across but up to 1 mm, and muscovite and rare chlorite flakes 0.2 - 0.5 mm in length. Grains consist mostly of quartz which exhibits undulose extinction. The greywacke is poorly sorted, with about 15% matrix composed of quartz, sericite, chlorite, iron oxide and opaques. The detritus is probably derived from Precambrian rocks with only a minor volcanic component.

The vitric tuff (M11-M16) is composed of very fine ash(?) (less than 0.1 mm) and less than 5% silt to mud grade quartz grains. The thick beds are massive and nondescript, lacking bedding or lamination, although a microscopic foliation is apparent from alignment of coarser ash within some beds. The thin tuff beds (*i.e.* less than one metre thick) exhibit lamination and well developed sedimentary slump structures [677744].

Felsic lava above Animal Creek Greywacke

Overlying the Animal Creek Greywacke, in the area west of Mt Charter, is a sequence of distinctive felsic lava. A similar lava forms part of a large xenolith within one of the quartz-feldspar porphyry bodies further west, but the lava has not been located to the west of Bulgobac Plain.

The lava is characterised by spheroidal-ovoid quartz-filled vesicles up to 5 mm in diameter, occurring in an aphanitic pink and green rock exhibiting a fine ocellar- to vermicular-like texture defined by the colour variation. The ocellar-like texture is most evident on cut surfaces of the weathered lava.

In thin section (M17-M18), the lava is composed of a felted mass of interlocking feldspar grains, variably altered to sericite, quartz and chlorite, and fine glomerocrysts of quartz, generally 0.05-0.2 mm in diameter. The quartz glomerocrysts have irregular margins, but with an overall spherical outline, and are invariably enveloped by a narrow cream-pink coloured zone which probably represents a reaction halo surrounding the glomerocrysts. These narrow reaction zones surrounding the fine quartz glomerocrysts give rise to the ocellar-like texture. Parts of the lava are feldspar-phyric, the phenocrysts occurring as laths up to 3 mm in length. The vesicles are filled with quartz (as interlocking crystals) and minor radiating clusters of chlorite and zircon(?). The quartz filling the

123

vesicles is of a different generation to the fine glomerocrysts.

Shale and tuff sequence in Boco Creek - Bulgobac valley

A NE-SW trending sequence of dark grey shale, white-buff crystal tuff, tuffaceous greywacke and intercalated feldspar phyric-lava is exposed from the headwaters of Boco Creek (north-east of Burns Peak) towards Bulgobac, along the east flank of The Pinnacles, and in the headwaters of the Bulgobac River (fig. 21). Grading in thin beds of tuffaceous greywacke indicates a west facing sequence. In the south, the sequence is wedged between the lava of the central volcanic sequence to the east and The Pinnacles lava to the west. Further north, and west of Boco, the sequence overlies the Animal Creek Greywacke, while east of Bulgobac Plain it overlies felsic lava. Between The Pinnacles and Bulgobac the sequence is overlain to the west by the tuffaceous greywacke and shale sequence of the western part of the area.

The unit is intruded by a large body of quartz-feldspar porphyry, which contains numerous xenoliths derived from the shale and tuff sequence, [*e.g.* 616713 and 616708].

The vitric-crystal tuff (M19-M21) is composed of quartz and feldspar crystals 0.2 - 0.5 mm in length and up to 1.5 mm across, opaque minerals, and minor lithic and volcanic fragments up to 2 mm in length in a fine grained vitric and argillaceous matrix which exhibits a fine to medium grained (0.1 - 0.5 mm) glass shard texture. The matrix comprises 50-75% of the rock. The feldspar crystals occur as broken laths and are variably decomposed to sericite, quartz and chlorite. Quartz crystals are generally angular and some exhibit corroded and embayed margins. A finely bedded vitric-crystal tuff (M22) is composed of quartz and decomposed feldspar grains and crystals (up to 1.5 mm) in a vitric and argillaceous matrix (75%) but with thin laminae of concentrations of argillite and devitrified glass shards defining the bedding.

The unit is well exposed on logging tracks south-west of Bulgobac, where it also includes a coarse grained feldspar-quartz crystal tuff. In thin section (M23), the tuff comprises decomposed feldspar as euhedral laths and broken crystals 0.2 - 3 mm in length (generally 1.0 - 1.5 mm), broken and embayed quartz crystals 0.2 - 3 mm across (generally 1 mm across), de-vitrified pumice fragments up to 5 mm long and rare lava fragments in a fine grained, felted, feldspathic matrix with intergranular chlorite and sericite.

Intercalated with the sediments are feldspar-phyric lavas such as those exposed in a logging track 1.2 km west of Boco [625707] and in a railway cutting 1.5 km north of Boco [633718]. The lava (M24, M25) consists of orthoclase and plagioclase (albite - oligoclase) phenocrysts occurring as laths up to 1.5 mm in length or as glomerocrysts up to 3 mm across in a felted matrix of feldspar and chlorite. The phenocrysts comprise about 20% of the rock.

Felsic lava at Bulgobac

A distinctive unit of quartz-feldspar-phyric lava crops out in Sawmill Creek to the west of Bulgobac and in railway cuttings north of Bulgobac. The lava is wedged between two intrusive bodies of quartz-feldspar porphyry, and may be intercalated with the previously described shale and tuff sequence. The lava is characterised by the occurrence of quartz as phenocrysts which makes it distinct from most other lavas within

124

the mapped area. This lava is not correlated with the feldspar-phyric
lavas cropping out on The Pinnacles, although in Figure 21 they appear to
be structurally equivalent.

In thin section (M26-M28), quartz and feldspar occurring as pheno-
crysts comprise 30-50% of the rock, the quartz and feldspar occurring in
approximately equal proportions. The matrix has a felted texture and is
composed of feldspar and minor chlorite and sericite, and is partially
recrystallised. Quartz phenocrysts occur as euhedral to subhedral crystals
generally 0.5 - 1 mm but up to 2 mm across. The phenocrysts may have
corroded and embayed outlines, but in specimen M28 thin rims of quartz
regrowth occur around some of the quartz phenocrysts. Feldspar phenocrysts
occur as euhedral laths up to 2 mm in length, are slightly altered to
sericite, and are albite - oligoclase in composition.

Although the genetic situation of the quartz-feldspar-phyric lava
is unresolved, it is feasible that it is the extrusive equivalent of the
quartz-feldspar intrusive bodies as indicated by a petrographic similarity
between the lava and the porphyry, and the position of the lava wedged
between the two bodies of porphyry.

Quartz-feldspar porphyry intrusive

Two major NNE-SSW trending, sub-concordant bodies of quartz-feldspar
porphyry extend through the Bulgobac - Que River area. The eastern body
occurs mainly within the tuff and shale and felsic lava sequences (units
G & H) of the Boco Creek - Bulgobac River areas, and includes narrow
strips of the enclosing sediments and lavas. The western body abuts the
westernmost tuffaceous greywacke and shale sequence in the Bulgobac -
middle Que valley area. A small body of quartz-feldspar porphyry, petro-
logically similar to the two major bodies, crops out on the north flank of
Burns Peak [582677].

Intrusive contacts with the enclosing sediments are well exposed in
a creek flowing north into the Bulgobac River near its confluence with the
Que River [615748]. Elsewhere, the contacts may be semi-concordant. For
example, on The Pinnacles track between the Murchison Highway and Burns
Peak [602683] the contact strikes 045°, dip 70°W and bedding in the shale
and siltstone to the west strikes 040°, dip 70°W.

The boundary between the western quartz-feldspar porphyry body and the
greywacke, mudstone and quartzite sequences to the west has been generally
considered as the western limit of the Mount Read Volcanics. Finucane
(1932) considered that the irregular nature of the contact is strongly
suggestive that the porphyry is intrusive into the sediments. However, the
nature of this boundary has since been the subject of much discussion,
particularly the exposure of the contact in a cutting on the Emu Bay Railway
line 1.5 km north of Bulgobac [620757]. Campana *et al.*, (1960) interpreted
the contact as an angular unconformity, with the porphyry body truncated by
an erosional surface. They reported waterworn fragments of the underlying
porphyry contained in gritty and pebbly layers in the supposed overlying
sediments, and suggested that the Dundas Group rests upon this erosional
surface. Banks and Solomon (1961) questioned the angular unconformity,
and while agreeing that there was erosion of the Mount Read Volcanics
during deposition of the overlying sediments, and admitting local disconfor-
mity, they suggested that there was no evidence of angular discordance.

At the particular cutting referred to by Campana *et al.*, (1960) and
Banks and Solomon (1961), the porphyry/sediment contact is near vertical

and strikes 177°M, whereas bedding in laminated siltstone and tuffaceous sandstone to the west strikes 173°M, dip 73°W. The actual contact is wavy, and the porphyry appears finer grained adjacent to the contact than a 100 mm or more into the porphyry. There has been some shearing parallel to the contact and there is no indication of baking of the sediments adjacent to the contact. The nature of the contact in this cutting is indecisive and it is only from better exposures of the western contact elsewhere that the intrusive nature of the porphyry has been determined.

The porphyry is generally deeply weathered and cream to pale yellow in colour, with the fresh rock being pale greenish-grey. The unit is characterised by prominent large quartz phenocrysts up to 5 mm across, and large altered feldspar phenocrysts (less prominent on deep weathered surfaces), also up to 5 mm in length. In thin section (M29-M36) the quartz phenocrysts (up to 6 mm) are ubiquitously embayed and corroded, occurring as individual crystals and as rounded glomerocrysts. The feldspar pheno-crysts (up to 5 mm) also occur as individual laths and as glomerocrysts, and exhibit varying degrees of alteration to sericite and chlorite. Both plagioclase (oligoclase) and K-feldspar are present. The fine grained (0.01 - 0.1 mm) matrix consists of a felted mass of feldspar, chlorite, sericite and scattered apatite and zircon. In M33, calcite and minor quartz is filling possible voids in the porphyry, and in M35 chlorite alteration of the matrix is widespread.

Tuffaceous greywacke and shale sequence of The Pinnacles - Bulgobac area

Interbedded tuffaceous greywacke and shale with siltstone, black slate and acid tuff beds occur extensively in the western part of the mapped area, west of Burns Peak - The Pinnacles - Bulgobac. Further west the unit probably grades into, and is equivalent to, the mudstone, quartz-ite and greywacke sequence of the upper Hatfield valley and the middle Que valley (unit D).

Many of the tuffaceous greywacke beds exhibit features typical of turbidites; for example, graded bedding, basal flame structures, and laminated tops of beds. The greywacke also contains shale clasts, some contorted, and some of the larger beds exhibit a reverse size grading of pumice and lighter volcanic fragments, suggesting that they may represent large subaqueous tuff flows. Crossbedding textures are apparent in some thin greywacke beds. The tuffaceous greywacke beds vary from about 100 mm to in excess of 20 m in thickness, but are generally 1 - 5 m thick. They appear to be less common, and the siltstone and mudstone more common, towards the west. The sedimentary structures (*i.e.* grading and flame structures) indicate a consistently west facing sequence.

The green-brown weathering tuffaceous greywacke consists of elongate shale fragments 20 - 50 mm in length (but may be in excess of 200 mm), felsic volcanic fragments (quartz porphyry and quartz-feldspar porphyry) up to 50 mm across, and abundant quartz and altered feldspar grains (up to 5 mm) in a green-buff matrix. In thin section (M37), the quartz occurs as angular, broken crystals and grains averaging 0.5 mm and up to 1 mm across. The feldspar is altered and weathered, occurring as broken laths up to 2 mm in length. This quartz and feldspar with intergranular chlorite and sericite comprises the bulk of the finer grained portion of the greywacke. Quartz also occurs as rounded grains up to 5 mm in diameter, and displaying embayed edges. These grains are very similar to the large quartz phenocrysts in the quartz-feldspar porphyry intrusive bodies. Sample M37 also contains a frag-ment (20 mm across) of quartz-feldspar-phyric lava consisting of feldspar laths (up to 2 mm) and quartz crystals (up to 1.5 mm) in a felted feldspathic

matrix. This lava fragment is similar to the quartz-feldspar-phyric
lava at Bulgobac. Mica has not been observed in the tuffaceous greywacke.

The abundance of quartz and feldspar in the greywacke and the angular
nature of the grains suggest a source area no great distance from the site
of deposition. The occurrence near Bulgobac of large quartz grains and
quartz-feldspar-phyric lava fragments in the greywacke, similar to the
quartz in the quartz-feldspar porphyry intrusive bodies and the felsic lavas
respectively, indicate that the provenance for the tuffaceous greywacke
may well have been the volcano-sedimentary sequences immediately east of
this unit. If this is so, then there was probably a stratigraphic hiatus
prior to deposition of the tuffaceous greywacke and shale sequence and
that the suggestion by Campana *et al.* (1960) of an erosional surface at
this stratigraphic position could be correct. Although the large quartz-
feldspar porphyry bodies are demonstrably intrusive, it is possible that
there are extrusive equivalents of the porphyry (*i.e.* the quartz-feldspar-
phyric lava at Bulgobac), and an erosional level at this approximate
stratigraphic position near the base of this unit is feasible. More
detailed mapping of The Pinnacles - Bulgobac area is required.

The sequence also contains beds of crystal-vitric tuff, fine vitric
tuff and black shale. The grey-green crystal-vitric tuff (M38) consists
of a poorly-sorted aggregate of quartz and decomposed feldspar grains
(30%), volcanic fragments (up to 3 mm) and irregular masses of chlorite,
in a matrix of very fine grained quartz, sericite, feldspar and chlorite
which exhibits a fine glass-shard texture. The quartz grains (up to 0.5
mm) are angular, sub-rounded and euhedral and the decomposed feldspar
(plagioclase and K-feldspar) occurs as euhedral and broken laths (up to
1 mm). The fine grained vitric tuff (M39) consists of poorly preserved
glass shards (less than 0.01 mm) and rare angular quartz grains (also less
than 0.01 mm). Pyritic black shale occurs principally along the eastern
margin of the sequence immediately west of the Pinnacles mines below
Burns Peak.

A massive coarse grained porphyry-like crystal-vitric tuff crops out
as a possible continuous bed (50-100 m thick) on the western edge of the
mapped area, extending south from near Silver Falls in Ross Creek, across
John Lynch Creek to the Marionoak River below Burns Peak, a distance of
4 - 5 km (fig. 21). The weathered tuff is brownish-green in colour, and
the fresher rock is pale green with dark green stringers of chlorite.
Quartz and feldspar occur as phenocrysts (up to 5 mm and 7 mm respectively)
and are generally in approximately equal proportions, though in some
exposures feldspar appears to be more abundant than quartz. In thin
section (M40, M41), the variably altered feldspar (albite-oligoclase and
K-feldspar) occurs as euhedral crystals, broken laths and glomerocrysts (up
to 5 mm), and generally exhibits corroded edges. The quartz occurs as
broken, angular crystals generally 0.5 - 1 mm and up to 5 mm across. Poorly
preserved devitrified pumice fragments consist of interlocking masses of
chlorite and feldspar. Dark green chlorite occurs as stringers and
irregular masses (up to 1 mm). The fine grained, nondescript matrix (25%)
consists of feldspar, pale green chlorite, sericite and scattered zircon.

The origin of the crystal-vitric tuff is unresolved. The contact
between the tuff and the enclosing sediments has not been observed, but the
tuff appears to be conformable with the sediments. The absence of lithic
fragments, the lack of bedding, the generally random orientation of the
crystal fragments, and the occurrence of pumice fragments indicate that
the tuff was deposited subaerially, probably by air-fall deposition.
However, such an origin is contrary to the subaqueous environment of

127

deposition of the enclosing sediments.

CENTRAL VOLCANIC SEQUENCE

The eastern part of the volcanic sequence is a complex assortment
of felsic lavas and pyroclastic rocks, sedimentary horizons, minor mafic
volcanic rocks and probable intrusive bodies. Mappable units within the
central volcanic sequence are rare. The only distinctive units are mafic
andesitic bodies north of Mt Charter and a crystal tuff (Mackintosh
crystal tuff) in the south-east of the mapped area.

The rocks are predominantly feldspar-phyric. Minor quartz-feldspar
and quartz-phyric volcanic rocks have been observed only towards the
western margin of the central volcanic sequence, in the Mt Kershaw - The
Pinnacles area. In the middle portion of the sequence, in the Farm Creek -
Boco Creek area, only feldspar-phyric lava has been observed. The lava and
tuff in the middle part of the sequence are generally grey to greenish-
grey in colour compared with the pink colouration commonly observed for
lava towards the western edge of the central volcanic sequence, particularly
in The Pinnacles area.

From the mapping undertaken it can only be considered that all of
the rocks comprising the central volcanic sequence are approximately coeval.
However, there are indications that the Mackintosh crystal tuff unit is
possibly younger than the remainder of the volcanic sequence. The rocks
of the central volcanic sequence are therefore described by particular
geographical areas and no genetic sequence is implied.

All of the significant occurrences of base-metal sulphide mineralisa-
tion in the Mackintosh Quadrangle are located within the central volcanic
sequence (which may here be considered to include the Farrell Slate and
the Mt Farrell silver-lead-zinc deposits). On the east flank of Mt Kershaw
is the stratiform, volcanogenic massive pyrite deposit at the Chester mine
(p.89), and 3 - 4 km to the north, on the western flank of Burns Peak, are
the probable volcanogenic copper-lead-zinc deposits of the Pinnacles mine
(p.82). Towards the north of the mapped area is the recently developed
Que River massive sulphide deposit (Duggan, 1980).

Mt Kershaw tuff - lava sequence

A complex sequence of felsic tuff and lava with minor mafic intrusives,
and including the massive pyrite and interbedded pyrite-chert at the Chester
mine, crop out on the northern and eastern flanks of Mt Kershaw and in
cuttings on the Emu Bay Railway (old alignment) from Farrell Junction to
the Pieman River. The rocks are extensively altered (chlorite and calcite)
and primary textures may be obliterated by the alteration. Surrounding
the Chester mine and extending at least two kilometres to the south is a
zone of quartz-sericite-pyrite alteration (Stevens, 1974; Collins, this volume,
p.89). Despite the complex nature of the volcanic rocks in this area, it
appears that to the west of the Chester mine the sequence is composed
predominantly of feldspar-phyric, feldspar-quartz-phyric and quartz-phyric
lavas with minor tuff, whereas at the Chester mine and to the east of the
mine the sequence is dominated by tuff with minor lava.

The grey-green to pink coloured lava to the west of Chester mine
generally appears to be massive, but flow banding and auto-brecciation
textures are common and are most evident on weathered surfaces. On a cut
fresh surface the flow banding is highlighted by alternating bands of
pink albitised feldspar and green chlorite alteration. Auto-brecciated
lava consists of pink to cream lava blocks (some flow banded) and fragments
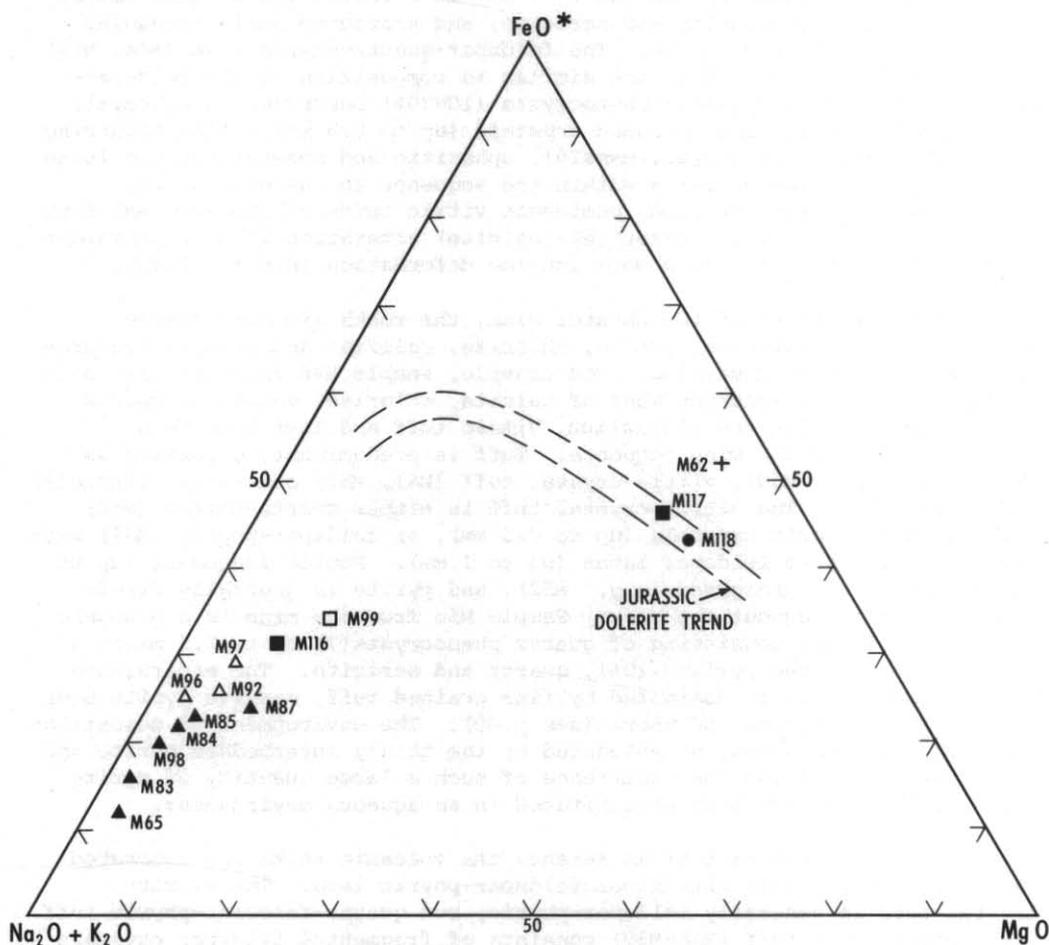
up to 100 mm in a grey-green matrix. The feldspar-phyric lava (M42, M43) consists of decomposed feldspar phenocrysts (20%) occurring as laths (up to 2 mm) and as glomerocrysts (up to 3 mm) in a felted feldspathic matrix with intergranular chlorite and sericite, and scattered small irregular masses of dark green chlorite. The feldspar-quartz-phyric lava (M44, M45) and quartz-phyric lava (M46) are similar in composition to the feldspar-phyric lava, but with quartz phenocrysts (10-20%) occurring as euhedral, but commonly embayed and corroded crystals (up to 0.5 mm). Also occurring within the sequence are grey, massive, aphanitic and non-porphyritic lavas (e.g. M47). Tuffaceous units within the sequence to the west of the Chester mine are fine grained, pumiceous vitric tuffs of probable ash flow origin. Quartz-sericite-(chlorite)-(calcite) alteration is most prevalent in the tuff, which also show more intense deformation than the lavas.

In the vicinity of the Chester mine, the rocks are extensively altered (quartz, sericite, pyrite, chlorite, calcite) and primary textures have generally been destroyed. For example, sample M48 from the main adit consists of an interlocking mass of calcite, chlorite, sericite, quartz and pyrite. Despite the alteration, vitric tuff and lava have been recognised within the mine sequence. Tuff is predominant, occurring as vitric tuff (M49, M50), vitric-crystal tuff (M51, M52) and vitric-lithic(?) tuff (M53, M54). The vitric-crystal tuff is either quartz-phyric (M52) with euhedral quartz crystals (up to 0.5 mm), or feldspar-phyric (M51) with partially preserved feldspar laths (up to 1 mm). Pumice fragments (up to 30 mm) are rarely preserved (e.g. M52), and pyrite is generally finely disseminated throughout the rock. Sample M55 from the mine is a probable quartz-phyric lava consisting of quartz phenocrysts(?) up to 0.5 mm in a mass of fine grained pyrite (10%), quartz and sericite. The mineralised sequence at Chester is dominated by fine grained tuff, massive pyrite beds and interbedded pyrite and chert (see p.89). The environment of deposition was probably subaqueous, as evidenced by the thinly interbedded pyrite and chert, bedded tuff and the occurrence of such a large quantity of pyrite which could only have been precipitated in an aqueous environment.

East and south-east of Mt Kershaw the volcanic rocks are dominated by vitric-crystal tuff with minor feldspar-phyric lava. The vitric-crystal tuff is generally feldspar-phyric, but quartz-feldspar-phyric tuff also occurs. The tuff (M56-M59) consists of fragmented feldspar crystals (up to 1.5 mm) and chloritised altered pumice fragments, usually occurring as fiamme (up to 15 mm), in a devitrified fine glass shard matrix. Sample M60 consists of fragmented quartz and feldspar grains (up to 0.5 mm) and clumps (up to 1.5 mm) of crystals of quartz and feldspar (partially altered to calcite and chlorite) in a devitrified matrix of quartz, sericite and chlorite.

Intruding the tuff-lava sequence are several mafic dykes of probable basaltic composition. These dykes are well exposed at the Chester mine (fig. 15). In thin section (M61, M62), the green dyke-rock consists of a fine grained mass of chlorite, quartz, feldspar and sericite, exhibiting a remanent igneous texture, and intergranular carbonate (10%). In M62 are rare relict feldspar phenocrysts and rare quartz-chlorite filled vesicles (?). An analysis of the dyke illustrated in Figure 17a (M62) reveals that the rock has a relatively high TiO_2 content and is depleted in alkalis (Na_2O, K_2O) (table 10, fig. 23), indicative of the basaltic nature of these dykes.

North of Mt Kershaw altered, dark green, vesicular basalt is exposed in a track [578648]. The basalt (M63) consists of a fine grained mass of interlocking decomposed feldspar laths, intergranular chlorite and opaques

FeO*

50

50

M62 +

M117 ■

● M118

JURASSIC
DOLERITE TREND →

□ M99

M97 ■ M116
△

M96 △ M92
△

M87 ▲

M85 ▲
M84 ▲

M98 ▲

M83 ▲

M65 ▲

Na₂O + K₂O

50

MgO

▲ Feldspar–phyric lava (The Pinnacles, Farrell Tramway)

△ Feldspar–phyric tuff and agglomerate (Farrell Tramway)

+ Basic dyke (Chester mine)

□ Mackintosh crystal tuff

■ Andesitic bodies (Que River area)

● Jurassic Dolerite (Mt Charter)

Figure 23. $Na_2O + K_2O - FeO^* - MgO$ diagram for volcanic rocks and dolerite, The Pinnacles - Que River area. FeO^* = total Fe as FeO.

5 cm

with rare decomposed feldspar phenocrysts occurring as laths up to 1 mm in length. The ovoid vesicles (5-10%) are up to 2 mm in diameter and filled with chlorite.

The Pinnacles lava-tuff sequence

The NNE-SSW trending ridge extending as a thumb-shaped projection off the main body of the central volcanic sequence, from Hollway Rivulet north through Burns Peak and The Pinnacles (fig. 21), is composed predominantly of feldspar-phyric lava and minor vitric tuff. The northern limit of The Pinnacles lavas, in particular that portion north of the NW-SE trending cross-fault (fig. 21), has not been confirmed. The Pinnacles lavas are not correlated with the quartz-feldspar-phyric lava at Bulgobac. There is no evidence to indicate that The Pinnacles lavas are separate from the main body of the central volcanic sequence. The shale and tuff sequence in the headwaters of Boco Creek has not been observed south of Burns Peak. The Pinnacles lavas can probably best be described as a structural offshoot of the central volcanic sequence.

The lavas are pale pink-cream to green and pink in colour, bleached on weathered surfaces, and commonly exhibit flow banding and auto-brecciation textures. Feldspar-phyric lava is predominant, but non-porphyritic and quartz-(feldspar)-phyric lava also occurs. The feldspar-phyric lava (M64-M69) consists of phenocrysts of feldspar (10%), occurring as euhedral - subhedral laths, generally less than 1.5 mm but up to 4 mm, in a felted cryptocrystalline feldspathic matrix with minor quartz, chlorite, sericite and opaques, and in which spherulites (up to 0.2 mm) are common. A variety of feldspar-phyric lava (M70-M73) contains rare subhedral and embayed quartz phenocrysts (up to 0.5 mm) and spheroidal quartz-filled vesicles dispersed through the rock. The feldspar phenocrysts are both K-feldspar and plagioclase (oligoclase), and green biotite (replaced by chlorite) occurs as rare flakes (*e.g.* M70).

Flow banding is usually defined by bands of pink albitised feldspar and green chloritic bands which may occur as laminae (less than 1 mm thick) with phenocrysts aligned parallel to the lamination (*e.g.* M68). Auto-brecciated lavas consist of fragments and blocks of cream-pink flow-banded and porphyritic lava (up to 100 mm) in a pale green chloritic matrix (*e.g.* M67).

Chemical analysis of a flow-banded feldspar-phyric lava (M65) indicates a rhyolitic composition and a relatively high alkali ($Na_2O + K_2O$) component (table 10, fig. 23).

Quartz-(feldspar)-phyric lava is similar in colour and texture to the feldspar phyric lava, but in thin section (M74) contains rounded and embayed quartz phenocrysts (5-10%) up to 0.5 mm, and tabular masses (up to 2 mm) of sericite and quartz probably representing altered feldspar phenocrysts, in a felted feldspathic matrix. The non-porphyritic lavas are massive and featureless and in thin section (M75, M76) are composed of a felted mass of feldspar and minor chlorite, sericite and quartz, of variable grain size.

Tuff within The Pinnacles lava sequence is either fine to very fine grained, finely banded(?) vitric tuff of probable air-fall origin, or ignimbritic tuff of possible ash-flow origin. The vitric tuff (M77, M78) is composed of devitrified glass shards, generally less than 0.5 mm but up to 1 mm in length, and rare quartz-filled spherules (up to 0.5 mm).

Ignimbritic vitric and crystal-vitric tuffs are buff-green in colour

131

Table 10.   *WHOLE-ROCK CHEMICAL ANALYSES OF VOLCANIC ROCKS AND DOLERITE*

Specimen No.	M62	M65	M83	M84	M85	M87	M92
Registered No.	750989	750990	750982	750983	750981	750984	750985

Major elements (mass %)

SiO_2	46.6	77.8	78.0	72.6	61.2	70.6	72.6
TiO_2	0.90	0.13	0.24	0.28	0.41	0.24	0.26
Al_2O_3	18.2	11.6	12.4	13.7	18.0	13.3	13.1
Fe_2O_3	2.1	0.65	0.51	0.67	1.1	0.62	0.95
FeO	10.8	0.52	0.81	1.4	1.6	2.0	1.3
MnO	0.42	0.02	0.02	0.08	0.10	0.07	0.10
MgO	10.6	0.24	0.18	0.33	0.51	1.0	0.49
CaO	0.37	0.06	0.33	2.0	3.9	2.1	2.5
Na_2O	0.07	1.1	2.9	3.5	3.8	3.0	0.69
K_2O	1.2	6.7	3.7	3.3	4.3	3.9	5.0
P_2O_5	0.21	0.03	0.04	0.05	0.06	0.04	0.04
CO_2	–	–	–	–	–	–	–
H_2O^+/L.O.I.	6.8	0.89	1.1	2.6	4.8	2.8	3.6
H_2O^-	–	–	–	–	–	–	–

Total	98.27	99.74	100.23	100.51	99.78	99.67	100.63

Trace elements (ppm)

As	<10	14	15	<10	<10	<10	13
Ba	–	–	–	–	–	–	–
Co	8	<6	<6	<6	<6	<6	<6
Cr	–	–	–	–	–	–	–
Cu	<5	7	14	13	<5	5	7
Li	74	5	5	10	10	10	10
Nb	–	–	–	–	–	–	–
Ni	66	6	12	7	<4	5	6
Pb	22	80	120	44	95	16	20
Rb	52	162	119	131	182	122	201
Sc	–	–	–	–	–	–	–
Sn	<4	<4	9	9	4	6	7
Sr	50	83	82	101	108	87	67
V	–	–	–	–	–	–	–
Y	24	31	28	43	45	42	40
Zn	962	65	113	61	47	47	44
Zr	94	122	221	271	383	260	242

Analyst : Department of Mines Laboratories, Launceston.

Rock type and locations are given in Table 11.

Table 10. (continued)

Specimen No.	M96	M97	M98	M105	M116	M117	M118
Registered No.	750987	750986	750988	791036	791035	791034	750980

Major elements (mass %)

SiO_2	74.6	60.5	71.6	65.4	69.2	49.9	51.7
TiO_2	0.22	0.43	0.29	0.63	0.35	0.52	0.58
Al_2O_3	12.4	18.4	11.2	14.8	14.6	13.8	13.8
Fe_2O_3	0.67	1.3	0.44	1.8	0.90	2.2	1.7
FeO	1.6	2.7	1.2	3.1	2.9	7.2	6.5
MnO	0.06	0.09	0.12	0.08	0.09	0.17	0.16
MgO	0.29	0.81	0.29	1.7	1.1	8.0	10.2
CaO	1.7	3.6	3.6	2.1	0.28	10.7	8.4
Na_2O	3.9	5.7	3.4	4.5	6.3	2.2	1.9
K_2O	2.5	2.9	2.8	2.8	0.94	0.58	1.1
P_2O_5	0.03	0.07	0.07	0.12	0.11	0.42	0.14
CO_2	–	–	–	0.00	0.00	0.05	–
H_2O^+/L.O.I.	2.2	4.3	3.7	1.8	1.9	3.3	3.2
H_2O^-	–	–	–	0.26	0.48	0.31	–
Total	100.17	100.80	98.71	99.09	99.15	99.35	99.38

Trace elements (ppm)

As	<10	<10	12	–	–	–	<10
Ba	–	–	–	973	410	837	–
Co	<6	<6	<6	9	<5	38	34
Cr	–	–	–	66	31	389	–
Cu	<5	<5	<5	26	<5	100	<5
Li	<5	5	<5	15	10	15	20
Nb	–	–	–	12	8	10	–
Ni	9	8	9	23	20	82	141
Pb	22	16	18	10	<6	19	138
Rb	99	107	81	92	18	13	27
Sc	–	–	–	6	9	33	–
Sn	10	9	5	–	–	–	<4
Sr	108	215	196	145	135	701	385
V	–	–	–	69	13	266	–
Y	44	51	35	34	21	23	25
Zn	48	60	28	65	57	91	76
Zr	245	283	206	231	176	102	110

Analyst : Department of Mines Laboratories, Launceston.

Rock type and locations are given in Table 11.

with fiamme, up to 50 mm in length, being most apparent on weathered surfaces. In thin section (M79, M80), the vitric tuff consists of de-vitrified pumice fragments with inter- and intra-pumice quartz. Sample M81 is a crystal-vitric tuff composed of feldspar phenocrysts (15%) and devitrified fiamme (up to 15 mm) in a devitirified fine glass shard matrix of quartz, sericite and chlorite. The feldspar phenocrysts occur as laths (up to 3 mm) and as clumps of crystals (up to 6 mm) with interstitial dark green chlorite and zircon, and consist of both plagioclase and K-feldspar.

On the western edge of The Pinnacles lava-tuff sequence, west of Burns Peak, is a series of small, north-south trending pods of copper-lead-zinc mineralisation of probable volcanogenic origin (Pinnacles mine), occurring between ignimbritic tuff to the west and aphanitic rhyolite/chert to the east (fig. 14).

A small body of quartz-feldspar porphyry crops out on the north flank of Burns Peak [582677]. The porphyry (M36) consists of quartz and feldspar phenocrysts (25%, up to 4 mm) in a greyish-green aphanitic matrix, and is similar to the two large quartz-feldspar porphyry intrusive bodies in the Bulgobac area.

Farm Creek - Boco Creek lava-tuff sequence

The Farm Creek - Boco Creek area encompasses the lava and tuff which crop out to the north of and along the Farrell Tramway between Farrell Junction and Farm Creek, along the western slopes of the valley of Farm Creek, and in the northern part of Boco Creek valley. In the mapped area this sequence constitutes the middle portion of the central volcanic sequence. The lava and tuff are characteristically feldspar-phyric, with a paucity of quartz phenocrysts.

The grey to greenish-grey coloured feldspar-phyric lava commonly exhibits flow banding and auto-brecciation textures, particularly evident on weathered, bleached surfaces. In thin section (M82-M89), the lava consists of phenocrysts of feldspar (10-20%), occurring either as laths (0.5 - 2 mm) or as glomerocrysts (1 - 5 mm), in a fine to medium grained felted matrix of feldspar, chlorite, sericite, quartz and opaques with small irregular masses of dark green chlorite and rare spherulites (up to 0.2 mm). The feldspar phenocrysts consist of K-feldspar and plagioclase (albite-oligoclase), and the glomerocrysts contain interstitial chlorite. The cores of some feldspar grains are altered to chlorite, sericite and quartz. Secondary calcite is a common constituent of the lava, occurring in the matrix as irregular elongate masses (up to 8 mm) and replacing feldspar phenocrysts. The matrix calcite masses commonly have narrow rims of chlorite and quartz.

Flow banded, feldspar-phyric lava crops out on The Pinnacles track south of Boco Creek, but here includes a narrow unit (about 30 m thick) of brown weathering micaceous greywacke and siltstone [610683]. The greywacke is similar to and probably part of the Animal Creek Greywacke. The lavas on either side of the greywacke-siltstone unit are feldspar-phyric (*e.g.* M90) and generally similar to the feldspar-phyric lava to the south. However immediately east of the sedimentary unit [611681] is an unusual vesicular lava composed of white, sub-parallel, lenticular, quartz-filled vesicles within a green matrix. In thin section (M91), this lava consists of decomposed feldspar as phenocrysts (up to 3 mm) in a fine to medium grained matrix of feldspar, quartz, sericite, chlorite, clinopyroxene (altered to amphibole) and sphene. The vesicles are up to 15 mm in length and are filled with chalcedony. The feldspar phenocrysts are crudely aligned parallel to the vesicles.

134

This middle portion of the central volcanic sequence also includes crystal-vitric tuff, vitric tuff and lithic-vitric tuff. The crystal-vitric tuff is very similar to the feldspar-phyric lava from which it may be difficult to distinguish, even in thin section. It is only the presence of pumice, lava fragments and broken crystals that allows identification of the tuff. In thin section (M92, M93), the crystal-vitric tuff consists of broken and euhedral feldspar crystals (0.5 - 2 mm), clumps of feldspar crystals (up to 3 mm) and minor feldspar-phyric lava fragments (2 - 5 mm) and pumice fragments (up to 5 mm). The matrix is a fine grained mass of feldspar, chlorite, sericite, quartz and calcite. Calcite alteration of the phenocrysts and of the matrix is similar to that in the lava. The fine grained, equigranular vitric tuff (M94) is composed of a mass of very fine grained feldspar, quartz, sericite, chlorite and calcite, which in thin section, exhibits a glass shard texture when observed under low power magnification. These tuffs may contain rare feldspar phenocrysts (up to 0.2 mm). The greenish-grey lithic-vitric tuff (M95) is similar to the vitric tuff but contains feldspar-phyric lava fragments and pumice fragments.

Agglomerate, consisting of blocks of pale grey-green lava contained in a dark grey-green crystal tuff matrix, is exposed in cuttings along the Farrell Tramway [601625, 596627]. The matrix of the agglomerate (M96, M97) consists of broken euhedral feldspar crystals, clumps of feldspar crystals, small angular lava fragments and pumice fragments in a groundmass enriched in chlorite with sericite, feldspar, quartz and opaques. The lava blocks (up to 200 mm) are angular and unsorted. A block from one agglomerate unit is of feldspar-phyric lava, which in thin section (M98) is similar to the enclosing lavas. The matrix and the lava blocks have been subjected to the same calcite alteration as occurs in the enclosing feldspar-phyric lava.

Analyses of feldspar-phyric lava, crystal-vitric tuff and agglomerate (table 10) indicate a range in composition from andesite to rhyolite (based on SiO_2). Generally, the rocks analysed are chemically similar, particularly in their trace element composition, and form a short linear trend on an AFM diagram (fig. 23). The agglomerate is of similar composition to the lava and tuff, but there is a marked difference in SiO_2, Al_2O_3 and slight difference in FeO, MgO and Na_2O between the matrix (M97) and lava blocks (M98) of the agglomerate (table 10).

Mackintosh crystal tuff

A distinctive blotchy dark green and pink crystal tuff and minor agglomerate crops out in the south-eastern part of the mapped area between Farm Creek and Mackintosh River. The tuff is well exposed in cuttings on the Farrell Tramway and Murchison Highway, in particular at the Mackintosh River bridge [656625].

The tuff is characteristically dark green with blotches (up to 100 mm) of pink albitised feldspar, and minor pale green blotches. Throughout the tuff are white-pale green feldspar crystals (up to 10 mm). In thin section (M99-M105), the tuff consists of a poorly sorted aggregate of feldspar and clinopyroxene crystals (up to 3 mm) and clumps of crystals of feldspar and clinopyroxene (up to 5 mm) in a matrix of fine grained feldspar and chlorite with minor opaques and epidote(?). Fragments of vesicular lava and pumice may also occur in the tuff. The feldspar (plagioclase and K-feldspar) and clinopyroxene occur as broken and euhedral crystals, commonly containing inclusions of each other. The pyroxene is generally partially altered to chlorite-actinolite. The crystal clumps consist of fine to coarse feldspar and pyroxene with interstitial chlorite. The feldspar and

pyroxene crystals constitute approximately 40% of the tuff. Calcite alteration of the matrix is minor and variable. In contrast to the feldspar-phyric lava and tuff to the west, sericite is rare. A chemical analysis of the tuff cropping out at the Mackintosh River bridge indicates a dacite composition (table 10).

A distinctive agglomerate or breccia consisting of pink lava blocks within a dark green crystal tuff matrix crops out on the eastern side of Farm Creek valley and defines the western edge of the Mackintosh crystal tuff in this area. The poorly sorted agglomerate is well exposed in a cutting on the Murchison Highway [637648], where it has been intruded by a green-brown weathering, vesicular basic(?) dyke. Massive, flow banded and feldspar-phyric lava blocks constitute 40-60% of the agglomerate and range in size from less than 10 mm up to 0.5 m. The blocks are angular to sub-angular and appear to be of uniform composition. The matrix (M106) is similar to the remainder of the crystal tuff unit but with a greater pro-portion of small (less than 10 mm) feldspar-phyric lava and volcanic frag-ments, and less pyroxene.

The Mackintosh crystal tuff is a massive body lacking internal structures, although in the agglomerate unit there is an apparent banding within the matrix associated with some of the larger blocks. The absence of bedding and of flow structures is suggestive of an air-fall origin, and the coarseness of the agglomerate or breccia indicates close proximity to the source.

The contact between the Mackintosh crystal tuff and the lava and tuff to the west has not been observed and hence the stratigraphic relationship between these two sequences is uncertain. However, on the west bank of Farm Creek near its confluence with the Pieman River is a small outcrop [620621] of dark green crystal tuff apparently overlying grey vesicular(?) feldspar-phyric lava. The lava crops out in the bank of the creek and above this, on a small rise, is an outcrop of crystal tuff. The contact between the two units was not observed. The crystal tuff is similar in appearance to the Mackintosh crystal tuff but lacks the blotches of pink albitised feldspar. However, the tuff contains clinopyroxene which is a character-istic component of the Mackintosh crystal tuff. In thin section (M107), the tuff consists of feldspar phenocrysts (up to 2 mm) and clumps of feldspar and clinopyroxene crystals in a sheared matrix of feldspar, chlorite and calcite. Some of the feldspar-clinopyroxene crystal clumps have beards of chlorite and calcite.

Lava-tuff sequence of Mt Charter - Bulgobac Hill

Along the western edge of the central volcanic sequence in the Mt Charter - Bulgobac Hill area is a complex assortment of feldspar-(quartz)-phyric lava, feldspar-quartz-phyric tuff and ignimbritic tuff. Flow banding and autobrecciation textures may be observed on weathered surfaces of the lava, and fiamme in the tuff is defined by chloritic wisps.

The cream-pink lava is dominantly feldspar-phyric and in thin section (M108-M110) is composed of phenocrysts of altered feldspar (K-feldspar and plagioclase) occurring as crystals (up to 1 mm) or as glomerocrysts (up to 5 mm) in a fine to medium grained, felted, feldspathic matrix with minor feldspar microphenocrysts, spherulites, chlorite, sericite and opaques. Quartz occurs rarely as corroded and embayed phenocrysts(?) up to 0.5 mm. Sample M111 is a pink feldspar-phyric lava composed of K-feldspar and plagioclase (albite) crystals (up to 2 mm) and glomerocrysts (up to 4 mm), and clinopyroxene phenocrysts (up to 1 mm), in a felted

feldspathic matrix with minor chlorite, quartz, clinopyroxene, opaques and iron oxides. The clinopyroxene is partially to wholly altered to dark green chlorite, and quartz occurs as small (less than 0.5 mm) corroded grains either in the matrix or within the feldspar glomerocrysts.

In contrast to the lava, quartz is common in the grey to buff weathering tuff which is commonly thinly to thickly bedded. In thin section, the fine grained crystal-vitric tuff (Ml12, Ml13) is composed of grains of feldspar and quartz (20-40%) and minor spherulites in a matrix of devitrified glass shards. The feldspar is generally decomposed to a very fine grained mass of quartz, sericite and chlorite and occurs as broken or tabular laths up to 1 mm. The quartz occurs as angular grains up to 0.5 mm. Feldspar is more abundant than quartz. Pumice occurs rarely as fiamme (up to 2 mm), and the glass shards are aligned parallel to the bedding. The tuff is generally poorly sorted, and although fine grained, has a broad range in grain size of both crystals and glass shards. There are also well sorted fine grained vitric tuffs, almost devoid of quartz and feldspar grains, thinly interbedded with the crystal-vitric tuff (Ml14). The fine bedding and the presence of small scale sedimentary structures in the vitric tuff is indicative of subaqueous deposition, but the occurrence of fiamme suggests that some of the sequence was deposited in a subaerial environment.

Que River andesitic bodies

The central volcanic sequence north of Mt Charter is dominated by brown weathering, green to dark green porphyritic and vesicular pyroxene andesitic bodies. The nature of emplacement of the bodies is not known, but the vesicular and commonly brecciated textures indicate they are at least in part lava flows or near surface intrusions. The areal extent of the andesitic bodies has not been defined, but they are probably far more extensive than indicated in Figure 21.

The breccia is composed of greenish-grey sub-rounded to angular boulders and blocks (generally 50 - 100 mm, but up to 400 mm) of aphanitic, banded, porphyritic or vesicular lava(?) in a dark green matrix containing minor disseminated pyrite and chalcopyrite. On some weathered surfaces, the breccia has the appearance of close-packed conglomerate. In sample Ml15 the vesicular, porphyritic lava blocks are composed of phenocrysts of subhedral clinopyroxene (10%) and rare feldspar laths (both up to 1 mm), and vesicles (40%) in a pilotaxitic matrix of feldspar laths, chlorite and pyroxene. The vesicles are filled either with calcite or with quartz and chlorite. The matrix of the breccia is composed of a felted mass of fine grained feldspar, chlorite, clinopyroxene and sphene with rare pyroxene micro-phenocrysts (up to 0.2 mm).

Breccia composed of non-vesicular, porphyritic blocks also occurs, and in thin section (Ml16) the matrix and the blocks are similar in composition but with more chlorite in the matrix. Feldspars (K-feldspar and some plagioclase) occur as phenocrysts (up to 2 mm) in a felted, fine grained matrix of feldspar, chlorite, sphene, opaques and iron oxide. Quartz occurs rarely as euhedral phenocrysts (up to 0.5 mm) with corroded margins. Pyroxene is not present in Ml16, although some chlorite masses are regular in outline and have possibly replaced pyroxene phenocrysts. Feldspar phenocrysts constitute about 15% of the blocks and of the matrix.

The dark green, massive porphyritic andesite is the most common form and in thin section (Ml17) consists of clinopyroxene (augite) phenocrysts

(30%) occurring as subhedral cyrstals (up to 1 mm) and as glomerocrysts (up to 3 mm), and altered feldspar phenocrysts (5%) in a pilotaxitic matrix of very fine grained feldspar laths (less than 0.1 mm) and inter-granular chlorite and pyroxene.

Chemically, the andesitic bodies vary in composition from dacite to basaltic andesite (table 10). In an AFM diagram, the dacite (M116) plots on the end of the short trend line of the volcanic rocks analysed from the mapped area, but the basaltic andesite (M117) is markedly depleted in alkalis (fig. 23).

Mt Charter dolerite

The andesitic bodies are not to be confused with the body of Jurassic (?) dolerite which crops out on the western flank of Mt Charter (fig. 21). The dolerite (M118) is medium grained, has a sub-ophitic texture, and consists of plagioclase (andesine-labradorite) laths averaging 0.5 – 1 mm; euhedral-subhedral pyroxene (augite and pigeonite) averaging about 0.5 mm; and a groundmass of chlorite, actinolite, sphene, K-feldspar, quartz and opaques. Most of the feldspar has decomposed to a fine mass of sericite, quartz and chlorite and much of the pyroxene has segregated into irregular masses of prismatic crystals. The dolerite is petrologically similar to the Tasmanian Jurassic dolerite, and an analysis of the dolerite from Mt Charter indicates a chemical composition also very similar to the Jurassic dolerite (table 10). In an AFM diagram the dolerite plots on the differentiation trend for the Tasmanian dolerites (fig. 23).

STRUCTURAL RELATIONSHIPS

The western volcano-sedimentary sequence has a general NE-SW trend and dips consistently towards the north-west (figs. 21, 22). Sedimentary structures, principally graded bedding, indicate a consistent north-west facing sequence. The only major exceptions to this general trend are the syncline to the west of The Pinnacles, and a small synclinal structure in the upper Que valley (fig. 21).

The Pinnacles syncline plunges 35° to the north on a bearing of 025°, which is sub-parallel to the synclinal and anticlinal structures (40°N, 030°) in the upper Hatfield valley (fig. 21). The folds at The Pinnacles and in the upper Hatfield valley are also sub-parallel to the major NNE plunging open synclinal structure in the Ordovician siliceous clastic beds which rise above the plateau of Tertiary basalt at Mt Pearse further to the north. The Mt Pearse syncline is attributed to Middle Devonian deformation (see p.47) and hence it is concluded that the main deformation of the western sequence is also of Middle Devonian age. In the mapped area, the sedimentary and volcanic rocks of the western sequence are interpreted as forming the eastern limb of a broad, open, NNE-SSW trending syncline with smaller folds (such as at The Pinnacles) located probably towards the hinge zone of this syncline. The smaller synclinal structure to the south of the Que River bridge trends ENE-WSW and its age is uncertain.

In the central volcanic sequence, folds have generally not been observed, and little reliance can be placed on flow banding in lava, which is generally randomly orientated, as a structural indicator. However at the Chester mine, the sequence dips steeply west to north-west, and small scale folds have a shallow NNE plunge (p.89). These folds parallel the probable Middle Devonian structures.

Of the faults indicated on Figure 21, and within the mapped area, the most significant is the NNE-SSE trending fault between Bulgobac River and Mt Charter, and which apparently offsets the boundary between the two major sequences. The age relationship between this fault and the body of Jurassic dolerite is not known.

The boundary between the western volcano-sedimentary sequence and the eastern (central) volcanic sequence has a north-south trend between the Pieman River and Burns Peak. At Burns Peak there is a sudden eastward strike change and the boundary has a NE-SW trend between Burns Peak and Que River. North of Burns Peak is the NNE-SSW trending Pinnacles lava sequence, which is believed to be part of the central volcanic sequence. The boundary is not exposed anywhere within the mapped area, but a faulted boundary has recently been exposed in a road cutting on the north bank of the Pieman River south of Mt Kershaw [569608]. Apart from this recent exposure, there is other evidence (such as apparent truncation of bedding at the boundary) which indicates a discordant and possibly faulted boundary between the two sequences. For example, a thick, fine grained vitric tuff unit within the Animal Creek Greywacke appears to be terminated where it intersects the boundary south-west of Mt Charter [677638], and there is a slight discordance between the sediments and lavas along the western and eastern boundaries of The Pinnacles lava sequence (figs. 21, 22).

The Pinnacles lava sequence extends in a north-north-east direction from Burns Peak, beginning at the bend in the boundary between the two major sequences. The projection of The Pinnacles lavas is interpreted as a structural off-shoot or failed arm of the central volcanic sequence, and is considered to be genetically associated with this abrupt change in the direction of the boundary at Burns Peak.

The Que River Beds are the only rocks in the area known to contain fossils and for which their age has been determined. However, the stratigraphic position of the Que River Beds has not previously been fully resolved. The Que River Beds are the easternmost unit within an apparently conformable north-west dipping and west facing sedimentary-volcanic sequence. In the north, the Beds are underlain by a possible mudflow breccia containing massive pyrite fragments and altered felsic volcanic fragments, and are overlain by a crystal-vitric tuff. Despite a preponderance of andesitic volcanic rocks in the central volcanic sequence in the Que River area, andesitic fragments have not been observed in the breccia at the base of the Que River Beds. The occurrence of muscovite in the Beds is indicative of a Precambrian basement provenance for at least some of the sediment. To the south, the Beds are structurally overlain by the Animal Creek Greywacke, which also contains much Precambrian detritus. Hence, it may be concluded that the Que River Beds are the oldest sediments in the western volcano-sedimentary sequence in The Pinnacles - Que River area. Their provenance is probably Precambrian basement rock and not the dominantly andesitic volcanic rocks of the central volcanic sequence to the east of the Beds. However, the occurrence of volcanic material above and at the base of the Que River Beds indicates that there was contemporaneous volcanic activity during deposition of the Beds. This interpretation places the boundary between the two major sequences along the eastern edge of the Que River Beds.

Assignment of the Que River Beds to the western volcano-sedimentary sequence, and in particular as the basal sediments of that sequence, indicates that the western sequence is laterally equivalent to the Dundas Group (see Jago, 1979). However, the geological mapping reported here has not resolved the problem of the age of the central volcanic sequence which

includes the bulk of the volcanic rocks in The Pinnacles - Que River area.
There occurred contemporaneous volcanic activity during deposition of the
Que River Beds, but there is no evidence to indicate that this volcanic
activity is represented by the dominantly andesitic volcanic rocks
immediately east of the Que River Beds. In the Queenstown area it has
been shown that the great bulk of the Mount Read Volcanics lies below the
late Middle-early Late Cambrian Comstock Tuff, and hence are probably of
Middle or Early Cambrian age (Jago *et al.*, 1972; Corbett *et al.*, 1974).
By analogy, it may be assumed that the central volcanic sequence in The
Pinnacles - Que River area is also of Middle or Early Cambrian age, but
there is no evidence to indicate that the Que River Beds are younger
than the central volcanic sequence and the evidence presented here suggests
a discordant, probably faulted boundary between the two major sequences.

CONCLUSIONS

The Cambrian rocks in the western portion of the Mackintosh Quadrangle
may be divided into the following two major sequences:

(1) The western volcano-sedimentary sequence, which is composed of
turbiditic greywacke, tuffaceous greywacke, quartz- and
feldspar-phyric lava and tuff, siltstone and shale and large
quartz-feldspar porphyry intrusive bodies. The sediments of
the western sequence were deposited primarily in a subaqueous,
probably marine environment. The Que River Beds, of late
Middle Cambrian age, are interpreted as the basal sediments
of the western volcano-sedimentary sequence in The Pinnacles-
Que River area.

(2) The eastern (central) volcanic sequence, which is composed pre-
dominantly of feldspar-phyric lava, tuff and agglomerate with
minor siltstone shale and chert, and includes the volcano-
genic massive sulphide deposits at the Chester, Pinnacles
and Que River mines. Minor quartz-feldspar-phyric lava and
tuff are restricted to the western edge of the sequence where
they exhibit a pink colouration in contrast to the grey-green
lava and tuff elsewhere. Andesitic volcanic rocks dominate
the sequence north of Mt Charter. The depositional environ-
ment is interpreted as being primarily subaerial, with some
subaqueous deposition, as evidenced by a predominance of ash-
flow and air-fall tuffs. The thumb-shaped projection of The
Pinnacles lavas are interpreted as being genetically a part
of the central volcanic sequence.

The boundary between the two sequences is apparently discordant and
in places is faulted. The boundary trends north-south from the Pieman
River to Burns Peak, where there is an abrupt eastward strike change, and
it then continues along a NE-SW trend to the Que River. The Pinnacles
lavas protrude in a north-north-east direction from the actual bend in the
boundary at Burns Peak and are interpreted as a structural off-shoot of
the central volcanic sequence, genetically associated with the structural
change in direction of the boundary.

REFERENCES

ANDERSON, W.B. 1972. *The Mt Read Volcanics in the Rosebery - Tullah area.* B.Sc.Hons.thesis, University of Tasmania : Hobart.

BANKS, M.R.; SOLOMON, M. 1961. Cambrian succession in West Tasmania. *Aust.J.Sci.* 23:337.

BARTON, C.M.; BURNS, K.L.; GEE, R.D.; GROVES, D.I.; GULLINE, A.B.; JENNINGS, D.J.; LONGMAN, M.J.; MARSHALL, B.; MATTHEWS, W.L.; MOORE, W.R.; NAQVI, I.H.; THREADER, V.M.; URQUHART, G. 1966. Geological atlas 1 mile series. Zone 7 Sheet 44 (8014N) Mackintosh. *Department of Mines, Tasmania.*

CAMPANA, B.; KING, D.; McKENNA, D. 1960. Unconformable units of the Cambrian succession of West Tasmania. *Aust.J.Sci.* 22:352-353.

CORBETT, K.D. 1979. Stratigraphy, correlation and evolution of the Mt Read Volcanics in the Queenstown, Jukes - Darwin and Mt Sedgwick areas. *Bull.geol.Surv.Tasm.* 58.

CORBETT, K.D.; REID, K.O.; CORBETT, E.B.; GREEN, G.R.; WELLS, K.; SHEPPARD, N.W. 1974. The Mount Read Volcanics and Cambrian-Ordovician relationships at Queenstown, Tasmania. *J.geol.Soc.Aust.* 21:173-186.

DUGGAN, N.T. 1980. The Que River deposit - a zinc-lead-copper occurrence in Western Tasmania, *in* GEOLOGICAL SOCIETY OF AUSTRALIA. *Fourth Australian geological convention, programmes and abstracts;* p.50.

FINUCANE, K.J. 1932. The geology and ore deposits of the Rosebery district. *Unpubl.Rep.Dep.Mines Tasm.* 1932(2):1-132.

GEE, C.E.; JAGO, J.B.; QUILTY, P.G. 1970. The age of the Mt Read Volcanics in the Que River area, western Tasmania. *J.geol.Soc.Aust.* 16:761-763.

JAGO, J.B. 1979. Tasmanian Cambrian biostratigraphy - a preliminary report *J.geol.Soc.Aust.* 26:223-230.

JAGO, J.B.; REID, K.O.; QUILTY, P.G.; GREEN, G.R.; DAILY, B. 1972. Fossiliferous Cambrian limestone from within the Mt Read Volcanics, Mt Lyell mine area, Tasmania. *J.geol.Soc.Aust.* 19:379-382.

RIVERS, W.M. 1975. *The geology and geochemistry of the Tullah area.* B.Sc.Hons.thesis, University of Tasmania : Hobart.

STEVENS, A.G. 1974. *The geology and mineralisation of the Chester - Pinnacles area, W.Tasmania.* B.Sc.Hons.thesis, University of Tasmania : Hobart.

Table 11. CATALOGUE OF SPECIMENS REFERRED TO IN TEXT AND THEIR LOCATIONS

Specimen No.	Serial No.	Description	ANG Reference*	AMG Reference†
M 1	73-771	Agglomerate	710783	901946
M 2	75-613	Crystal-vitric tuff	707796	898958
M 3	75-615	Vitric tuff	697766	889930
M 4	75-616	Crystal-vitric tuff	694764	886929
M 5	76-909	Crystal-vitric tuff	697768	889932
M 6	73-484	Micaceous quartzwacke	627705	826874
M 7	75-618	Micaceous quartzwacke	687750	880916
M 8	75-761	Micaceous quartzwacke	682759	876924
M 9	76-901	Weathered lithic wacke	610682	811853
M 10	76-904	Weathered greywacke	682760	875925
M 11	73-483	Fine grained vitric tuff	632706	830875
M 12	75-624	Fine vitric tuff	680743	874909
M 13	75-625	Fine, banded vitric tuff	675742	869908
M 14	75-626	Fine vitric tuff	676740	870906
M 15	76-902	Fine, banded vitric tuff	676740	870906
M 16	76-906	Fine vitric tuff	665735	860902
M 17	75-759	Vesicular felsic lava	667750	862915
M 18	76-903	Felsic lava	678764	872928
M 19	73-769	Feldspar-phyric vitric-crystal tuff	600684	801854
M 20	73-759	Vitric tuff, quartz- and feldspar-phyric	619726	818893
M 21	73-761	Vitric tuff, quartz-(feldspar)-phyric	616727	816894
M 22	73-757	Laminated vitric and crystal tuff	625710	824878
M 23	73-762	Feldspar-quartz-phyric crystal tuff	615729	815896
M 24	73-756	Feldspar-phyric lava	625708	824877
M 25	73-763	Feldspar-phyric lava	633718	831886
M 26	73-760	Quartz-feldspar-phyric lava	621733	820899
M 27	73-764	Quartz-feldspar-phyric lava	628738	826904
M 28	73-765	Quartz-feldspar-phyric lava	626745	824910
M 29	73-485	Quartz-feldspar porphyry	617722	816889
M 30	75-614	Quartz-feldspar porphyry	695798	887960
M 31	75-758	Quartz-feldspar porphyry	662767	857931
M 32	75-762	Quartz-feldspar porphyry	669764	864928
M 33	73-758	Quartz-feldspar porphyry	621721	820888
M 34	73-766	Quartz-feldspar porphyry	623748	822913
M 35	73-767	Chlorite altered quartz-feldspar porphyry	622749	821914
M 36	73-770	Quartz-feldspar porphyry	581676	784847
M 37	73-25	Tuffaceous greywacke	579697	782866
M 38	73-403	Crystal-vitric tuff	569712	773880
M 39	73-467	Fine vitric tuff, quartz-phyric	571700	775869
M 40	73-402	Quartz-feldspar-phyric crystal tuff	568718	772885
M 41	73-473	Quartz-feldspar-phyric crystal tuff	566682	770852
M 42	73-480	Feldspar-phyric lava	576653	780826
M 43	73-481	Feldspar-phyric lava	573635	777809

Table 11. (continued)

Specimen No.	Serial No.	Description	ANG Reference*	AMG Reference†
M 44	73-394	Autobrecciated quartz-feldspar-phyric lava	578647	782820
M 45	73-482	Flow banded quartz-feldspar-phyric lava	577643	781817
M 46	74-290	Quartz-phyric lava	575637	779811
M 47	74-287	Aphanitic felsic lava	576634	780808
M 48	74-280	Feldspar-phyric altered volcanic rock	582635	785809
M 49	74-539	Vitric tuff	580635	784809
M 50	74-540	Altered vitric tuff	580635	784809
M 51	74-284	Vitric-crystal tuff, feldspar-phyric	582635	785809
M 52	74-286	Quartz-phyric vitric-crystal tuff	573631	777806
M 53	74-281	Vitric-lithic(?) tuff	582635	785809
M 54	74-283	Vitric-lithic tuff	582635	785809
M 55	74-538	Quartz-phyric lava(?)	580635	784809
M 56	73-751	Feldspar-phyric vitric-crystal tuff	581614	785790
M 57	73-752	Feldspar-phyric vitric-crystal tuff	581608	785785
M 58	73-753	Feldspar-phyric vitric-crystal tuff	584610	787787
M 59	73-754	Feldspar-phyric vitric-crystal tuff	586616	789792
M 60	73-755	Vitric-crystal tuff, quartz-feldspar-phyric	590627	793802
M 61	74-282	Mafic dyke	582635	785809
M 62	74-537	Mafic dyke	580634	784808
M 63	73-395	Vesicular basalt	578647	782820
M 64	73-460	Feldspar-phyric lava	581687	784857
M 65	73-462	Flow banded feldspar-phyric lava	579691	782861
M 66	73-468	Feldspar-phyric lava	579685	782855
M 67	73-469	Autobrecciated feldspar-phyric lava	577685	780855
M 68	73-470	Flow banded feldspar-phyric lava	576685	779855
M 69	73-472	Flow banded feldspar-phyric lava	579683	782853
M 70	73-463	Flow banded feldspar-(quartz)-phyric lava	579692	782862
M 71	73-464	Feldspar-(quartz)-phyric lava	579693	782863
M 72	73-465	Autobrecciated feldspar-(quartz)-phyric lava	580693	783862
M 73	73-471	Feldspar-(quartz)-phyric lava	575685	778855
M 74	73-466	Quartz-phyric lava	580694	783863
M 75	73-461	Felsic lava, autobrecciated	580690	783860
M 76	73-476	Felsic ash flow(?) lava	575676	779847
M 77	73-474	Vitric tuff	579678	782849
M 78	73-475	Vitric tuff, laminated	576676	779847
M 79	73-396	Ignimbritic tuff	568667	772839
M 80	73-477	Ignimbritic tuff	574673	778844
M 81	73-478	Ignimbritic crystal-vitric tuff	575661	779833

Table 11. *(continued)*

Specimen No.	Serial No.	Description	ANG Reference*	AMG Reference†
M 82	74-660	Feldspar-phyric lava	616623	817799
M 83	74-662	Flow banded feldspar-phyric lava	604620	806796
M 84	74-663	Feldspar-phyric lava	605622	807798
M 85	74-664	Feldspar-phyric lava	603623	805799
M 86	74-665	Feldspar-phyric lava (calcite alteration)	603624	805800
M 87	74-666	Feldspar-phyric lava (calcite alteration)	607626	808801
M 88	73-748	Altered lava	617646	817820
M 89	73-749	Autobrecciated feldspar-phyric lava	621644	821818
M 90	76-899	Feldspar-phyric lava	606685	807855
M 91	76-900	Vesicular feldspar-phyric lava	611682	811853
M 92	74-661	Feldspar-phyric crystal-vitric tuff	611622	811798
M 93	74-667	Crystal-vitric tuff, feldspar-phyric	605626	807801
M 94	74-671	Fine grained vitric tuff	595629	797804
M 95	73-603	Welded lithic-vitric tuff	639673	837845
M 96	74-668	Agglomerate, crystal tuff matrix	600626	802801
M 97	74-670	Agglomerate, crystal tuff matrix	597627	799802
M 98	74-669	Lava block in agglomerate (M97)	597627	799802
M 99	73-15	Crystal tuff	656625	853801
M100	74-672	Crystal tuff	645636	843811
M101	74-673	Crystal tuff	643640	841815
M102	74-657	Crystal tuff	638610	837787
M103	74-658	Crystal tuff	636612	835789
M104	74-659	Crystal tuff	627676	826847
M105	76-910	Crystal tuff	657625	854801
M106	73-750	Agglomerate, crystal tuff matrix	638657	836830
M107	73-768	Sheared crystal tuff	620620	820796
M108	75-619	Autobrecciated feldspar-phyric lava	687749	880915
M109	75-623	Feldspar-phyric lava	683745	877911
M110	76-905	Feldspar-phyric lava	688748	881914
M111	75-760	Feldspar-phyric lava	678731	872898
M112	75-620	Crystal-vitric tuff	686747	879913
M113	75-622	Fine crystal-vitric tuff	685745	878911
M114	75-621	Laminated vitric tuff	686747	879913
M115	76-908	Andesitic breccia	715775	906939
M116	76-907	Andesitic breccia	710767	901931
M117	76-911	Pyroxene-phyric andesitic lava	719772	909936
M118	75-617	Dolerite	692758	885923

* All localities lie within the kilogrid grid square 38, Zone 7.
† All localities lie within 100 km grid square CP.

APPENDIX 2

Transformation of grid references

The Australian National Grid (ANG), in which coordinates are given in yards, is used on the Mackintosh geological map sheet and ANG references are given in this report. The ANG is now obsolete and has been superseded by the metric Australian Map Grid (AMG). When using this report in conjunction with later maps printed with the AMG the equivalent references may be found by consulting the following table:
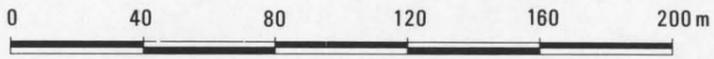
ANG 100-yard reference	AMG 100-metre reference	ANG 100-yard reference	AMG 100-metre reference
38/544705	CP750873	38/612795	CP811956
38/552707	CP757875	38/615748	CP814913
38/553770	CP757933	38/616708	CP816877
38/554793	CP758954	38/616713	CP816881
38/555830	CP759987	38/620621	CP820797
38/556793	CP760954	38/620757	CP819921
38/562806	CP765966	38/625707	CP824876
38/562809	CP765968	38/625807	CP823967
38/563602	CP768779	38/627600	CP827778
38/563857	CQ766012	38/630700	CP829869
38/564728	CP768894	38/633718	CP831886
38/565668	CP770839	38/637648	CP836822
38/565682	CP769852	38/639645	CP837819
38/566628	CP771803	38/640880	CQ836034
38/568667	CP772839	38/641680	CP839851
38/569608	CP774785	38/643684	CP841855
38/570610	CP775786	38/647893	CQ842046
38/571672	CP775843	38/648730	CP845897
38/571674	CP775845	38/649753	CP845918
38/572607	CP777784	38/650730	CP847897
38/578629	CP782804	38/655610	CP852787
38/578648	CP782821	38/656625	CP853801
38/578655	CP782828	38/657601	CP854779
38/579674	CP782845	38/657893	CQ851046
38/580608	CP784785	38/658605	CP855783
38/580835	CP781992	38/660592	CP857771
38/581634	CP785809	38/660609	CP857786
38/582598	CP786776	38/660610	CP857787
38/582677	CP785848	38/661599	CP858777
38/587604	CP790781	38/661612	CP858789
38/591804	CP792964	38/661613	CP858790
38/594627	CP796802	38/662615	CP859792
38/595635	CP797810	38/663660	CP859833
38/596627	CP798802	38/663770	CP858934
38/596643	CP798817	38/664619	CP861796
38/597626	CP799801	38/670705	CP865874
38/601625	CP803800	38/671765	CP865929
38/602683	CP803854	38/672623	CP868799
38/603609	CP805786	38/677638	CP872813
38/603615	CP805791	38/677744	CP871910
38/609791	CP808952	38/679735	CP873902
38/610683	CP810854	38/684746	CP877912
38/610791	CP809952	38/686673	CP880845
38/611681	CP811852	38/690630	CP884806

Appendix 2 (continued)

ANG 100-yard reference	AMG 100-metre reference	ANG 100-yard reference	AMG 100-metre reference
38/690650	CP884824	38/880860	DQ055018
38/690660	CP884833	38/880870	DQ055027
38/698680	CP891852	38/888616	DP065795
38/699748	CP891914	38/889602	DP066783
38/700650	CP893824	38/890855	DQ065014
38/704745	CP896911	38/890870	DQ064027
38/707796	CP898958	38/892628	DP069806
38/710680	CP902852	38/892778	DP067943
38/710690	CP902861	38/894615	DP071794
38/710783	CP901946	38/895628	DP072806
38/711803	CP902964	38/900640	DP076817
38/716727	CP907895	38/900810	DP074973
38/720690	CP911861	38/900850	DQ074009
38/720720	CP911889	38/910807	DP083970
38/720740	CP910907	38/915805	DP088968
38/724664	CP915837	38/916808	DP089971
38/725687	CP916858	38/923809	DP095972
38/727778	CP916942	38/925620	DP099799
38/730645	CP921820	38/925875	DQ096032
38/730680	CP920852	38/926595	DP100776
38/730720	CP920889	38/926635	DP100813
38/732660	CP922834	38/929622	DP103801
38/736707	CP925877	38/930605	DP104786
38/736772	CP925936	38/930622	DP104801
38/742730	CP931898	38/930860	DQ101019
38/744703	CP933873	38/930870	DQ101028
38/750810	CP937971	38/936650	DP109827
38/754704	CP942874	38/948623	DP120802
38/760670	CP948843	38/950660	DP122836
38/760860	CQ946017	38/950700	DP121873
38/770626	CP957803	38/950727	DP121897
38/785795	CP969958	38/952604	DP124785
38/790737	CP974905	38/952668	DP123843
38/800605	CP985784	38/955669	DP126844
38/833727	DP014896	38/956669	DP127844
38/837695	DP018867	38/964792	DP133957
38/840695	DP021867	38/964810	DP133973
38/841723	DP021893	38/965650	DP135827
38/842723	DP022893	38/965700	DP135873
38/847610	DP028789	38/966815	DP135978
38/849741	DP028909	38/967680	DP137855
38/851806	DP029969	38/967796	DP136961
38/853832	DP031992	38/970660	DP140836
38/856732	DP035901	38/980635	DP149814
38/857587	DP037768	38/980770	DP148937
38/860850	DQ037009	38/981642	DP150820
38/862787	DP040951	38/982821	DP149984
38/869745	DP047913	38/983596	DP152778
38/871746	DP048914	38/988814	DP155977
38/873798	DP050961	38/991817	DP157980
38/875597	DP054778	38/995790	DP161955
38/875746	DP052914	38/997892	DQ162049
38/875795	DP052959		

CHESTER MINE
PLAN OF OPEN CUT WORKINGS

P.L.F. COLLINS 1978

0   40   80   120   160   200 m

LEGEND

Plane table survey by P.L.F. Collins and P. Komyshan
Contour interval 5 m

Basic dyke

Bedding, dip and strike

Cleavage, dip and strike

Vertical cleavage

Minor fold direction and plunge

Fault

BENCH A
BENCH B
BENCH C
BENCH C
BENCH D
BENCH D
BENCH E
BENCH F
BENCH F
BENCH G

pyrite vein

dyke (?)
dyke (?)
dyke (?)

basic dyke

HAULAGE LINE

TN

A

Rubble

OPEN CUT BENCH B
BENCH C
BENCH D

OPEN CUT BENCH G

Rubble

ENTRANCE TO MAIN TUNNEL
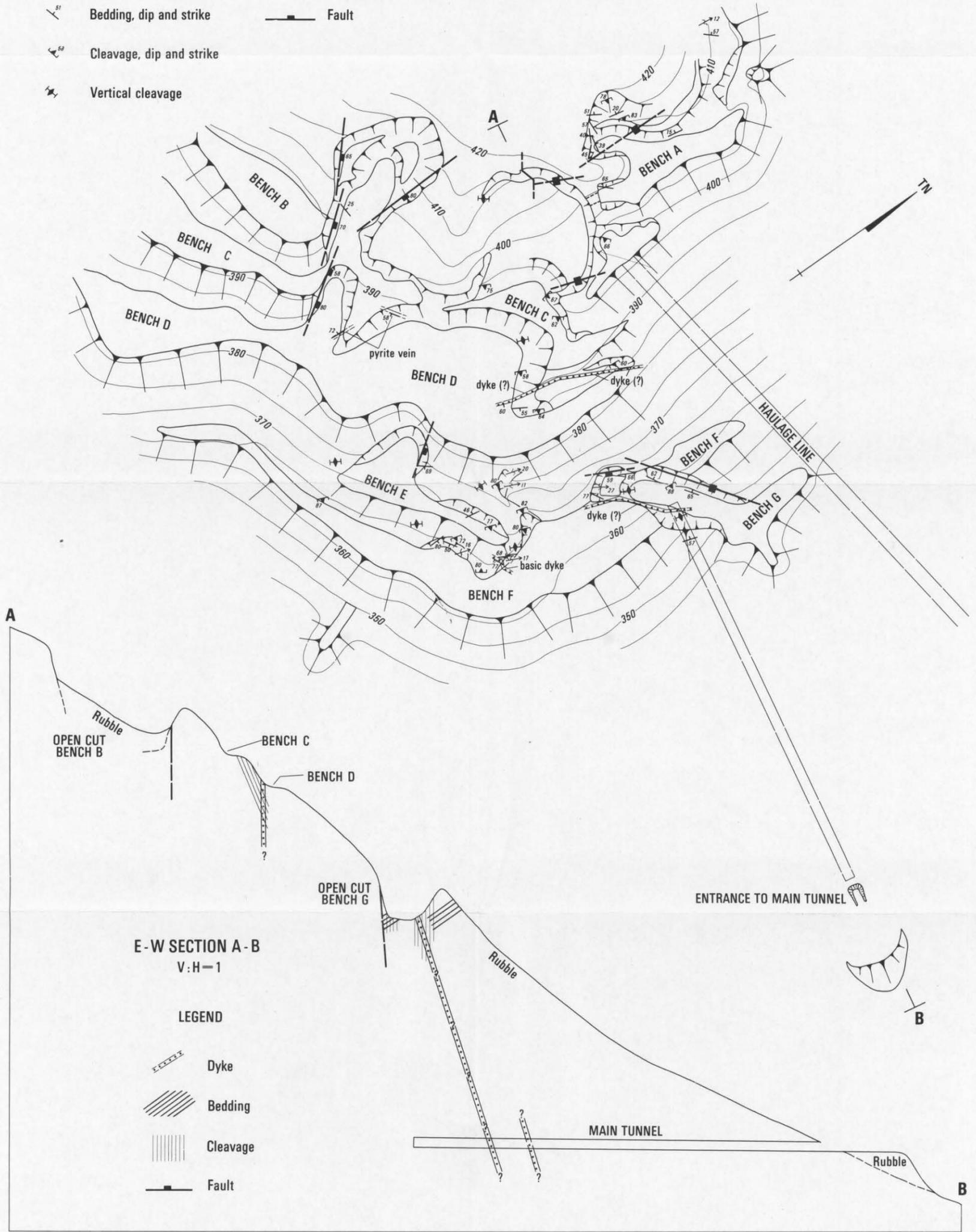
E - W SECTION A - B
V : H — 1

LEGEND

Dyke

Bedding

Cleavage

Fault

MAIN TUNNEL

Rubble

B

A   B

Figure 15   Mackintosh Explanatory Report

5 cm
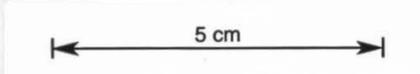
ER8014N
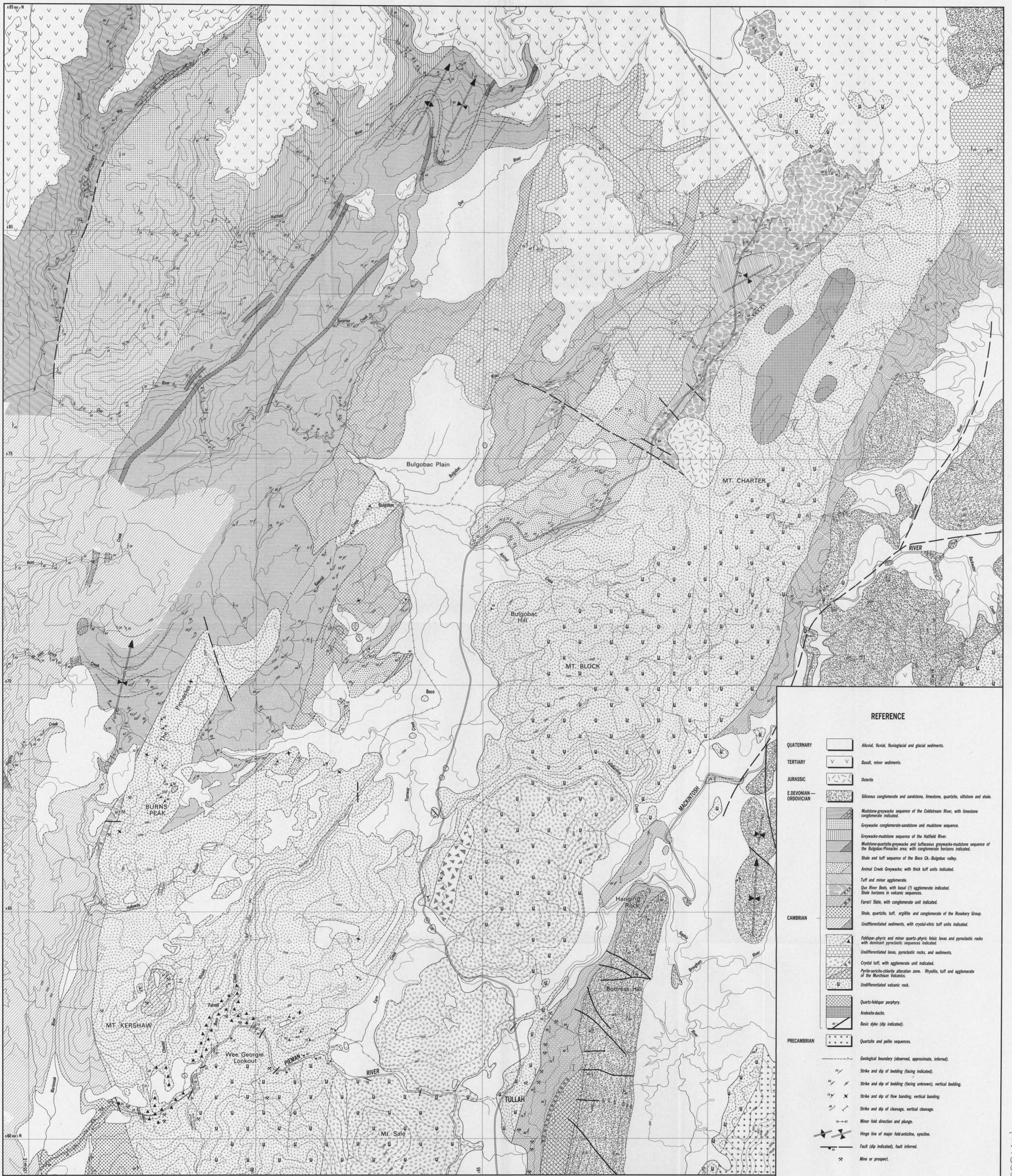
GEOLOGY OF THE PINNACLES—QUE RIVER AREA

P. L. F. COLLINS   MAY 1980

0 ____ 1 ____ 2 Miles
0 __ 1 __ 2 __ 3 Kilometres
SCALE 1:36,680
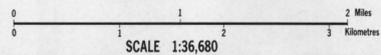
REFERENCE

QUATERNARY		Alluvial, fluvial, fluvioglacial and glacial sediments.
TERTIARY		Basalt, minor sediments.
JURASSIC		Dolerite.
E.DEVONIAN—ORDOVICIAN		Siliceous conglomerate and sandstone, limestone, quartzite, siltstone and shale.
CAMBRIAN		Mudstone-greywacke sequence of the Coldstream River, with limestone conglomerate indicated.
		Greywacke conglomerate-sandstone and mudstone sequence.
		Greywacke-mudstone sequence of the Hatfield River.
		Mudstone-quartzite-greywacke and tuffaceous greywacke-mudstone sequence of the Bulgobac-Pinnacles area with conglomerate horizons indicated.
		Shale and tuff sequence of the Boco Ck.-Bulgobac valley.
		Animal Creek Greywacke; with thick tuff units indicated.
		Tuff and minor agglomerate.
		Que River Beds, with basal (?) agglomerate indicated. Shale horizons in volcanic sequences.
		Farrell Slate, with conglomerate unit indicated.
		Shale, quartzite, tuff, argillite and conglomerate of the Rosebery Group.
		Undifferentiated sediments, with crystal-vitric tuff units indicated.
		Feldspar-phyric and minor quartz-phyric felsic lavas and pyroclastic rocks with dominant pyroclastic sequences indicated.
		Undifferentiated lavas, pyroclastic rocks, and sediments.
		Crystal tuff, with agglomerate unit indicated.
		Pyrite-sericite-chlorite alteration zone. Rhyolite, tuff and agglomerate of the Murchison Volcanics.
		Undifferentiated volcanic rock.
		Quartz-feldspar porphyry.
		Andesite-dacite.
		Basic dyke (dip indicated).
PRECAMBRIAN		Quartzite and pelite sequences.

Geological boundary (observed, approximate, inferred).

Strike and dip of bedding (facing indicated).

Strike and dip of bedding (facing unknown); vertical bedding.

Strike and dip of flow banding, vertical banding.

Strike and dip of cleavage, vertical cleavage.

Minor fold direction and plunge.

Hinge line of major fold-anticline, syncline.

Fault (dip indicated), fault inferred.

Mine or prospect.

Map compiled by P. L. F. Collins from original mapping by P. L. F. Collins and from Barton et al. (1966), and additional unpublished mapping by W. B. Anderson, C. Barton, D. I. Groves, A. B. Gulline, B. Marshall, W. L. Matthews and Rio Tinto Australia Exploration.
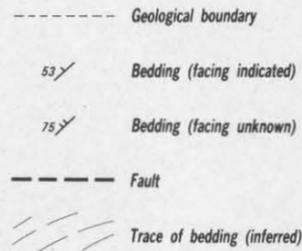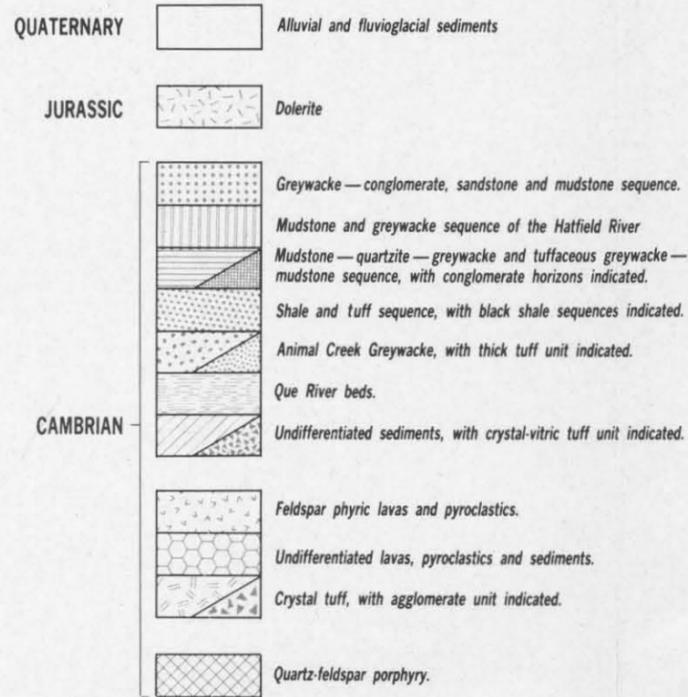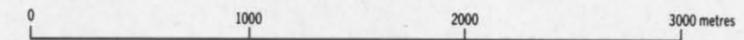
Cartography by:— P. B. NANKIVELL

5 cm

FIG. 21

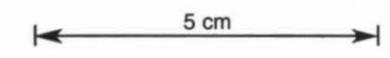MACKINTOSH EXPLANATORY REPORT.

DIAGRAMMATIC NW–SE GEOLOGICAL SECTIONS
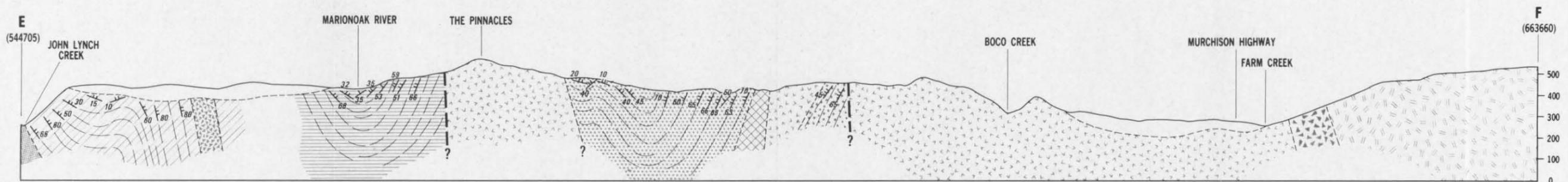# ACROSS THE PINNACLES—QUE RIVER AREA

P.L.F. COLLINS

For location of sections see Figure 20
V:H = 1.65:1

Legend:

QUATERNARY — Alluvial and fluvioglacial sediments

JURASSIC — Dolerite

CAMBRIAN:
- Greywacke — conglomerate, sandstone and mudstone sequence.
- Mudstone and greywacke sequence of the Hatfield River
- Mudstone — quartzite — greywacke and tuffaceous greywacke — mudstone sequence, with conglomerate horizons indicated.
- Shale and tuff sequence, with black shale sequences indicated.
- Animal Creek Greywacke, with thick tuff unit indicated.
- Que River beds.
- Undifferentiated sediments, with crystal-vitric tuff unit indicated.
- Feldspar phyric lavas and pyroclastics.
- Undifferentiated lavas, pyroclastics and sediments.
- Crystal tuff, with agglomerate unit indicated.
- Quartz-feldspar porphyry.

Geological boundary

53 Bedding (facing indicated)

75 Bedding (facing unknown)

Fault
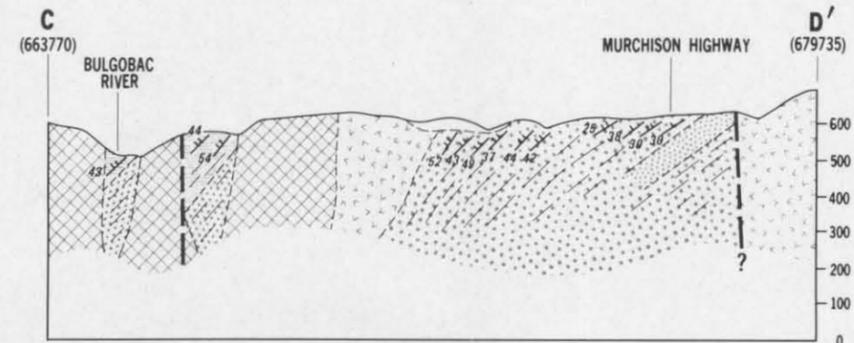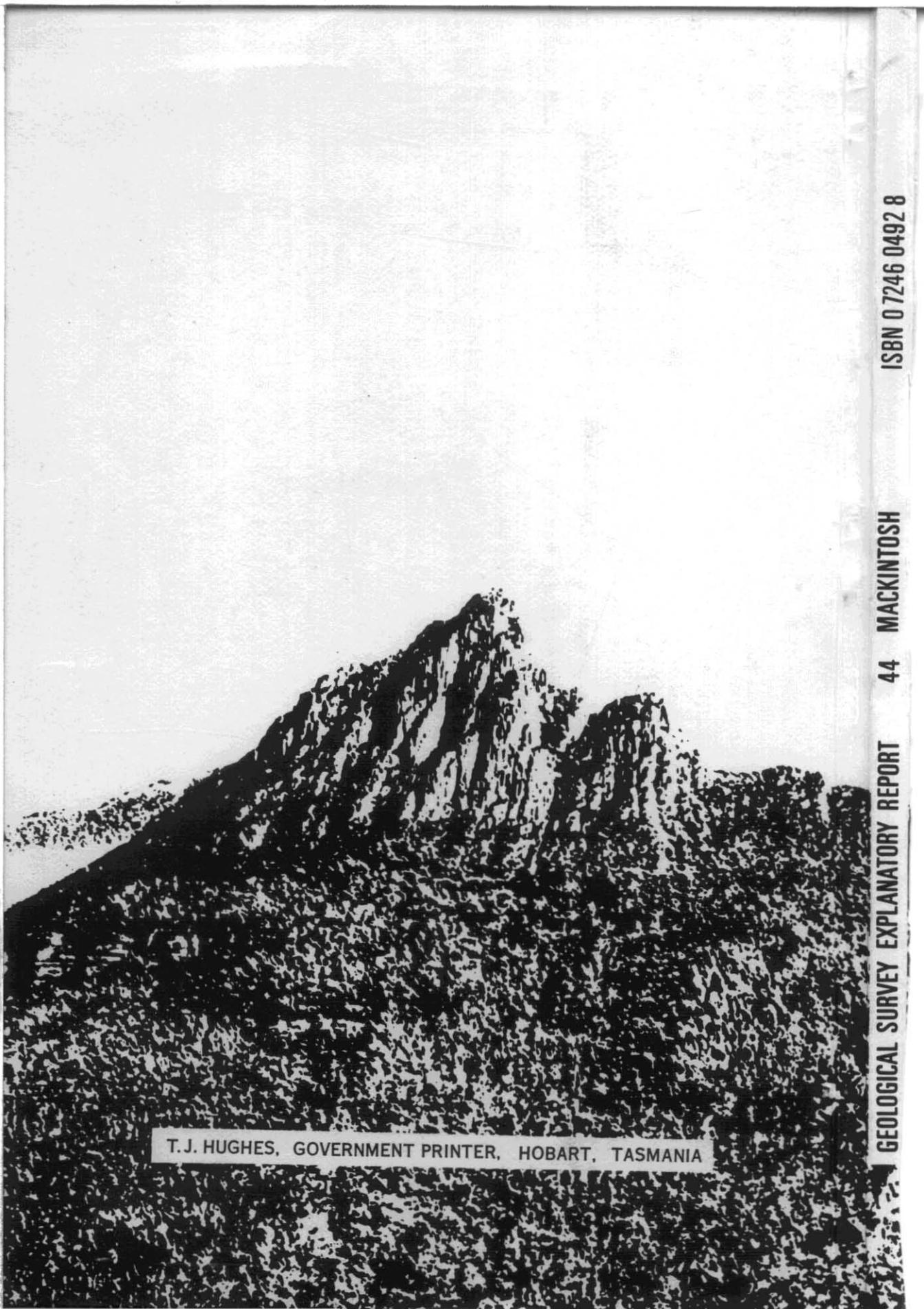
Trace of bedding (inferred)

Part A-B in section A-B-C-D is after D. J. Jennings in Mackintosh Explanatory Notes (fig. 5)

Folding is diagrammatic but includes all possible data.

Figure 22