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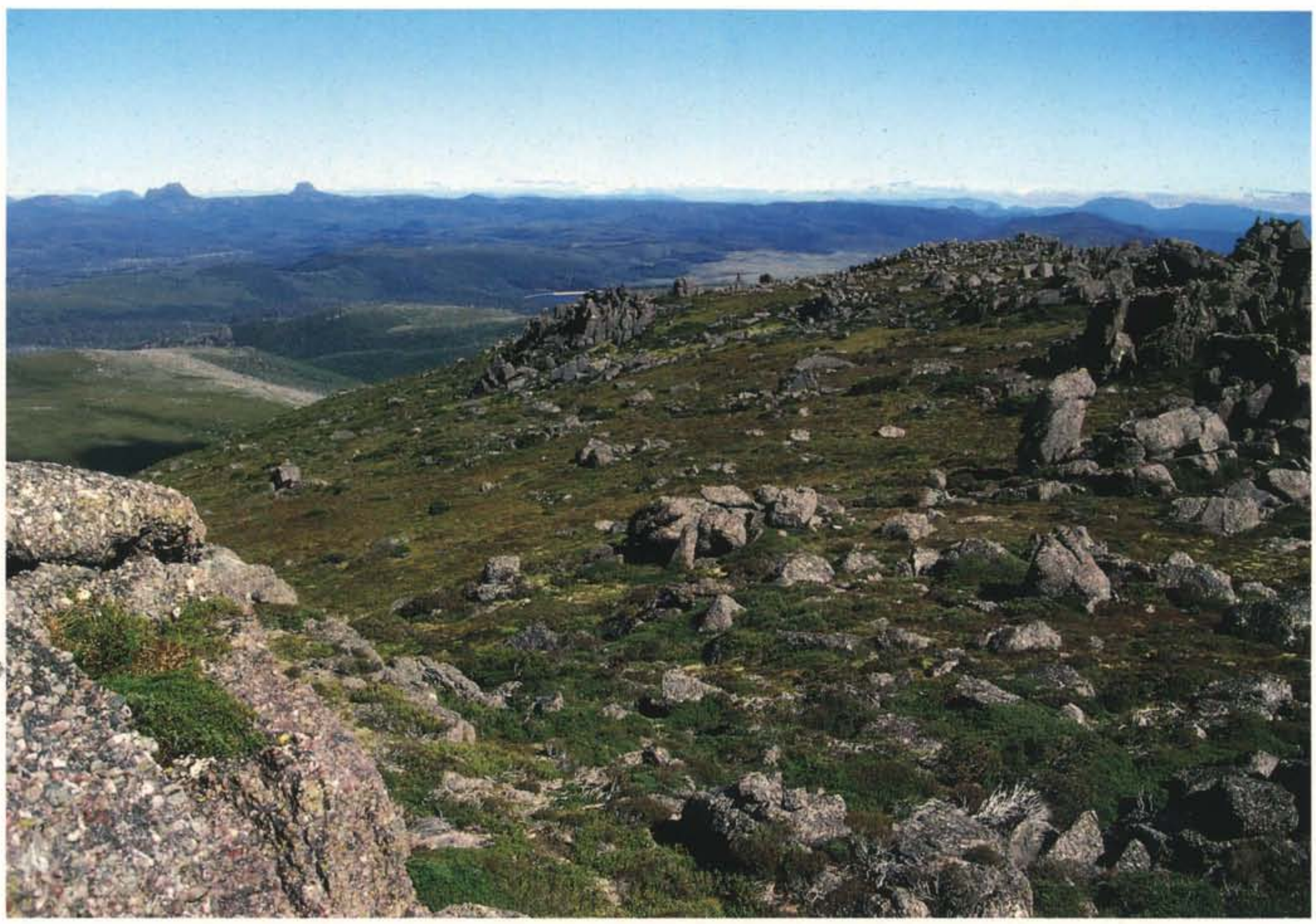
MT READ VOLCANICS PROJECT
GEOLOGICAL REPORT 4

GEOLOGY OF THE CRADLE MOUNTAIN LINK ROAD – MT TOR AREA
(Maps 7 and 8)



DEPARTMENT OF RESOURCES AND ENERGY

DIVISION OF MINES AND MINERAL RESOURCES

TASMANIA

. LINK ROAD– MT TOR AREA ● GEOLOGICAL REPORT MT READ VOLCANICS PROJECT 4 ● ISBN 0 7246

COVER PHOTOGRAPH

Looking south from Black Bluff Range. Cradle Mountain and Barn Bluff to left; Lake Lea and Vale of Belvoir in middle ground; Back Peak, Mt Beecroft and Mt Murchison to right.
Basal conglomerate of Upper Pink Sandstone in foreground.

[K. D. Corbett]

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Geology of the Cradle Mountain Link Road – Mt Tor area

(Maps 7 and 8)

by J. PEMBERTON, B.Sc. (Hons), M.Sc., M. J. VICARY B.Sc. (Hons) and K. D. CORBETT, B.Sc. (Hons), Ph.D.

DEPARTMENT OF ENERGY AND RESOURCES • DIVISION OF MINES AND MINERAL RESOURCES
GPO BOX 56, ROSNY PARK, TASMANIA 7018
ISBN 0 7246 2107 5

PEMBERTON, J.; VICARY, M. J.; CORBETT, K. D. 1991. Geology of the Cradle Mountain Link Road–Mt Tor area. *Geol. Rep. Mt Read Volc. Proj. Tasm.* 4

ISBN 0 7246 2107 5

TECHNICAL EDITOR: E. L. Martin

TEXT INPUT: Jan Howie, Lisa Doran, Anne Taylor
LINE ART / CAD: A. S. McGuinness, J. Ladiniwskyj

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INTRODUCTION

Scope of study

This report describes the geology of the Cradle Mountain Link Road–Mt Tor area, covered by Maps 7 and 8 of the Mt Read Volcanics Project (Vicary and Pemberton, 1988; Pemberton and Vicary, 1988), and should be read in conjunction with those maps. The mapping was carried out during the summer of 1987–1988, using 1:10 000 scale contoured base maps and colour air photographs. The major aim of the work was to elucidate the stratigraphy and structure of the Cambrian volcanic sequences, particularly with respect to the mineralised and highly prospective Que–Hellyer sequence which occurs just south of Map 7 (see MRVP Map 1, Komyshan, 1986). Younger sequences of Cambro–Ordovician rocks, particularly the siliciclastic sequence of the Black Bluff Range, were also examined in some detail, since the stratigraphy and structure of these provide important clues to the disposition of the underlying volcanics.

A considerable amount of new data, particularly in the form of geochemical analyses and drilling information, has become available since the maps were published, and is incorporated in this report. In some cases, these new data have led to modifications of earlier interpretations.

Topographically, the mapped area comprises an undulating western plateau at 600–700 m elevation, largely covered by Tertiary basalt (and associated forest), a broad central ridge (Black Bluff Range) of siliciclastic rocks (900–1200 m) with mainly open sub-alpine vegetation, and a rugged, deeply dissected area of Cambrian and Precambrian rocks to the east bordering the Cradle Mountain National Park. The Vale of Belvoir, a scenically impressive limestone valley containing the basalt-ponded Lake Lea, lies diagonally across the eastern part of the area. The new Cradle Mountain Link Road, and a network of forestry roads in the western area, provide good access to part of the map sheets, but some remote areas were mapped using helicopter access.

Thin sections of some 650 rock samples have been examined, and brief descriptions of some of these are given in the report. Chemical analyses of 32 rock samples are also included. Locations of all samples referred to in the report are shown on Figures 2a and 2b (in pocket). The complete sample collection is housed in the Division of Mines and Mineral Resources, and can be accessed via the Tasrock computerised database.

Previous work

The area has previously been mapped by the Department of Mines as parts of the Mackintosh Sheet (Barton *et al.*, 1966) and St Valentines Sheet (Baillie *et al.*, 1986). Notes for the Mackintosh Sheet were compiled by Collins *et al.*, (1981) and for the St Valentines Sheet by Seymour (1989*a*).

Except for Seymour's (1980), thesis on the Devonian deformation in the Black Bluff area, most of the recent work is in unpublished company reports. These reports are referenced in the Economic Geology section.

Nomenclature

A lithological nomenclature has been used for the pyroclastic and epiclastic rocks based on previous mapping by the MRVP and the guidelines set down by Wright *et al.*, (1980).

The pyroclastic rocks have been divided according to grain size, constituent fragments and welding. Grain sizes used were:

0–2 mm = ash or tuff

2–64 mm = lapilli tuff

>64 mm = blocks, bombs or breccia.

In most instances, rocks containing clasts greater than 64 mm have been described as mass flow breccias because of their unsorted chaotic nature.

Constituent fragment types used in naming the pyroclastics were crystals, shards, pumice and lithics. The relative dominance of each of these components is indicated by their order, e.g. a crystal-lithic tuff. If shards were present the rock was referred to as a vitric tuff.

The epiclastic rocks have been described by using the term tuffaceous or volcaniclastic as a prefix to the traditional sedimentary terminology.

Grain size terms used are from the Udden-Wentworth scale; roundness, sphericity and sorting were from Pettijohn *et al.* (1973), and sandstone classification is from Folk (1974). Textural maturity terms are based on Folk (1951).

Igneous intrusives and extrusives have been named according to their silica percentages as proposed by Ewart (1982), e.g.

basalt <52%;

basaltic andesites and andesites 52–63%;

dacite 63–69%;

rhyolite >69%.

In cases where chemical information is not available or alteration has affected the chemistry, a name has been assigned from the petrography, e.g. quartz-feldspar porphyry or feldspar-phyric lava.

Acknowledgments

Support in the field from John Potter, John-Paul van Moort and Grant Eagling as Technical Officers helped to make the mapping a success.

Numerous exploration geologists have contributed to this work through their reports and discussions. In particular we would like to acknowledge Wally Herrmann (Outokumpu), Andrew McNeill and Rod Henham (Aberfoyle), and Jeff Randall (Billiton).

Once again Chris Meech and Peter Nankivell of the Cartographic Section excelled in deciphering our maps and accommodating some very late changes. Jane Mackey and Janine Triffett are thanked for their sterling effort in preparing all the thin sections. Launceston Laboratories are thanked for providing the geochemical and assay data. Ralph Bottrill and Richie Woolley provided valuable assistance with mineral identification.

STRATIGRAPHY AND PETROLOGY

Introduction

The Cradle Mountain Link Road–Mt Tor area includes a wide range of rock types of various ages. A simplified geological map of the area is presented as Figure 1. The geology of the Que–Hellyer area has been included to show its relationship to the mapped area.

The oldest rocks exposed within the area are of Precambrian age. They are unconformably overlain by a complex sequence of Cambrian volcanic, sedimentary and intrusive rocks constituting the Mt Read Volcanics. The economically important Que–Hellyer Volcanics form part of this pile.

The Cambrian sequence is overlain by Late Cambrian to Early Ordovician siliciclastic conglomerates and sandstones which comprise the Denison Group (the 'Owen Conglomerate' of traditional West Coast terminology). These are overlain by Ordovician limestones and Siluro-Devonian sediments.

A major break in the geological record occurs from the Devonian until the extrusion of basaltic lava flows and minor sedimentation in Tertiary times. Post-Tertiary deposits include glacial, alluvial and slope deposits.

Precambrian rocks

Precambrian quartzites and pelites crop out extensively in the south-eastern region of Map 7. Detailed reassessment of early work in the area by R. D. Gee *et al.* (1970) was considered outside the scope of this report, and only a brief summary of their work is presented.

PELITIC SEQUENCE (Ꝑp)

The most common pelitic rock type is well-foliated phyllite. In thin section it consists of alternate quartz-rich and muscovite-rich layers, up to one millimetre thick. Microporphyroblasts of albite, tourmaline and chlorite were reported in the micaceous layers. The muscovite is 'stringy and dirty', and is aligned parallel to the quartz-muscovite layering. The quartz-rich layers consist of a fine-grained interlocking mosaic of quartz. Foliation in this rock type is planar or anastomosing, and crenulation cleavage is common.

Moving eastwards from Mt Remus there is an apparent increase in metamorphic grade, and the phyllites grade into medium-grained quartz-muscovite schist and reach garnet schist grade in the Cradle Mountain Road area.

The schists are composed of metamorphic segregations of quartz and muscovite, up to 5 mm, and exhibit a well developed schistosity. Gee *et al.* (1970) note that the schistosity is oblique to a probable lithological banding. In thin section the schists consist of quartz, muscovite, chlorite and minor biotite, with porphyroblasts of albite and/or garnet. Quartz occurs as an interlocking mosaic of xenoblastic grains, up to 0.2 mm in diameter, and has little orientation with respect to the dominant foliation. The main sheet silicate mineral is muscovite, which is commonly ragged and dirty due to the presence of minute leucoxene and ilmenite inclusions. It is strongly oriented parallel to the main foliation.

Sample V259 is a muscovite-quartz schist from the Iris River area [DP097969]. It consists of thin, indistinct lamellae of quartz-rich and muscovite-rich layers, up to 0.5 mm wide. The quartz-rich layers consist of an interlocking mosaic of quartz grains with minor interspersed small muscovite and leucoxene grains. The muscovite-rich layers define the main foliation in the rock. Muscovite grains commonly have their long axes oriented in the plane of the cleavage, and have a dirty, irregular appearance. Alteration to sericite and/or epidote is common. Relatively inclusion-free muscovite is also present, and is oriented obliquely to the main cleavage direction. The main cleavage direction is also indicated by alignment of leucoxene, tourmaline and hematite. The tourmaline forms irregular elongate microporphyroblasts up to one millimetre long which may be enclosed by a rim of muscovite.

QUARTZITES (Ꝑq)

Precambrian quartzites are less common than schists and phyllites in the Mt Remus–Hounslow Heath area. They occur as isolated patches and bands reaching a maximum thickness of about one kilometre in the Heap of Rocks area. They also occur at Mt Remus, Quailes Hill and in an ENE-trending belt that extends from the Fury River to just north of Cradle Valley, in the extreme south-east corner of Map 7.

Gee *et al.* (1970) subdivided the quartzites into two distinct lithologies. Well bedded platy quartzite occurs at Mt Remus, Heap of Rocks and at Quailes Hill, while the ENE-trending belt is mainly schistose quartzite.

The platy quartzite may be thinly to thickly bedded and consists predominantly of an interlocking mosaic of quartz grains, 0.03–0.1 mm in diameter. Muscovite up to 0.3 mm also occurs and defines a weak foliation probably parallel to bedding.

The schistose quartzite has a higher modal proportion of sheet silicate minerals than the platy quartzite. Quartz is still the most dominant mineral and has an interlocking mosaic textures. Muscovite and chlorite are also common. Garnet, feldspar and tourmaline may be present as xenocrysts, and accessory opaque oxides and zircon have been reported.

On the Mackintosh Sheet (Barton *et al.*, 1966) at DP084969, a third Precambrian lithology of non-metamorphosed interbedded shales, siliceous sandstones and siltstones, was mapped. Although no specific mention is made of this unit in the Mackintosh Explanatory Report (Collins *et al.*, 1981), recent mapping by the authors in this area suggests that the unit is part of the Cambrian Back Peak Beds sequence that abuts the Precambrian rocks in this region.

Cambrian Mt Read Volcanics and associated sequences

INTRODUCTION

Cambrian rocks on Maps 7 and 8 are part of the Mt Read Volcanics belt, and occur in four main areas (fig. 1):

(1) around the Southwell River, where there is continuity with the rocks of the Que–Hellyer area;

(2) in the Mt Cattley–Mt Tor–Two Hummocks area, where there is much cover by Tertiary basalt;

(3) in small 'windows' through the Denison Group cover rocks on the Black Bluff Range; and

(4) in a continuous belt abutting Precambrian rocks in the Back Peak-Bonds Range area.

The Mt Cattley–Two Hummocks area lies along strike from the Que River and Hellyer mines, and there has been considerable interest in whether or not the mineralised basaltic-andesitic Que–Hellyer Volcanics are represented in the area. No such basalts or andesites have been mapped in the available surface exposures. However, several drill holes put down through the Tertiary basalt cover in 1986 (by the Pancontinental-Outukumpu joint venture) did intersect Que–Hellyer-type basalts and andesites in the southern part of the area. The stratigraphic position of these rocks remained uncertain until further drilling by the Division of Mines and Mineral Resources confirmed the correlation with the Que–Hellyer Volcanics in 1990.

This drilling has also indicated that a major greywacke unit in the Leven River–Black Marsh Road area is equivalent to the Animal Creek Greywacke of the Hellyer–Mt Charter area.

A thick sequence of vitric tuffs underlying the greywacke in the Two Hummocks area is correlated with a similar sequence underlying the micaceous Animal Creek Greywacke at Mt Charter. Although the latter was referred to as the lower part of the Animal Creek Greywacke by Corbett and Komyshan (1989), further information and regional considerations indicate that this terminology is inappropriate, clumsy, and possibly confusing. Consequently, this report refers to the unit simply as the 'lower vitric tuff sequence', pending formal re-naming, and restricts the term 'Animal Creek Greywacke' to the distinctive micaceous greywacke unit originally named by Collins (1981) from Animal Creek on the Murchison Highway.

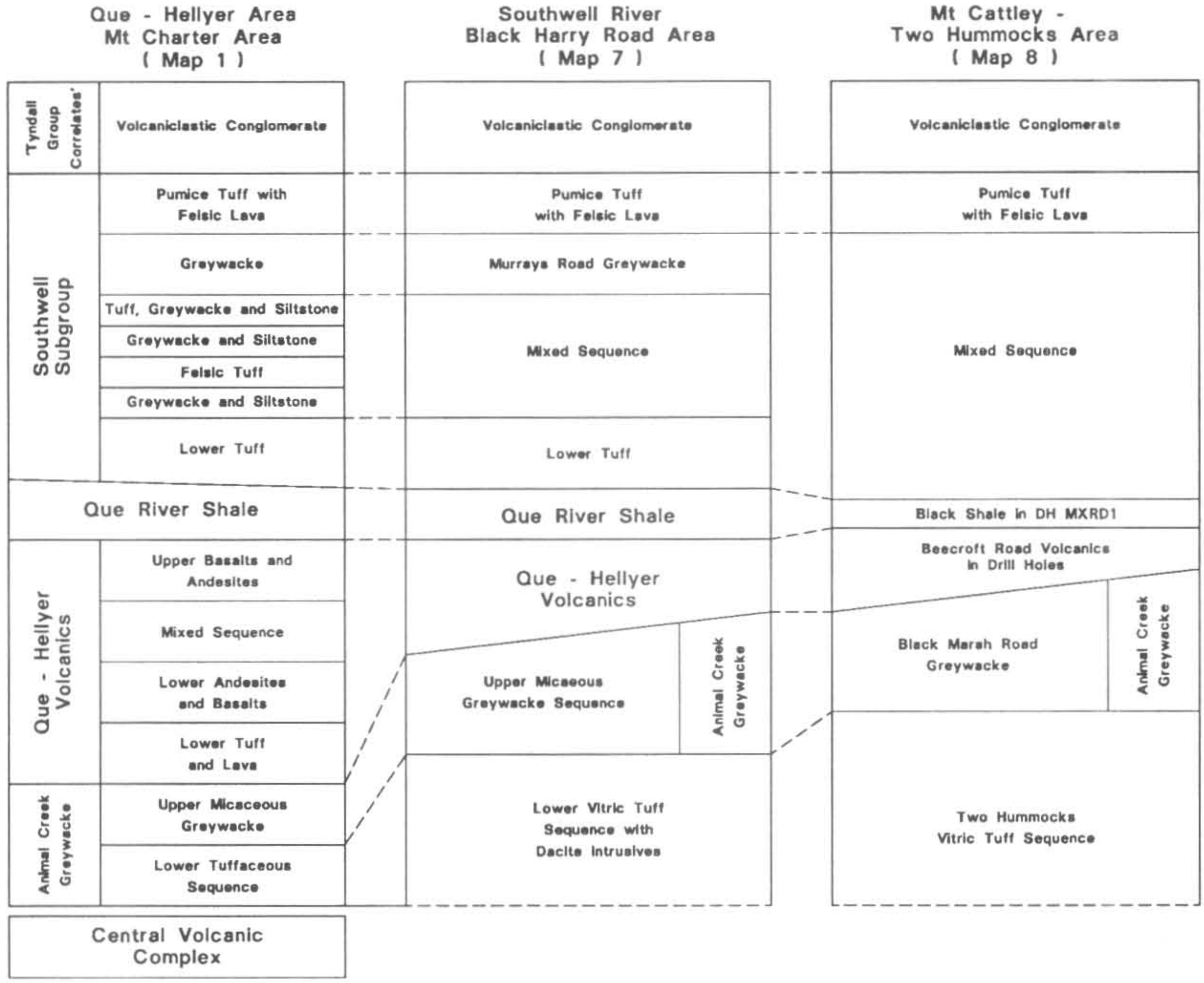


Figure 3. Stratigraphic terminology and correlation chart for Hellyer–Two Hummocks area.

The presently accepted stratigraphic correlations are shown on Figure 3.

SOUTHWELL RIVER – BLACK HARRY ROAD AREA

POSSIBLE CENTRAL VOLCANIC COMPLEX

A small area of feldspar-phyric lava-like rocks was mapped at Black Harry Road [CP904997], and shown on Map 7 as possible Central Volcanic Complex. Subsequent investigations have shown that these dacitic rocks occur as a series of intrusives and possible lavas in a sequence of interbedded vitric tuff, tuffaceous siltstone, sandstone, black shale and mass-flow breccia. This sequence is now correlated mainly with the lower vitric tuff sequence, rather than the Central Volcanic Complex, and is described below.

LOWER VITRIC TUFF SEQUENCE AND ASSOCIATED DACITES AT BLACK HARRY ROAD

Costeaning work carried out by Aberfoyle Resources at Black Harry Road (in response to the discovery of the dacites during mapping on Map 7) has shown that the dacitic rocks are 'overlain' by micaceous greywacke typical of the Animal Creek Formation. A drill hole (BLHY-1) to investigate the dacites at depth was undertaken by the Department of Mines in mid-1989, and reached a depth of 489 m. The hole was collared in Tertiary basalt, and located about 100 m south of a poorly exposed contact between massive dacite and SE-dipping micaceous greywacke. A cross-section of the hole is give in Figure 4, and a detailed log and other information are given in Appendix B.

The drill hole intersected a sequence of interbedded vitric tuff, tuffaceous siltstone and sandstone, micaceous sandstone and siltstone, black shale, and minor mass-flow tuff, interspersed with dacite bodies ranging in thickness from a few centimetres to over 100 m. The largest dacite body occurs at the top of the hole.

The uppermost sedimentary unit in the hole (121–160 m) consists mainly of black micaceous sandstone and siltstone, with minor vitric tuff and pumice-bearing units, and might be considered as gradational to the overlying Animal Creek Greywacke. The bulk of the sequence, however, is tuffaceous and rich in vitric material, typical of the lower vitric tuff sequence.

The typical vitric tuffs and inter-gradational tuffaceous siltstones and sandstones are thinly laminated to massive, and vary in colour from dark grey to green or brown. Abundant devitrification nodules, up to 200 mm diameter, occur in some units, and irregular colour mottling and banding parallel to bedding is common. In thin section the rocks consist largely of fine-grained sericitic material in which recrystallisation and later carbonate alteration obscures the shard textures. Minor grains of volcanic quartz and detrital muscovite were observed.

Coarse tuffaceous sandstone units commonly grade down-hole into coarse, polymict volcaniclastic breccia. The highly erosive bases of these units indicate a mass-flow origin. Clasts include yellow to pink feldspar-phyric lava (similar to the dacite), green chloritic pumice, vitric tuff, and black siltstone.

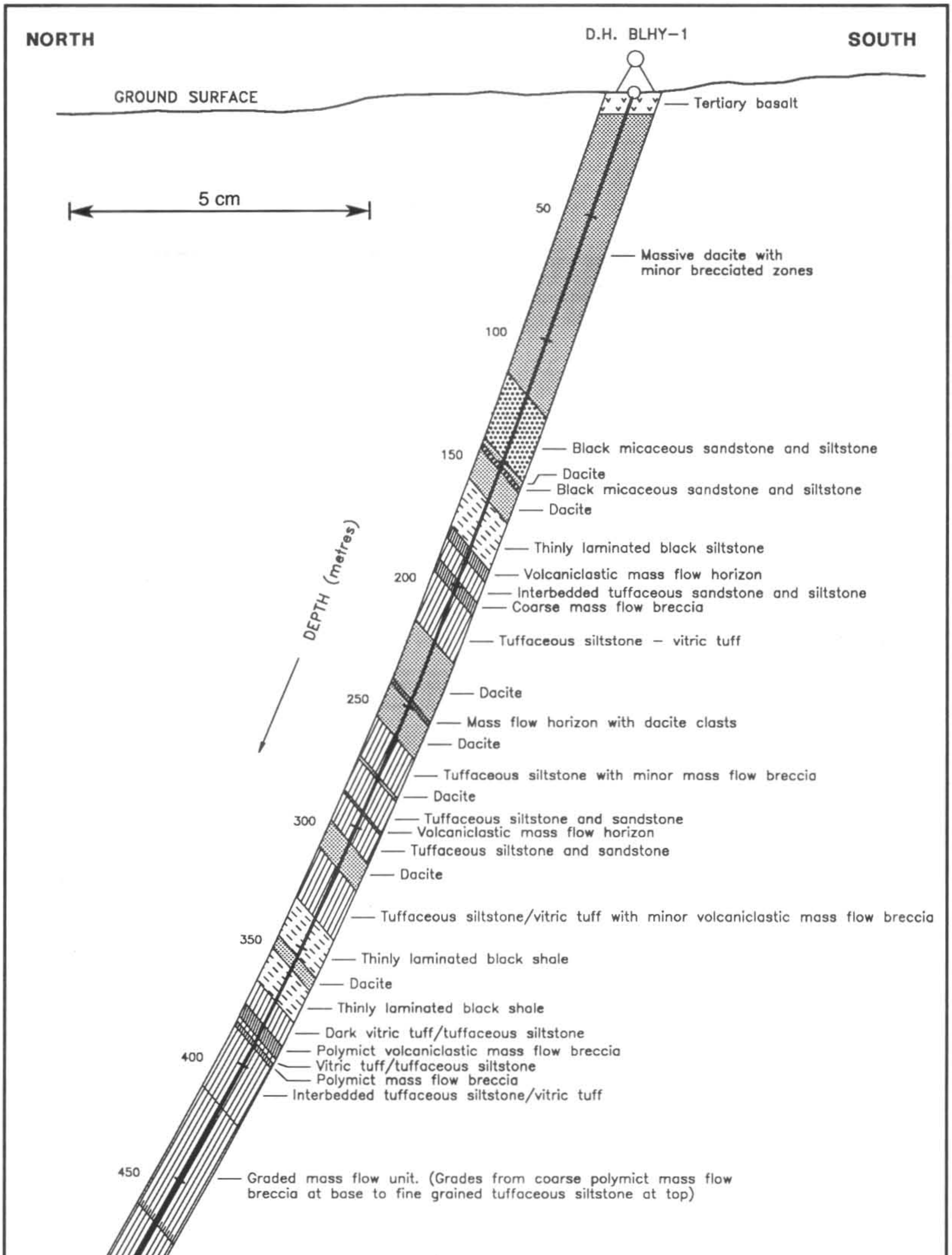


Figure 4. Cross-section of Black Harry Road drill hole.

The dacites are generally massive and uniform except for internal zones of brecciation which, from the 'jig-saw' nature of clasts and the secondary nature of the infilling matrix, appear to be the result of hydraulic fracturing. The core was carefully examined for evidence of an intrusive and/or extrusive origin for the bodies. Most contacts of dacite and sediment show fracturing, shearing and/or quartz veining, and contact relationships are not clear. However, some preserved contacts are sharp, with flow-banding and alteration selvages in the dacite suggestive of an intrusive origin. Some of the sharp contacts are at a significant angle to bedding in the host sediments. Injection-like features of dacite into the host sediments in places are also suggestive of intrusion.

There is no obvious autobrecciation or evidence of explosive or hydroclastic processes associated with extrusion into an aqueous environment or unconsolidated wet sediments. However, several of the polymict epiclastic mass-flow breccias in the sequence contain clasts of essentially identical pink dacite, and one unit in particular (at 246 m) is packed with subangular dacite clasts up to 100 mm across. Such units imply an exposed source of dacite in the general area, and at least some extrusive activity.

It is concluded that many of the dacite bodies are probably intrusive, but that the origin of some is uncertain and could be extrusive. Such an abundance of felsic igneous bodies in one area, in association with clastic detritus of similar composition, is highly unusual if not associated with some kind of nearby volcanic edifice.

In hand specimen, the dacites are massive fine-grained grey-yellow-green rocks with visible sericitised feldspar phenocrysts up to 3 mm. Small vughs or vesicles up to 8 mm are common and are filled mainly with clay minerals (i.e. dickite – R. Woolley pers. comm.) and rare yellow-orange sphalerite. Disseminated pyrite may be common.

In thin section the dacites consist of subhedral (lathlike) to irregular sericitic feldspar phenocrysts, up to 3 mm, in a fine-grained (0.1–0.2 mm) mosaic of equigranular quartz, feldspar, sericite and epidote. Patchy and vein-like carbonate alteration is common, and many of the vugh-like cavities seen in hand specimen are in fact weathered out zones of carbonate. Secondary quartz and carbonate-filled vughs are also present, and may represent an amygdaloidal texture.

Leucoxene and minor pyrite commonly form irregular rims around sericitic feldspar phenocrysts, and may also occur in the groundmass. Minor leucoxenised ferromagnesian minerals, with a relict four and six sided prismatic habit, and minor tabular or acicular apatite, are also present.

All of the dacitic bodies from the Black Harry drill hole are texturally and mineralogically very similar, with only minor variation in constituent mineral abundances and groundmass textures. The only textural difference noted is in the size of the individual snowflakes in the groundmass, which were generally <0.2 mm in diameter. Fine-grained groundmasses with snowflake diameters of <0.05 mm were reported, and generally were associated with very thin dyke like bodies (i.e. sample BH-5), or near contacts of larger bodies.

Sample BH-7 is a thin 200 mm wide dyke intersected in BLHY-1 at approximately 164 m. In thin section it is distinct from all other intrusive bodies in the hole. It has a fine-grained, uniform (chilled) sericitic groundmass with relatively abundant feldspar laths, up to 3 mm, and minor embayed quartz crystals, up to one millimetre. Minor euhedral apatite, pyrite and leucoxenised opaques are present.

ANIMAL CREEK GREYWACKE (€dm)

This formation was described by Corbett and Komyshan (1989) as consisting of two parts – an upper micaceous greywacke unit (largely of Precambrian derivation), and a lower tuffaceous sequence rich in vitric tuffs. However, work by the present authors on Maps 7 and 8 (and also by McNeill on Map 2), has shown that the lower unit is much thicker and more complex than earlier envisaged, and should be treated as a separate unit to avoid the cumbersome terminology. The distinctive micaceous greywacke to which the term was originally applied by Collins (1981) is now recognised as a widely mappable unit, and the term 'Animal Creek Greywacke' is restricted to that unit in the following discussion. It has a gradational contact with the underlying 'lower vitric tuff sequence'.

The Animal Creek Greywacke is well exposed on the western end of the Cradle Mountain Link Road between 600 m and 2.3 km east of the Murchison Highway junction. It occurs as a sequence of predominantly well bedded grey to white weathering micaceous greywacke with minor interbedded siltstone. The sequence is generally dipping and facing to the south-east, although small scale folding is common. Exposure is very poor on the button-grass plains to the north and south of the Cradle Mountain Link Road.

South of the Link Road at CP911978, the Animal Creek Greywacke is overlain conformably by the Que–Hellyer Volcanics, although further to the west at CP908976 it is overlain by the Que River Shale. The latter contact is highly deformed and may be partly tectonic.

In thin section, the medium-grained micaceous greywackes which constitute the dominant lithology in the sequence are composed predominantly of Precambrian-derived detritus. This is in the form of polycrystalline quartzite and schist clasts, abundant rounded to subrounded quartz grains with undulose extinction, and elongate, (sometimes kinked and/or ragged) muscovite flakes. Minor phases present include subangular to subrounded grains of chromite and tourmaline. Minor chlorite and sericite are present in the groundmass, and rare volcanic-derived clasts may be present.

QUE–HELLYER VOLCANICS (€db)

The Que–Hellyer Volcanics were defined by Corbett and Komyshan (1989) as the sequence of andesitic to basaltic volcanics, with minor felsic volcanics and sedimentary rocks, lying stratigraphically between the Animal Creek Greywacke and the Que River Shale in the Hellyer–Que River–Mt Charter area. The unit has a maximum thickness of about 1000 m in the Que River mine area but thins dramatically to the west, north-west and south-west.

A thin unit (≈10 m thick) of Que–Hellyer Volcanics basalt (€db) is exposed between the Animal Creek Greywacke and the Que River Shale at CP912979. Recent canal excavations in this vicinity have provided good exposure. The contact between the basalt and the overlying Que River Shale is sharp and irregular, and pyrite nodules and framboids are abundant in the adjacent Que River Shale. Irregular masses of pyrite are also present at the basalt-shale contact. Observations by Aberfoyle Resources geologists indicate that the basalt is part of the Upper Basalts of the Que–Hellyer sequence (A. W. McNeill, pers. comm.).

QUE RIVER SHALE (€dq)

The Que River Shale is a unit of black to grey pyritic siltstone and shale, with minor greywacke and tuff, conformably overlying the Que–Hellyer Volcanics and conformably overlain by felsic tuffs of the Southwell Subgroup (Corbett and Komyshan, 1989). It was originally described by C. E. Gee *et al.* (1970) as the Que River Beds, and contains a late Middle Cambrian fauna of agnostid trilobites, hydroids, dendroids, inarticulate brachiopods and sponge spicules.

On Map 7, the Que River Shale occurs near the western end of the Cradle Mountain Link Road, and dips gently to the south-east. Folding is quite irregular, and a minor SE-plunging syncline was recognised at CP907975. The lower contact with the underlying Que–Hellyer Volcanics is well exposed in a drainage canal at CP912979. Although the contact is highly variable, bedding in the Animal Creek Greywacke (directly underlying the Que–Hellyer Volcanics) and the Que River Shale suggests a uniformly dipping conformable sequence.

West of the canal, at CP908976, the Que River Shale is in direct contact with the Animal Creek Greywacke. Near the contact, the Que River Shale is highly deformed, and quartz veining is common. Although the contact has been interpreted as a fault by Aberfoyle geologists (A. McNeill, pers. comm.), conformable dips in the Que River Shale and Animal Creek Greywacke suggest a sedimentary type contact.

SOUTHWELL SUBGROUP

The Southwell Subgroup was defined by Corbett and Komyshan (1989) as the sequence of felsic tuff, greywacke and siltstone, with minor felsic lava, conformably overlying the Que River Shale in the vicinity of the Hellyer Mine, and conformably overlain by Tyndall Group correlates in the Murrays East and Cradle Mountain Link Roads area.

Corbett and Komyshan (*op. cit.*) divided the Southwell Subgroup into seven units, however a four-fold subdivision is used here (fig. 3). The basal unit of the Southwell Subgroup is a quartz-feldspar-phyric tuff exposed on Murrays West Road. It is overlain by a mixed sequence of interbedded felsic tuff, mass-flow breccias, greywacke, siltstone and shales. The highest unit is a sequence of pumice-bearing tuffs with intercalated vitric tuff and flow-banded lava.

Lower tuff unit (€dt)

The lower tuff unit overlies the Que River Shale and consists of quartz-feldspar-phyric crystal-vitric-lithic tuffs with minor interbedded shale, siltstone and greywacke. The geology depicted on Map 7 is taken directly from MRVP Map 1 (Komyshan, 1986), with minor modification to the tuff, Que River Shale and Tertiary basalt contact at approximately CP919975. Corbett and Komyshan (1989) give a detailed description of this unit.

Mixed sequence of felsic tuffs and tuffaceous greywackes (€dts)

This unit is well exposed on the Cradle Mountain Link Road about 500 m west of the junction with Murrays Plain Road. It consists of quartz-feldspar-phyric tuff and mass-flow tuff with clasts of green chloritic pumice and lava clasts up to 100 mm across, interbedded with medium- to coarse-grained graded tuffaceous greywacke and minor grey siltstone and shale. Spectacular graded mass-flow units up to 5 m or more thick, with multi-coloured volcanic clasts, are prominent within the sequence.

The sequence is intruded on its eastern side by a spherulitic felsic porphyry body. A five metre wide zone of strongly cleaved tuffaceous greywacke and tuff is present at the contact. This probably represents a zone of local shearing along the intrusive/sediment contact during deformation, and is not the site of a major structural discontinuity (i.e. the Henty Fault Zone of Komyshan (1986)).

The total thickness of this unit has not been established, although a minimum thickness of at least 250 m can be inferred.

Murrays Road Greywacke (€dg)

The Murrays Road Greywacke may be defined as that sequence of brown-weathering, fine- to coarse-grained greywacke, granule conglomerate and micaceous siltstone which crops out at the Murrays Plain Road – Cradle Mountain Link Road junction [CP949985]. Grading, rip-up shale clasts and flame structures are present in the sandstone beds and indicate an east facing sequence. It is bounded to the west by an intrusive porphyry body, and is overlain and interbedded with a sequence of pumice-rich tuffs (€dp) to the east.

Compositionally, the clastic rocks of this sequence are highly variable, and have varying abundances of volcanic- and Precambrian-derived clasts. The major Precambrian component is in the form of polycrystalline quartzite and schist clasts, up to granule grade, and small muscovite flakes, up to one millimetre, which are common in the groundmass. Corbett and Komyshan (1989) note an increase in the modal abundance of muscovite in the matrix of the siltstones and finer grained sandstones.

Volcanic detritus includes sericitic volcanic clasts and rare andesitic clasts. Subrounded to subangular quartz grains with minor evidence of embayment are considered to be of volcanic derivation. In contrast to Precambrian-derived quartz in the form of polycrystalline quartzites and schists, volcanic-derived quartz has one crystallographic orientation and has no minute muscovite inclusions. Detrital pyrite is common and may also be a volcanic-derived component. Chlorite, sericite, pyrite and quartz are commonly found as matrix materials.

Pumice-rich tuff sequence (€dp)

Conformably overlying the Murrays Road Greywacke is a sequence of pumice-bearing crystal and crystal-lithic tuffs with minor mass-flow units, vitric tuffs, greywackes and flow-banded quartz-feldspar- phyric lavas. The typical tuff is well exposed on the Cradle Mountain Link Road at CP951986, and is characterised by the presence of green chloritic pumice clasts and pink albitised lava clasts, up to 60 mm in length. This rock type is similar to tuffs in the mixed sequence previously described.

Sample V024 is typical of the pumice-bearing crystal tuffs that dominate this unit. In thin section it consists of sparse, subrounded and partially embayed quartz and sericitic feldspar grains, up to 2 mm, in a fine-grained recrystallised groundmass of secondary quartz, sericite and chlorite. Pumice fragments are also quartz-feldspar-phyric, and are characterised by a strong cellular fabric and fiamme-like shapes. They are replaced by chlorite, sericite and secondary quartz, and range in size from less than one millimetre to several centimetres. Most of the fine matrix material with no cellular fabric is probably pumice-derived. Fine-grained pumice-bearing crystal tuffs without obvious chloritisation of pumice clasts, and a high degree of secondary replacement of the matrix by quartz and sericite, often resemble quartz-feldspar-phyric lava. Other rock types within this sequence are described in Corbett and Komyshan (1989).

Several tabular bodies of felsic lava are interbedded within this sequence and may be difficult to distinguish from the pumiceous rocks in thin section. In outcrop, however, they are obviously lavas, with flow-banding and autobrecciation textures preserved.

Similar pumice-bearing tuffs and interbedded felsic lavas were also noted on a small range of low hills to the north of the Cradle Mountain Link Road at CQ976012.

Felsic lava (€dlt)

Quartz-feldspar-phyric lava conformably overlies the pumice tuff sequence on the Cradle Mountain Link Road at CP952987, and Corbett and Komyshan (1989) describe several other tabular bodies of lava occurring to the south. In thin section the lavas are commonly quartz-feldspar-phyric, although feldspar-phyric varieties are known. The groundmass is predominantly quartz and sericite, with little original texture preserved. Small spherulites and poorly defined flow-banding may be found in some sections. Flow-banding is well developed in outcrop at CP954982, and autobrecciation may occur. A similar lithology was recognised about 3 km to the north-west at CQ972011.

Sample V075 [CQ974009] is a spherulitic quartz-feldspar porphyry that is distinct from other samples of this felsic lava lithology. It is very similar to welded ashflow tuffs or quartz-feldspar-phyric lavas which occur in the overlying Tyndall Group correlates.

VOLCANICLASTIC CONGLOMERATE AND ASSOCIATED ROCKS ('TYNDALL GROUP CORRELATES')

A sequence of volcaniclastic conglomerate, sandstone, siltstone, crystal-lithic tuff, micaceous greywacke and minor siliciclastic conglomerate conformably overlies the uppermost pumice tuff and felsic lava unit of the Southwell Subgroup on the Cradle Mountain Link Road about 500 m east of the junction with Murrays Plain Road [CP953987]. It contains a well preserved late Middle Cambrian trilobite fauna. The sequence has been referred to as 'Tyndall Group correlates' by Corbett and Komyshan (1989), but as noted by these authors (p. 38) the Tyndall Group as originally defined by Corbett *et al.* (1974) could include equivalents of the Southwell Subgroup as well. This terminological problem may be resolved in the near future.

In the Southwell River area it is possible to subdivide the sequence into four units;

(1) Lower unit of siltstone and siliciclastic conglomerate;

(2) Crystal tuff sequence with minor felsic and andesitic lavas;

(3) Unit of interbedded fossiliferous siltstone, shale and volcaniclastic sandstone;

(4) Thick upper unit of volcaniclastic conglomerate and sandstone.

Lower units of siltstone and siliciclastic conglomerate (€ts)

A locally developed unit of interbedded grey to black siltstone and pale-weathering siliciclastic sandstone and conglomerate is exposed on the Cradle Mountain Link Road at CP953987. The contact with the underlying Southwell Subgroup is not exposed.

At the base of the sequence is a lower unit, approximately 20 m thick, of thinly bedded black to grey micaceous siltstone. Cross bedding in this unit indicates easterly facing. This is conformably overlain by a massive 2–3 metre thick clast-supported pebble-cobble conglomerate composed mainly of Precambrian-derived quartzite clasts, with minor felsic volcanic fragments (sample V039). Some boulder grade clasts are present at the base of this unit. Rip-up clasts of the underlying black siltstone are also present. Carbonate veining and replacement of the clasts is common, and minor chalcopyrite was observed.

The conglomerate unit thickens northwards to possibly 10 m. Sample V019 [CP953989] is from an outcrop about 200 m due north of the exposure on the Link Road. It is a grey-brown pebble conglomerate and contains abundant Precambrian-derived quartzite and muscovite schist fragments in a very micaceous and siliceous matrix. It contains fairly common volcanic-derived clasts, including snowflake-textured lava, and feldspar-quartz porphyry.

Overlying the massive pebble-cobble conglomerate is a 70 m thick sequence of interbedded black siltstone and micaceous sandstone. Sample V040 [CP953987] is a coarse sandstone, and consists of abundant subrounded to subangular quartz grains with undulose extinction, and muscovite flakes up to 0.2 mm. Minor Precambrian quartzite clasts and volcanic-derived clasts are present. Some of the quartz is of volcanic origin. This unit grades upward into thinly bedded black to grey siltstone. Carbonate and hematite alteration is present.

The lower siliciclastic conglomerate-siltstone sequence is discontinuous along strike, and has a maximum thickness of about 200 m.

The less resistant siltstones are only poorly exposed to the north of the Cradle Mountain Link Road, whereas conglomeratic units tend to form better outcrops. It is possible that further detailed mapping will reveal that this sequence is more extensive to the north than shown on Map 7. It does, however, appear to lens out to the south.

The eastern contact with the overlying crystal tuff sequence is well exposed in costeans located about 100 m south of the Link Road at CP953986. Near the contact, the siltstone sequence is highly folded and the contact is very irregular. There is very little change in the attitude of the bedding across the siltstone-tuff contact and the contact is interpreted as a tectonically disturbed depositional surface.

Crystal tuff sequence with minor felsic and andesitic lavas (€tt)

Overlying the lower unit is a sequence dominated by pink-weathering crystal tuffs interbedded with tuffaceous sandstone and siltstone and minor quartz-feldspar-phyric ignimbrite and andesitic lava.

The major lithology is quartz-feldspar-phyric crystal and crystal-lithic tuff. In outcrop the tuffs are generally massive to poorly bedded, although pink and green colour banding identical to that in the Comstock Tuff at Queenstown (Corbett *et al.*, 1974) is present in some outcrops. In thin section they consist of an aggregate of subangular to subrounded quartz and feldspar grains in a matrix of chlorite, feldspar, hematite and secondary quartz. They are moderately well sorted and have a characteristic pink colouration. The grain size varies from coarse sand to very coarse sand grade. Lithic fragments include sericitic flow-banded lava, quartz-feldspar-phyric lava, and andesite. Rare massive sulphide clasts up to 150 mm were recorded at the contact with the underlying siliciclastic sequence at CP953986.

Interbedded with the massive crystal tuffs are well bedded thinly laminated tuffaceous siltstones and fine-to medium-grained tuffaceous sandstones. The siltstones consist of graded layers (10–15 mm thick) of silt to fine sand size volcanic quartz and feldspar grains. The grains are typically subangular to subrounded. Muscovite is commonly observed in the sandstone beds.

Quartz-feldspar-phyric welded ignimbrites are a minor lithology within the crystal tuff sequence. In outcrop they are massive, pink, hard rocks similar to the crystal tuffs but with a more abundant and finer grained matrix. In thin sections, phenocrysts of embayed quartz, feldspar, and a chloritised ferromagnesian mineral, up to 2 mm long, appear to 'float' in a fine-grained matrix showing shard texture and occasional spherulitic and snowflake texture. Welded shard texture is evident between phenocrysts in samples V033, V041 and V070. Other samples of this rock type are V028, V031 and V043.

A small irregular body of purplish-brown porphyritic andesite (€a) is poorly exposed within the unit at CP958988. Sample V049 in thin section is composed of phenocrysts of plagioclase, and chlorite pseudomorphs (after pyroxene ?), in a fine-grained chloritic matrix. Plagioclase occurs as subhedral to euhedral or glomeroporphyritic crystals ranging in size from 0.05 to 6 mm. It is commonly replaced by sericite. Minor carbonate and chlorite replacement is also observed, the chlorite replacement being most common along cleavage traces.

Chlorite occurs as subhedral to euhedral hexagonal pseudomorphs up to one millimetre, and may also be present in feldspar glomerocrysts as irregular shaped masses. No primary ferromagnesian mineral or relict cleavage was observed in the chlorite pseudomorphs, but the euhedral shape of crystals closely resembles that of pyroxenes. It is also possible, however, that the chlorite pseudomorphs are after hornblende. Amorphous quartz beads, up to 0.1 mm in diameter, with highly irregular grain boundaries, are common within chlorite. Late stage carbonate replacement of the chlorite pseudomorphs is observed in some sections.

Apatite is a common accessory in this rock. It occurs as euhedral prisms, up to 2 mm, in the groundmass, and may also be observed as inclusions in pyrite and chlorite pseudomorphs.

The groundmass of the feldspar-pyroxene porphyry is very fine and glassy. It has a characteristic greenish colour due to chlorite alteration, and some sericite, carbonate and quartz replacement is also observed. Small feldspar laths, usually less than 0.03 mm, are common, and opaque oxide up to 0.01 mm is also present.

Sample V048 (plate 1a) comes from the same outcrop as V049. It is composed of angular andesite clasts, up to 10 mm, set in a pink matrix of feldspar detritus, pink lava clasts, subrounded Precambrian quartzite clasts and minor quartz grains. Another sample (V017) shows a large andesite clast in a matrix that is similar to the matrix in V048 except that quartz grains (some embayed) are more common and welded tuff clasts are also present. The andesite clasts probably resulted from fragmentation at the outer margins of an andesite lava flow.

Andesites were also observed to be interbedded with volcaniclastics at CP972999 (sample V090), and large boulder sized andesite clasts are present in volcaniclastic conglomerate at CP961987 (sample V045) and at CP967988.

Fossiliferous siltstone and shale unit (€tsh)

A sequence of fine-grained, friable, yellow to brown siltstone and shale interbedded with volcaniclastic sandstone crops out on the Cradle Mountain Link Road about one kilometre east of the Murrays Plain Road junction. It occurs as a wedge-shaped body within volcaniclastic conglomerates and sandstones and crystal tuffs. The exact stratigraphic position of this unit is uncertain due to unresolved structural problems in this area, however despite anomalous north-easterly strikes and southerly facing, the contact with the overlying volcaniclastic sandstone and conglomerate sequence (€tcs) at CP963989 appears conformable.

Well preserved fossils were found in the shales during the mapping program at approximately CP961989, and specimens have subsequently been described by Dr J. B. Jago, of the Department of Applied Geology, South Australian Institute of Technology. He was able to recognise three different faunas.

The first fauna contains abundant trilobite fossils including the agnostid trilobites *Valenagnostus banksi*, *Clavagnostus*, (?) *Lejopyge laevigata*, *Grandagnostus*, *Agnostascus*, and other unidentifiable agnostoid fragments. Other trilobites include the pagetiid *Helepagetia*, the polymeroid *Pianaspis*, and unidentified nepeids, dolichometopids, anomocarids, and others. Rare acrotretid brachiopods are also present. This fauna essentially corresponds with Assemblage 3, but with some influence from Assemblage 2, of Jago (1973).

The second fauna occurs in thin sandstone layers interbedded within the shale sequence, and consists primarily of broken up fossils, including hyolithids, anomocarids (possibly *Dorypyge*) and other fragmentary polymeroid trilobites.

The third fauna contains *Lejopyge laevigata* and *Goniagnostus*, and is tentatively correlated with Assemblage 1 of Jago (1973).

The age of the trilobite faunas from the Cradle Mountain Link Road ranges over two or three late Middle Cambrian Zones, i.e. *Lejopyge laevigata* II and III and the very late Middle Cambrian *Damesella torosa–Ascionepea janitrix* zones. This is a similar age to faunas from Native Track Tier (Baillie and Jago, 1985), St Valentines Peak (Jago 1976) and from the Comstock Tuff unit of the Tyndall Group at Queenstown (Jago *et al.*, 1972). The fossils are slightly younger than the late Middle Cambrian, *Ptychagnostus punctuosus* or *P. nathorsti* zone, fauna from the Que River Shale (Gee *et al.*, 1970).

Upper volcaniclastic conglomerate sequence (€tcs)

The upper unit consists of cobble to boulder-grade volcaniclastic conglomerate with minor interbedded sandstone and siltstone. The sequence faces to the east, and is conformably overlain by Owen Conglomerate at CP975990.

The main lithology in this sequence is a thickly bedded, hematitic, cobble to boulder grade, clast-supported volcaniclastic conglomerate. The clasts are well rounded and are predominantly of either andesite or quartz-feldspar porphyry. In thin section (V045 from CP961987) the andesite clasts consist of feldspar and ferromagnesian (pyroxene?) phenocrysts in a fine-grained hematitic groundmass. The feldspar crystals are replaced by sericite, carbonate and hematite, while the ferromagnesian minerals are characteristically chloritic, with minor carbonate and hematite replacement. Minor apatite and pyrite are present. They are texturally and mineralogically similar to andesitic lava flows in the lower part of the sequence, and to andesites of the Que–Hellyer Volcanics.

Higher in the conglomerate sequence the abundance of quartz-feldspar porphyry clasts increases. In thin section (V050 from CP964988) they contain abundant quartz and feldspar phenocrysts, up to 2 mm, in a fine-grained, hematitic, snowflake-textured groundmass. Other clasts observed include quartz-feldspar-biotite porphyry (similar to Bonds Range porphyry), flow-banded felsic lava, vitric tuff, black siltstone and minor Precambrian quartzite. Excellent exposure of the volcaniclastic conglomerate may be found on the Cradle Mountain Link Road at CP967988.

Interbedded within the massive conglomeratic sequences are thin volcaniclastic sandstone horizons up to 0.3 m, with minor matrix-supported pebble conglomerate and siltstone. In thin section, the sandstones contain the same lithic clast assemblage as the conglomerates, with abundant subangular volcanic-derived quartz grains with embayed margins, sericitic feldspars, and minor pyrite and muscovite grains. The matrix is hematitic with minor sericite and chlorite. There is a general increase in the abundance of sandstone horizons towards the contact with the overlying Owen Conglomerate. The sandstone beds are graded in some cases, and face in an easterly direction.

MT CATTLEY–TWO HUMMOCKS AREA

INTRODUCTION AND CORRELATION PROBLEMS

Cambrian sequences are rather poorly exposed in a strip along the Leven River west of Mt Cattley and Mt Tor, and in a window in the Tertiary basalt at Two Hummocks. Several kilometers of basalt cover separate these sequences from those in the Cradle Mountain Link Road–Hellyer mine area, and there has been some debate as to correlation between the two areas.

Five major units or sequences have been recognised:

(1) a sequence of mainly fine-grained vitric tuffs at Two Hummocks and in the Medway River;

(2) a younger sequence of micaceous greywacke and siltstone occupying a major synclinal axis along the Leven River;

(3) a mixed sequence of felsic volcanics and sediments immediately to the east of the major greywacke unit, resembling parts of the Southwell Subgroup;

(4) a sequence of pumice-bearing tuff, breccia and minor felsic lava further east again, with obvious similarities to the upper part of the Southwell Subgroup; and

(5) an uppermost unit of volcaniclastic conglomerate and sandstone immediately underlying the siliciclastic Denison Group to the east, and clearly a correlate of the volcaniclastic conglomerate sequence on the Link Road.

During 1986, the Pancontinental-Outokumpu joint venture (on E.L. 14/85) drilled three short holes (MCPD 1, 2, 3; see fig. 5) through the Tertiary basalt, along strike from the major greywacke unit, to test the effectiveness of Sirotem predictions of basalt thickness (Herrmann, 1986*b*). These holes intersected Cambrian basalt and andesite, underlain by micaceous greywacke in MCPD1. There is no known outcrop of the basalts and andesites, and their correlation has been a source of considerable interest.

Mapping by Herrmann (1986*a*) to the south and north, in conjunction with the drilling, resulted in two possible interpretations:

(1) That the basalts and andesites were overlying Animal Creek Greywacke correlates and were therefore stratigraphically equivalent to the Que–Hellyer Volcanics;

(2) That the major greywacke unit was stratigraphically equivalent to the Murrays Road Greywacke, in the Southwell Subgroup, and therefore these basalts and andesites were higher in the sequence than the Que–Hellyer Volcanics.

In late 1988, Outokumpu ran a Gefinex EM survey over the area and drilled two targets to the east of MCPD2 (see fig. 5). In MCDD4 an interbedded sequence of micaceous greywacke, felsic epiclastic and mass-flow breccia was intersected, while MCDD5 had mass-flow pumice breccias and black shale. Core orientations indicated that the holes were drilled on the eastern limb of the syncline mapped in the Black Marsh Road area. Herrmann (1989) interpreted these sequences as correlates of the Southwell Subgroup. In this report by Herrmann (1989), Dr A. J. Crawford examined the basalts and andesites from MCPD 1 to 3 and came to the conclusion on petrological and geochemical criteria that they were equivalent to the footwall rocks of the Que–Hellyer sequence.

A drilling program was undertaken by the Mines Department in 1989–1990 to try and resolve the stratigraphic position of the basalt-andesite sequence and obtain a complete intersection. A pilot hole (BTRD-1) was drilled close to MCPD1 to obtain a bedding orientation on the greywackes, and this confirmed the interpreted southerly plunging syncline. A major stratigraphic hole (MXRD-1) was commenced in May 1990, one kilometre south of MCPD1, near the interpreted axis of the syncline (fig. 5)

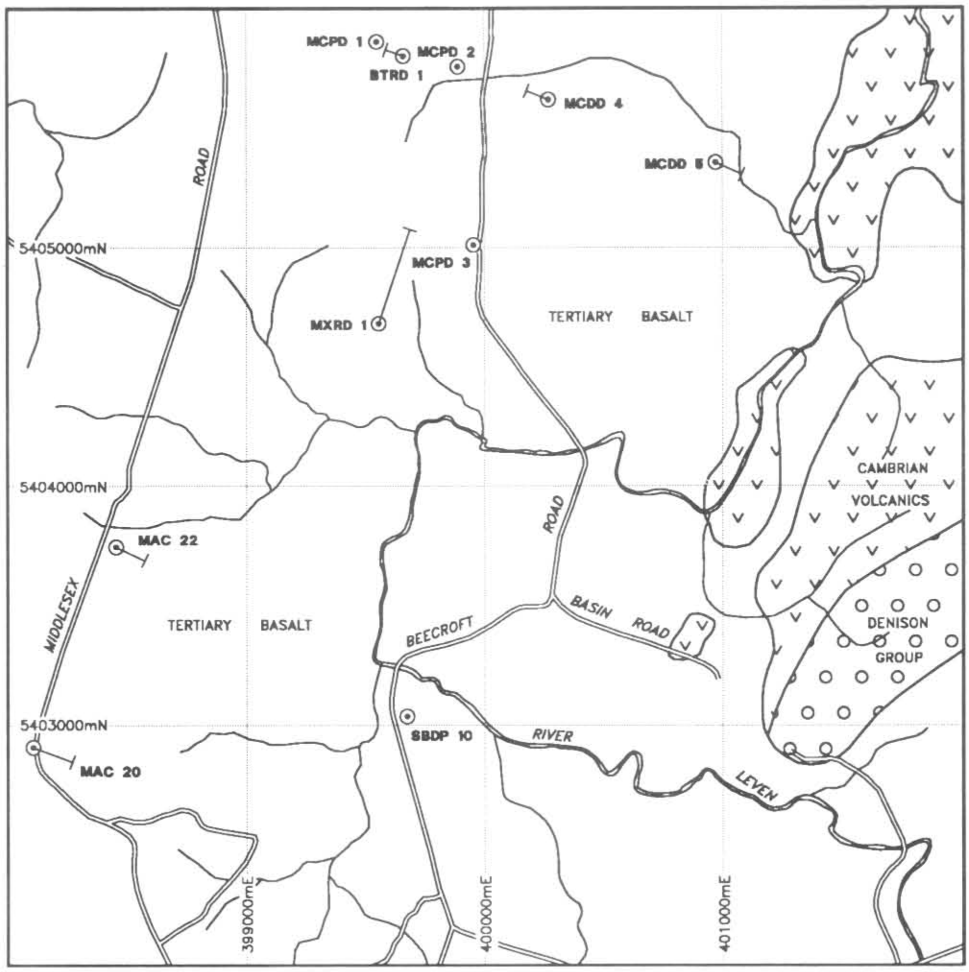
This hole penetrated 185 m of Tertiary basalt, followed by 120 m of mixed tuffs and sediments (including a 65-metre dolerite sill), 50 m of black pyritic shale, 245 m of vesicular basalt, and 150 m of micaceous greywacke (to EOH at 750 m). The stratigraphic section obtained (fig. 6) clearly indicates correlation with the Que–Hellyer sequence, from Southwell Subgroup at the top through Que River Shale and Que–Hellyer Volcanics. The basal greywacke intersected is therefore likely to be the Animal Creek Greywacke, indicating that the major greywacke sequence mapped to the north in the core of the syncline should also be a correlate of that formation.

LOWER VITRIC TUFF SEQUENCE AT TWO HUMMOCKS AND THE MEDWAY RIVER (€dvt)

The road metal quarries on the south-eastern flanks of Two Hummocks give good exposure of this sequence. It is dominated by fine-grained green vitric tuffs with intercalated mass-flow breccias, tuffs and greywacke-shale lithologies. The sequence dips moderately to the north-east, and is right way up.

In the larger southern quarry, a pumiceous vitric tuff is exposed in the south-western corner with nodular devitrification structures up to 100 mm in circumference. Thin section J005 (from DQ007141) shows the uppermost part of the tuff unit to consist of flattened pumice clasts to one millimetre, preserved glass shards, and a minor quartz crystal component. A coarse (up to cobble size) mass-flow breccia (€dmf) is in faulted contact with this unit, and is in turn underlain by an easterly-facing graded greywacke (€dg). The north-eastern wall has a well graded green pumiceous-feldspar-phyric lithic-vitric tuff unit with an erosional base showing a north-east facing. South of this quarry, barite veins up to 100 mm wide have attracted the attention of prospectors and explorers (see Economic Geology section). It is possible that these veins are associated with an outcrop of feldspar-phyric porphyry (J260 from DQ009137). This porphyry could be extensive, being very similar to that intersected in SBDP15 (Baillie and Green, in prep.).

In the smaller northern quarry, a pumiceous vitric-crystal-lapilli tuff on the south-western side shows well preserved pumice and glass shard textures (J003 from DQ008143; plate 1b). A sequence of well cleaved vitric



MCDD 4
0–58.5 Tb and Ts
58.5–158 € mixed tuff, greywacke, shale
158–170.7 € volcaniclastic breccia
170.7–171.5 fault
171.5–301 € pumiceous tuffs

MCDD5
0–97 Tb and Ts
97–119 € tuffaceous sandstone
119–146 € volcaniclastic breccia
146–244.6 € mixed tuff, siltstone, vitric tuff

MAC 20
0–51.4 Tb and Ts
51.4–159.4 € volcaniclastic breccia
159.4–184 € vitric tuff, Lapilli tuff
184–309.9 € micaceous sandstone
309.9 fault
309.9–347.6 € lapilli tuff
347.6–368.3 € volcaniclastic breccia
368.3–397.5 € vitric tuff

MAC 22
0–130.1 Tb and Ts
130.1–144.2 € polymict conglomerate
144.2 fault
144.2–175.4 € micaceous sandstone
175.4–214.9 € volcaniclastic breccia
214.9–294 € mixed sediment tuff
294–396 € volcaniclastic breccia, minor sediment
396 fault
396–424.3 € vesicular rhyolite lava

BTRD 1
0–88.83 Tb
88.83–120.28 € basalt
120.28–127 € volcaniclastic breccia
127–128.78 € andesite
128.78–138.28 € micaceous greywacke, siltstone, black shale

MXRD 1
0–184.6 Tb and Ts
184.6–225 € micaceous greywacke, siltstone
225–292.5 € dolerite
292.5–304.5 € volcaniclastic breccia
304.5–347 € black shale
347–352.6 € siltstone, lapilli and vitric tuff
352.6–597.6 € vesicular basalt
597.6–608.4 € pumiceous volcaniclastic breccia
606.4–750 € micaceous greywacke, black shale

MCPD 1
0–87 Tb
87–96 € weathered tuff
96–114.4 € basalt
114.4–129.2 € felsic tuff
129.2–144.4 € micaceous greywacke

MCPD 2
0–60 Tb and Ts
60–117.5 € basalt

MCPD 3
0–83 Tb
83–109.4 € andesite
109.4–125.1 € rhyodacite
125.1–129.5 € andesite

SBDP 10
0–248 Tb and Ts
248–321 € pumiceous volcaniclastic breccia

Figure 5. Locality map for drill holes in the Beecroft–Middlesex Road area.

5 cm

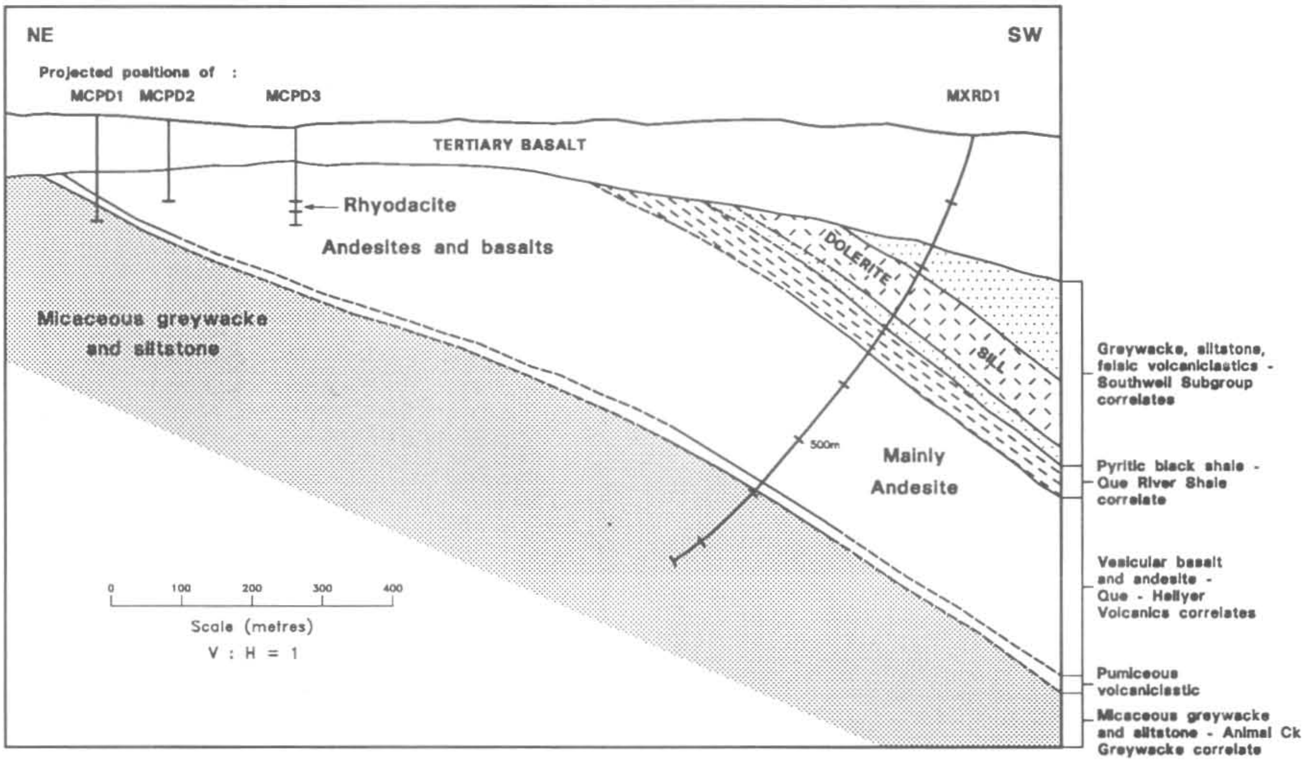


Figure 6. Generalised cross-section for drill holes in the Beecroft Road–Middlesex Road area.

5 cm

tuff beds (up to 0.3 m thick), with devitrification structures up to one metre across, overlies this unit and is up to 50 m thick. The unit is overlain by a black shale with a cherty brecciated base. Minor pyrite and galena mineralisation is associated with the base of this shale (see Economic Geology section). As the shale is discordant with the tuff, and the base brecciated, a fault parallel to the base of the shale has been interpreted. The contact relationship with the Denison Group in this area is unconformable.

A similar sequence was intersected in SBDP14, 3 km south of Two Hummocks (see Baillie and Green, in prep.). A total of 426.5 m of vitric tuff, crystal-lithic tuff, mass-flow breccia, dacitic lava, black shale, siltstone and tuffaceous lithic greywacke was intersected. The dip was shallow (≈25°), and a marine environment was inferred from the presence of a sponge spicule seen in thin section.

A minimum thickness for the Two Hummocks sequence would be 400 m, and from extrapolated contacts on the ground at least 600 m.

MICACEOUS GREYWACKE SEQUENCE – CORRELATE OF THE ANIMAL CREEK GREYWACKE (€dg)

This unit crops out along Black Marsh Road and in the Leven and Medway Rivers, in the core of a syncline with a north-easterly trend. In the Medway River the interfingering relationship with the Two Hummocks sequence is seen, with an increasing mica and sediment content with stratigraphic height. A number of mass-flow breccias and vitric tuffs are interbedded with the greywackes. In the Medway River a highly sericitised vesicular lava or intrusive crops out, with a thickness of less than a metre. It is medium grained, with plagioclase glomerocrysts and an intersertal texture in a fine-grained groundmass of plagioclase (J023 from DQ025109).

The Black Marsh Road quarry [DQ026106] has good exposure of this sequence, with graded and cross-laminated greywackes and siltstones striking north-east and dipping ≈20° to the east. An interbedded vitric tuff (J014 from DQ026106) can be traced through into the Medway River.

An isolated inlier of lithic greywacke (J012 from DQ018140), 800 m east of the Two Hummocks quarry and just below the base of the Denison Group, defines the most northern and western position of this unit. The thin section shows a poorly sorted rock with angular grains of polycrystalline quartz of Precambrian provenance (≈30%), volcanic-derived quartz (≈30%), and mica (≈10%).

The axis of the syncline is apparent in the Leven River at its confluence with Cattley Creek, with shallow dips in the micaceous greywacke suggesting a northerly plunge. The eastern limb of the syncline has steep dips (≈60°) compared to the western limb (≈30°), and the micaceous greywacke sequence is rapidly passed out of. Thin section J055 [DQ040117] is very similar to J012, with ≈40% Precambrian-derived lithics, ≈40% volcanically derived quartz, ≈5% mica, and some carbonate alteration in the matrix and of feldspars. Rip-up clasts of black shale were noted, and the facing was to the west.

The synclinal axis, occupied by micaceous greywacke, can be traced to the south in the Leven River, where it is offset by a north-west trending fault. On Cobbers Road North, the dips indicate a southerly plunge on the syncline.

BASALT-ANDESITE SEQUENCE IN DRILL HOLES – CORRELATE OF QUE–HELLYER VOLCANICS

Three holes (MCPD1,2,3) drilled by the Pancontinental-Outokumpu joint venture in the Beecroft Road–Middlesex Road area intersected Cambrian basalt, andesite and minor rhyodacite. Hole MCPD-1 passed

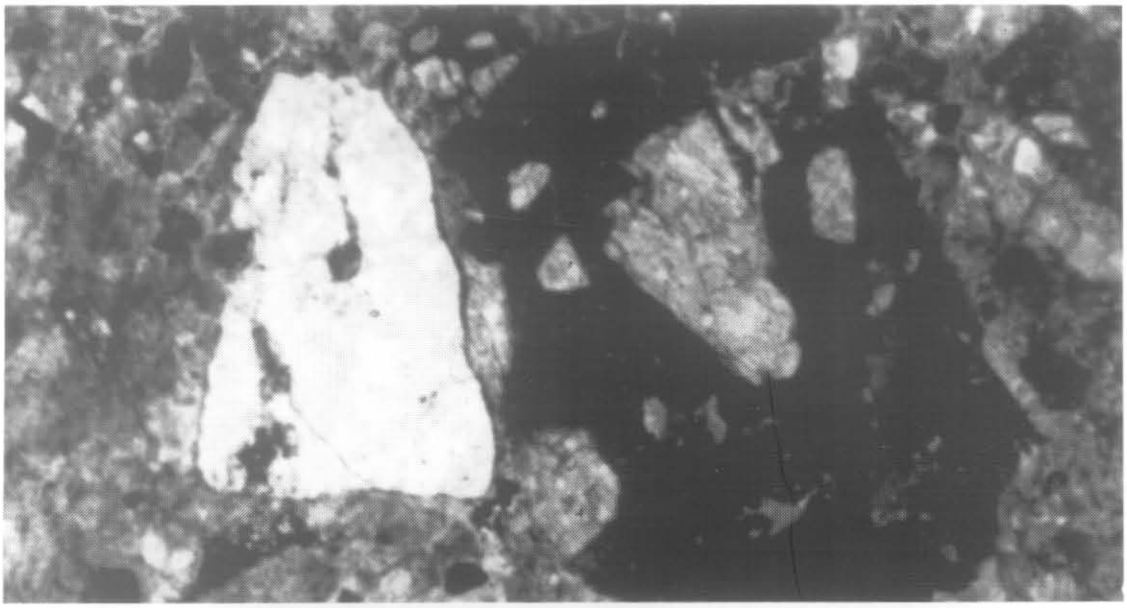


Plate 1a. Photomicrograph of volcaniclastic conglomerate (sample V049) from Cradle Mountain Link Road showing clasts of dark porphyritic andesite with plagioclase and ferromagnesian phenocrysts in fine-grained groundmass. Also present is a white clast of Precambrian-derived quartzite. Field of view 4.3 × 2.2 mm; plane

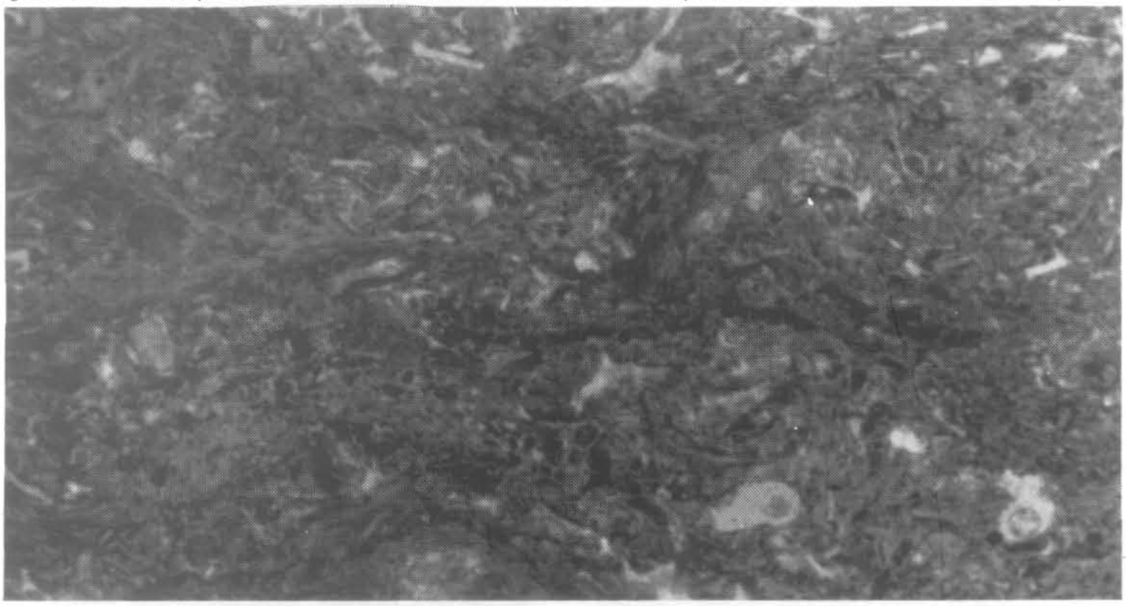


Plate 1b. Photomicrograph of pumiceous vitric tuff (sample J003) from Two Hummocks quarry. Note relatively undeformed glass shards, and poorly-defined pumice clasts, some with vesicular structure preserved. Field of view 4.3 × 2.2 mm; plane light.

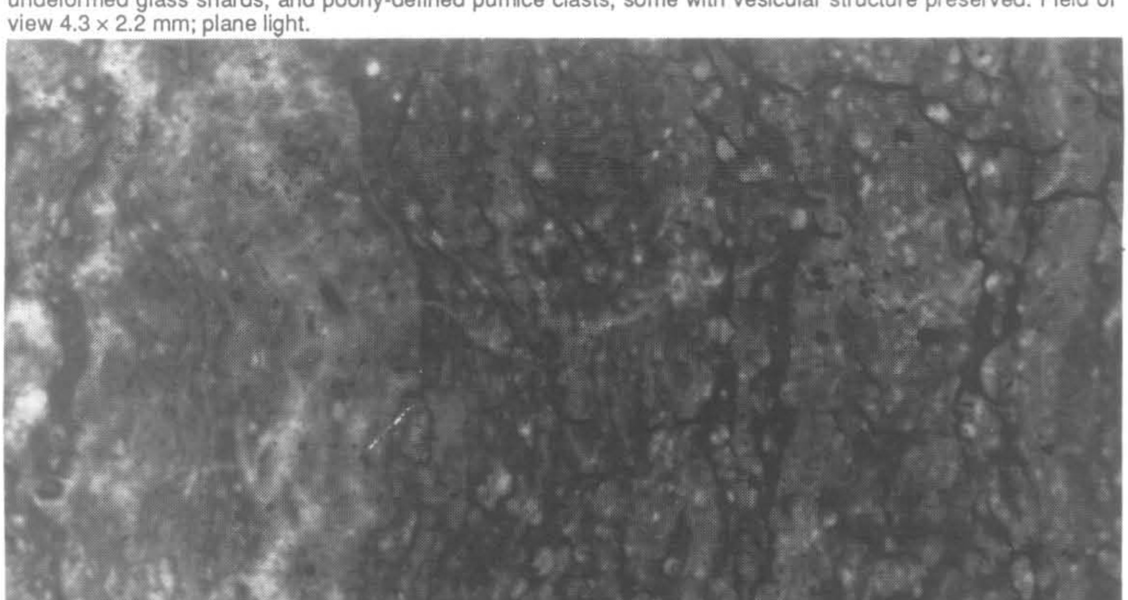


Plate 1c. Photomicrograph of flow-banded, glassy, feldspar-phyric lava (sample J096) from Ring Road. The flow-banding is defined by darker and paler bands, the latter being richer in fine sericite and microlites of quartz. Field of view 4.3 × 2.2 mm; plane light.

5 cm

through the base of the basalt into micaceous greywacke. Hole locations and brief logs are given on Figure 5. A pilot hole, BTRD-1, drilled close to MCPD1 by the Division of Mines and Mineral Resources, also intersected the lavas and obtained two bedding orientations (21° towards 104°, and 34° towards 054°) from the basal greywacke. A thin section from the basaltic rock at 105.6 m (J636) shows rare amphibole phenocrysts (to 2 mm), altered to chlorite and sericite, in a sericite-altered groundmass of fine feldspar laths. Chlorite-filled vesicles to 10 mm across are common.

In the recently completed drill hole, MXRD-1, a complete intersection of the Que–Hellyer Volcanics was obtained but petrological and geochemical data were not available by the time of writing. The cross-section presented in Figure 6 shows the interpreted relationship between the various intersections in the four holes. An approximate stratigraphic thickness for the basalt-andesite sequence is about 245 m. The upper part of the basalt sequence in MXRD-1 shows well-developed pillow structure in places, with pillow margins defined by vesicle concentrations. Fine-grained grey cherty material is present as infilling between pillows. Zones of hydroclastic and hydraulic brecciation are also present. The basalts in the lower part (below 550 m) are notably pale in colour due to sericite-carbonate alteration, and resemble some of the altered pale basalts in the Hellyer area (Corbett and Komyshan, 1989). No obvious correlate of the dacites and epiclastic breccias of the Que–Hellyer host sequence can be seen. The base of the basalt has an abrupt contact on a pumiceous volcaniclastic breccia.

CORRELATES OF QUE RIVER SHALE, SOUTHWELL SUBGROUP AND MT CHARTER DOLERITE IN DRILL HOLE MXRD-1

A 50-metre thick unit of black pyritic shale in MXRD-1 (from 305 to 355 m) directly overlies the Que–Hellyer Volcanics correlate, and is therefore likely to be equivalent to the Que River Shale (fig. 6). The shale unit is massive to poorly bedded, and lacks obvious greywacke interbeds. Pyrite framboids up to 20 mm across are scattered through the unit. The contact with the underlying basalt is marked by a 3-metre thick unit of epiclastic breccia containing clasts of both felsic and mafic volcanics in a shale-rich matrix.

The shale unit was not intersected in any of the other drill holes, and has not been recognised on the surface. Its interpreted sub-Tertiary position is shown on the sub-basalt map (fig. 19).

Between the black shale and the base of the Tertiary sediments at 185 m is a sequence of some 120 m of felsic volcaniclastic and sedimentary rocks with an intercalated dolerite sill 67 m thick (fig. 6). The sequence is correlated with the lower part of the Southwell Subgroup. The lower 12 m of the sequence (below the dolerite) comprises a varicoloured volcaniclastic mass-flow unit with clasts of green pumice and pink lava in a quartz-feldspar-rich matrix. The basal part of this unit contains clasts and intercalations of shale and siltstone. Above the dolerite, the upper 40 m of the sequence consist predominantly of interbedded siltstone and greywacke, with graded bedding indicating up-hole facing.

The dolerite sill is medium grained, and has well preserved chilled margins at the top and bottom contacts. Carbonate-filled amygdales, up to 10 mm across, are present near the upper contact. The rock is massive, pale greenish grey in colour, and fairly fresh. A thin section (J844) from the middle part of the sill shows an intergranular texture, with sub-radial laths of sericitised plagioclase (to 1 mm) surrounding subhedral to anhedral pyroxene (augite) grains (to 0.5 mm). Scattered small pools of chlorite, with associated quartz in some cases, probably represent original interstitial glass.

The dolerite is petrographically similar to the bodies of dolerite which intrude the Que River Shale and lower Southwell Subgroup in the Mt Charter–Hellyer area (Corbett and Komyshan, 1989), and is tentatively correlated with those dolerites.

MIXED SEQUENCE OF VOLCANICS AND SEDIMENTS IN THE LEVEN RIVER–RING ROAD AREA (€dts)

A complex mixed sequence of felsic tuffs and epiclastics, greywacke, shale and lava crops out at the Ring Road and in adjacent sections of the Leven River. The sequence abuts the micaceous greywacke unit to the west, and has a gradational, probably interfingering boundary with the overlying pumice tuff sequence to the east. Similar sequences occur to the south as far as Hodgetts Road, and have in part been included with the upper pumice sequence.

The mixed sequence is generally similar to the lower and middle parts of the Southwell Subgroup of the Cradle Mountain Link Road area, but parts of it are also similar to the lower vitric tuff sequence below the Animal Creek Greywacke. The sequence dips and faces east for the most part, but a disturbed zone of steep dips interpreted as an anticlinal structure has been mapped in the Leven River at DQ042117. To the west of this, the bedding dips steeply west and faces west for several hundred metres to the contact with the greywacke sequence.

A partial section of the sequence is exposed along the southern Ring Road from the Leven River bridge. Here, a thin black shale is overlain by a graded greywacke bed containing rip-up shale clasts. This is followed by quartz-phyric vitric-crystal tuff containing pyrite blebs up to 100 mm across. Overlying this is a flow-banded rhyolitic lava (J108 from DQ044120) containing embayed quartz phenocrysts in a carbonate-sericite-altered spherulitic groundmass. A sequence of vitric tuff and quartz-phyric tuff follows the lava. Above this, on a corner in the road, is a silicified quartz-feldspar porphyry (J106a, b, c from DQ044118), which is brecciated, carries shale inclusions, and is cut by later pyrite and hematite veins. Higher in the sequence occur felsic mass-flow breccia, feldspar-phyric lava and micaceous greywacke. A similar variety of rock types was mapped in the Leven River.

A large plug-like body of metadolerite, with associated mafic dykes, intrudes the upper part of the sequence and is described in a later section.

CARBONATE ALTERATION IN THE MIXED SEQUENCE

Petrographic work on the mixed sequence rocks revealed that an extensive zone of carbonate alteration was present in the Ring Road area, and smaller zones in the Upper River Road area (fig. 7). Alteration and replacement by carbonate was present in sedimentary, volcaniclastic and igneous rock types. The carbonate occurs as a replacement of groundmass, matrix and phenocrysts; as alteration of phenocrysts; with quartz as vein-infillings; and as detrital grains.

At the Leven River bridge (DQ044122) a quartz-feldspar-hornblende-phyric rock (J050) shows unusual pseudomorphing of amphibole by quartz and carbonate. The pseudomorphs have the habit and cleavage of amphibole, with opaque minerals preserving the cleavage. It appears that alteration to quartz and

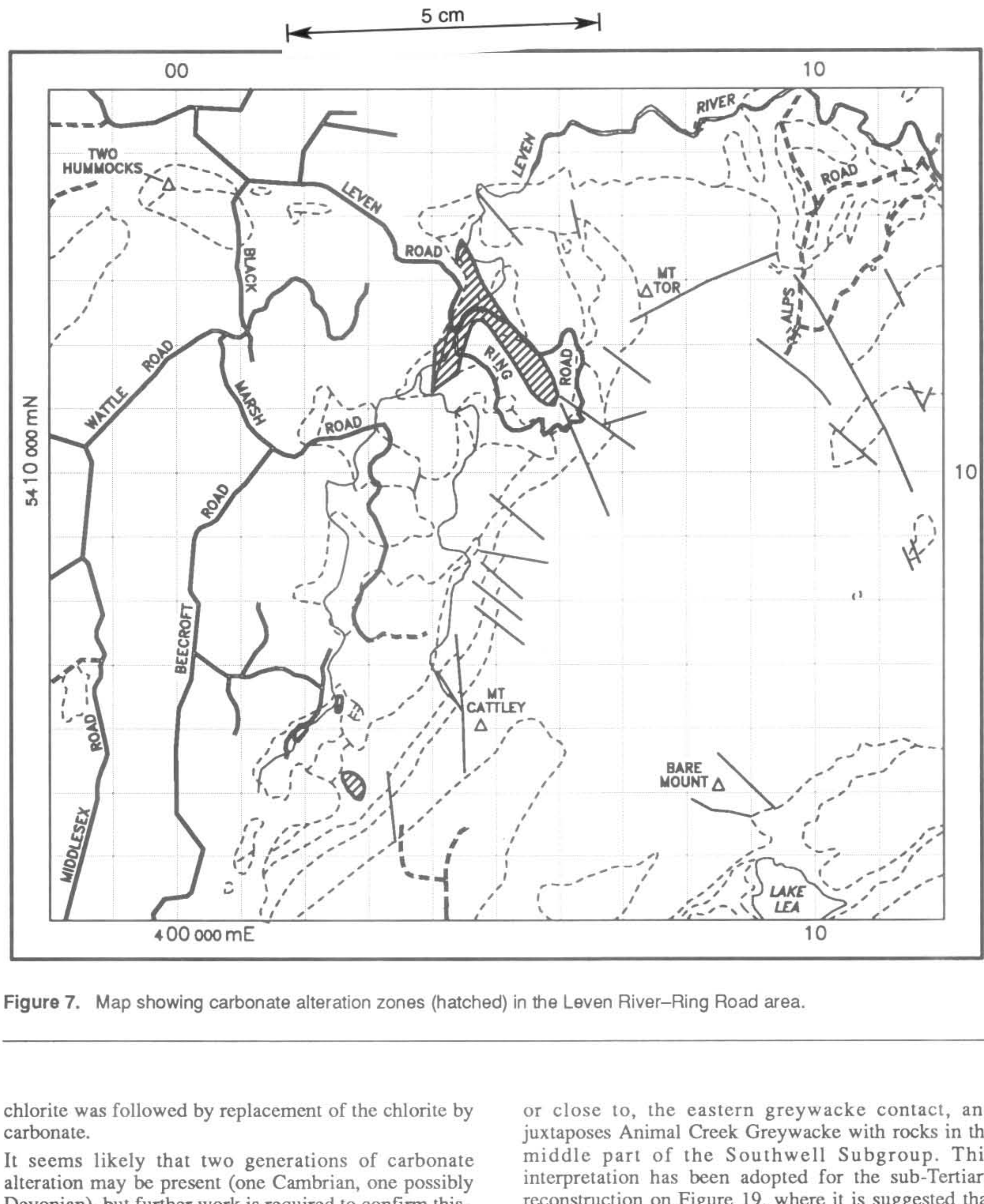


Figure 7. Map showing carbonate alteration zones (hatched) in the Leven River–Ring Road area.

chlorite was followed by replacement of the chlorite by carbonate.

It seems likely that two generations of carbonate alteration may be present (one Cambrian, one possibly Devonian), but further work is required to confirm this.

RELATIONSHIPS AND CORRELATION OF THE MIXED SEQUENCE

The presence of west facings and an anticlinal structure in the Leven River at DQ042117 suggests that the mixed sequence ***underlies*** the major greywacke unit. However, this contradicts the stratigraphic correlations of the greywacke with the Animal Creek Greywacke (based on drilling which shows the greywacke to be overlain by Que–Hellyer Volcanics), and the mixed sequence with the Southwell Subgroup (based on its gradational relationship with the upper Southwell pumice tuffs to the east). A second anomaly concerns the apparent absence of any equivalents of the Que–Hellyer Volcanics, and Que River Shale, *east* of the greywacke contact, although these units are well represented in the Beecroft Road–Middlesex Road drill holes.

Two possible interpretations are suggested to resolve these anomalies. The first solution is that a major fault, with significant west-side-up displacement, lies along, or close to, the eastern greywacke contact, and juxtaposes Animal Creek Greywacke with rocks in the middle part of the Southwell Subgroup. This interpretation has been adopted for the sub-Tertiary reconstruction on Figure 19, where it is suggested that the fault represents the continuation of the Henty Fault. The steep bedding and anticlinal structure in the Leven River could be related to this fault. A similar fault in approximately this position has been interpreted by Randell (1989).

The fault may lie somewhat east of the greywacke contact, in which case the mixed sequence rocks west of the fault must belong to the 'lower vitric tuff sequence' (below the Animal Creek Greywacke), a correlation quite consistent with the lithologies observed.

The second interpretation requires that the western part of the mixed sequence represents an anticlinal ridge of the lower vitric tuff sequence, with abrupt changes in facies and thickness across an anticline, such that most or all of the Animal Creek Greywacke and Que–Hellyer Volcanics disappear on the eastern flank of the structure. This is perhaps possible for the Que–Hellyer Volcanics, which are known to be lensoidal in occurrence, but seems rather unlikely for the otherwise widespread turbidite sequence of the Animal Creek Greywacke.

PUMICE-RICH TUFF SEQUENCE WITH FELSIC LAVAS (€dp)

This group of rocks crops out from north of the Ring Road to the Basin Road area, and has affinities with the upper Southwell Subgroup on the Cradle Mountain Link Road. It is characterised by a series of pumiceous mass-flows, which are interbedded with feldspar-phyric lavas in its upper half.

Outcrop is best seen on the northern loop of the Ring Road, where a minimum of five mass-flows was recognised, with an average thickness of 80 m. They have a coarse base (up to cobble size) of locally-derived material which fines up to an ash and shale-rich top. A pink feldspar-phyric lava unit occurs within the sequence, and similar lava occurs as clasts in overlying mass-flow units. A typical thin section of the pumice tuff (J091 from DQ057118) has clasts of pumice, perlitically-cracked rhyolite, feldspar-phyric lava and black shale, in a sericite and carbonate-altered groundmass.

The fine-grained feldspar-phyric lavas have microlites of quartz and sericite with rare altered feldspar phenocrysts to 0.4 mm. Flow-banding is present in some of the lavas (J096 from DQ061122, plate 1c), with alternating irregular bands of sericite-rich and quartz-rich material. Vitric tuff, pumiceous tuffs and breccias are interbedded with the lavas. This upper unit is only delineated on the map in the northern Ring Road area, but later petrography showed that some units mapped to the south as vitric tuff were actually fine-grained lava. The constituents of the mass-flows indicate a proximal source and a close relationship with the eruption of the lavas.

Further to the south, this sequence crops out along Upper River Road and in the Leven River and its tributaries draining Mt Cattley. A variety of intrusives and possibly extrusives, and a lack of structural data have complicated the interpretation of the geology of this area.

In the Leven River south of Hodgetts Road, a coarse, well-graded, west-facing mass-flow breccia overlies a thick sequence of fine- to medium-grained vitric tuff and pumice-bearing tuff with minor intercalated siltstone and black shale.

In a small window in the Leven River to the north of the Basin Road quarry, an anticlinal axis is present. Pumiceous crystal-vitric-lapilli tuffs and breccias were the dominant rock type in this area, with subordinate vitric tuffs, tuffaceous greywackes and black shales.

A black shale and micaceous sandstone unit (€dg) outcrops within the pumiceous tuff units in the Leven River in the south, and in tributaries of the Leven draining Mt Cattley to the north. The unit shows cross-laminations and grading giving an easterly facing, and in thin section (V175 from DQ011042) is an immature micaceous greywacke of mixed volcanic and Pre-cambrian provenance.

SBDP hole 10 (Baillie and Green, in prep.) intersected this sequence from 248 m to E.O.H. at 321 m. An approximate thickness for the pumiceous breccia and lava sequence in the Ring Road area would be 1000 m.

VOLCANICLASTIC CONGLOMERATE SEQUENCE ('TYNDALL GROUP CORRELATES')

This sequence of purple volcaniclastic sediments, with minor interbedded tuffs, appears to conformably overlie the Southwell Subgroup and consistently dips steeply east and faces east.

Volcaniclastic conglomerates up to boulder grade occur, but pebble grade units predominate. A typical sample (e.g. J068 from DQ058106), shows poorly sorted angular clasts of low sphericity. The rock contains quartz grains which are embayed and broken, sericitically altered and zoned plagioclase grains, altered mica and ferromagnesian minerals. Lithic clast types include black shale, pumice and quartz-feldspar porphyry. A sample (J266 from DQ050079) of tuffaceous litharenite has angular, low-sphericity grains and is poorly sorted. Grains of volcanic quartz, polycrystalline Precambrian quartz, tuff, vitric ash and quartz-biotite-feldspar porphyry were identified. Similar samples from the upper part of this sequence indicate an increasing contribution from a Precambrian provenance up-sequence. Most thin sections cut from lithologies in this sequence show clasts of quartz-feldspar-biotite± hornblende porphyry, with the Bonds Range Porphyry to the east being the most likely source.

The sequence thickens from about 300 m in the south to 600 m in the north.

BLACK BLUFF RANGE WINDOWS

CATTLEY CREEK WINDOW

This is the largest of three Cambrian inliers exposed beneath Denison Group siliciclastics in the southern part of the Black Bluff Range, and its position straddles the boundary between map sheets 7 and 8. It is located in the head waters of Cattley Creek [DQ065033] on the north-western slopes of Prospect Mount.

The rocks exposed in this window have been subdivided into two mappable units. A predominantly volcaniclastic sequence (€wvc) occurs in the western third of the window, and this is flanked to the east by an extensive sequence of quartz-feldspar-phyric flow rocks (€ww). A thin andesitic lava or intrusive body occurs within the volcaniclastic sequence.

Volcaniclastic sandstone, breccia and conglomerate (€wvc)

A complex sequence of volcaniclastic sandstone, breccia and conglomerate, with minor volcanic rocks, was mapped in the western third of the Cattley Creek window. The volcaniclastic sediments consist of subangular to subrounded granule to pebble-sized clasts of fine-grained pink lava and porphyry in a medium-sand to granule-sized matrix of broken subangular quartz grains, 1–2 mm in diameter, and fine-grained sericite. The rocks are generally strongly cleaved, and are usually hematitic near contacts with the overlying Denison Group. Elongate vitric tuff fragments up to 0.3 m were recorded in the coarser breccias. Graded volcaniclastic sandstones are commonly interbedded with the conglomerates, and local scoured bases were observed on some beds.

Near the contact with the overlying Denison Group, network-like quartz and jasper veins are common, and the rocks have a strong angular breccia texture. Pink and white compositional bands, 50–100 mm thick, were observed in one outcrop at DQ057032.

Samples V198 [DQ058034] and V192 [DQ057034] are pumice-bearing crystal-vitric-lapilli tuffs. Both exhibit a strong cleavage and have flattened sericitised pumice fragments, up to 200 mm, in a fine-grained quartz- and feldspar- (now sericite) rich matrix. Some of the quartz grains show embayments. Hematite, pyrite and brown mica are also present.

Samples V194 [DQ057031] and V197 [DQ059033] resemble the flow rocks (€ww) which crop out in the eastern portion of the window. Sample V194 consists of large embayed and fractured quartz crystals, up to 2 mm,

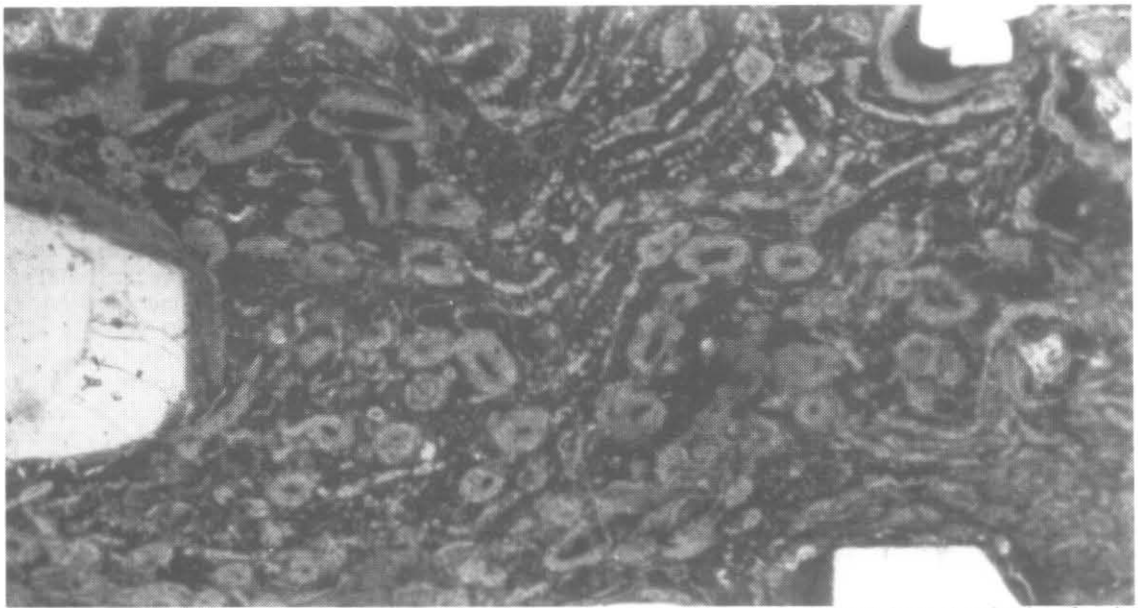


Plate 2a. Photomicrograph of flow-textured quartz-feldspar porphyry (sample V197) from the Cattley Creek window. Note prominent devitrification-spherulitic texture developed around small grains, coalescing in places to form irregular bands. Similar devitrification structures are developed around the quartz phenocrysts. Field of view 4.3 × 2.2 mm; plane light.

Plate 2b. Part of outcrop showing large quartz-feldspar-phyric clasts in fine-grained, pale tuffaceous siltstone, in quarry near Cradle Mountain Link Road (DP088985). Note the irregular shapes and diffuse, feathered margins of the clasts, with inter-penetration of the siltstone matrix. Note inter-folded siltstone layer at top right, indicating soft-sediment deformation associated with emplacement of clast. Lens cap at top right is 50 mm across.

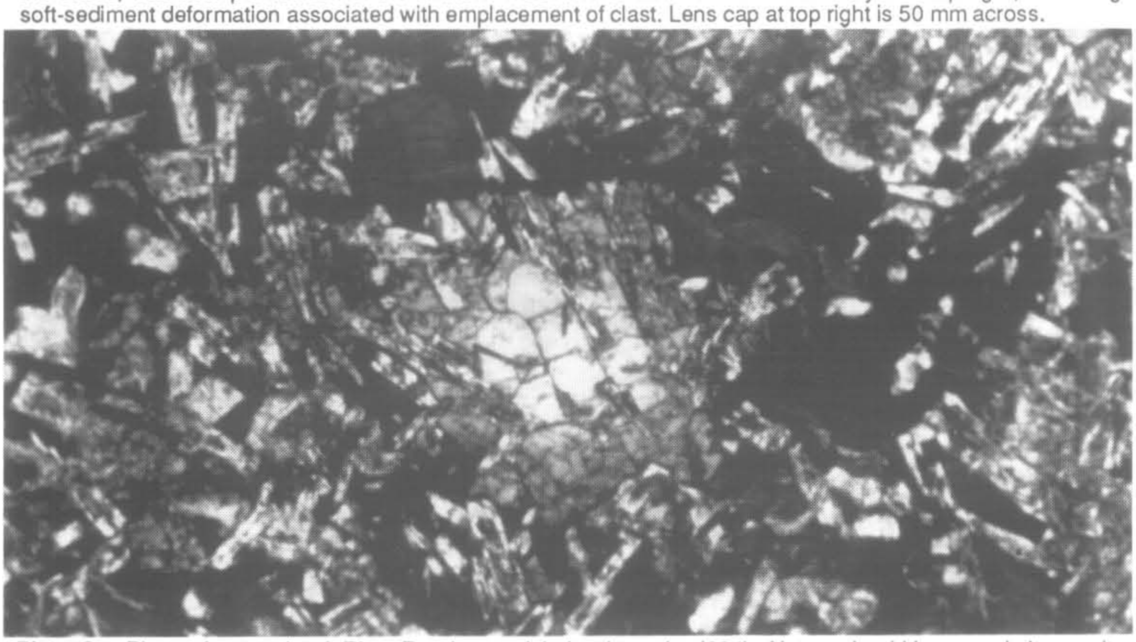


Plate 2c. Photomicrograph of Ring Road metadolerite (sample J034). Note subophitic, zoned titanaugite phenocryst in centre, in groundmass of sericitised feldspar laths and opaque leucoxene. Patches of dark chlorite may represent pseudomorphed pyroxene or a replacement of interstitial glass. Field of view 4.3 × 2.2 mm; plane

and some feldspar crystals, in a fine hematitic, possibly recrystallised, groundmass with abundant perlitic cracks. Flow-like textures are present around some phenocrysts, and on weathered surfaces a brecciated texture, with clasts up to 0.5 mm, is displayed.

Sample V197 (plate 2a) is a flow-banded quartz-feldspar-phyric rock. In thin section, the flow-banding is clearly evident due to the development of small (≈0.02 mm) devitrification spherulites along the banding. When the density of the devitrification centres is intense, the spherulites may coalesce and form continuous devitrification bands. These bands may be seen to wrap around the phenocrysts. Chlorite and sericite occur as thin irregular bands between each devitrification front. Larger spherulites (lithophysae?), up to 0.5 mm, are also present in the groundmass and are characterised by a core zone of chlorite and minor opaque oxide, giving the 'doughnut' appearance seen in Plate 2a. Irregular zones of devitrified groundmass commonly form thin rims around phenocrysts. Probable welded shard textures are evident in this rock, suggesting that the majority of the 'flow rocks' are probably welded ignimbrites rather than lavas.

Quartz-feldspar-phyric lavas and associated rock types (€ww)

A sequence of distinctive massive quartz-feldspar-phyric, and minor feldspar-phyric, flow rocks was mapped in the eastern and central regions of the Cattley Creek window. On Map 8 (Pemberton and Vicary, 1988) these rocks were designated as a sequence of predominantly welded ash-flow tuffs, but it is possible that some examples are flow banded lavas.

Sample V199 [DQ063033] is typical of the flow rocks. It consists of large subrounded quartz crystals, up to 3 mm in diameter, with straight extinction and embayed margins. Feldspar occurs as subhedral crystals, up to 2 mm, and is partially replaced by sericite. It may occur on its own or as glomerocrysts of two or three crystals. Some feldspar phenocrysts exhibit granophyric intergrowths with quartz, either at the rims or throughout the grain. In plane polarised light there is a distinct flow-type texture developed in the groundmass that may be observed to flatten and wrap around phenocrysts. In cross-polarised light this texture is masked by the development of snowflake texture due to devitrification of the glassy groundmass.

Sample V201 [DQ068038] is a flow rock with a very glassy and hematitic groundmass. The flow texture is very well developed but less uniform than Sample V199. Close inspection reveals that the rock has a poorly developed breccia texture. Quartz grains are broken and fractured into many fragments, and there are many microfractures present in the fine groundmass. Feldspar occurs as sericitic grains up to 2 mm. This rock is texturally similar to V194 from the volcaniclastic sequence to the west.

Three samples (V203, V226, V227) from the extreme eastern corner of the Cattley Creek window are probably lavas, two being feldspar-phyric while V203 is quartz-feldspar-phyric. These rocks lack obvious primary flow banding, and have a strongly recrystallised groundmass of quartz and sericite. Snowflake texture is not preserved.

Andesite lava or intrusive (€wa)

A small northerly-trending andesite body was mapped at approximately DQ059032. Field relationships and subsequent thin section examination failed to resolve whether the body is an intrusive or a lava flow.

In thin section, samples V195 and V196 [DQ059032] consist of pseudomorphed ferromagnesian phenocrysts in a fine-grained snowflake-textured groundmass. Plagioclase can occur as solitary or glomeroporphyritic subhedral crystals, 0.3 mm to 0.6 mm in diameter, pervasively altered to sericite with minor chlorite and secondary quartz. Zoning is present in some crystals.

Relict ferromagnesian minerals occur as subhedral (six-sided prisms) to anhedral crystals up to one millimetre in diameter. Very little original texture is preserved, as grains have been totally replaced by chlorite, with minor hematite and carbonate. Faint 120° cleavage or parting was observed in one crystal, and may suggest that hornblende is the primary ferromagnesian mineral present. Opaque oxides are common within and adjacent to the chlorite pseudomorphs.

Apatite is a common accessory mineral and occurs as small inclusion-rich subhedral prisms up to 0.9 mm. The length of the prisms is usually about three times that of the width. Apatite was also observed as an inclusion in pyrite.

Sparse subrounded quartz grains, up to 0.2 mm, were also observed, but quartz is more common as an alteration product in the groundmass.

Snowflake texture is variably preserved in the groundmass. Major groundmass phases include sericite, quartz, chlorite and opaque oxides, with minor carbonate and hematite.

CAMBRIAN WINDOW NEAR CRADLE MOUNTAIN LINK ROAD

This window is 1.5 km long and 500 m wide, and is located about 500 m south-west of Prospect Mount and about 400 m NNW of the highest point of the Cradle Mountain Link Road on the Black Bluff Range.

Two distinctive lithologies were mapped in this window: quartz-feldspar-phyric flow rocks (€ww) in the western half, and pumice-bearing tuffs (€wpt) in the eastern portion.

Quartz-feldspar-phyric flow rocks and associated rock types (€ww)

Rocks which occur in the western half of the window are texturally and mineralogically identical to rocks described from the Cattley Creek window to the north.

Sample V237 [DQ053013] has large subrounded, embayed quartz crystals, up to 4 mm in diameter, and sericitic plagioclase crystals up to 3 mm. The groundmass shows faintly developed 'flow-type' texture in plane-polarised light, and patchy snowflake texture in cross-polars. Quartz crystals are often surrounded by a thin reaction rim, up to 0.2 mm wide. Flow-type textures are not as well developed in V238 [DQ050013], and quartz grains are less rounded and not as embayed. Some grains show slight fracturing.

Sample V239 [DQ051014] is a breccia with clasts to 60 mm. It consists of large subangular to subrounded, partially embayed and fractured quartz grains in a recrystallised groundmass of quartz and sericite.

Pumice-bearing vitric tuff sequence (€wpt)

A complex sequence of pumice-bearing vitric and crystal tuffs, with interbedded lavas and volcaniclastic sandstones, was mapped on the eastern side of this window.

Sample V235 [DQ054012] is a pumice-bearing vitric-crystal-lapilli tuff and is typical of the majority of pumice tuffs within this unit. In hand specimen it consists of abundant light coloured feldspar laths, up to 3 mm long, set in a fine-grained dark green chloritic matrix. Intensely chloritic patches up to 10 mm long occur and may represent pumice fragments. In thin section the feldspar laths are highly sericitic, and small subangular quartz grains are also present. The matrix is composed of flattened sericitic pumice fragments, up to 10 mm long, and fine-grained devitrified glass, now altered to sericite and chlorite. Samples V232 [DQ054011] and V242 [DQ059023] are additional examples of pumice-bearing tuffs.

Volcaniclastic sandstones are the most abundant rock type in the extreme south-eastern corner of the window. Although they may appear similar to pumice-bearing tuffs in hand specimen, they are readily distinguished in thin section by the abundance of volcanic-derived rock fragments. Minor Precambrian-derived quartzite clasts, up to 7 mm in diameter, are also present.

Sample V231 [DQ054011] is a poorly sorted coarse sandstone, and contains detritus from both Cambrian and Precambrian sources in a fine-grained vitric and sericite groundmass. Volcanic-derived clasts include quartz-feldspar-biotite porphyry and feldspar-phyric snowflake-textured lava. Volcanic quartz grains and subhedral feldspar grains are also present. The quartz grains have straight to slightly undulose extinction, and are subangular to subrounded. Highly fractured quartz grains are common.

Sample V244 [DQ060024] is a very fine-grained tuffaceous sandstone. It is composed of subangular quartz grains up to one millimetre in a fine-grained vitric matrix. A brecciated texture is evident in thin section. The rock is hematitic due to oxidation at the contact with the Denison Group.

Sample V233 [DQ054012] is a snowflake-textured feldspar-phyric lava. Feldspar occurs as irregular shaped masses, up to 4 mm long, and is replaced by sericite. Small patches of coarsely crystalline quartz may represent amygdales. Variations in the size of the snowflake domains in the groundmass may suggest that the lava is autobrecciated. Other examples of similar lavas from this window are V234 [DQ053012] and V243 [DQ059023].

MACKINTOSH CREEK WINDOW

The southernmost and smallest Cambrian window on the Black Bluff Range is located approximately one kilometre north-west of Mt Beecroft [DP038980], in the headwaters of Mackintosh Creek.

Sample V212 [DP039981] is typical of the flow rocks which form the dominant rock type in this window. In thin section it consists of subhedral to subrounded, slightly embayed quartz crystals with straight extinction, up to 4 mm in diameter. Some quartz crystals have been broken and have slightly undulose extinction. Plagioclase is present as subhedral crystals, up to 2 mm long, and may have partial granophyric development. The groundmass consists of discontinuous bands of variably coloured devitrified glass. Such bands commonly wrap around large crystals and are indistinct in cross polarised light due to snowflake texture development. These rocks are texturally and mineralogically similar to the flow rocks from the previously described windows.

PATRICKS CREEK WINDOW

An extensive Cambrian window is exposed beneath Denison Group siliciclastics on the north and north-western slopes of Black Bluff. It extends from the headwaters of Tor Creek [DQ105105] across a major NW fault zone to an unnamed creek [DQ120130] on the northern slopes of Black Bluff.

Preliminary mapping in this area has identified an extensive volcaniclastic sedimentary sequence (€wc) and an undifferentiated tuffaceous sequence (€wu). Additional mapping of this window was performed during the 1988–1989 field season (Pemberton and Vicary (1989)).

Volcaniclastic conglomerate and sandstone (€wc)

The volcaniclastic sequence consists of interbedded volcaniclastic conglomerate, sandstone and siltstone with minor interbedded vitric tuff units. Petrographic examination of rock samples from this unit reveals that the volcaniclastic units can be subdivided into two distinct types, depending on the relative abundance of quartz grains in the sample.

Samples V269 [DQ107109] and V270 [DQ107109] are granule to pebble-grade, clast-supported volcaniclastic conglomerates. In thin section they consist mainly of subrounded clasts of vitric tuff, snowflake-textured lava, tuffaceous sandstone and possible welded tuff, up to 10 mm in diameter. Precambrian-derived quartzite clasts are also present. Subrounded to subangular quartz grains up to 0.7 mm are common, and there is little feldspar detritus. Detrital (?) pyrite grains up to 0.4 mm also occur. Sericitisation and carbonate alteration in interstices occurs, and there is selective replacement of some volcanic-derived clasts by chlorite.

Sample V263 [DQ113119] is a quartz-poor coarse-grained volcaniclastic sandstone. It consists of fine-grained vitric tuff clasts and minor snowflake-textured lava clasts in a sericitic matrix. Detrital feldspar and quartz grains are present but are low in abundance. Secondary quartz is present as a replacement mineral in volcanic clasts. Samples V267 [DQ118126] and V268 [DQ119127] are shown on Map 8 as belonging to the undifferentiated sequence. In thin section these rocks are petrologically similar to V263, although both have a strongly developed cleavage. Strongly flattened quartz-feldspar porphyry clasts, up to 0.4 m long, were recorded in these rocks.

Closely associated with the quartz-rich volcaniclastic sandstones and conglomerates are fine-grained, light grey vitric-crystal-lithic tuffs (e.g. sample V271 [DQ107110]). In hand specimen, pale coloured lithic clasts up to 10 mm are present, and light brown mica flakes up to 2 mm are quite abundant. Small white sericitic feldspar laths (<1 mm) are also present. In thin section the matrix is highly sericitic, and poorly preserved shard textures are evident. The rock contains about 5% opaque oxides. Ragged elongate biotite crystals with visible basal cleavage have been pseudomorphed by hematite and leucoxene. Subhedral grains of pyrite, partially replaced by hematite, are also present.

Undifferentiated tuffaceous rocks (€wu)

This sequence of rocks is poorly defined and consists of crystal-vitric-lithic tuffs and volcaniclastic sediments.

In thin section the tuffs consist of abundant crystals of quartz and plagioclase in a fine matrix of devitrified glass. Shard textures are not evident. Samples V265 [DQ117124] and V266 [DQ117125] are characterised by abundant subrounded and embayed quartz grains, up to 2 mm, and subhedral plagioclase, partially altered to chlorite. Sample V264 [DQ115119] is feldspar-rich and has a more sericitic matrix than V265 and V266. Sericitic alteration and carbonate replacement are common in all slides from this window, and pyrite is concentrated along the margins of thin (up to 3 mm) carbonate and chlorite veins in Sample V264. Lithic clasts up to 5 mm may occur. Three types of clasts were recognised: fine-grained feldspar-phyric lava, snowflake-textured quartz-phyric lava, and welded quartz-feldspar-phyric tuff.

CAMBRIAN WINDOW SOUTH-WEST OF BLACK BLUFF

A small window of Cambrian volcanics crops out beneath Denison Group siliciclastics in a small area about 1.5 km south-west of Black Bluff [DQ118090]. The volcanics are predominantly quartz- feldspar-phyric flow rocks with minor tuffaceous sandstone (J290). The flow rocks are characterised by large quartz and feldspar phenocrysts, up to 4 mm, in a fine-grained spherulitic groundmass. Brecciation of the groundmass was clearly evident in sample (J288). The rocks are texturally and mineralogically similar to rocks described in the Cattley Creek, Cradle Mountain Link Road and Mackintosh Creek windows.

Subsequent mapping of this window (Pemberton and Vicary 1989) has revealed that the unit of volcaniclastic sandstones and conglomerate (€wc on Map 8) which overlies the flow-rock sequence (€wpt) probably represents the basal part of the overlying Denison Group.

VALE RIVER 'WINDOW'

A small area of undifferentiated Cambrian volcanic rocks occurs near the Vale River at approximately DP052972. The rocks are overlain by Denison Group siliciclastics to the west, and are in contact with Bonds Range Porphyry to the east. Outcrops from this window have been described by Herrmann (1984) as acid quartz crystal and lithic tuffs that are often hematitic. Chloritic tuffs containing magnetite were also reported.

Four rock samples were collected from a brief reconnaissance visit to this window. Samples V275 and V276 [DP053973] are both hematitic vitric-crystal tuffs. In thin section they contain subrounded crystals of embayed quartz up to 3 mm in diameter. The groundmass is fine-grained and composed of sericite (after glass?) and hematite. Lithic clasts (up to 5 mm) may be present and are volcanic-derived. Snowflake-textured lavas are the most common clast type. Sample V275 also contains some texturally modified quartzite-like clasts which may in fact be volcaniclastic sandstones. In both samples the high degree of hematite alteration precludes positive identification. Such alteration is common near the contact between Cambrian rocks and the overlying Denison Group siliciclastics.

Sample V277 [DP053973], from near V275 and V276 shows a pronounced breccia texture in thin section, with quartz grains, up to 4 mm but commonly less than 2 mm in diameter, in a fine-grained glassy groundmass in which snowflake texture is poorly developed. Highly altered feldspars, up to 2 mm, irregular chlorite patches (possibly after hornblende), and relict biotites are also present. This rock may represent a brecciated chilled margin of the Bonds Range Porphyry or a small intrusion of the same magma into the vitric-crystal tuff sequence. Despite a lack of brecciation, sample V146 [DP075970], from near the contact between the Bonds Range Porphyry and the Back Peak Beds in the Etchells Creek area, is texturally very similar to this sample, and is also considered to be a chilled margin of the large porphyry body.

Sample V278 [DP053974] is a welded crystal-vitric lithic tuff which is unlike either V275 or V276. It consists of large embayed quartz and sericitic feldspar crystals, up to 3 mm, in a fine-grained sericitic matrix with relict shard textures, up to 0.1 mm long. Shards are often flattened against the margins of phenocrysts. Lithic clasts include snowflake-textured quartz-feldspar phyric lava, up to 6 mm in diameter.

Samples V275, V276 and V278 are quite distinct from rocks that make up the Back Peak Beds (see Section 2.3.5.2), and may represent a stratigraphically higher unit if the Bonds Range Porphyry is considered to be a sill-like intrusive body.

BONDS HILL WINDOW

A small window of Cambrian rocks occurs 800 m north-west of Bonds Hill in the core of an anticline. It exposes a sequence of quartz-rich tuffs and tuffaceous sandstones. Samples (J282 to J285 from DQ099020) have subhedral and embayed quartz grains, altered feldspar, biotite and zircon in a fine reworked groundmass of angular quartz and sericite. These rocks are closely related compositionally to Bonds Range Porphyry, which crops out to the north and east, and may largely have been derived from weathering of that body.

A bed of tuffaceous sandstone and breccia was mapped with a strike conformable to the base of the Denison Group but with steeper dips.

BACK PEAK AREA

CORRELATE OF STICHT RANGE BEDS (€srb)

A thin sequence of quartzite, sandstone, granule conglomerate and minor siliciclastic breccias unconformably overlies Precambrian quartzites, schists and phyllites in the Sumer Spur–Speeler Creek area. The sediments have been correlated with the Sticht Range Beds previously mapped in the Lake Dora–Mt Murchison area (Corbett and Jackson, 1987; McNeill, 1987; Baillie, 1989*a*).

The sequence reaches a maximum thickness of approximately 500 m on Sumer Spur, and thins to the north where it is discontinuous. Interbedding between the Sticht Range Beds and the Back Peak Beds was observed at a number of places. Thickness variations in the Sticht Range Beds appear to be fault related in the Sumer Spur area.

Typical outcrops consist of thinly-bedded, pale grey to white, fine- to medium-grained quartz sandstone with few obvious sedimentary structures. Close blocky jointing is common, leading to extensive scree development. Thin interbeds of brown micaceous siltstone occur in some areas. A basal conglomerate or breccia rich in Precambrian-derived clasts is present in some areas, and minor granule- to cobble-grade conglomerate beds, up to 2 m thick, were noted within the sequence at Speeler Creek.

Sample V109 [DP032900] is a medium-grained quartz sandstone with a pale pink colouration due to hematite staining. It is typical of the sandstone units of the Sticht Range Beds. In thin section it consists of 95% subrounded quartz grains with undulose extinction and corroded margins. Minor muscovite, blue-green to pale green pleochroic tourmaline, and polycrystalline quartz clasts are also present. The rock is grain supported and moderately well-sorted. It appears to be predominantly derived from adjacent Precambrian quartzites and schists.

Sample V112 [DP032902] is a medium-grained quartz sandstone from near the top of the Sticht Range Beds in the Sumer Spur area. In thin section it consists of 95% subrounded quartz grains with undulose extinction, together with minor muscovite, tourmaline and polycrystalline quartzite fragments. In all respects it is similar to V109 however these two samples are separated by approximately 100 m of interbedded fine-to coarse-grained tuffaceous sandstone correlated with the Back Peak Beds. This suggests that the contact between the Sticht Range Beds and the Back Peak Beds is gradational, and that as one moves upwards through the section the predominantly Precambrian-derived lithologies of the Sticht Range beds are gradually replaced by the more volcanic-derived lithologies of the Back Peak Beds.

Samples V142 and V143 [DP076963] come from near the Cambrian–Precambrian contact exposed in Speeler Creek. Both are matrix-supported granule to pebble-cobble conglomerate, and contain both Precambrian and volcanic-derived detritus. Precambrian quartzite and schist occurs as subangular to subrounded clasts characterised by polycrystalline quartz with consertal grain boundaries, triple point junctions and oriented muscovite flakes. Phyllitic rock fragments are more irregular in shape.

Volcanic-derived lithic clasts are petrographically similar to the adjacent vitric tuffs and tuffaceous sandstones of the Back Peak Beds. Minor shard-bearing welded tuff clasts were also observed. Volcanic-derived monocrystalline quartz grains, up to 1.5 mm in diameter, are common. They are subangular to subrounded in shape and have straight extinction in cross polarised light, although slightly undulose extinction is present in some grains. Highly sericitic feldspar laths up to one millimetre are also present.

The matrix of the conglomerate is an irregular mixture of sericite, chlorite, quartz, mica and rare zircon, and most probably contained a high proportion of reworked glass shards together with minor Precambrian and volcanic detritus. It is very similar to the matrix material common in Back Peak Bed lithologies.

Sample J280 [DP076963] is a clast-supported conglomerate and is predominantly composed of Precambrian detritus. No volcanic detritus was observed in this sample.

BACK PEAK BEDS (€bp, €bpp)

A complex sequence of quartz-feldspar-rich vitric tuffs, cherty siltstones, tuffaceous sandstones and minor mass-flow breccias occurs as an extensive belt trending around the margin of the Precambrian from near Mt Remus [DP011902] to Sunshine Creek [DP115982]. It is intruded on the western side by the Bonds Range Porphyry (€qfbp), and is interbedded with, but generally stratigraphically higher than, the Sticht Range Beds (€srb) to the east. About one kilometre NNW of the Heap of Rocks [DP064942], and between Etchells Creek [DP076967] and Black Bog Creek [DP100970], it is in direct contact with Precambrian phyllites and schists. The true thickness of this sequence is unknown but a total exposed thickness of about one kilometre is present on Sumer Spur and in the Iris River area. The thickness is variable along strike, and a minimum exposed thickness of about 100 m is recorded at DP064942.

Burns (1963) proposed the unofficial name 'Sumer Group' for the same sequence of rocks, but since the exact stratigraphic boundaries and position of the sequence are not known, a less formal name, the Back Peak Beds, is used here. Burns also correlated the Sumer Group with the Precambrian Rocky Cape Group. In view of the high volcanic content to these rocks, their clear affinities with the Mt Read Volcanics, and their relationship with the underlying correlate of the Sticht Range Beds, such a correlation is unwarranted.

The Back Peak Beds are a complex sequence of volcanic and predominantly volcanic-derived sedimentary rocks. Since lack of exposure and time prevented the establishment of a detailed stratigraphic section, discussion will be aimed at describing the major lithologies.

Fine-grained vitric-crystal tuff

Samples V133 [DP040915] and V253 [DP104978] are fine-grained vitric-crystal tuffs, and represent a major rock type of the Back Peak Beds. In hand specimen both are massive fine-grained dark grey rocks with a glassy or cherty groundmass and abundant medium-sand-grade (<0.5 mm) quartz grains. They have a conchoidal fracture when broken, and have a 5–10 mm light grey to white bleached rind on weathered surfaces.

In thin section, sample V253 consists of 10–15% angular to subrounded quartz crystals with straight or slightly strained extinction. Grain boundaries can vary from irregular and diffuse to straight and distinct. Feldspar is partially replaced by sericite and makes up between 2–5% of the rock. In plane polarised light the matrix is dominated by well preserved cuspate glass shards up to 0.2 mm.

Sample V133 is similar to V253 but has slightly larger quartz and feldspar grains, and a coarser-grained matrix which has more sericite, chlorite and minor leucoxene alteration. In plane-polarised light, the shard textures clearly evident in V253 have been completely masked by the increase in groundmass alteration.

The above two rock samples have been interpreted as being tuffs, with a primary pyroclastic origin, but an alternative explanation is that they are immature tuffaceous sandstones deposited by epiclastic processes. However, they lack obvious bedding features, and appear not to contain any Precambrian detritus. Some polycrystalline quartz grains are present in both V253 and V133, but these grains appear to be secondary quartz replacement of pre-existing grains, or clasts of unknown type, rather than Precambrian-derived detritus.

Medium-grained pumice-bearing crystal-vitric-lithic-tuff

Medium-grained crystal-vitric-lithic lapilli tuff is a coarser grained equivalent of the fine-grained vitric crystal tuff and also constitutes a major lithology of the Back Peak Beds. There are four main types.

Sample V115 [DP029904] is a pumiceous crystal-vitric-lithic tuff. In thin section it is composed of subrounded to subangular quartz grains up to 0.8 mm in diameter. Some quartz grains appear to be broken, and extinction can vary from straight to slightly undulose. Highly sericitic feldspar grains up to 0.8 mm are also present. The groundmass is predominantly devitrified glassy material. In cross polarised light a highly irregular sericitic pattern is developed. Many of the sericitic patches resemble pumice fragments, some of which are up to 10 mm in length. Lithic clasts are rare except for a few snowflake-textured lava clasts, up to 4 mm.

In hand specimen, sample V134 [DP039916] is a grey rock with a cherty matrix and abundant quartz and feldspar grains up to 2 mm. Dark chloritic pumice clasts up to 15 mm are present. In thin section the matrix consists of abundant well preserved glass shards, and some pumice-like textures are present. The rock is a pumice-bearing crystal-vitric tuff.

Lithic-rich varieties occur, but are not abundant. Sample V258 [DP093973] consists of a variety of lithic fragments but no pumice clasts were observed. In many respects it resembles some of the basal conglomerates and breccias of the Sticht Range Beds, and consists of a mixture of Precambrian quartzite clasts, juvenile volcanic quartz and feldspar grains, quartz-feldspar-biotite-phyric hematitic welded tuff clasts, and clasts of Back Peak-type vitric tuffs.

Vitric tuff

Very fine-grained cherty vitric (crystal) tuff is another common rock type of the Back Peak Beds. Although such tuffs are present south of Back Peak, they are most abundant in the Etchells Creek–Iris River area. In outcrop they are generally somewhat cleaved, and often show bedding. This is in direct contrast to the more massive medium-grained vitric-crystal tuffs. In thin section they consist of 2–5% fine to very fine sand sized subangular quartz grains in a very fine devitrified matrix. Relict shard textures are present in some sections. In general they can be considered to be crystal-depleted equivalents of the medium-grained vitric-crystal tuffs previously described.

Tuffaceous siltstone and laminated black siltstone

Beds of fine grained grey to yellow tuffaceous siltstone and thinly laminated black siltstone occur locally within the Back Peak Beds. In thin section (samples V186, V119, and V219) the tuffaceous siltstones consist of abundant silt to fine sand sized muscovite and quartz grains in a very fine devitrified tuffaceous matrix. The muscovite grains tend to be oriented parallel to bedding.

Thinly laminated black siltstones are well exposed in the upper reaches of Anio Creek at DP032903, and in the Iris River area at DP110980 and DP083971. Sample V255 [DP110980] in thin section consists of abundant siltsize grains of quartz and muscovite in a dark matrix.

Upper sequence of vitric tuff, pumice tuff and mega-lithic vitric tuff (€bpp)

In the Iris River–Sunshine Creek area, the Back Peak Beds grade into a distinctive sequence of vitric tuff, pumice tuff and lithic-vitric tuff. Although similar to the underlying Back Peak Beds, this sequence (€bpp) is characterised by the presence of large (>1 m) quartz-phyric clasts, the nature of which will be discussed later. Minor quartzite-bearing lithic 'tuffs' were also reported. This sequence of rocks only crops out in two locations on Map 7. At DP088985, there is excellent exposure of the contact between the clast-rich sequence and the Bonds Range Porphyry, although recent infilling of the quarry has covered much of the outcrop. Similar rocks were also observed on a low ridge to the north of the Cradle Mountain Link Road at DP118991.

Plate 2b shows two of the large quartz-phyric clasts in a faintly bedded vitric tuff. Contacts between the clast and the ashy matrix can either be sharp, or feathered and gradational. At some locations, the flattened and wispy nature of the clasts resembles large pumice fragments, with distortion of the clasts due to post-depositional compaction. A thin, ≈50 mm wide, sinusoidal ash bed in Plate 2b suggests soft-sediment deformation associated with emplacement of the clasts.

In thin section the pumiceous nature of the clasts is less apparent, and the cellular internal texture typical of pumice is absent. Texturally, the clasts consist of embayed and fractured quartz phenocrysts, up to 3 mm, in a fine-grained (≈0.04 mm), interlocking mosaic of quartz and sericite. Each quartz phenocryst is surrounded by a thin (≈0.1 mm wide), halo of very fine quartz mosaic groundmass which is noticeably non-sericitic. Sparse feldspar, biotite and opaque oxide phenocrysts are also present.

The host rock for the clast-rich sequence is dominantly fine-grained tuffaceous siltstone. Shard-rich vitric-crystal tuffs were reported at DP120992. In sample V191, the contact between a clast and the tuffaceous matrix is gradational, and there is evidence to suggest some disaggregation of the clasts. The tuffaceous matrix is sericite-poor, while sericite is abundant in the clasts as an interlocking network of thin veinlets. The sericitic veinlets from the clast penetrate into the tuffaceous matrix, and the clast boundary appears gradational over 5–10 mm.

The irregular shapes and feathered edges of some of the clasts suggest that they were originally clastic rocks (i.e. tuffs or tuffaceous sediments) which were broken up and partially disaggregated before coming to rest in the fine-grained host sediments. Possible origins include some kind of mass-flow mechanism, or the sinking of water-logged pumice clasts. The absence of chilled margins on the clasts, and of evidence for hyaloclastic brecciation, suggest that a 'hot' origin (e.g. as peperitic lava flows or as intrusive effects associated with the margin of the Bonds Range porphyry) is unlikely.

Cambrian intrusive rocks

SPHERULITIC FELSIC INTRUSIVE (€ps)

The northern part of a large body of feldspar-quartz porphyry intrudes Southwell Subgroup rocks in the Murrays West Road area [CP948981]. It is bounded to the east by the Murrays Road greywacke unit (€dg), and to the west by a mixed sequence of tuffs and sediments (€dts). Komyshan (1986) mapped this unit as a northerly trending body, up to 400 m thick, that extends for over 3 km from just south of the Hellyer Portal to north of the Cradle Mountain Link Road. Recent mapping has shown that the body thins rapidly to the north and swings to a north-west trend, following an anticlinal structure.

Excellent outcrop of the porphyry may be found in the gravel quarry on Murrays West Road [CP948982]. To the north of the Cradle Mountain Link Road, outcrop is extremely poor. In hand specimen the rock is fine-grained with a light brown to pale yellow-green groundmass. Feldspar phenocrysts, up to 3 mm, are common and flow banding may be observed.

In thin section the rock consists of subhedral feldspar phenocrysts up to 2 mm in a fine snowflake-textured to spherulitic groundmass. The feldspar phenocrysts are rarely fresh, and are commonly replaced by sericite and late quartz. In sample V008 [CP949981], hematite and leucoxene replace sericitic feldspars.

Quartz occurs as rare, highly embayed phenocrysts, up to 0.7 mm, but more commonly as small irregular secondary grains, up to 0.3 mm, in the groundmass, or replacing feldspar laths. Sub-parallel alignment of feldspar phenocrysts and variations in groundmass texture may indicate flow banding.

BONDS RANGE PORPHYRY (€qfbp)

A large NE-trending body of quartz-feldspar-biotite-hornblende porphyry has been mapped from Anio Creek [CP986893] in the south to north of Bonds Hill [DQ108016]. It forms part of an extensive porphyry body that has been reported from approximately one kilometre north-west of Mt Swallow, near the Sophia River Valley, to Stormont and Lorinna in the north (Barton *et al.*, 1966 and Jennings and Burns, 1958), and has in part been termed the Bonds Range Porphyry (Burns, 1963).

The thickness of the body varies greatly and reaches a maximum exposed thickness of 3.5 km in the Tumbling Creek area [DP032940]. In the vicinity of Etchells Creek [DP070976], a major zone of NW-trending faults disrupts the porphyry and reduces its thickness to less than one kilometre. The body is steep-sided, sub-conformable to bedding in the Back Peak Beds, and appears to be an intrusive sill.

In the Mt Remus area [DP011902] the eastern margin of the porphyry body is in contact with Precambrian quartzites and phyllites. Marshall (in Collins *et al.*, 1981) noted that the contact appears to be fracture-related, and reports intrusive quartz-feldspar-biotite porphyry dykes striking subparallel to the dominant schistosity in the Devils Ravine area. Similar dykes also occur in the Mt Remus and Heap of Rocks area.

North-east of Mt Remus, the Bonds Range Porphyry is in contact with the Cambrian Back Peak Beds. The actual contact was not observed, and at the north-western edge of Sumer Spur [DP035914] thin quartz porphyry dykes intrude both the Bonds Range Porphyry and the Back Peak Beds.

On the rough track to the Fleece Creek Grid at approximately DP088970, a one metre wide body of quartz-feldspar-biotite porphyry intrudes the Back Peak Beds. It strikes 067° true, which is conformable to the dominant bedding trend in the area. Marshall (in Collins *et al.*, 1981) also reports sill-like quartz-feldspar-biotite porphyries within Cambrian sediments in the Sumer Spur area.

The Bonds Range Porphyry is bounded and overlain to the west by sandstones and conglomerate of the Denison Group except near the Vale of Belvoir [DP053972] where it is in contact with undifferentiated Cambrian volcanics and volcaniclastics.

The Bonds Range Porphyry (€qfbp) is a complex quartz-feldspar-biotite-hornblende porphyry body. It has a highly variable grain size, colour, degree of alteration and deformation, and phenocryst assemblage. When fresh it is characterised by a fine-grained reddish-brown groundmass with distinctive quartz, feldspar, biotite and/or hornblende phenocrysts. Weathered samples are commonly pale pink in colour. Highly weathered porphyry is often reddish brown in colour and somewhat resembles weathered Tertiary Basalt but is readily identified by the presence of resistant quartz grains and thin chloritised biotite flakes.

In thin section, quartz occurs as subrounded, partially embayed phenocrysts with slightly resorbed margins up to 7 mm in diameter. It can have straight or partially undulose extinction. Broken quartz grains with highly undulose extinction and carbonate replacement were observed near the contact with the Denison Group in the Etchells Creek area. Quartz phenocrysts commonly have a dusty appearance due to minute fluid inclusions concentrated along thin fractures within the crystal. Quartz is also common in the groundmass, where it occurs as anhedral grains up to 0.05 mm in diameter.

Both plagioclase and K-feldspar occur in the porphyry. Plagioclase occurs as sericitised subhedral phenocrysts up to 5 mm in diameter. It is characteristically multiply twinned in fresher samples and may show weak core to rim zoning and can occur as individual grains or as glomerocrysts. Small lath-like plagioclase crystals up to 0.05 mm are present in the groundmass. K-feldspar occurs as sparse megacrysts up to 30 mm in diameter, distinguished by simple twinning. It commonly shows evidence of late stage growth, and thin bands of fine quartz inclusions are often found within the crystal oriented parallel to crystal edges. It is often relatively fresh compared to plagioclase.

Biotite occurs as subhedral to ragged crystals up to 4 mm in diameter. It has a straw yellow to brown pleochroism and can be partially or wholly replaced by chlorite and leucoxene. Leucoxene is most common along grain boundaries and cleavage traces.

Hornblende can occur as solitary or glomeroporphyritic subhedral to euhedral phenocrysts, up to 2 mm. It is commonly partially or entirely replaced by chlorite, epidote and actinolite. It has a straw yellow to khaki pleochroism, and may be twinned.

Chlorite is always present in the Bonds Range Porphyry. It forms pseudomorphs after biotite and hornblende, and can also occur as irregular shaped masses up to 5 mm. Accessory minerals include pyrite, leucoxene, apatite and zircon.

Sample V146 [DP075970] comes from near the Porphyry–Back Peak Beds contact at Etchells Creek. In thin section it is distinct from all other samples of the Bonds Range Porphyry and has a fine-grained groundmass with poorly developed snowflake texture. Large quartz and feldspar grains and chlorite pseudomorphs of biotite and hornblende, features diagnostic of the Bonds Range Porphyry, are present. This sample is considered to be a chilled margin of the porphyry.

Samples V144 [DP069978] and V184 [DP063976] come from near the contact between the Porphyry and the Denison Group conglomerate, and shows evidence of deformation. Quartz phenocrysts are often broken and flattened and have very undulose extinction. Feldspars are totally replaced by sericite, and form irregular shaped flattened lenticles that are partially oriented with respect to the broken quartz crystals. Relict ferromagnesian minerals (possibly biotite) show deformation of mineral cleavage planes and may also show sub-parallel alignment. Sample V184 is from the actual contact between the porphyry and the conglomerate. Broken quartz grains, flattened and sericitised feldspars and kinked biotites are again present, but this rock is very hematitic due to oxidation at the contact. Bands of hematite cut across a planar fabric defined by feldspar orientation suggesting that the deformation of the porphyry occurred prior to deposition of the siliciclastics.

PORPHYRY INTRUSIVES IN THE BACK PEAK AREA (€p)

In the Back Peak–Mt Remus area quartz-feldspar porphyry dykes are intrusive into Precambrian and Cambrian sequences. They contain minor chloritised hornblende and biotite and are mineralogically similar to the Bonds Range Porphyry. It is possible that they represent ferromagnesian-depleted late stage differentiates of the Bonds Range Porphyry magma.

On the north-western slopes of Sumer Spur [DP033916], a thin 1–2 m wide flow-banded quartz-feldspar-phyric dyke with minor hornblende intrudes the Bonds Range Porphyry. In thin section the dyke consists of embayed subhedral to rounded quartz and sericitic feldspar grains, up to 3 mm, with minor chloritised hornblende, up to 2 mm, in a fine-grained snowflake-textured groundmass with an irregular network of chlorite. The Bonds Range Porphyry near the contact with the dyke shows intense chloritisation of ferromagnesian minerals, and chloritisation and sericitisation of feldspars.

Similar quartz-feldspar porphyry bodies with minor biotite and hornblende intrude the Back Peak Beds and are most common in the Sumer Spur to Heap of Rocks area. They may be up to 200 m thick, and are sub-conformable to the dominant Cambrian NE-SW strike.

In contrast, quartz-feldspar porphyry dykes intrusive into Precambrian rocks in the Mt Remus–upper Anio Creek area have a NNE to NNW orientation and are subconformable to the dominant schistosity in the area (Marshall in Collins *et al.*, 1981). In thin section these rocks are similar to those described above with quartz and feldspar phenocrysts and minor chloritised ferromagnesian minerals in a fine-grained snowflake-spherulite-textured groundmass with irregular patches of chlorite. Carbonate and sericite alteration is common.

Sparse K-feldspar phenocrysts up to 3 mm were observed.

RING ROAD METADOLERITE (€m)

This large mafic body (1 × 0.5 km) intrudes the mixed sequence and pumice breccia sequence in the Leven River and Ring Road area. In thin section, a sample from the Leven River (J031 from DQ048127), is porphyritic with glomerocrysts of sericitised plagioclase and chloritically altered pyroxene in a eutaxitic and perlitically cracked groundmass of chlorite and plagioclase. A thin section (J034 from DQ051129 – see plate 2c) from the centre of the body is medium grained with an ophitic texture. Bladed plagioclase is enclosed by titaniferous augite with chlorite, quartz and leucoxene as alteration of the groundmass. A tentative identification of the plagioclase suggests it could be andesine, indicating that the rock could be a quartz diorite or diorite. It has a chemical composition ranging from basaltic andesite to andesite (see Geochemistry section).

Faulting appears to control the shape of the body on the south-western side and perhaps on the eastern side. Contact metamorphism is visible on the Ring Road on the western side, with baked sediments of the mixed sequence. The degree of alteration (with chlorite, epidote, carbonate and sericite), the petrography, and the geochemistry, discount any connection with Tertiary or Jurassic mafic volcanism or magmatism.

OTHER MAFIC BODIES IN LEVEN RIVER AREA (€m)

Two mafic bodies were mapped to the north-east of the Ring Road metadolerite. A dyke-like body exposed on the road at DQ056125 is extensively hematitically altered, with a remnant ophitic texture just visible in thin section (J086).

A larger body occurs further to the north-east within the volcaniclastic conglomerate sequence at DQ061135. Extensive epidote-quartz alteration is apparent in sample J074, which in thin section has a relict subophitic texture of altered plagioclase laths in highly altered pyroxene. Epidote and quartz make up some 70% of the thin section. Quartz replaces chlorite with a radiating and poorly crystalline habit. Actinolite occurs as acicular crystals in the quartz and epidote. A second sample (J075) is less altered, and shows a clear subophitic texture. The pyroxenes are altered to chlorite, leucoxene and quartz. Although this mafic body is petrologically similar to the Ring Road metadolerite, its alteration is different and its geochemistry is distinct, as discussed later.

A small body of similar mafic rock occurs on Upper River Road at DQ024059, and is weathered to a deep brown soil. A thin section (J233) shows the rock to be altered to chlorite, quartz and epidote, with a relict subophitic texture. An identical metadolerite is exposed in the Leven River 450 m to the north-east at DQ026063. A thin section (J237) shows intense chlorite-sericite-carbonate alteration overprinting a subophitic texture with plagioclase laths enclosed by an altered ferro-magnesian mineral. The above two bodies are probably connected, as indicated by a drill intersection of dolerite between the two occurrences (Randell, 1988).

FELDSPAR-HORNBLENDE PORPHYRIES IN THE LEVEN RIVER AREA (€fh)

Outcrops of medium-grained pink feldspar-hornblende-phyric porphyries occur in the Leven River and on Upper River Road [DQ020060].

Thin sections cut from samples J229 and J245 (from DQ021059) have a porphyritic texture of medium-grained glomerocrysts of plagioclase, and some altered amphibole (probably hornblende), in a vesicular spherulitic groundmass of quartz and plagioclase. The vesicles have secondary polycrystalline quartz as infillings. In the Leven River at DQ018055, samples of a chilled margin to this body were collected. A thin section of V177 shows the porphyritic texture with glomeroporphyritic feldspars in a very fine-grained glassy groundmass.

Further to the north at DQ025064 in the Leven River, a dyke of this porphyry some 4 m wide was mapped cutting a quartz-feldspar porphyry and vitric ash. It is possible that these porphyries are extrusive as they are roughly parallel to the regional strike and are vesicular. However, the intrusive relationships described above and the chilled margins favour an intrusive origin. The presence of vesicles is not uncommon in shallow intrusives.

QUARTZ-FELDSPAR PORPHYRY IN LEVEN RIVER–BASIN ROAD AREA (€p)

A number of quartz-feldspar porphyries intrude the pumiceous breccia sequence in the south-west of Map 8. Autoclastic brecciation and flow banding was noted at DQ023052, and brecciation at DQ027063 and DQ025064. A thin section (J218) from DQ025064 is medium grained with quartz, plagioclase and rare hornblende phenocrysts in a snowflake-textured groundmass.

Rocks from the Basin Road quarry [DQ008033] were tentatively assigned to this porphyry. Samples V91 and V92 from the quarry were highly sheared, with quartz phenocrysts in a sericitic groundmass with possible altered feldspars.

DOLERITE IN HELLYER MINE AREA (Ddl)

Intrusive dolerite bodies in the Hellyer–Mt Charter area were mapped by Komyshan (1986) and have been described by Corbett and Komyshan (1989). The northern extension of one of these bodies extends on to Map 7 at CP938972, where it intrudes the lower part of the Southwell Subgroup.

Although originally considered to be possibly Devonian in age, based on a minimum K-Ar date of 390±10 Ma, geochemical and petrological considerations indicate that the dolerites are more likely to be late Cambrian and related to the Que–Hellyer Volcanics (Corbett and Komyshan, 1989).

One of the 'dolerite' bodies mapped by Komyshan (1986), near the Cradle Mountain Link Road–Murchison Highway junction [CP906971], was subsequently shown to be Tertiary basalt (Corbett and Komyshan, 1989). A thin section from this area (V065) shows a fresh basalt with zeolite-filled vesicles.

Denison Group correlates (Owen Conglomerate)

INTRODUCTION

The Denison Group (Corbett, 1975*a*) was defined in the Adamsfield area for the siliciclastic sequence lying conformably beneath Ordovician limestone (Gordon Group) and unconformably overlying Middle Cambrian rocks. In the West Coast Range area, the sequence has long been referred to as the Owen Conglomerate. Recent mapping on the Tyndall Range (Corbett and Jackson, 1987), Mt Murchison (McNeill, 1987), and Mt Owen–Mt Lyell (Corbett *et al.*, 1989) has established the following succession, based on the original terminology of Wade and Solomon (1958):

— — — —

Top	Grey sandstone and shale	
	Pink sandstone and granule conglomerate	Upper Owen
	Haulage Unconformity	
	Thin-bedded sandstone	
	— — — —	
	Massive cobble-boulder conglomerate	Middle Owen Conglomerate
	Grey to pink sandstone and siltstone with rare marine fossils	Newton Creek Sandstone
	Cobble-boulder conglomerate and sandstone	Lower Owen Conglomerate
	Local volcaniclastic conglomerate	Jukes Conglomerate

The uppermost sandstone units, above the Haulage Unconformity, are referrred to as the Pioneer Beds.

Mapping in the Black Bluff Range area for Maps 7 and 8 has shown that a similar sequence is present, except for the Lower Owen. A diagrammatic column for the Black Bluff sequence is shown on Figure 8. The Upper Owen correlates tend to dominate the sequence, while the Newton Creek Sandstone and Middle Owen Conglomerate correlates tend to be lensoidal. The upper grey sandstone becomes prominent to the north, and is treated as a separate formation correlated with the Moina Sandstone of Jennings (1958).

The mapping has revealed the presence of a large sill-like dolerite body, and of basaltic lava flows and associated volcaniclastic rocks, within the siliciclastic sequence.

CORRELATE OF JUKES CONGLOMERATE (€Oj)

A poorly defined unit of volcaniclastic conglomerate and interbedded siliciclastic sandstone was mapped in the lower reaches of Tumbling Creek [DP028944], about 500 m upstream from its junction with the Vale River. It occurs as a discontinuous lens between the Bonds Range porphyry and the overlying Upper Owen sequence. The unit was tentatively correlated with the Jukes Conglomerate (Map 7). However, subsequent petrological examination suggests it probably represents a thin volcaniclastic horizon which occurs in the basal part of the Upper Owen sequence elsewhere, i.e. as part of the general siliciclastic sequence.

A sample, V104 [DP028944], is a clast-supported coarse volcaniclastic sandstone to granule conglomerate. In thin section it is composed mainly of subrounded, often slightly elongate, fine-grained vitric ash fragments, up to 6 mm in diameter. Polycrystalline quartzite clasts, of Precambrian derivation, and snowflake-textured lava clasts, are also present. Matrix material is mainly subangular quartz grains with undulose extinction, sericite, chlorite, hematite and minor secondary carbonate. Pyrite occurs as an interstitial mineral and may also been seen to replace Precambrian quartzite clasts. Minor biotite replaced by leucoxene is also present.

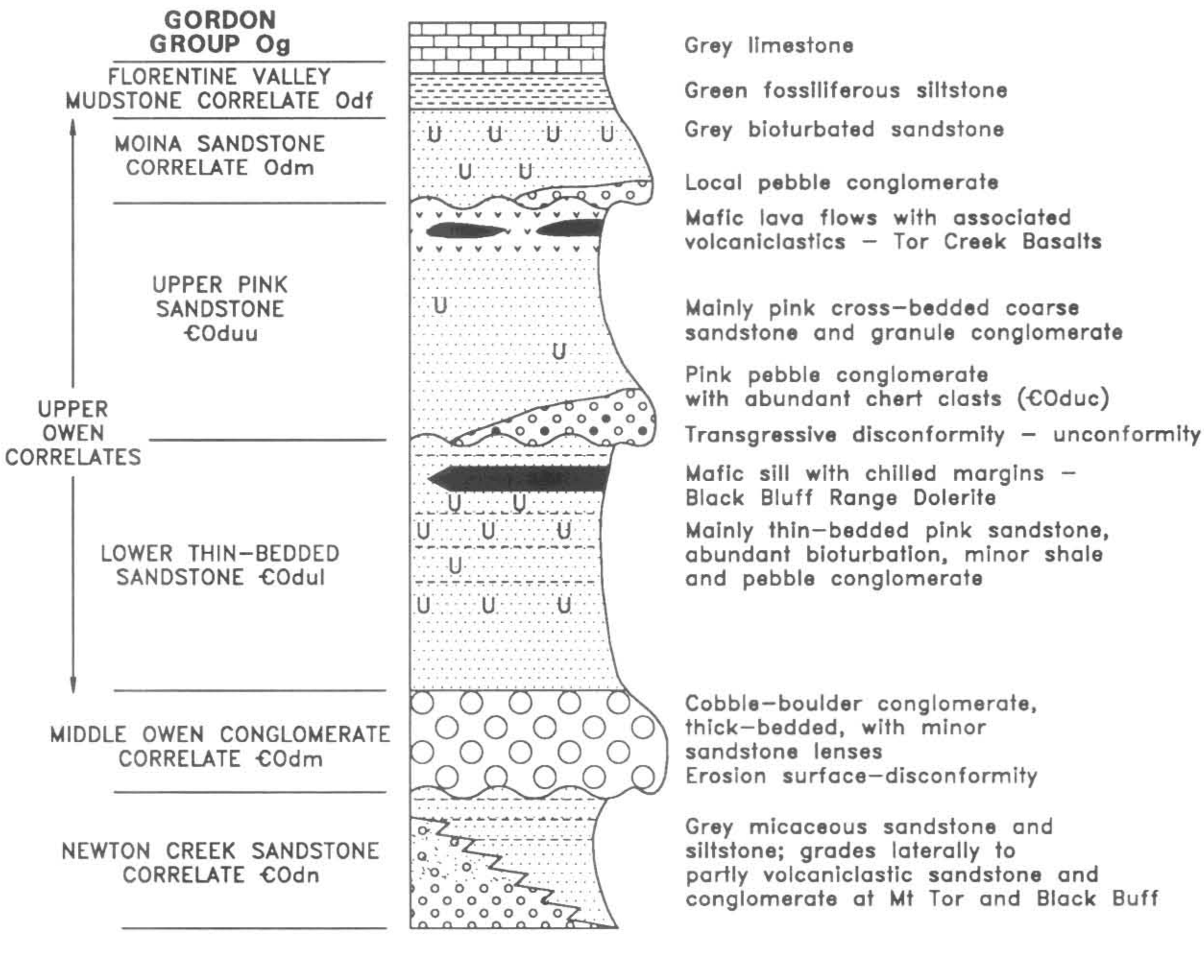


Figure 8. Generalised stratigraphic column for Denison Group sequence on the Black Bluff Range.

5 cm

CORRELATE OF NEWTON CREEK SANDSTONE (€Odn)

Correlates of the Newton Creek Sandstone are present on the western slopes of Mt Cattley and Mt Tor, and on the northern slopes of Black Bluff. It consists largely of thin-bedded micaceous sandstone and siltstone between Mt Cattley and the Ring Road area, but coarsens northwards to consist mainly of conglomerate and sandstone on Mt Tor and Black Bluff. Its thickness is of the order of 100 m.

No exposure of the basal contact on the underlying volcaniclastic sequence was found, but dips and strikes are conformable. The lowermost part of the unit seen, in a tributary of Cattley Creek at DQ050081, consisted mainly of volcaniclastic sandstone. In thin section, this rock (J268) is a poorly sorted tuffaceous litharenite composed predominantly of volcanic quartz and volcanic rock fragments (vitric tuff, spherulitic lava). A minor amount of Precambrian detritus is present. The upper part of the sequence in this creek consists of thin-bedded to laminated grey micaceous sandstones. A sample (J267 from DQ050082) shows a moderately sorted, bioturbated, submature litharenite, with about 30% Precambrian detritus (mainly quartzite grains and mica). The upper contact with Middle Owen Conglomerate in this creek is abrupt, erosional and oxidised, with thin-bedded siltstone abruptly overlain by massive cobble-boulder conglomerate. A similar contact was seen on the ridge top near Mt Cattley (DQ034047), where highly oxidised hematitic siltstone-shale is abruptly overlain by massive siliciclastic conglomerate. An excellent exposure of this contact occurs in a creek at DQ063101, where a waterfall over the massive conglomerate exposes the underlying purple siltstone. These relationships indicate a period of exposure and erosion prior to deposition of the overlying conglomerate.

On Mt Tor, the upper contact is well exposed over about 100 metres, and is a low-angle unconformity. The upper part of the Newton Creek correlate here (DQ073123) consists of granule-pebble conglomerate (partly volcaniclastic, partly siliciclastic) grading up to sandstone, but lacking the siltstones and shales seen only 1.5 km to the south. The sandstone strikes 164°E 37°, while the overlying Middle Owen Conglomerate correlate strikes 034°E 53°. Both units, and the overlying Lower Thin-Bedded Sandstone, are then truncated by a conglomerate at the base of the Upper Pink Sandstone, suggesting that the Mt Tor area represents an active basin margin.

Exposures of the unit on the western and northern sides of Black Bluff consist mainly of massive coarse sandstone with interbeds of granule-pebble conglomerate up to one metre thick. Some cross-bedding was noted in a coarse sandstone at DQ098091. A thin section (J292) from here shows an immature tuffaceous lithic greywacke with a mixed provenance of volcanic and Precambrian detritus. Precambrian material constitutes about 50% of the clasts seen in outcrops in this area.

MIDDLE OWEN CONGLOMERATE CORRELATE (€Odm)

The Middle Owen Conglomerate outcrops on the Mt Cattley–Mt Tor Range and on the Black Bluff Range adjacent to the Cambrian windows. It is a massive to thick-bedded, pink pebble-cobble-boulder conglomerate with occasional sandy lenses, and averages some 60 m in thickness on the Cattley and Tor Ranges.

On the Mt Cattley Range at DQ034047, the base of the conglomerate fills an erosional trough in the Newton Creek Sandstone. The conglomerate is matrix-supported, with Precambrian-derived quartzite clasts to 200 mm. In a tributary of the Leven River cutting the Mt Cattley–Mt Tor Range at DQ063101, the conglomerate fines up from boulder grade over 20 m to pebble grade. On the ridge striking south-west from Mt Tor [DQ072120], the conglomerate is clast-supported and of boulder grade.

In the Cambrian windows on the Black Bluff Range, thin discontinuous lenses of this conglomerate were mapped. The window just south of Black Bluff at DQ119090 has lenses of conglomerate on the northern and eastern sides. It is a cobble to boulder grade conglomerate up to 5 m thick in the north, pinching out into discontinuous lenses down the eastern side, some of which are only a single boulder thick.

UPPER OWEN CORRELATES (€Odu)

The Upper Owen Correlates have been subdivided into three units: Lower Thin-Bedded Sandstone, Upper Pink Sandstone, Moina Sandstone Correlate.

LOWER THIN-BEDDED SANDSTONE (€Odul)

This unit consists dominantly of thin-bedded pink to grey sandstone with some beds of granule-pebble conglomerate, bioturbated sandstone, siltstone and calcareous sandstone. A maximum thickness of just over 500 m is developed on the Black Bluff Range.

Good exposure of the lower part of this unit is present in a creek cutting the Mt Cattley–Mt Tor Range. Sample J072 [DQ064100] was collected immediately overlying the Middle Owen Conglomerate. In thin section it is an immature quartzwacke with a predominance of Precambrian quartzite and vein quartz clasts, some embayed volcanic quartz and a minor amount of fine-grained siltstone clasts. This is followed by an interbedded sequence of pink pebble conglomerate and grey sugary textured sandstone. Further up the creek are grey to green bioturbated micaceous siltstones containing brachiopod fossils similar to *Tritoechia* (J073 from DQ066101). Thin interbeds of nodular calcareous siltstone and micaceous sandstone are associated with the fossiliferous beds.

On the northern end of the Black Bluff Range this lower part of the Upper Owen was mapped from its base on the Cambrian window at DQ117090 to its upper erosional contact with the overlying conglomerate (€Oduc). Pink and grey sandstone and grits in this area show bioturbation and cross lamination. Slumping and rip-up structures were noted, as was selective hematitic alteration along bedding planes.

PINK PEBBLE–COBBLE CONGLOMERATE (€Oduc)

The pink pebble–cobble conglomerate unconformably overlies the thin bedded sandstone unit. It crops out on the northern end of the Black Bluff Range and at Mt Tor as a pink pebble-cobble conglomerate with characteristic pink chert and jasper clasts to 50 mm. The transgressive nature of this unit is apparent on Mt Tor, where the underlying sandstone, Middle Owen Conglomerate and Newton Creek correlates wedge out progressively against this unit [DQ074124]. On the northern end of the Black Bluff Range [DQ110097], the unconformity is not as spectacular but still present.

The conglomerate includes some coarse pink sandstone lenses and tends to fine upwards, with a gradation into the overlying sandstone (€Oduu). The maximum thickness for the unit is 50 m.

In the southern Black Bluff Range area, the overlying sandstone (€Oduu) has a basal conglomerate which may be a correlate of this unit. However, due to the discontinuous outcrop and apparent thinness, it was included as part of the sandstone (€Oduu) sequence.

The conglomerate and overlying sandstone are regarded as correlates of the lower part of the Pioneer Beds, and the unconformity may be equivalent to the Haulage Unconformity (Wade and Solomon, 1958).

PINK COARSE SANDSTONE AND GRANULE–PEBBLE CONGLOMERATE (€Oduu)

This unit crops out extensively on the Black Bluff Range and on Mt Cattley–Mt Tor. It is a sequence of coarse, pink sandstone and granule–pebble conglomerate, commonly with pink to white chert clasts. As noted above, it is transgressive over the lower part of the Upper Sandstone, and in the Mt Cattley area it unconformably overlies the Middle Owen. A thickness of some 300 m is attained in the north.

In the Bare Mountain area, the unit contains interbeds of massive cross-bedded medium-grained pink sandstone. At DQ080035 this unit is rich in hematite, and a similar occurrence of hematite-rich sandstone on Rocky Mount has been prospected by three shallow trenches. The unit fines upwards in all areas, with some bioturbated beds occurring in the upper sandstones.

Towards the top of this sequence in the Tor Creek–Alps Road area, volcaniclastic sediments and basic to intermediate flows were mapped. The volcaniclastic sediments outcrop in a tributary of Loongana Mill Creek [DQ098124]. Thin sections cut from sample J298 and VP7 [DQ101122] (see plate 3b) show a volcaniclastic granule-pebble conglomerate which is poorly sorted and immature. It is dominated by grains of typical Upper Sandstone chert, Precambrian quartzite, volcanically derived quartz and some reworked conglomerate. Scattered through the sample are irregular clasts of chloritic vesicular feldspar-phyric lava. The vesicles are filled with secondary quartz, and the irregular shape of the clasts suggests a minimum of transport. These clasts have probably been derived largely from the intercalated basaltic flows.

TOR CREEK BASALTS (€Odub)

Altered basaltic lavas were first recognised in the siliciclastic sequence by Weste (1978) in two drill holes at Mt Jacob, 8 km east of Black Bluff. Seymour (1980) mapped the basalts in Tor Creek and interpreted them as being part of an upfaulted block of Cambrian rocks. Subsequently, following the mapping reported here (see Pemberton and Vicary, 1988), Seymour (1989) re-interpreted the Tor Creek outcrops as being possible correlates of the Mt Jacob lavas. The term 'Tor Creek Basalts' is used here for the first time to describe the distinctive basaltic lavas which occur within the Upper Pink Sandstone near the base of the overlying Moina Sandstone correlate. Subsequent mapping to the east for Map 9 (Pemberton and Vicary, 1989) has traced the Tor Creek Basalts some 12 km to the Wilmot River gorge.

The basalts occur at two slightly different stratigraphic levels, and there are significant petrological differences between the occurrences. Those closest to the base of the Moina Sandstone are red-weathering, strongly hematitic, strongly altered, small flows with amygdaloidal and porphyritic textures, while those lower in the sequence form larger bodies, are less altered, are characterised by epidote alteration, and are porphyritic but non-amygdaloidal.

The upper hematitic basalts occur within a few metres or tens of metres of the overlying basal conglomerate of the Moina Sandstone, and occur as lenses of fine-grained, strongly cleaved reddish-purple rock easily mistaken for shale. The surrounding rock is typically a coarse-grained partly volcaniclastic sandstone or granule-pebble conglomerate. Outcrops are known in Tor Creek at DQ094133 and DQ093131, and beside Alps Road at DQ097124. Sample VP5, from the latter locality, is a hematite-altered, amygdaloidal, olivine(?)-phyric basalt (plate 3a). The olivine(?) occurs as a high-relief, subhedral mineral forming phenocyrsts (to 1 mm) and also smaller grains in the groundmass. It is totally replaced by sericite, and has a distinctive irregular fracture pattern outlined by fine hematite.

The groundmass consists of irregular sericitic feldspar laths, up to 0.5 mm, and minor olivine, but has been almost totally replaced by fine-grained hematite and sericite which obliterate much of the texture. The abundant amygdales are up to 15 mm across, and are filled with sericite plus minor quartz and hematite.

Sample VP3 [DQ094133] is similar to VP5 but is more strongly deformed and sericitised. In thin section, the amygdales have indistinct and irregular boundaries, and their smeared shapes merge with the smeared feldspar laths of the groundmass. Pseudomorphed olivine phenocrysts are again apparent from their high relief and the hexagonal form in some sections.

A quarry on Alps Road at DQ096121 provides a relatively large exposure of the lower, epidote-rich basalt, which lies approximately 80 m below the basal Moina conglomerate. This rock is greenish in colour, massive to blocky jointed, and relatively fresh. In thin section (J297) it consists of pseudomorphed olivine phenocrysts, up to one millimetre, in a fine groundmass of small plagioclase laths (to 0.2 mm), abundant epidote grains, chlorite and minor opaques. The olivine phenocrysts are subhedral to euhedral and are replaced by chlorite and epidote. Some textural evidence suggests that the epidote post-dates chloritisation. Sparse hexagonal crystals up to one millimetre, with two cleavages at 120°, are replaced by chlorite and epidote, and may represent original hornblende.

Plagioclase in the groundmass shows only minor sericitisation. The groundmass epidote appears to be mainly replacing ferromagnesian minerals, possibly pyroxene and/or olivine.

Sample V349 (from DQ109132) comes from a second area of the lower basalts about one kilometre east of Alps Road. This massive rock is fresher than any of the other occurrences, and is distinct in its abundance of plagioclase both as phenocrysts and groundmass laths. In thin section, the abundant plagioclase phenocrysts are up to 3 mm long, and show both albite and carlsbad twinning. It is only slightly sericitised. Unusual untwinned or simply twinned plagioclase phenocrysts with a boxwork-like internal structure outlined by chlorite blebs are also present.

The groundmass is dominated by abundant plagioclase laths (up to 1 mm), showing a weak trachytic flow texture, and subophitic clinopyroxene grains up to one millimetre. Blebs of chlorite within interstices of the groundmass are possibly replacing a glassy residuum. Some larger, more euhedral grains of chlorite may be replacing ferromagnesian minerals. There is no indication of vesicular texture. Epidote occurs in the groundmass, replacing clinopyroxene, and in prominent later veins.

No contacts have been seen between the epidote-rich basalts and their host rocks, and the reason for the petrological differences from the hematitic flows is not clear. They may simply represent thicker flows which were not subject to the oxidation and weathering, possibly during an interval prior to deposition of the basal Moina conglomerate, which affected the upper flows. It is also possible that they represent shallow

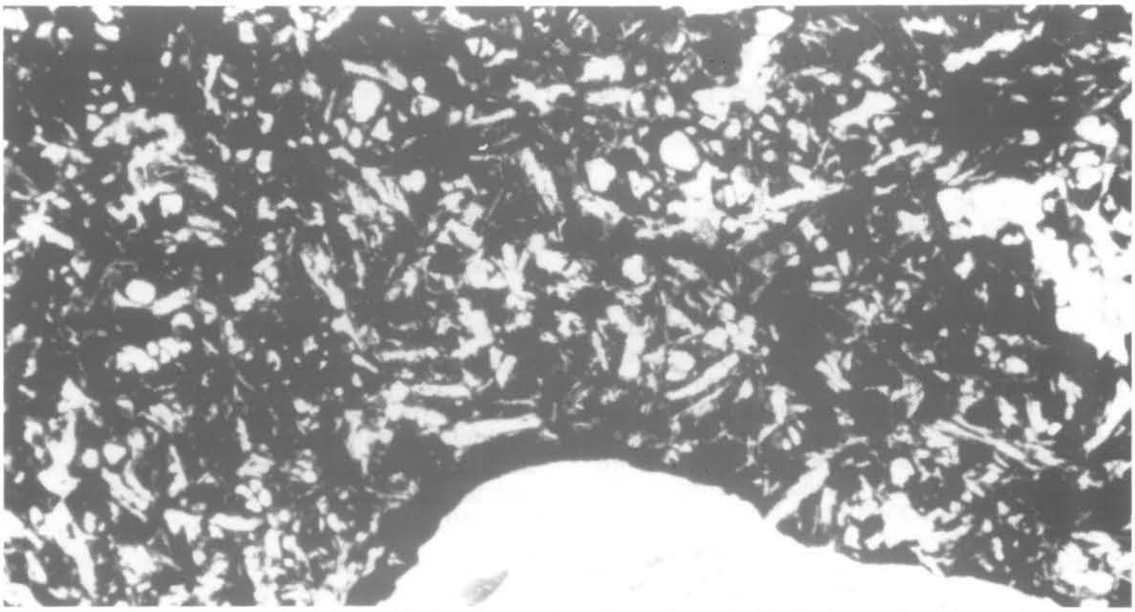


Plate 3a. Photomicrograph of hematitic basalt from Tor Creek (sample VP5). Note relict feldspar laths and rounded olivine grains in hematite-sericite-replaced groundmass. One large sericite-filled vesicle is shown. Field of view 4.3 × 2.2 mm; plane light.

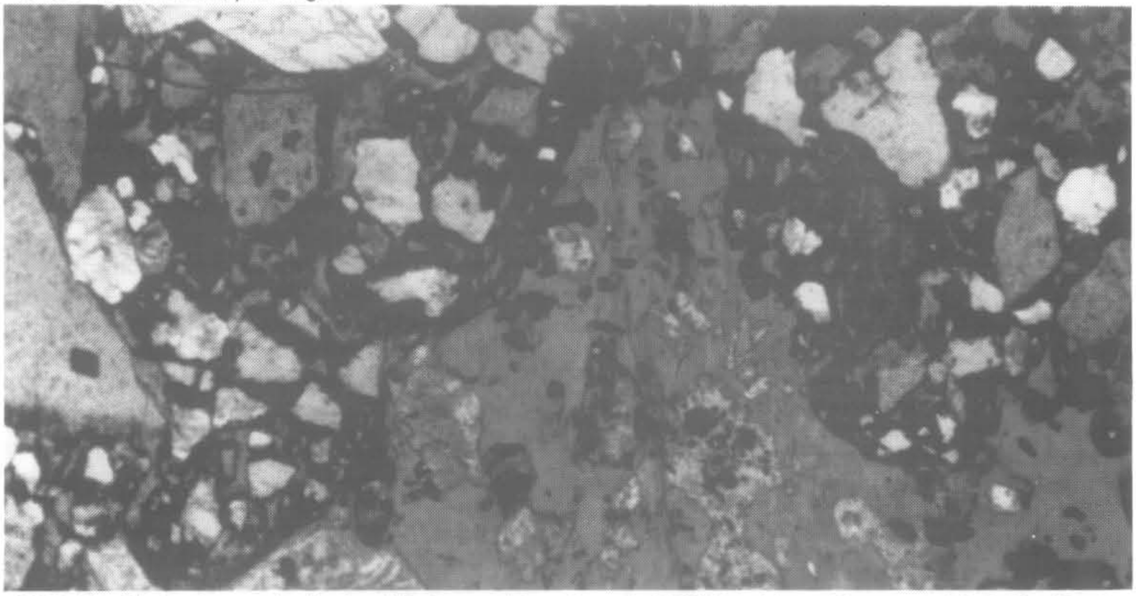


Plate 3b. Photomicrograph of volcaniclastic sandstone (sample VP7) from Upper Owen correlate in Tor Creek. Note large irregular clast of vesicular, feldspar-phyric basalt, clear clasts of quartz, and clasts of grey chert. Field of view 4.3 × 2.2 mm; plane light.

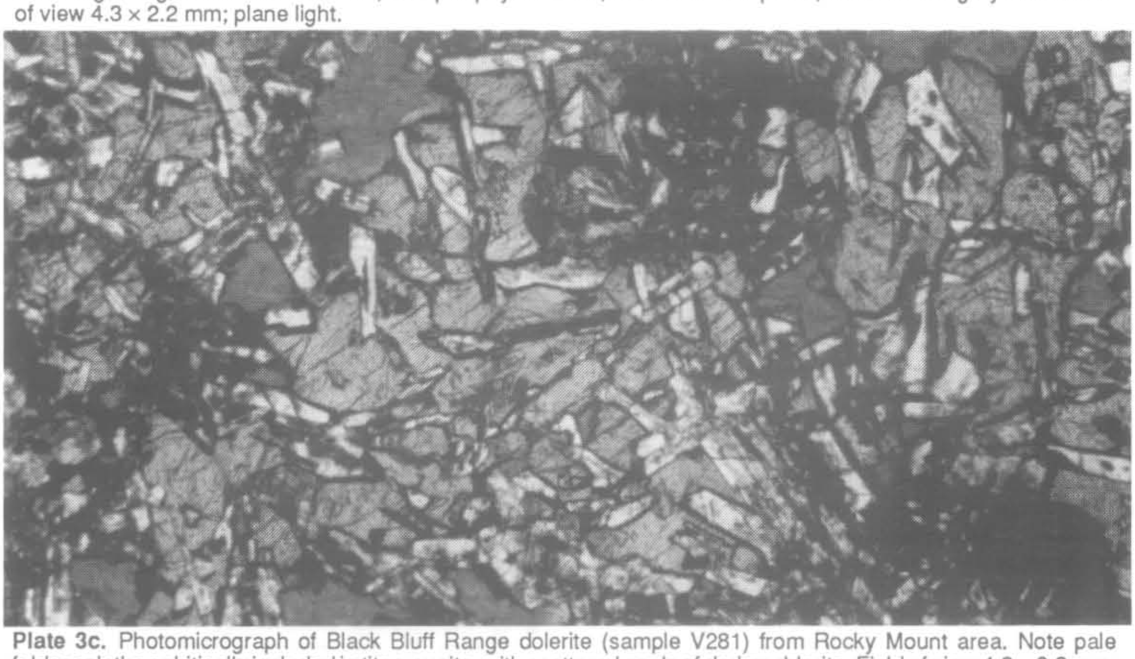


Plate 3c. Photomicrograph of Black Bluff Range dolerite (sample V281) from Rocky Mount area. Note pale feldspar laths ophitically included in titan-augite, with scattered pools of darker chlorite. Field of view 4.3 × 2.2 mm; plane light.

5 cm

intrusive bodies or feeders for the upper flows. Alternatively, they may represent a separate and unrelated magmatic event. Their degree of alteration, particularly the abundance of epidote, is greater than that known for any of the Tertiary basalts.

BLACK BLUFF RANGE DOLERITE (€Oduv)

A thin sill-like body of fine- to medium-grained dolerite was mapped on the western limb of the Black Bluff Range anticline in the Mt Beecroft to Rocky Mount area, where it intrudes the Lower Thin-Bedded Sandstone. It is discontinuous over a length of 4 km, and is in the order of 50 m thick. The discontinuous nature of the body can be explained in terms of poor outcrop or complexities in the fold pattern caused by NW-SE trending faulting. The body extends from the Cradle Mountain Link Road [DQ047012] to Mackintosh Creek [DP033989]. A southern limit of [DQ027976] has been determined from airphoto interpretation. On airphotos, the dolerite body appears to follow a minor topographic low and is commonly exposed in north-westerly flowing creeks and on open saddles. It is associated with a belt of 1–2 m high eucalypt forest. On this basis it is possible that the body extends as far north as DQ052032. Dolerite was not seen on the eastern limb of the Black Bluff Range Anticline, but outcrop is such that a thin sill could be present in places beneath a cover of sandstone scree. The dolerite crops out again to the south-east of Black Bluff on MRVP Map 9 (Pemberton and Vicary, 1989).

The petrology of the dolerite body is highly variable along strike. On the Cradle Mountain Link Road the dolerite is highly weathered and appears as a fine-grained red-grey to yellow massive clay. Sample V280, from an outcrop 600 m south of the Link Road [DQ047005], is a fine-grained light green-yellow rock that is highly altered. In thin section it consists of abundant leucoxene grains up to 0.04 mm in a fine-grained groundmass of sericite and chlorite. Relict feldspar laths up to 0.77 mm are the only indication that the rock may be a dolerite. The sample probably comes from the original chilled margin of the body.

Sample V206 [DP033989] from Mackintosh Creek consists of abundant sericitic feldspar laths up to 1.6 mm and skeletal leucoxene grains up to one millimetre. Minor secondary quartz and epidote after feldspar is also present. Deeply weathered dolerite with minor quartz veining crops out at this location.

Sample V281 [DP041994] comes from an area where fresh dolerite is exposed near a ridge top. In thin section (plate 3c) it is characterised by pale pink pleochroic titanaugite crystals up to 10 mm with plagioclase laths up to 0.5 m giving an ophitic to subophitic texture. Both the pyroxene and the feldspar exhibit undulose extinction suggestive of post-crystallisation deformation. Feldspar also occurs as small laths in the chloritic groundmass (which may originally have been glass), and have a dirty appearance and irregular grain boundaries. Chlorite also occurs as large masses, up to 0.8 mm, which may be either altered glass or pseudomorphed titanaugite crystals, the former being favoured because of the presence of feldspar inclusions. Opaque oxides may occur as interstitial euhedral grains, euhedral grains in chlorite, and irregular masses along grain boundaries. Tentative reflected light petrography suggests that magnetite and pyrite may be present as euhedral interstitial grains and as inclusions, while leucoxene is common as an alteration product along grain boundaries.

K-Ar geochronology on a plagioclase concentrate from sample V281 was performed by Amdel, and gave an early Carboniferous age of 329 ± 4 Ma. In view of the degree of alteration and strain in the thin section, this age would represent a minimum age only.

The fact that the dolerite is altered, and appears to have been affected by the same faulting and folding as the siliciclastic host rocks, suggest a pre-Devonian age, and the body is tentatively assigned to the Ordovician. The possible relationship to the Tor Creek basalts is discussed in the Geochemistry section.

MOINA SANDSTONE CORRELATE (€Odmc + Odm)

A distinctive unit of grey, thick-bedded, bioturbated sandstone forms the upper part of the Denison Group siliciclastic sequence in most areas, and is correlated with the Moina Sandstone (Jennings, 1958; Jennings *et. al.*, 1959).

The unit was mapped west of Two Hummocks on Grasstree Ridge, north and east of Mt Tor, in Cattley Creek, on the eastern side of the Black Bluff Range, and on Bonds Range. A thickness of about 100 m is estimated for this unit.

In the Tor Creek–Alps Road area, a basal conglomerate, approximately 10 m thick, of pebble-cobble grade was mapped. Clasts of jasper, quartzite, hematite shale/lava and reworked conglomerate were present. On the saddle between the Black Bluff Range and Mt Tor [DQ085090], the Upper Sandstone (€Oduu) is overlain on an erosional contact by a small outlier of this conglomerate.

A similar basal unit of interbedded conglomerate and sandstone on the Bonds Range was mapped as undifferentiated Upper Sandstone. Subsequent mapping (see Pemberton and Vicary, 1989) has established that this is the basal conglomerate of the Moina Sandstone.

The formation is typically a grey to buff coloured siliciclastic sandstone, commonly strongly bioturbated (hence the old names 'Tubicolar Sandstone' or 'Pipestem Sandstone'). In Tor Creek at DQ093128, vertical worm burrows of 1.5 m in length were recorded. On a branch of Alps Road just north of the old Loongana Mill at DQ114148, a Lower Ordovician orthid brachiopod was collected (sample V272) in fine grey to buff sandstone with carbonate nodules. Poorly preserved brachiopods were found on the Cradle Mountain Link Road at DP054999.

In thin section (V273 – DQ115148) the sandstone is an immature quartzwacke dominated by quartz grains with undulose extinction. Some grains of chert, polycrystalline quartzite, zircon, tourmaline, rutile and opaque oxides are also present.

FLORENTINE VALLEY MUDSTONE CORRELATE (Odf)

A unit of fossiliferous shale and siltstone has been mapped between the Moina Sandstone and overlying Gordon Group limestone in several areas, and is correleted with the Florentine Valley Mudstone of Corbett and Banks (1974).

The unit is exposed in a tributary of Tor Creek, in Cattley Creek, on the eastern side of the Vale of Belvoir on the Cradle Mountain Link Road, and 1.5 km to the north of the Link Road. It consists of a fawn-weathering grey calcareous mudstone, siltstone and minor sandstone. In thin section (V248 – DP077994) it is extensively bioturbated, with a mix of fine sericite and clean silt defining the burrows.

UNDIFFERENTIATED DENISON GROUP

MT CRIPPS–UPPER SOUTHWELL RIVER AREA (€Od)

Undifferentiated Denison Group conglomerates and sandstones occur in the Mt Cripps area and on the hills to the north of the Cradle Mountain Link Road [CQ973010]. On Mt Cripps the sequence strikes northerly and dips to the east, but swings to a north-easterly trend on a small hill [CP974987] after being offset by a major NW-trending fault.

The contact with the underlying volcaniclastic sequence (€tcs) is well exposed on the Cradle Mountain Link Road at CP975991. The contact is conformable and is marked by distinct bleaching of the underlying volcaniclastic conglomerates and sandstones. The base of the Denison Group is marked by a one metre thick red to orange siltstone horizon, followed by pebble-conglomerate, with clasts up to 60 mm, interbedded with fine to medium-grained quartz sandstone (with scattered pebbles) layers up to one metre thick. The conglomerate-sandstone sequence is rich in chert clasts, and appears to be a correlate of the Upper Owen. Several hundred metres to the south, however, the upper chert-rich unit and basal siltstone are separated by a southwards-thickening wedge of thick-bedded pebble-cobble conglomerate which appears to be a correlate of the Middle Owen Conglomerate.

To the north of Mt Cripps [CQ974010], the siliciclastic sequence is transgressive across pumice tuffs and flow banded rhyolitic lavas of the Southwell Subgroup. The sequence consists of interbedded pink hematitic coarse quartz sandstone and pebbly sandstone layers, up to one metre thick, with pebbly conglomerate layers up to 2 m in thickness. The conglomerates are composed mainly of Precambrian detritus and pink to brown chert clasts are quite abundant. A basal unit of pebble-cobble conglomerate was reported at CQ980007. Medium-grained grey quartz sandstone with rare bioturbation at CQ971010 and CQ965007 appears to overlie the hematitic sandstones and conglomerates, and is probably a correlate of the Moina Sandstone.

MT BEECROFT – BONDS RANGE AREA

A large area of undifferentiated Upper Owen Correlate extends from south of Ten Mile Creek to about one kilometre south of Mt Beecroft. The geology for this area is taken largely from the early work of Barton *et al.* (1966) and little information about the Denison Group lithologies in this area was available.

In the Ten Mile Creek–Reynolds Falls area, the Denison Group consists of a variety of lithologies including coarse hematitic sandstones with chert clasts, pink to grey siliceous sandstone with minor chert and bioturbation, and white siliceous pebble conglomerate. Such lithologies suggest that these units are high in the stratigraphy of the Denison Group and a possible Upper Owen to Moina sandstone correlation is suggested.

In the Fourways area [DP049961], structural complications due to faulting and folding affect the Denison Group succession. The presence of a 3-metre thick basal conglomerate overlain by white to grey sandstone with minor chert, and the occurrence of Gordon Limestone within a small synclinal structure, again suggests that an Upper Owen to Moina Sandstone correlation is most likely. The stratigraphy in the Fourways area is also complicated by rapid thinning of the Denison Group sequence on the east side of the Vale of Belvoir syncline.

From north of Fourways to Bonds Hill, there is a thin siliciclastic sequence beneath the Moina Sandstone. The transition between the two units is well defined in some places, with pink hematitic quartz sandstone (commonly cross-bedded), with minor gritty conglomerate beds, being overlain conformably by a thicker sequence of bioturbated quartz sandstone. In other places, however, the contact between the two units is indistinct and/or gradational, and it is uncertain whether the basal sandstone unconformably overlying the Bonds Range Porphyry is a correlate of the Upper Owen or a basal facies of the Moina Sandstone.

Gordon Group (Og)

The Gordon Group is a sequence of limestone and minor shales that occurs stratigraphically between the Florentine Valley Mudstone and the Siluro–Devonian Eldon Group. Its distribution on Maps 7 and 8 is confined to the core zones of synclinal structures.

The largest occurrences on Maps 7 and 8 are in the Mackintosh Creek–Cattley Plain area and in the Vale of Belvoir, with a minor occurrence in the Leven River at DQ082153.

The limestone in the Vale of Belvoir has been briefly described by Seymour (1980). It consists of successive sequences of thinly bedded dolomicrite, thinly bedded bioturbated dolomicrite, chert-nodular micrite, and calcareous mudstone, considered to have been deposited in lower intertidal-subtidal to high intertidal environments. The total thickness has been estimated at over 400 m, although no base or top to the section have been recorded. Burrett (1978) reported a middle–Middle Ordovician to late Middle Ordovician age for the Gordon Group in the Vale of Belvoir.

Silurian–Devonian Eldon Group

Silurian–Devonian Eldon Group sediment occur only on Map 7, where they outcrop in the core of a NE-trending syncline in the Mackintosh Creek area. They have also been identified in Sub-Basalt Drilling Project Hole 6, located at Racecourse Road (Baillie and Green, 1988).

BELL SHALE CORRELATE (Db)

A sequence of interbedded dark grey siltstone and mudstone was intersected in SBDP6 [CQ927027] between 226 and 316 m (Baillie and Green, 1988). The siltstone is fossiliferous, with shell fossils and solitary corals, and a correlation with the Bell Shale of the Zeehan area has been suggested. No lower stratigraphic unit was encountered before the hole was terminated.

FLORENCE SANDSTONE (Df)

White to grey well-bedded quartz sandstone with minor thinly laminated sandstone and siltstone crops out on the Cradle Mountain Link Road at DP013999. Minor fossiliferous horizons containing *Favosites*, crinoid stems and brachiopod fossils are present, and suggest a correlation with the Florence Sandstone (Baillie, 1989*b*). Soft sediment slumping and cross-bedding is common. Silicified breccias of Florence Sandstone at this locality are considered to be of Tertiary age.

To the south-west of this location is a large area of undifferentiated Silurian–Devonian rocks. Limited traverses in this area revealed the presence of poorly exposed quartz sandstone and siltstone with rare *Favosites*.

Sample V260 [CP994971] is a fine- to medium-grained quartz sandstone. It consists primarily of subrounded quartz grains with undulose extinction and secondary rims of optically continuous quartz giving triple point grain boundaries. Minor green tourmaline, zircon and polycrystalline rock fragments are present. This rock is typical of samples found near the contact with Tertiary Basalt.

Sample V261 [DP003973] is a siltstone, with a high proportion of matrix material and abundant sericite and muscovite flakes up to 0.1 mm. Accessory tourmaline and zircon are present.

?Devonian–?Cretaceous mafic dykes in Hellyer tailings dam area

An unusual xenolith-rich mafic dyke intrudes Animal Creek Greywacke beds in the Hellyer tailings dam canal at CP913980. The dyke is 1–2 m wide, and is fine to medium-grained, with a thin, chilled margin. Carbonate-filled vesicles and large mica crystals are evident in places, as well as xenoliths up to 60 mm across. Xenolithic rock types include granite, quartzite and schist.

A thin section from the rather weathered dyke (sample 400359 collected by R. Bottrill) consists of sparse biotite, olivine(?), pyroxene(?), and quartz phenocrysts in a fine-grained groundmass of sericitic plagioclase laths (to 0.5 mm), biotite (up to 0.1 mm), and minor leucoxene, quartz, chlorite and sericite. Amygdales up to 2 mm across are filled with chlorite and polycrystalline quartz. One large biotite flake (8 mm) in the section has been completely replaced by leucoxene with minor sericite and quartz. Relict olivine(?) and/or pyroxene phenocrysts (up to 5 mm) have been totally replaced by sericite, chlorite and leucoxene.

Several similar dykes were intersected in Aberfoyle drill hole MAC-15, some 700 m south-west of the canal exposure (CP910974). A thin section from one of these is described as being a 'thoroughly argillised cognate xenolithic and weakly vesicular basic rock containing sericitised coarse phenocrystal pyroxene and xeno-crystal corroded quartz' (A. W. McNeill, pers. comm.).

Some trace element values from the dykes are discussed in the Geochemistry section.

The unfolded, uncleaved nature of the dykes, the presence of coarse mica, and the unusual geochemistry, suggest they most probably belong with the variable suite of lampophyric rocks of late Devonian to Cretaceous age occurring in various parts of western Tasmania (Sutherland and Corbett, 1974). The degree of alteration is unusual, however.

Tertiary basalt and associated sediments

TERTIARY BASALT (Tb)

Tertiary basalt covers the western parts of Map 7 and 8 as an undulating plateau at 600–700 m altitude. Basalt at higher elevations of up to 900 m is present in the Vale of Belvoir and Iris River areas.

Detailed study of the Tertiary basalt was not undertaken during this work, and the reader is referred to the excellent coverage of this topic by Everard and co-workers (in Seymour, 1989). The Sub-Basalt Drilling Project (Baillie *et al.* 1987) has also contributed to the understanding of the basalt types, interflow sediments, age, thickness and geophysical properties of the Tertiary basalt sequence.

The new Cradle Mountain Link Road has exposed fresh outcrop of the basalt, with good development of columnar joining in places. Two possible feeders were mapped in Cattley Creek. The northern one [DQ040112] was sill-like, intruding steeply-dipping Cambrian sediments, with jointing parallel to the contact. Everard (in Seymour, 1989) regards this as an unusual augite-phyric basalt. To the south at DQ046087, a similar sill-like intrusive was mapped but contacts were not so well exposed. To the south of Lake Lea on the divide of the Lea and Vale Rivers, Tertiary basalt occurs at a number of localities as a thin sheet which has collapsed in places into sinkholes in the underlying Gordon Group limestone.

TERTIARY SEDIMENTS (Ts, Tss)

Unconsolidated Tertiary sediments were mapped in the Leven River and on Leven Road. In the river at DQ024098, the basal part of the outcrop was not exposed but it is interpreted as being underlain by Tertiary Basalt. A rough section of the outcrop is:

3 m fining up from pebble conglomerate to clay
0.5 m silty sand with plant fossils
Base 1 m silt.

On the Leven Road at DQ044127 a similar section is present, with a basal cobble conglomerate containing quartzite and Cambrian volcanic clasts resting on an irregular surface of Cambrian volcanics. A fossiliferous silty sand overlies this, followed by pebble conglomerate, sand and silt.

Unconsolidated Tertiary sediments were mapped by Baillie *et al.* (1986) in the Leven River and cored in the Sub-basalt Drilling Project holes 10, 14 and 15 (on Map 8). Palynology on sections of the core assign the sediments to the lower *Proteacidites tuberculatus* zone and upper *Nothofagidites asperus* zone, with an age of 30–36 Ma (P. W. Baillie, pers. comm.).

Siliceous conglomerate which occurs in the Leven River at DQ031109 and DQ026075 and, north-east of Black Marsh Road, resembles large erratics of Owen Conglomerate. The conglomerate is interbedded within the basalt flows, and the various outcrops are at the same stratigraphic position. Sample J017 [DQ031109] in thin section is of pebble grade, with subrounded, high sphericity clasts and moderate sorting. Quartz grains are overgrown with secondary silica which, with a fine-grained chert, forms the cement. Other clasts are Pre-cambrian polycrystalline quartz, Owen Conglomerate, hematite shale and zircon crystals.

Tertiary silcretes or greybillys were logged by P. W. Baillie (pers. comm.) in hole SBDP 6, and mapped during this program at CQ956002 and DP014999.

FERRICRETE (Tf)

Several small outcrops of brown ferricrete-laterite occur in the Vale of Belvoir close to the margin of the Tertiary basalt. A sample (J270 from DQ086010) shows irregular bands of crustiform limonite with some development of pisolites. These deposits could represent remnants of a fossil Tertiary surface, or may have resulted from some chemical interaction between the basalt flows and underlying limestone.

Quaternary deposits

PLEISTOCENE GLACIAL DEPOSITS

Glacial deposits have been subdivided into morainal deposits (Qpm) and other coarse gravelly deposits of fluvioglacial and/or glacial origin (Qpg). The latter type undoubtedly include some morainal deposits.

MORAINAL DEPOSITS (Qpm)

Four small areas of bouldery morainal deposits were mapped on the Black Bluff Range between the Cradle Mountain Link Road and Mt Beecroft. The deposits contain clasts derived from the Bonds Range Porphyry to the east, indicating that ice over-rode the Black Bluff Range during glaciation. This is consistent with the map produced by Derbyshire (1968), which indicates a NNW direction for ice movement in this area.

At DP066983 on the Cradle Mountain Link Road close to Etchells Creek, glacial varves with dropstones were exposed by the road works.

FLUVIOGLACIAL AND/OR GLACIAL DEPOSITS (Qpg)

Extensive areas of poorly sorted cobble to boulder deposits were assigned to this unit. In the Vale of Belvoir, a mixture of Precambrian and Denison Group detritus makes up the deposits, while in the Hounslow–Heath–Iris River area they are predominantly Precambrian derived. Large erratics of Jurassic dolerite were reported by Derbyshire (1968) and Threader (in Collins *et al.*, 1981) in the Vale of Belvoir. These were not found during the present study, but dolerite erratics were found in the headwaters of the Fall River.

Deposits in the Tor Creek area, Black Bluff Range and Cattley Creek–Ring Road area were derived from Denison Group rocks of the Black Bluff Range. The deposit in the Cattley Creek–Ring Road area mantles the topography, and probable ice-push structures were recognised in weathered Cambrian bedrock to the south at DQ047104.

DUNE SAND DEPOSITS (Qs)

Two dune-like features of clean coarse sand were mapped in the Lake Lea area. The northern one, at DQ099037, is approximately 100 m back from the present shore. It is vegetated, about 1.5 m high, and 100 m long. The second dune is on the southern side of the Tertiary basalt isthmus, at DQ089028, and is not as well preserved as the northern one.

The position of the dunes on the northern side of stretches of water, and their orientation across the Vale of Belvoir, suggest a relationship to a prevailing southerly wind. The well established vegetation and distance from the present lake shore indicates some antiquity. Other similar dune systems have been dated as late Pleistocene (Baillie *et al.*, 1985).

ALLUVIUM AND SWAMP DEPOSITS (Qa)

Deposits of unconsolidated stream-related detrital material were included on the map where they were extensive. The Leven River around Loongana has large deposits of up to boulder grade material. Around Lake Lea, these deposits are reworked glacial deposits, and the delineation of the boundary between the two can be a matter for some conjecture. Large swamps on the Tertiary basalt, such as Romney Marsh, Yellow Marsh and in the headwaters of the Leven River, were mapped from aerial photos.

TALUS, SCREE AND SLOPE DEPOSITS (Qt)

The majority of slope deposits were mapped using air photos. They are under-represented on the map, as most steep slopes have a partial veneer of scree on them.

Some of the deposits close to the summit of Black Bluff are probably derived from nivation, as is the large block stream on the south-east side of Mt Beecroft [DP032965], which was classified as a nivation cirque by Derbyshire (1968).

ECONOMIC GEOLOGY

No mines have operated up to the present in the areas covered by Maps 7 and 8. A number of old prospects were noted on the Mackintosh Sheet (Barton *et al.*, 1966) and during this mapping program. Some of these prospects will be discussed here.

Active exploration in these areas using various models has resulted in some interesting prospects. The close proximity of the Que–Hellyer orebodies has increased the prospectivity of the Cambrian rocks for volcanogenic massive sulphides. Possible extensions of the Que–Hellyer Volcanics, the elusive extension of the Henty Fault zone, and the potential for gold deposits related to the Bonds Range Porphyry, have been the basis for recent exploration interest in the area.

Probable Devonian-related mineralisation is known in the Mt Remus area and to the north-east of Map 8.

Mt Remus prospect [DP015896]

The Mt Remus prospect has been reported on by Nye (1928), Burns (1963), Threader (1965) and Collins *et al.* (1981). A brief summary of their investigations is presented here.

The workings are to be found 700 m south-east of Mt Remus in Anio Creek. Numerous irregular veins of pyrite and quartz cut Precambrian schist but not the Cambrian quartz-feldspar ± biotite porphyry. Mineralised quartz and pyrite veins form a band 0.5 m to one metre wide striking north-east over some 200 m.

Pyrite and molybdenite are described as the only sulphides, with hematite, chlorite, epidote, zoisite, mica and quartz. Molybdenite is regarded as being later than the pyrite, as it is seen on joint planes and as veinlets cutting the pyrite.

Analyses of the ore gives the following grades: Mo 0.2% to 45.67%, V 0.19% to 4.38% and Co 0.18% to 1.49%. Loftus-Hills (1968) analysed the pyrite for Co and Ni, recording similar amounts to that from the ore analyses. Collins *et al.* (1981) suggested that there might be an early pure pyrite and a later cobaltiferous ore associated with the molybdenite. Stillwell (1932) suggested that the vanadium probably occurs in chlorite derived from alteration of vanadium-bearing mica (roscoelite).

A stream sediment sampling program with assays for Mo, V and Co undertaken by Threader (1965) showed anomalous areas to the south and east.

In conclusion, the mineralisation shows two ages, with an early quartz-pyrite vein system and later molybdenite and cobaltiferous pyrite possibly associated with the Devonian granites.

Anio Creek prospect – Anomaly 13 [DP028896]

Interest in this area started in 1972 when Cominco (now Aberfoyle) flew a helicopter-borne electromagnetic and magnetic survey over parts of EL2/70 using a McPhar 400 system. A marked electromagnetic anomaly and a coincident magnetic anomaly was positioned at DP029896 (Slade, 1972). Herrmann (1980) reported that weakly anomalous Cu and Pb values were obtained by Aberfoyle in several A-horizon soil samples.

In 1980, a Dighem II aeromagnetic-electromagnetic survey was flown over EL2/70 and surrounding areas for a Geopeko-Aberfoyle joint venture. A similar response to that of the early survey was obtained, with a combined anomaly 200 m to the north-east of the above position (fig. 9).

While mapping up Anio Creek to locate the Cambrian-Precambrian boundary during the present survey, a mineralised breccia was discovered at DP027900. The breccia strikes south-east, is approximately one metre wide, and was traced for approximately 30 m upslope to the south (see fig. 9). Sample J209 assayed:

Au 1.9 g/t   Ag 11 g/t   Cu 1.06%   W 0.13%

The breccia is within the Cambrian sequence, and in thin section (J210) is composed of clasts of the adjacent Back Peak Beds with secondary quartz, chlorite, tourmaline and sulphides. A major fault is interpreted at this position, with drag on the Back Peak Beds swinging the strike into a north-west trend, parallel to the fault, and overturning the bedding. Minor pyrite was noted in a second breccia and in the adjacent tuffaceous siltstone and vitric tuffs.

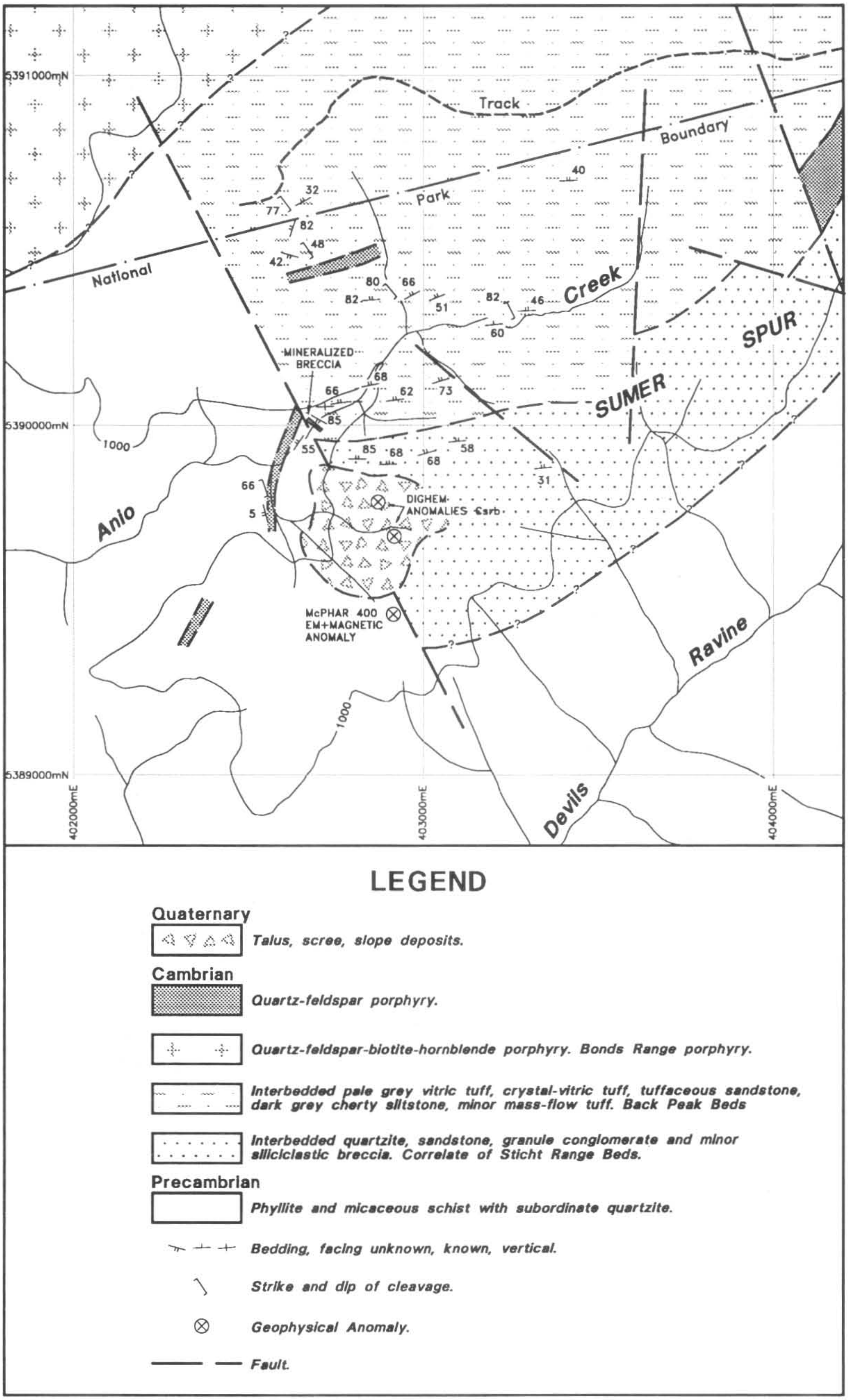
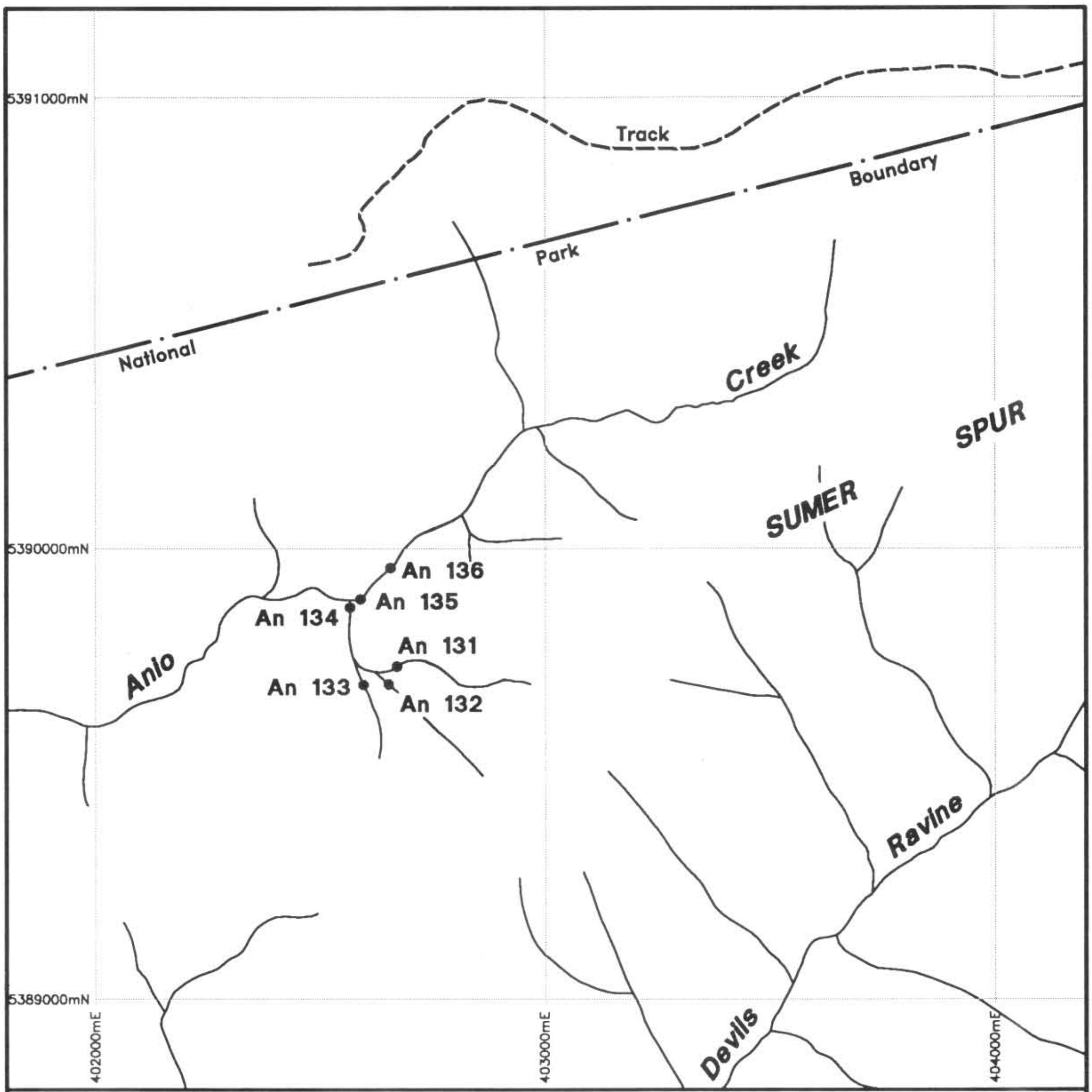


Figure 9. Generalised map of the Anio Creek prospect area.

5 cm



TABLE

Sample Point	As	Fe(%)	Mn(%)	Sn	W	V	Mo	Co	Pb	Zn
An 131	52	4.0	.04	7	135	53	24	72	260	97
An 132	73	5.7	.03	7	96	88	52	82	100	67
An 133	110	1.5	.03	5	135	25	12	26	80	43
An 134	43	4.5	.07	6	280	69	42	86	165	91
An 135	120	6.3	2.8	11	140	39	8	190	1200	410
An 136	130	5.9	2.4	6	310	35	11	160	1200	610

All readings in p.p.m. except where indicated.

Figure 10. Stream sediment samples localities and values, Anio Creek prospect.

5 cm

A sample of pyrite from the mineralised breccia gave a $\delta^{34}S$ value of +11.4% (Dr J. Taheri, pers. comm.). This value is slightly higher than those from systems dominated by Devonian mineralisation, such as Lakeside (Taheri and Green, 1989), where 80% of values are between +7 and +10%. In general, the $\delta^{34}S$ values for Cambrian sulphides are relatively high (+9 to +16, Polya *et al.*, 1986), but values for sphalerite as low as +6.3 have been reported from Hellyer (Jack, 1989). Thus, no firm conclusion can be drawn from the single Anio Creek sample.

A total of six –80 mesh stream sediment and panned concentrate samples were collected from three creeks draining the geophysical anomalies, and from downstream of the mineralisation in Anio Creek (fig. 10). The two samples from Anio Creek were strongly anomalous in Cu, Pb, Zn, W and As. The two samples from the creeks draining the Dighem anomalies had high Cu, Pb, Zn, W, Mo and As, while the third creek was anomalous in W.

As with the other prospects in these basal Back Peak and Sticht Range Beds, the style of mineralisation shows a genetic link with granite emplacement, with tourmaline in the chlorite-pyrite alteration and W-Mo-anomalies and mineralisation.

Carters prospect [DP066944]

This prospect is located within and adjacent to Fleece Creek. Mineralisation in the form of galena, sphalerite, minor chalcopyrite and pyrite is found within quartz veins, stockworks and breccias associated with north-west trending steeply dipping fracture zones in the basal Cambrian and Precambrian rocks. Krummei (1970) produced a map showing shafts, pits and trenches along the faults. Assays of the mineralisation illustrate its poddy nature:

35% Pb, 1.3% Zn, 60 g/t Ag from Collins *et al.*, 1981; 8.8% Pb, 0.9% Zn, 28 g/t Ag from Herrmann *et al.*, 1984; 4.04.% Pb, 2.3% Zn, 16 g/t Ag and 0.08 g/t Au from Jones, 1985.

Herrmann *et al.* (1984) reported that H. J. Stacpoole drilled a 33 ft (10 m) vertical diamond drill hole for the Carter syndicate who reported that it was in 'solid galena' all the way.

In a polished thin section, Collins *et al.* (1981) noted that galena occurred as regular shaped grains less than one millimetre across in a siliceous gangue with no evidence of deformation, while Rugless (1976) reported the presence of tourmaline associated with arsenopyrite, chalcopyrite and galena veinlets.

Prover 1 prospect [DP058934]

The Prover 1 prospect developed out of the early Aberfoyle work on Carters prospect. A large (900 m × 100 m) Pb anomaly with a peak value of 1.26% Pb (see Herrmann *et al.*, 1984) and a contourable high of 500 ppm to 2000 ppm, was found from C-horizon sampling. Prover 1 is in the basal Cambrian Back Peak Beds and Sticht Range Beds, with the anomaly being conformable with stratigraphy.

In 1982, Geopeko drilled a 156 m diamond drill hole under the peak of the Pb anomaly to relate the soil and rock geochemistry and to examine the style of mineralisation. From the surface to 70 m the hole intersected Back Peak Beds, with 23 m at 0.14% Pb and Zn. Sticht Range Beds siltstones and chert were logged to 88 m, where a quartz-biotite-feldspar porphyry intruded the sequence. From 53 m to 110 m, 0.14% Zn with only 0.01% Pb was assayed. Galena-sphalerite mineralisation occurs as veinlets, smears on fractures and as disseminated blebs associated with zones of chloritic alteration and fracturing.

Huston and Large (1987) discuss the zinc ratio from this prospect, which shows a bimodal distribution. The upper part of the hole has a low ratio while the Zn-enriched lower section has a higher ratio. The distribution of the ratios is unlike that at Rosebery and Hercules but similar to the Lake Selina values, and is typical of a Cambrian lead-zinc vein system related to high level subvolcanic granitoid intrusions.

Prover 3 prospect – Speeler Creek grid [DP080980]

This prospect lies to the north-east of Etchells Creek and covers the Back Peak Beds close to the contact with the Bonds Range Porphyry. The grid was established by Geopeko after highly anomalous stream sediments (2200 ppm Pb and 430 ppm Zn) were obtained. Pyritic and hematitic tuffaceous siltstones had anomalous C-horizon geochemistry with up to 0.3% Pb.

Cyprus joined the Geopeko-Aberfoyle joint venture and ran an EM37 survey over the grid (see Jones, 1986*a*). Four anomalous areas were followed up by sampling and mapping. A coincident geochemical anomaly (0.25 to 0.35 g/t Au and up to 0.22% Pb and 0.08% Zn) and EM37 response resulted in a 150 m drill hole. It intersected tuffaceous volcanics with pumiceous breccias dominating at the top of the hole, and crystal vitric tuffs and tuffaceous sediments in the lower part. Minor Pb-Zn mineralisation was encountered associated with brecciated rhyolitic bodies.

It was subsequently reported by Jones (1986*b*) that the anomalous gold values could not be confirmed in Amdel assays, and that poor laboratory technique was responsible for the anomalies.

Conclusions on mineralisation in basal Cambrian and adjacent Precambrian rocks

The evidence available on the mineralisation in these prospects suggests a Cambrian genesis with a later probable Devonian overprint. Intrusive bodies of Bonds Range Porphyry and related porphyries in the basal Cambrian and Precambrian rocks are in close proximity to all these prospects. Early faulting associated with the intrusion event is interpreted from field evidence. At Carters prospect, the major north-west striking fault did not displace the Precambrian/Cambrian contact to any degree, but the eastern boundary of the Bonds Range Porphyry appears to have been controlled by it. The fault which cuts the Anio Creek Prospect is interpreted as being an early structure which controlled the margin of the basin in which the Back Peak and Sticht Range Beds were deposited.

Mineralisation within these Cambrian rocks is either disseminated or occurs as veinlets, some of which are within intrusive rocks (e.g. Prover 1 and Prover 3). Huston and Large (1987) suggested a Cambrian age on the zinc ratio evidence.

It is probable that during the Devonian orogeny remobilisation of the earlier mineralisation took place (e.g. Carters prospect and perhaps Anio Creek prospect), with an overprint of Devonian granite-related mineralisation occurring in some areas (Mt Remus, Anio Creek prospect and Carters). Leaman and Richardson (1989) show the prospects under discussion to be in the centre of a block with estimated depth to the Devonian granite of 8 km. Although the depth to granite is large, a distinct metallogenic signature (W, Mo and tourmaline) related to long-acting fault systems strongly suggests a Devonian input.

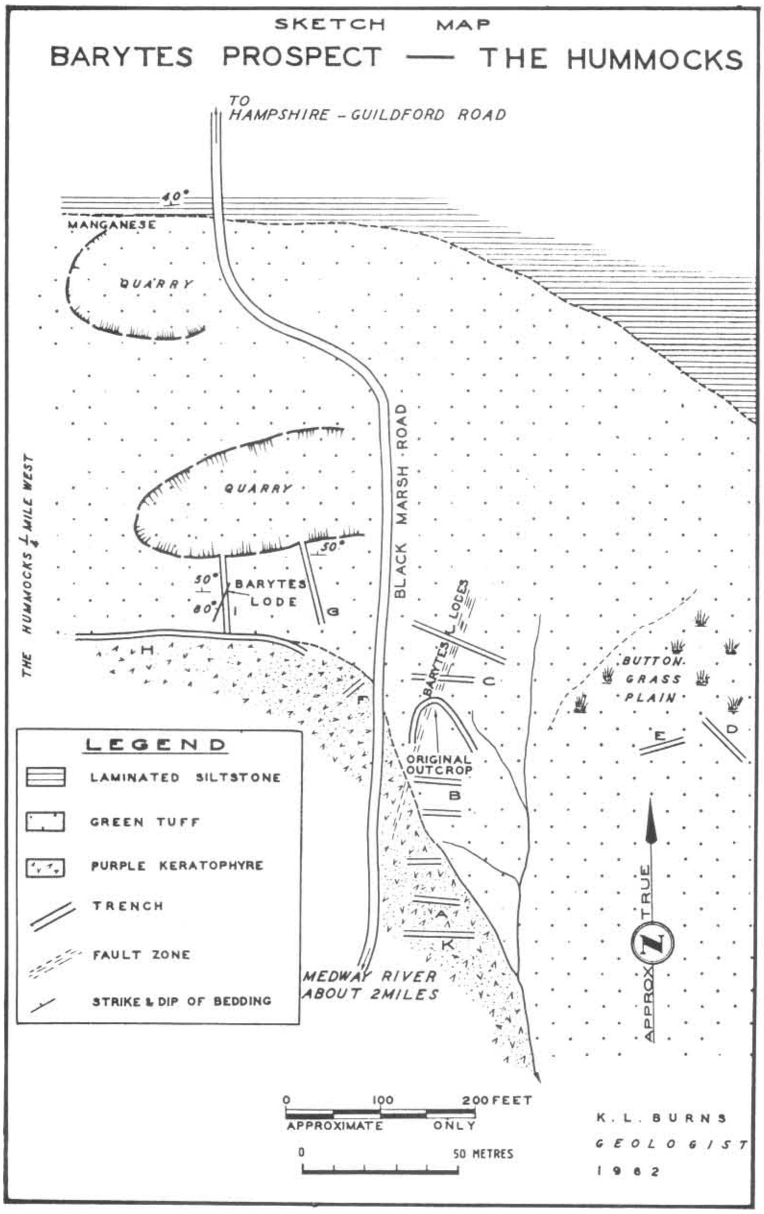


Figure 11. Sketch map of barite prospect, Two Hummocks. 5 cm

Ten Mile Creek prospect [DP000910]

Anomalous stream sediments (Sn, W, As, Pb and Au) were collected from Ten Mile Creek and the next creek to the north by Shell (see Smyth, 1983). Minor anomalies were also obtained in creeks draining to the south into Anio Creek (Mo, V, Au and Sn), and suggest a continuation of the Mt Remus style of mineralisation.

Follow-up work in the area by R. Poltock (from Funnel and von Strokirch, 1987) noted hematite veining, stockworks and breccias in the Bonds Range Porphyry. Quartz-albite-chlorite and hematite veins were also noted and thought to indicate Devonian mineralisation. Two anomalous rock chip samples of sericitised porphyry with minor pyrite assayed 8.08 g/t Au and 1.04 g/t Au. C. R. A. subsequently undertook a joint venture with Aberfoyle on EL 24/84. Petrological work done for Aberfoyle showed traces of chalcopyrite and one particle of gold within quartz-hematite veining (R. Henham, pers. comm.).

A number of thin and polished sections have been examined from samples taken on a traverse through the Ten Mile Creek hematite alteration zone during the present study. The porphyry has phenocrysts of quartz, plagioclase, ± K-feldspar, biotite and ± hornblende in a microcrystalline groundmass often devitrified to a spherulitic texture. Alteration of the feldspars to sericite, and biotite-hornblende to chlorite, is seen throughout the porphyry. At Ten Mile Creek, later hematite alteration has replaced the chlorite, some of the feldspars, pyrite and magnetite (now martite). Hematite-quartz-K-feldspar veining, stockworks and breccia-infilling is seen. Hematite was seen in a radiating habit which might have been after prehnite-pumpellyite (R. Bottrill pers. comm.). However, mild stress effects postdating the alteration have been reported by W. Fander (R. Henham, pers. comm.) .

Alluvial gold

An old alluvial gold show was mapped in the headwaters of Mackintosh Creek at DP031993. The workings were in alluvial gravels with a small adit and tram tracks. It is probable that a deep lead was being followed under the Tertiary basalt. These workings are located above a north-west striking fault cutting the Ordovician. Just over a kilometre due east, on a similar north-west striking fault, is a small adit in the Denison Group.

Approximately 800 m east of Bonds Hill is an extensive area (500 × 200 m) of old alluvial gold workings on a tributary of the Fall River [DQ114013]. The diggings followed leads in fluvioglacial sediments draining the eastern slopes of Bonds Hill. Water races, prospecting trenches and an old shaft were located up slope on the Bonds Range Porphyry.

Tasminex explored the area for uranium in the late sixties, and drilled a hole 300 m to the east of the workings. No records were lodged with the Department of Mines, but McGregor-Dawson (1975) analysed some core found lying near the collar. He reported 220 ppm Pb and 440 ppm Zn, while in the creeks draining this area Cu, Pb and Zn were anomalous.

Geopeko called this area Mariner 1, and extended the grid to the north-east (Van den Bogaart and Buckland, 1978). They ascribed the anomalies to chloritic alteration and associated quartz-pyrite-chalcopyrite veining, with anomalous gold, in the Bonds Range Porphyry.

Two Hummocks barite prospect [CP010140]

The barite at Two Hummocks has been an attraction for prospectors and explorers possibly since the first formed V. D. L. track skirted the Black Marsh. Burns (1962) reported on the prospect, and his original sketch map (fig. 11) is included here. Regrowth has made it difficult to locate all the prospecting trenches. Trench J is accessible but flooded and he reports three vertical lodes up to 200 mm wide with coarsely crystalline barite and minor pyrite traces. The barite occurs as irregular stockworks along joints and on fault planes. A sericitically-altered feldspar porphyry was mapped to the south-west of the barite lodes and could be genetically linked with them.

Geopeko explored the area (see Rogers, 1976 and Buckland, 1977) and called the prospect Challenger 3. Their best results were obtained from the cherty base of the black shale in the northern quarry. Specks of galena can be seen in hand specimen, and an assay of 0.14% Pb and 3 g/t Ag was reported.

GEOCHEMISTRY

Introduction

Thirty-two rock samples were submited for whole-rock analysis from the Back Peak–Cradle Mountain Link Road and the Mt Cattley–Mt Tor regions.

These comprise four from the Ring Road metadolerite, one from the northernmost dolerite body, four from the Black Bluff Range dolerite, four from the Tor Creek basalts, two andesites (Cradle Mountain Link Road and Cattley Creek window), three from the Bonds Range porphyry, two feldspar-hornblende lavas from the Hodgetts Road area, one felsic lava from the Ring Road, one felsic lava from the Southwell Subgroup on the Link Road, and nine felsic rocks from the Black Harry Road drill hole.

The northern dolerite body (1 km north-east of Ring Road metadolerite) was originally mapped as a similar metadolerite, but the chemical data show it to be distinct, and it is discussed separately.

Preliminary sample preparation was performed at the Division of Mines in Hobart, and consisted of removal of weathered rock surfaces and minor inhomogeneities before primary crushing into a coarse aggregate in a jaw crusher. Subsequent milling to fine powder in a Sieb Mill, and chemical analysis, was performed at the Division of Mines Chemical and Metallurgical Laboratory in Launceston, under the supervision of R. Roby.

Major element and trace element analysis was performed on a Philips 1400 XRF spectrometer using techniques described by Norrish and Chappell (1967). Ferrous iron was determined by wet chemical techniques, and volatile constituents were determined in a Leco furnace or by heating in an oven at constant temperature.

General geochemical features

Table 1 lists the major element data, re-calculated on a volatile-free basis to 100%, for the first 23 samples, while those for the Black Harry Road drill hole are listed in Table 2. Original analyses, together with sample descriptions and locality details, are given in Appendices A and B respectively.

Trace elements studies (Pearce and Cann, 1973; Winchester and Floyd, 1977) have shown that certain elements (e.g. Ti, Zr, Nb, Y and Cr) are relatively immobile during alteration, metamorphism and weathering, and can be used to discriminate between altered volcanic rock types. A major feature of this type of behaviour is that initial incompatible trace element ratios are maintained after chemical modification. Thus use of incompatible element discrimination diagrams can effectively see through element depletions and enrichments associated with alteration, metamorphism and weathering. The following discussion uses immobile trace element abundances to classify the composition of each rock type and to compare the analyses with other geochemical associations from the Mt Read Volcanics.

Figure 12 shows the variation of Zr/TiO_2 with respect to Nb/Y for analysed samples. The fields for the various rock types are from Winchester and Floyd (1977). The ratio Zr/TiO_2 increases with increasing igneous differentiation, while the Nb/Y ratio is a measure of alkalinity. The data set on this plot is incomplete due to a high niobium detection limit of 9 ppm. The major features shown by the plot are:

(1) All rocks plot in the subalkaline field.

(2) The compositional range is from subalkaline basalt to rhyolite, and is consistent with silica compositional limits as defined by Ewart (1982).

(3) There is some degree of correlation within each lithological unit.

(4) Most rock units have a relatively constant TiO_2/Zr ratio. The Nb/Y ratio tends to have more variation. This may reflect the high niobium detection limit.

Subalkaline rocks can be subdivided into two distinct chemical affinities: *(a)* tholeiites and *(b)* calc-alkaline rocks. The distinction between the two groups is shown on the AFM plot (fig. 13). The Ring Road metadolerite, northern dolerite, Black Bluff Range dolerite, Tor Creek basalts and the Tertiary basalt, plot within the tholeiitic field of Irvine and Baragar (1971), and despite poorly defined iron enrichment trends may be considered distinct from other rock types which have calc-alkaline affinities.

This subdivision is also demonstrated on a plot of Ti *vs* Zr (fig. 14). Tholeiitic rock types tend to plot as an array of points with a steep positive gradient, while the calc-alkaline rock types display a poorly defined subhorizontal trend. The tectonic fields of basalt types (Pearce and Cann, 1973) have been included for reference.

Table 1

RECALCULATED WHOLE-ROCK ANALYSES OF 23 ROCKS FROM THE CRADLE MOUNTAIN LINK ROAD – MT TOR AREA

	RING ROAD METADOLERITE (€m)				NORTHERN META-DOLERITE	BLACK BLUFF RANGE DOLERITE (€Oduv)				TOR CREEK BASALTS (€Odub)				TERTIARY BASALT (Tb)	ANDESITES (€a, €wa)		BONDS RANGE PORPHYRY (€qfbp)			FELDSPAR-HORNBLENDE PORPHYRY (€fh)		LAVA – RING ROAD (€dl)	LAVA – SOUTHWELL SUBGROUP (€dlt)
	J036	J035	J078	J059	J075	V280	V281	V205	V206	VP5	VP3	J297	V349	V284	V049	V196	V152	V125	J158	J245	V179	J281	V078
SiO_2	54.74	56.15	55.86	57.46	57.74	48.45	50.59	57.74	59.76	51.12	53.41	50.42	54.38	51.58	60.17	64.24	67.24	71.13	69.66	73.37	74.85	73.27	78.75
TiO_2	2.32	2.47	2.55	2.37	1.70	2.17	1.03	1.41	2.28	1.48	1.41	0.86	1.02	1.75	0.81	0.86	0.50	0.60	0.48	0.26	0.21	0.24	0.18
Al_2O_3	14.85	15.81	16.53	15.64	18.08	35.10	16.68	24.75	22.65	17.71	20.22	17.60	18.23	13.85	16.17	15.10	14.43	15.00	13.93	13.99	13.32	13.32	11.18
Fe_2O_3	2.57	2.82	4.36	2.33	3.16	1.76	2.10	2.44	2.44	13.30	12.28	2.05	1.87	2.06	2.37	3.14	2.08	0.59	1.04	0.98	1.21	0.76	5.16
FeO	9.18	9.23	9.51	9.79	8.22	0.74	8.02	0.74	0.72	3.98	2.58	6.62	6.09	9.54	5.35	5.31	2.65	2.54	2.85	1.52	0.74	2.66	0.11
MnO	0.15	0.14	0.11	0.08	0.14	0.01	0.17	0.01	0.01	0.11	0.04	0.14	0.13	0.15	0.10	0.75	0.08	0.05	0.07	0.01	0.01	0.04	0.01
MgO	3.49	3.57	4.10	4.10	6.38	0.87	7.81	1.04	1.12	6.77	3.70	7.65	6.59	8.35	4.70	2.67	3.09	1.77	2.55	0.90	0.40	0.62	0.54
CaO	6.39	3.52	0.80	1.79	0.95	0.23	10.36	0.06	0.08	0.11	0.28	11.35	5.47	8.30	1.94	0.47	3.34	2.04	1.89	0.08	0.05	0.77	0.04
Na_2O	3.84	2.67	3.73	5.49	3.19	0.28	2.73	0.08	0.08	0.04	0.16	2.42	5.38	3.25	4.18	3.56	1.83	1.75	2.71	3.42	2.56	2.56	0.54
K_2O	2.23	3.32	2.13	0.70	0.28	10.10	0.39	11.56	10.64	5.26	5.69	0.65	0.48	0.85	3.96	3.69	4.43	4.41	4.66	5.39	6.58	5.68	3.43
P_2O_5	0.24	0.30	0.32	0.25	0.16	0.28	0.13	0.17	0.20	0.11	0.24	0.24	0.36	0.31	0.24	0.21	0.15	0.11	0.15	0.08	0.06	0.08	0.06
Total	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00
LOI	2.28	4.17	4.36	4.01	5.54	4.36	1.70	2.91	2.95	5.26	4.36	2.53	2.89	0.40	3.77	3.53	2.30	1.34	1.59	1.41	1.15	2.74	2.25
Rb	53	100	68	17	16	210	18	230	210	165	185	18	120	29	78	135	175	190	185	130	92	135	105
Sr	430	175	65	210	110	37	155	21	51	9	12	300	80	290	220	57	26	150	200	92	105	47	8
Pb	<11	<11	<11	30	<11	<11	<11	105	<11	27	11	64	<11	<11	<11	39	13	<11	15	<11	<11	<11	<11
Th	<10	<10	<10	<10	11	<10	<11	<11	19	14	<11	<11	<11	<10	<11	15	27	17	24	27	23	13	17
U	<12	<12	<12	<12	<12	<13	<13	<13	<13	<13	<13	<13	<12	<13	<12	<12	<12	<12	<12	<12	<12	<12	<12
Zr	240	250	260	250	135	140	66	99	140	115	180	99	155	135	195	210	230	330	230	210	230	300	300
Nb	15	16	17	16	<8	9	<9	<9	<9	9	<9	<9	9	15	14	14	13	15	15	15	12	16	14
Y	48	47	67	53	28	58	22	36	40	27	47	23	17	27	26	38	35	38	35	37	40	42	42
Sc	27	27	30	28	29	69	35	46	65	48	40	35	25	25	22	17	12	11	12	11	<8	9	<8
V	150	160	175	150	200	310	180	240	350	99	105	165	155	180	170	150	84	78	67	11	8	14	4
Cr	15	20	9	19	200	640	360	420	390	520	290	230	110	350	68	41	190	115	150	48	62	92	43
Co	37	34	42	40	52	10	49	40	57	150	99	48	36	59	28	20	19	7	16	8	<7	7	7
Ni	<4	<4	<4	4	180	66	130	110	115	640	480	110	44	200	6	<4	41	17	34	<4	<4	<4	4
Cu	<4	<4	<4	<4	93	<4	105	<4	74	5	<4	61	79	48	10	<4	9	<4	11	<4	<4	<4	<4
Zn	105	220	270	195	110	11	74	61	26	150	98	115	83	110	150	550	65	44	88	74	33	42	15
Ga	16	16	14	16	15	20	12	15	20	17	13	12	15	15	13	13	13	13	14	10	10	11	10
Nb/Y	0.31	0.34	0.25	0.30	Nb<d.l.	0.16	Nb<d.l.	Nb<d.l.	Nb<d.l.	0.33	Nb<d.l.	Nb<d.l.	0.53	0.56	0.54	0.37	0.37	0.39	0.43	0.41	0.30	0.38	0.33
Zr/TiO_2	0.0104	0.0101	0.0102	0.0105	0.0079	0.0065	0.0064	0.0070	0.0061	0.0078	0.0128	0.0115	0.0152	0.0077	0.0239	0.0245	0.0460	0.0549	0.0475	0.0801	0.1082	0.1270	0.1637
FeO*	11.49	11.77	13.43	11.88	11.07	2.32	9.91	2.93	2.92	15.94	13.62	8.47	7.77	11.39	7.48	8.14	4.52	3.07	3.79	2.40	1.83	3.34	4.76

Major element values have been re-calculated volatile-free. Original major element analyses and sample descriptions and locations are given in Appendix A. Niobium detection limit (d.l.) = 9 ppm.
All analyses by Division of Mines, Launceston Laboratories.

Table 2
WHOLE-ROCK ANALYSES OF NINE DACITES FROM BLACK HARRY ROAD DRILL HOLE

	BH-2	BH-3	BH-5	BH-6	BH-8	BH-11	BH-12	BH-13	BH-14
SiO_2	73.21	72.09	74.48	72.95	70.85	70.42	73.29	70.61	70.94
TiO_2	0.32	0.30	0.42	0.38	0.37	0.37	0.39	0.37	0.40
Al_2O_3	14.53	14.41	15.98	14.16	14.09	14.12	13.82	14.18	14.07
Fe_2O_3	0.68	0.69	0.81	0.96	0.48	0.77	0.42	1.38	0.56
FeO	4.89	5.89	1.05	3.61	3.22	3.24	3.16	3.21	3.84
MnO	0.22	0.43	0.05	0.11	0.12	0.14	0.08	0.09	0.10
MgO	0.81	0.92	0.99	1.54	1.22	1.24	0.94	1.84	1.82
CaO	0.09	0.35	1.24	2.43	4.18	4.47	2.79	3.32	3.30
Na_2O	1.4	0.73	0.30	0.28	2.04	1.66	1.75	1.53	1.52
K_2O	3.64	3.99	4.43	3.34	3.15	3.30	3.17	3.22	3.22
P_2O_5	0.21	0.20	0.25	0.24	0.28	0.27	0.19	0.25	0.23
Total	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00
LOI	4.48	5.40	3.87	5.39	6.60	6.78	4.62	6.08	5.95
Ba	220	260	440	310	490	380	360	390	390
Rb	130	130	135	105	110	110	120	110	110
Sr	21	18	29	15	48	48	68	32	33
Y	27	25	17	17	18	18	20	17	19
Nb	13	12	9	8	8	6	9	7	7
Zr	210	210	175	160	160	155	180	155	155
Co	-	9	-	8	-	-	-	9	-
Ni	-	-	11	-	-	-	-	-	-
Cr	55	51	21	38	54	48	44	48	48
V	9	11	32	30	33	29	29	31	32
Sc	10	11	11	10	12	10	11	-	11
Cu	110	13	7	13	7	-	-	10	38
Zn	28	10	7	120	14	11	15	29	30
Ce	195	185	130	105	95	100	135	96	105
Ga	16	13	14	14	13	14	13	13	13
La	97	87	42	49	49	42	46	44	44
Nd	70	82	52	42	41	50	46	44	38
Th	20	12	-	-	-	-	-	-	-
Ti (ppm)	1918	1799	2518	2278	2218	2218	2338	2218	2398
Zr/Ti	0.109	0.117	0.069	0.070	0.072	0.070	0.077	0.070	0.065
Zr/TiO_2	0.066	0.070	0.042	0.042	0.043	0.042	0.046	0.042	0.039
Nb/Y	0.481	0.480	0.529	0.471	0.444	0.333	0.450	0.412	0.368

All analyses by the Department of Mines, Launceston Laboratories. Sample locations indicated on drill log, Appendix B.

Ring Road metadolerite

The four metadolerite samples show a chemical composition ranging from basaltic andesite to andesite, and plot within the andesite/basalt field on Figure 12. The samples plot as a fairly tight group within the tholeiite field on the AFM diagram (fig. 13). On the Ti *vs* Zr plot (fig. 14), the samples form a distinct field with a tholeiitic trend, and on the Ti-Zr-Y diagram (fig. 15), they define a sub-linear array adjacent to the boundary between the calc-alkaline basalt and low-K tholeiite fields of Pearce and Cann (1973).

The distinctively high Ti and Zr contents of the metadolerite appear to distinguish it from other mafic intrusive units in the area. In the Mt Read Volcanic belt generally, only one sample from the Miners Ridge basalt at Queenstown has comparable values (Corbett, 1989).

Northern metadolerite body

Sample J075 is from this body, and another analysis (VA22) quoted by Baillie (in Seymour, 1989) from the same body is also shown on the plots. The two samples plot within the sub-alkaline basalt field, or very close to it, on the Zr/TiO_2 *vs* Nb/Y diagram (fig. 12). The range shown for J075 is for a Nb value between 2 and 8 ppm. The samples plot close together in the tholeiitic field on the AFM diagram (fig. 13), and within, or on the boundary of, the within-plate basalt field on the Ti-Zr-Y diagram (fig. 14). On the Ti *vs* Zr plot (fig. 14), the two samples plot on a tholeiite trend.

It is notable that in all four plots, the two samples plot close to the Tertiary basalt sample (V284), and fall within the field of Tertiary basalts defined from the analyses of Everard (1989) on the Ti-Zr-Y diagram (fig. 15). This apparent similarity to the Tertiary basalts is rather surprising, considering that the considerable alteration suffered by the metadolerite is atypical of the Tertiary rocks (J. L. Everard, pers. comm.) and much more suggestive of a pre-Devonian age. A second unexpected feature is the lack of correlation in the plots with the Ring Road metadolerite, despite the apparent petrological and field similarities with that body.

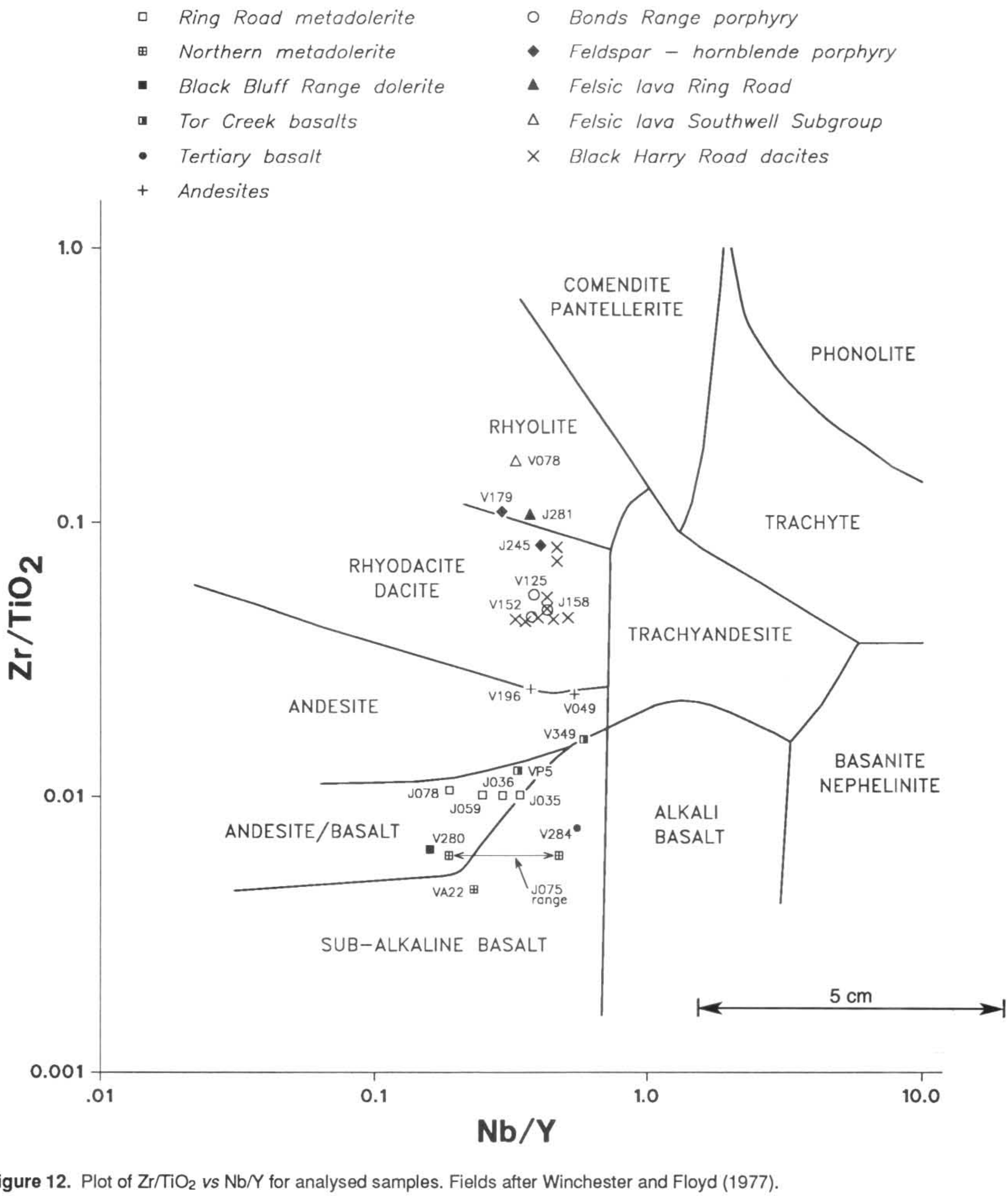


Figure 12. Plot of Zr/TiO_2 *vs* Nb/Y for analysed samples. Fields after Winchester and Floyd (1977).

Black Bluff Range dolerite

Four samples of the Black Bluff Range dolerite were submitted for analysis, of which only V281 was fresh. The other three samples were highly altered and/or weathered, and only indistinct primary textures were visible in thin section. Remnant feldspar laths and a high abundance of leucoxene suggest that these samples are petrographic equivalents of Sample V281. Sample V280 represents a chilled margin. The three altered samples have highly modified major element geochemistry compared to V281. They are characterised by very high abundances of Al_2O_3 and K_2O, and depletions in total Fe, MnO, MgO, CaO and Na_2O. TiO_2 and P_2O_5 show slight enrichment, while SiO_2 has a range of values and is noticeably higher in samples V205 and V206. The altered samples also have a higher LOI than the fresh sample.

The fresh dolerite sample has a recalculated anhydrous silica value of 50.6 %, which is a basaltic composition. Altered dolerite samples range in composition from basalt to andesite. On the AFM plot (fig. 13), sample V281 plots in the tholeiitic field. The marked depletion of MgO, FeO and Na_2O, and enrichment of K_2O, cause the altered Black Bluff Range dolerite samples to be displaced towards the $Na_2O + K_2O$ apex.

On the Ti *vs* Zr plot (fig. 14) both the fresh dolerite and altered dolerites plot as a linear array in a tholeiitic trend. This trend is steeper than that displayed by the Ring Road metadolerite. The four samples plot in a fairly close field on the Ti/100 *vs* Zr *vs* Y × 3 diagram

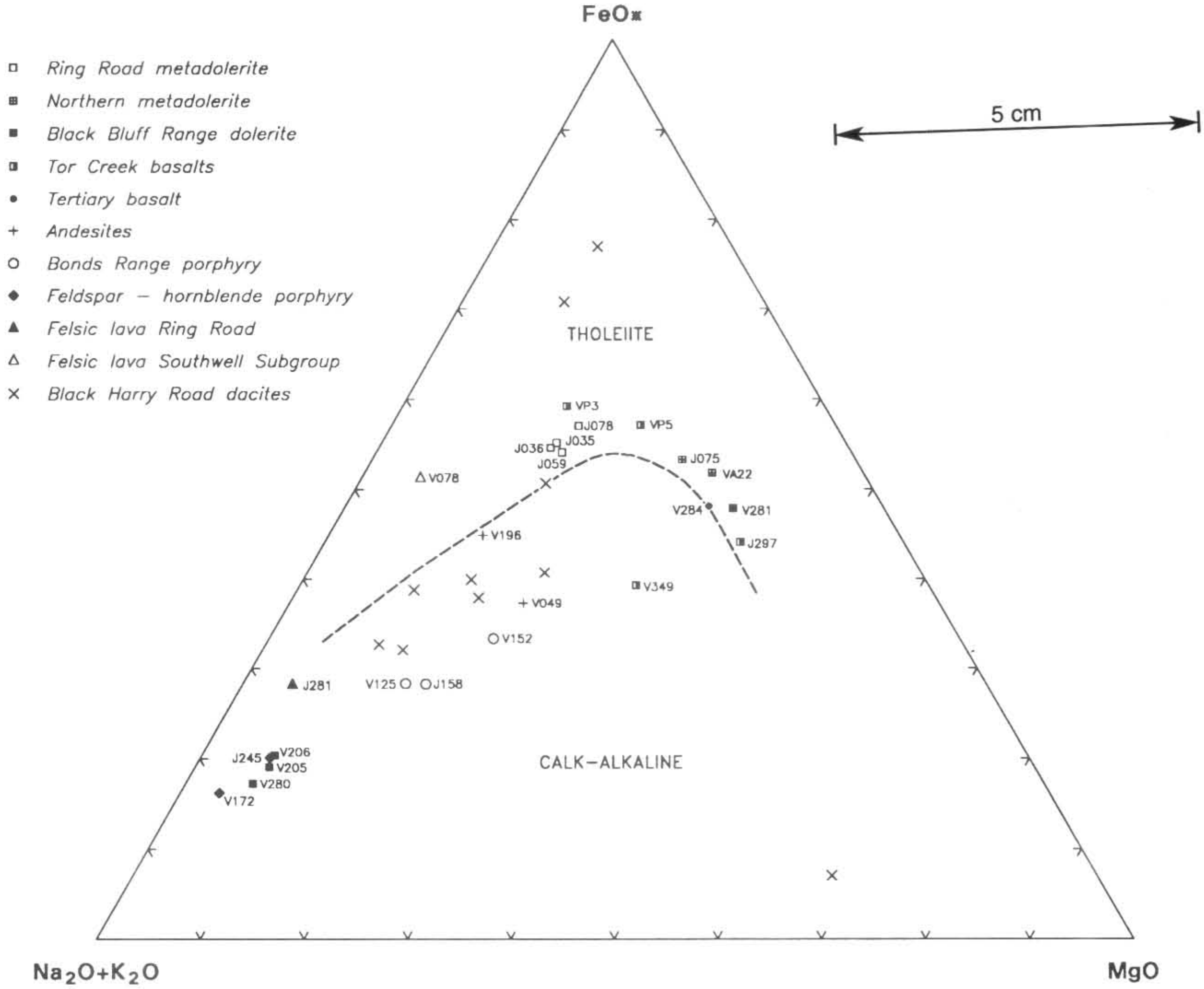


Figure 13. AFM plot for analysed samples. Fields of tholeiite and calc-alkaline compositions after Irvine and Baragar (1971).

(fig. 15), supporting the conclusion that the fresh and altered samples are from the same igneous body.

Tor Creek basalts

Four samples of these altered basalts have been analysed. Two of the samples (VP3 from Tor Creek, VP5 from Alps Road) are of the upper hematitic lavas, and are samples provided by D.B. Seymour. The other two are from the lower, epidote-rich bodies – J297 from the Alps Road quarry, and V349 from the body 1 km east of Alps Road.

The recalculated silica contents of the samples range from 50.4 to 54.4% SiO_2, indicating a basaltic to basaltic-andesite composition. The hematitic samples, as expected, are notably enriched in Fe_2O_3, while the epidote-altered samples are enriched in CaO but depleted in K_2O. TiO_2 values are lower in the epidote-altered samples. A comparison of trace elements shows the hematitic samples to be depleted in Sr, V and Cu, but enriched in Cr, Co and Ni.

On the AFM diagram (fig. 13), three of the samples plot in the tholeiite field, with the hematitic samples closer to the FeO apex. One sample (V349) plots in the calc-alkaline field, mainly as a consequence of its lower iron and higher alkali values.

On the Ti *vs* Zr diagram (fig. 14), the two epidote-rich samples plot in the upper part of the calc-alkaline field, while the hematitic samples are scattered in the general tholeiitic trend area.

On the Ti-Zr-Y diagram (fig. 15), three of the points are scattered in the general area of overlap of calc-alkaline and tholeiitic rocks (although well removed from the field of Mt Read andesites – Corbett, 1989), and VP5 is within the general tholeiite group close to the Tertiary basalt field.

The scatter of points shown even by the supposedly 'immobile' trace elements in these basalt samples, combined with the obvious alteration effects which have modified the major-element chemistry, makes it difficult to compare the basalts with other mafic rocks in the area. Table 1 indicates that there are general chemical similarities with the Black Bluff Range dolerite, and a genetic link between the two seems a distinct possibility. The relationship between the basalts and the unusual metadolerites to the west is difficult to assess. There appear to be closer similarities with the northern metadolerite, which also shows epidote alteration, than with the larger Ring Road body.

Tertiary basalt

One sample of Tertiary basalt (V284) was collected from the Cradle Mountain Link Road. Detailed description of the Tertiary basalt geochemistry of the St Valentines Peak area (including most of the region covered by Maps 7 and 8) has been given by Everard (1989), and

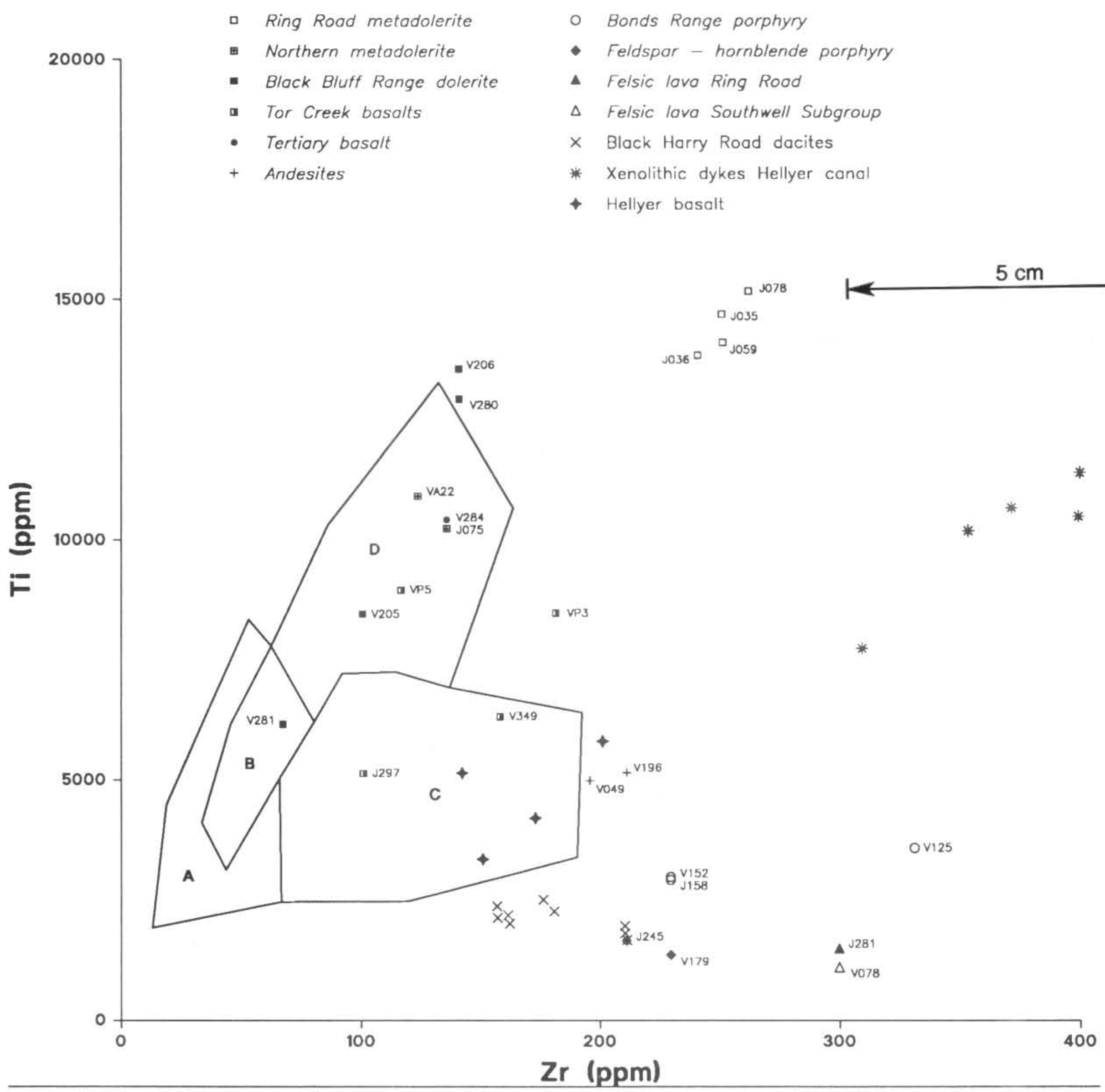


Figure 14. Plot of Ti *vs* Zr for analysed samples. Fields after Pearce and Cann (1973): A+B = low-K tholeiite; B+D = ocean floor basalt; B+C = calc-alkaline basalt.

some discussion is given by Corbett and Komyshan (1989) for the Que–Hellyer area.

Sample V284 is a hypersthene and olivine normative olivine tholeiite, and plots close to V281 (Black Bluff Range dolerite) within the tholeiitic field on the AFM diagram (fig. 13). In terms of major element composition, the Tertiary basalt sample has higher TiO_2, MgO and K_2O, and lower CaO contents, than sample V281. It is also higher in Rb, Sr, Zr, Nb, Y, Co, Ni and Cu and lower in Sc and Zn.

On the Ti-Zr-Y diagram (fig. 15) the basalt plots within the field of Tertiary basalts defined from Everard's (1989) data, as do the two samples from the northern metadolerite body. The Black Bluff Range dolerite samples plot well outside this field.

Andesites

Rocks of andesitic composition are very rare on Maps 7 and 8. A small flow within Tyndall Group correlates on the Cradle Mountain Link Road [CP958988] was sampled (V049), and another small body in the Cattley Creek window on the Black Bluff Range (V196).

The silica values of the andesites (60% and 64% SiO_2 anhydrous) straddle the andesite to dacite boundary of Ewart (1982), although loss of ignition values averaging 3.6% suggest that slightly more mafic compositions are likely. On the Zr/TiO_2 *vs* Nb/Y diagram (fig. 12), both samples plot near the andesite to rhyodacite/dacite boundary.

In terms of most major and minor elements the two samples are chemically similar, the only major differences being that V196 has slightly lower MgO, CaO and Na_2O values and an anomalous zinc value. The depletion in the above major elements may be a function of a slightly higher silica content.

On the AFM diagram (fig. 13), both analyses plot within the calc-alkaline field, although V196 is close to the tholeiitic-calc-alkaline boundary. The two samples plot close together on a calc-alkaline trend on the Ti *vs* Zr diagram (fig. 14). Their position on the Ti-Zr-Y diagram (fig. 15) is similar to that of the andesites from the Que–Hellyer Volcanics (Corbett, 1989).

Bonds Range porphyry

Three samples of this major porphyry body – from the Cradle Mountain Link Road (V152), Anio Creek (V125), and the Fury River (J158) – have been analysed. The Fury River sample was collected from a

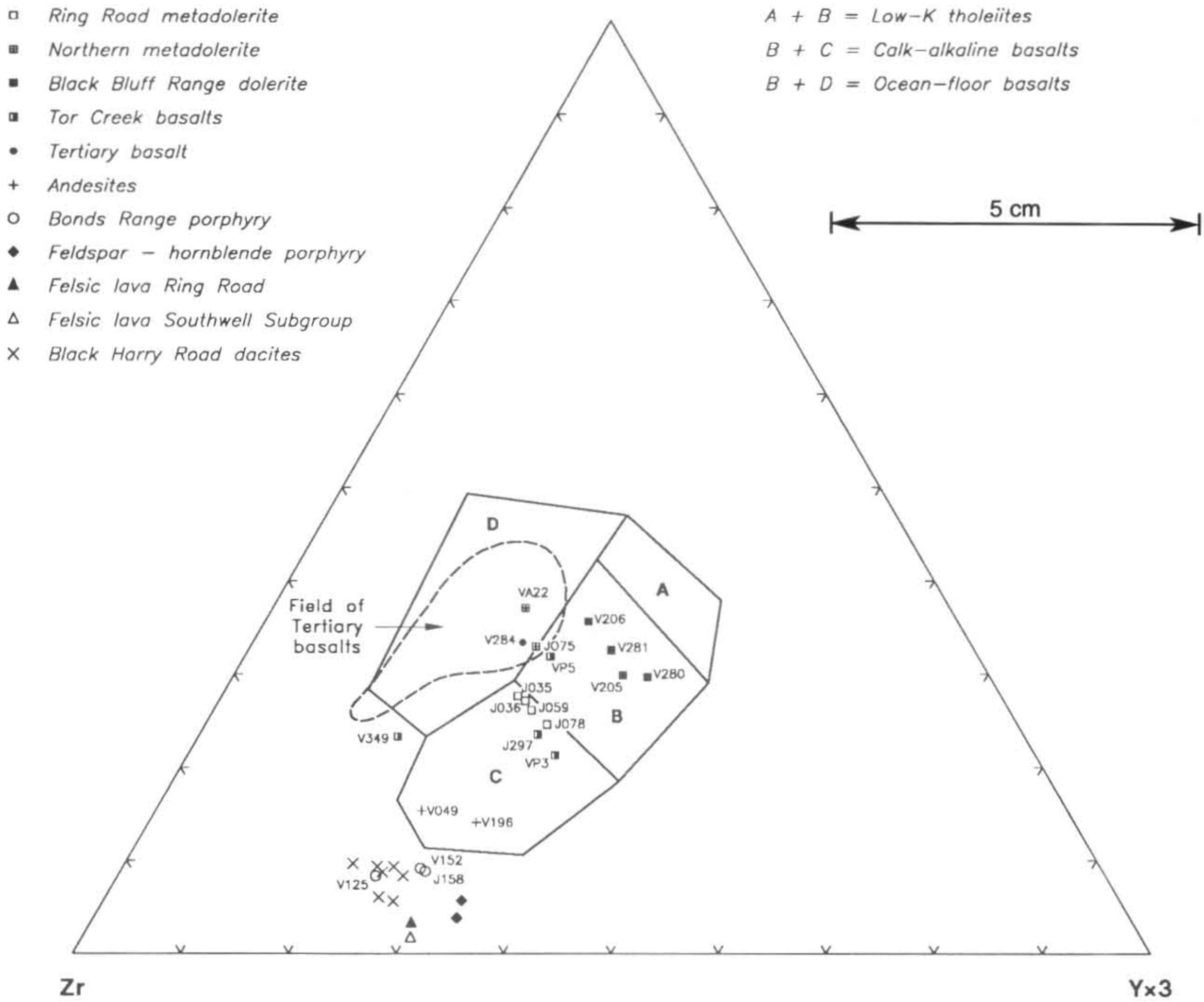


Figure 15. Plot of Zr - Ti/100 - Y×3 for analysed samples. Field of Tertiary basalts after Everard (1989).

coarse-grained phase within the porphyry 2 km south of the mouth of Anio Creek.

The silica range (67–71% SiO_2) indicates a dacitic composition, and the three samples plot in the middle of the rhyodacite-dacite field on Figure 12. Other diagrams show the calc-alkaline nature of the porphyries, with the samples plotting between the more mafic andesites and the more felsic rhyolites (fig. 13, 14, 15). The general chemical features and trace element abundances are also intermediate between those of the andesites and the more rhyolitic rocks.

Feldspar-hornblende porphyry

The distinctive pink hornblende-bearing porphyries in the Hodgetts Road area were originally considered to be possibly andesitic, but the analyses (J242, V179) indicate a rhyolitic composition, with 73–75% SiO_2. Thin sections show that secondary quartz is present in the rocks, and hence the original composition may have been somewhat more mafic. Trace-element ratios show the samples plotting close to the rhyolite-rhyodacite boundary (fig. 12).

The samples are fairly potash-rich (5.4–6.6% K_2O) and CaO-poor (0.05–0.08%), and this, together with the strong pink colouration, suggests the presence of fine-grained K-feldspar in the groundmass. Other plots demonstrate the calc-alkaline nature of the rocks (fig. 13, 14, 15).

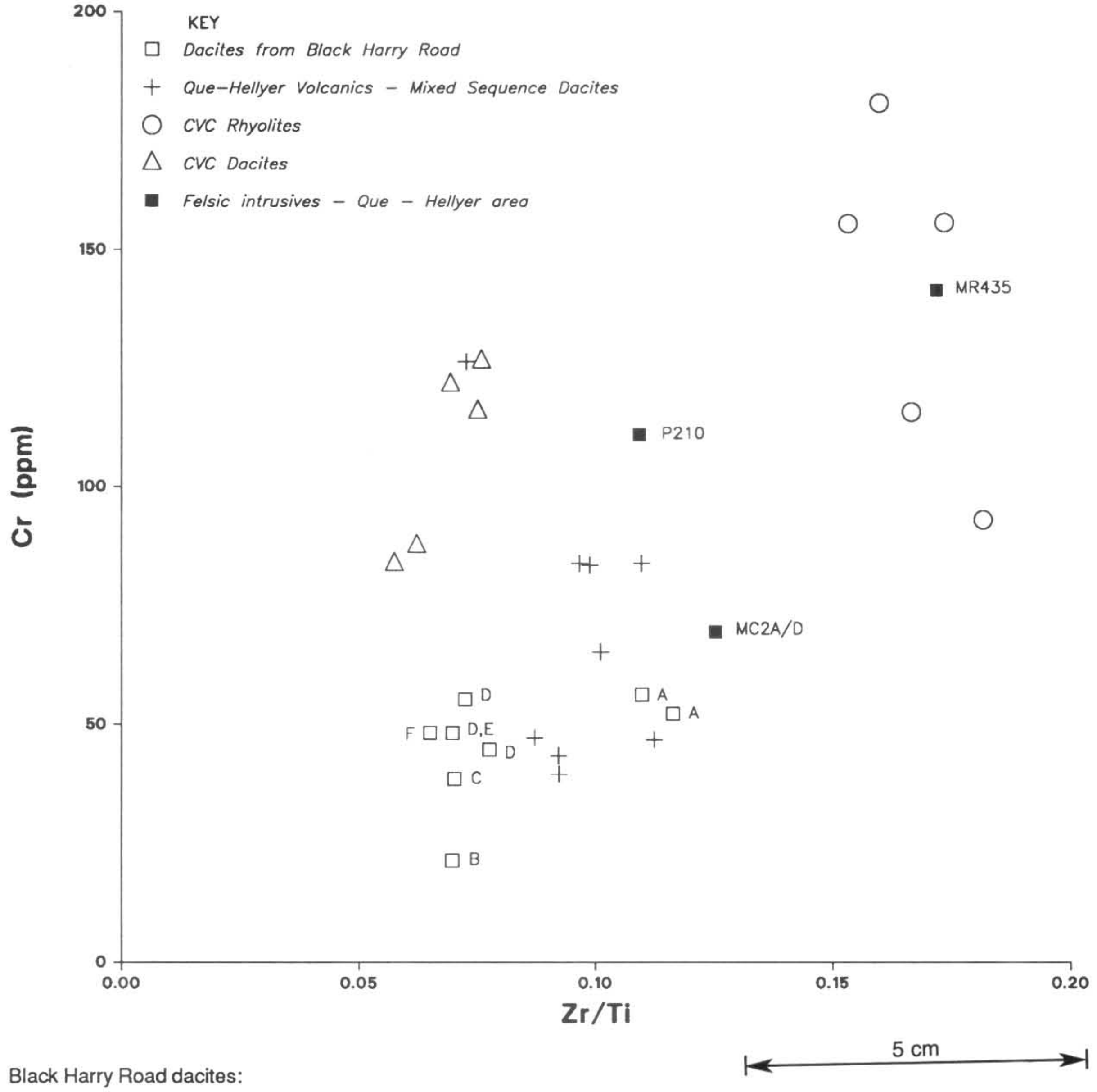
Felsic lavas from Ring Road and Southwell Subgroup

Samples of fine-grained felsic lava from the Ring Road (J281) and from the hills 2 km north of the Cradle Mountain Link Road (V078) both appear to be from the upper part of the Southwell Subgroup. Both are rhyolitic in composition, and plot in the rhyolite field of Figure 12. Sample V078 is enriched in Fe_2O_3 and depleted in Na_2O compared to J281, but the samples are otherwise fairly similar chemically. Secondary hematitisation associated with late Cambrian weathering and oxidation at the base of the Denison Group probably accounts for the iron enrichment in V078, and its anomalous plot on the AFM diagram (fig. 13).

Black Harry Road dacites

Major and trace element analyses of nine dacite samples from the Black Harry Road drill hole are shown in Table 2. Fillet grind assays for the hole are given in Appendix B.

The felsic bodies have recalculated anhydrous silica values ranging from 70.42 to 74.48%. The loss of ignition (LOI) is generally high (3.87–6.78%). In terms of Ewart's 1982 classification scheme, the intrusives are rhyolitic, however due to the high LOI a less felsic composition (rhyodacitic-dacitic) is more realistic. This is confirmed on Figure 12, where all nine analyses plot within the rhyodacite-dacite field of Winchester and Floyd (1977). Figures 14 and 15 show the samples



Black Harry Road dacites:

Unit	*Sample No.*	*Depth (m)*
A	BH-2–3	8.4–120.66
B	BH-5	147.2–149.23
C	BH-6	150.98–163.45
D	BH-8, 11, 12	220.92–277.39
E	BH-13	302.05–313.88
F	BH-14	350.14–355.84

Figure 16. Plot of Zr/Ti *vs* Cr for felsic intrusives and volcanic rocks from Black Harry Road drill hole and other areas. Central Volcanic Complex data from McNeill and Corbett (1989), other data from Corbett and Komyshan (1989).

plotting in the general field of other felsic calc-alkaline rocks from the area.

On the AFM diagram (fig. 13), the samples plot in the calc-alkaline field except for two notable exceptions which plot close to the FeO apex in the tholeiite field. These two samples (BH2, 3) are from the uppermost dacite unit (10–120 m), and are notably enriched in FeO and depleted in MgO compared to all other samples. Other differences are also apparent between this upper unit and the lower dacite bodies, including higher MnO, lower CaO, lower Ba and V, and higher Y, Nb, Zr, La and Nd.

A useful discrimination is obtained using a plot of Cr vs Zr/Ti (fig. 16). On this diagram, the two samples from the uppermost body (designated A) plot in a separate field with Zr/Ti ratios around 0.11, while the samples from five other bodies (B–F) have ratios around 0.07. This same subdivision is evident on a plot (fig. 17) using the fillet grind assays provided by Aberfoyle (Appendix B). Here, the 10 or so points from the upper body form a distinct field at around 0.13–0.15 Zr/Ti, while samples from the other bodies group around 0.06–0.09 Zr/Ti. The discrepancy between the two plots is mainly due to slightly lower Ti and Cr values obtained from the fillet grinds.

A comparison with felsic lavas from the Central Volcanic Complex in the Tullah–Mt Block area (McNeill and Corbett, 1989), and with dacites from the Que–Hellyer Volcanics (Corbett and Komyshan, 1989), is also given on Figure 16. The CVC rhyolites have

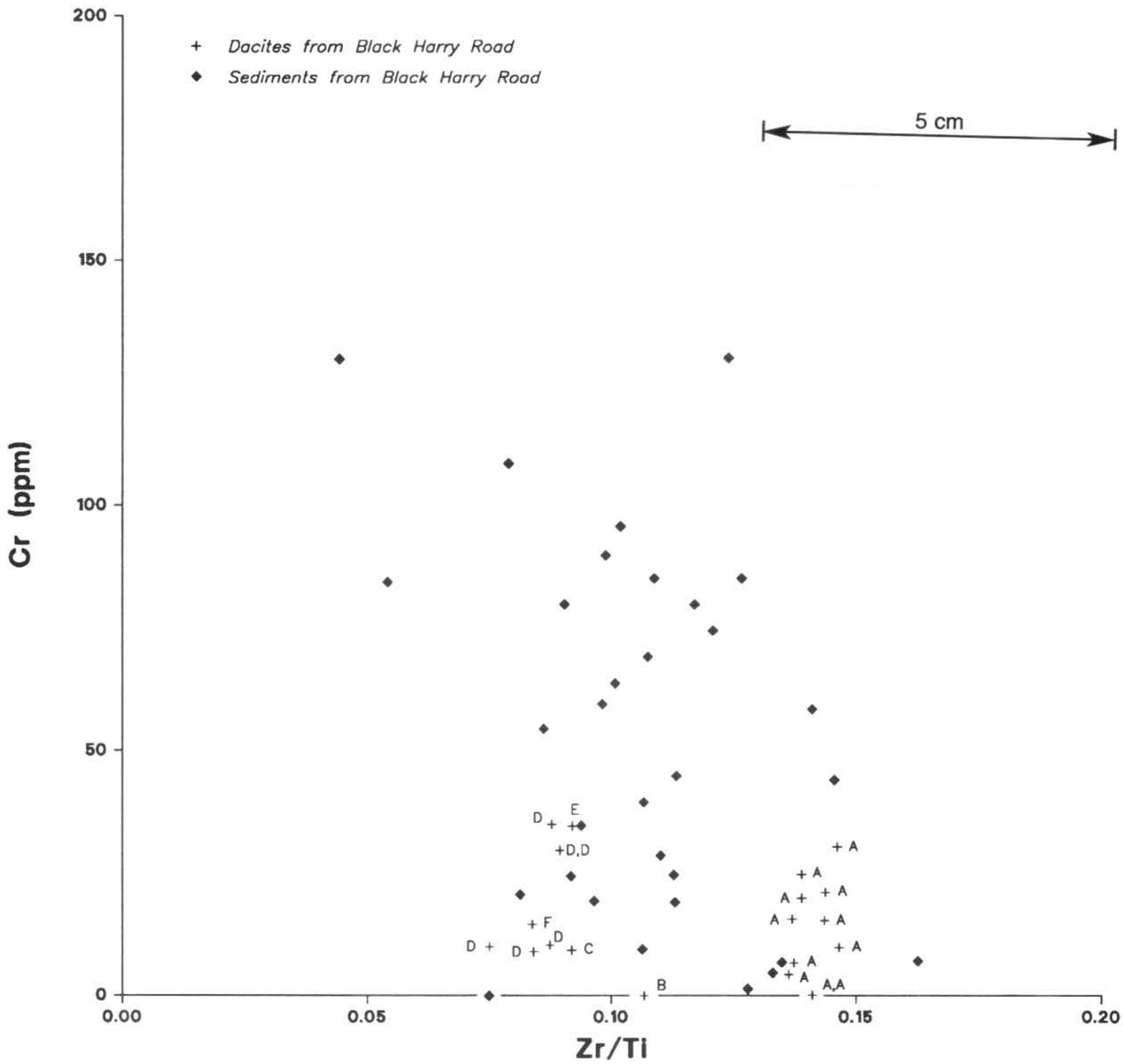


Figure 17. Plot of Zr/Ti *vs* Cr from fillet grinds of dacites and sediments in the Black Harry Road drill hole.

significantly higher Zr/Ti and Cr values, and are well separated from all other groups. Dacites from CVC have Zr/Ti ratios which overlap the lower part of the range of Black Harry Road rocks, but have higher Cr values and plot in a separate field. Dacites from the Mixed Sequence at Que–Hellyer have generally similar Zr/Ti ratios to the Black Harry dacites, and the two fields show considerable overlap. There is, however, some attenuation to higher Cr values in the Que–Hellyer rocks.

A comparison of other chemical features between the Black Harry Road and Que–Hellyer dacites shows many similarities, the differences being slightly lower MgO levels (0.8–1.8% for Black Harry rocks *vs* average 0.5% for Q–H), slightly higher CaO levels (1.4% *vs* average 0.9%), and lower values of Ba and Sr. While not conclusive, these comparisons suggest the possibility of a relationship between the intrusive and possibly extrusive dacites within the lower Animal Creek Greywacke sequence at Black Harry Road and the extrusive-intrusive dacites occurring in the host-rock sequence of the Que–Hellyer Volcanics.

Felsic intrusive rocks of rhyolitic to dacitic composition also occur in the Que–Hellyer area and in a few places on Maps 7 and 8. Three of the five samples analysed by Corbett and Komyshan (1989) are shown on Figure 16 (the other two plot off the diagram because of high Zr contents). The samples are widely scattered, and no obvious relationship to the Black Harry Road rocks is apparent.

Black Harry Road sediments and other sedimentary units – comments on Ti–Zr–Cr abundances

The fillet grind assays of sedimentary and epiclastic rocks in the Black Harry Road drill hole (Appendix B) show a wide range of Zr/Ti ratios, and Cr contents ranging from 0 to 130 ppm (fig. 17). All three elements are commonly more abundant in the sediments than in the dacite bodies. Highest Cr values tend to be in either the micaceous sandstones in the upper part of the hole, or in black shales, with low values being recorded in the tuffaceous rocks and a general tendency for decreasing Cr down the hole.

Four assays of fillet grinds of micaceous sandstones from the Animal Creek Greywacke in the Mt Charter drill hole are shown in Table 3 (from Corbett and Komyshan, 1989). These also show high Cr values (290–390 ppm), and Zr/Ti ratios of 0.06–0.08.

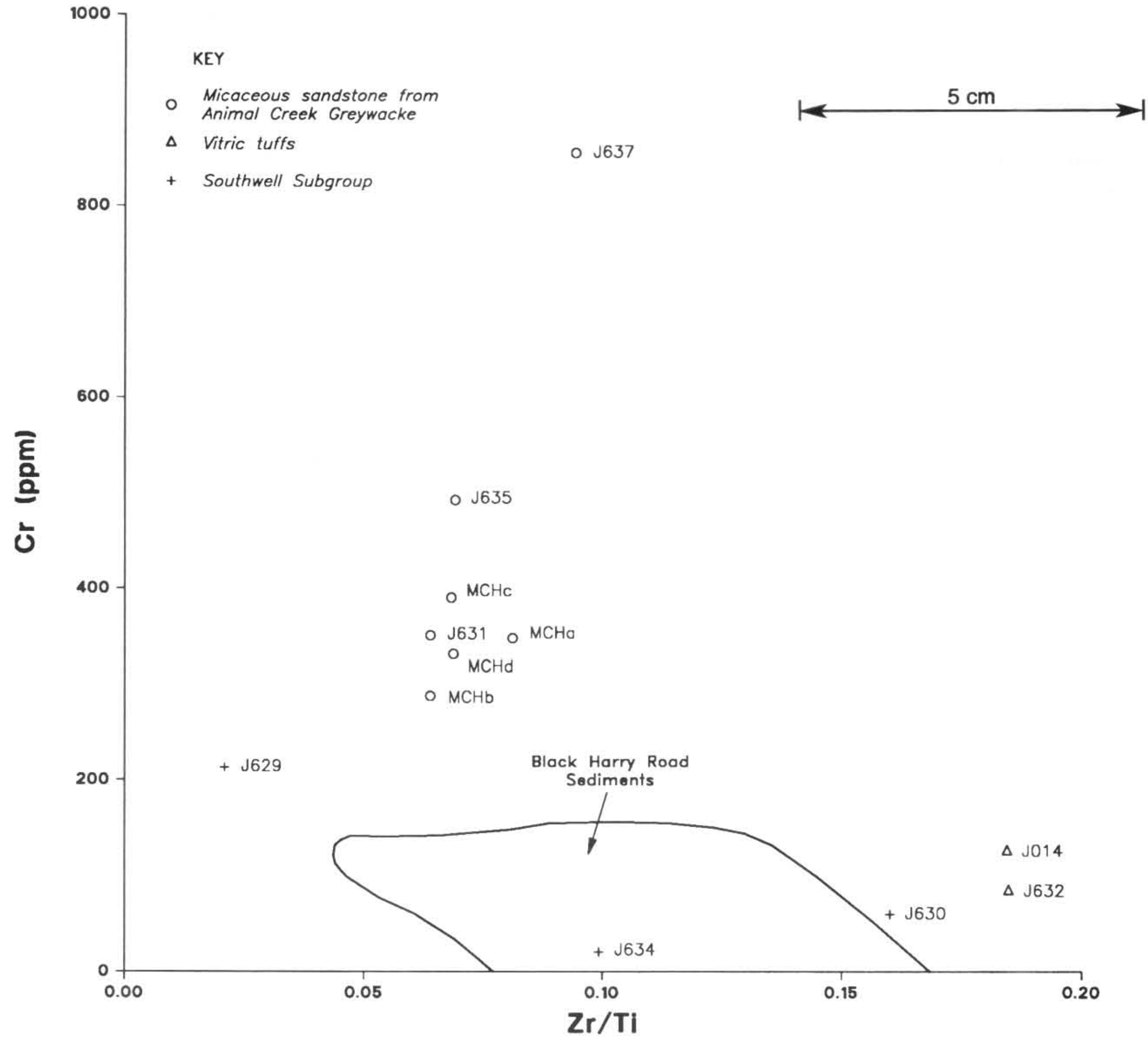


Figure 18. Plot of Zr/Ti *vs* Cr for various sedimentary rocks in the Hellyer–Two Hummocks area.

In order to test whether the abundances of these elements might be a useful stratigraphic guide, eight further samples of sedimentary and epiclastic rocks from Maps 7 and 8 were assayed (table 3). Three of these were micaceous greywackes from correlates of the Animal Creek Greywacke (one from Cradle Mountain Link Road, two from Black Marsh Road), and these also show high to very high Cr values (350, 490, 850 ppm), and Zr/Ti ratios in the 0.06–0.09 range (fig. 18). Detrital chromite was present in thin sections of these rocks.

Two of the samples were of vitric-rich tuffs or tuffaceous siltstones, also from the Black Marsh Road area but more typical of the lower vitric tuff sequence. These have much lower Cr values (80–120 ppm) and higher Zr/Ti ratios, similar to those of sediments in the Black Harry Road drill hole (fig. 18).

Three further samples were from tuffaceous siltstones in Southwell Subgroup correlates. These show low to moderate Cr values (19–210 ppm) and highly variable Zr/Ti ratios.

In conclusion, the limited data available suggest that the sandstones from the Animal Creek Greywacke are anomalously rich in Cr and have a limited range of Zr/Ti ratios, factors which could provide a useful stratigraphic guide. The sandstones are typically rich in detrital mica and other Precambrian-derived clastic material, but the source of the Cr (presumably as chromite grains) is unknown. An increase in the felsic volcanic component in the sediments is accompanied by decreasing Cr values, and this can be related to the low Cr levels seen in all dacites and rhyolites of the Mt Read belt (e.g. McNeill and Corbett, 1989; Corbett, 1989).

?Devonian–?Cretaceous dykes in Hellyer tailings dam area

Five assays of trace elements from these dykes – two from the canal exposure and three from drill holes – have kindly been supplied by Aberfoyle, and are shown in Table 4. Also shown for comparison are four similar assays from the Hellyer basalt (upper part of Que–Hellyer Volcanics) from the same area.

The dykes are highly enriched in Ti (13000–19000 ppm), and have much higher Zr levels than the basalts. On the Ti-Zr diagram (fig. 14), the dyke samples plot in a separate field well removed from any other known rock units in the area.

SUB-BASALT GEOLOGY

The distribution of Palaeozoic rock units beneath the Tertiary basalt cover in the area north and north-east of

Table 3
Zr, Ti AND Cr CONCENTRATIONS FOR SOME SEDIMENTARY ROCKS IN THE HELLYER–MT TOR AREA

Sample Number	Sample Description	Sample Location	Grid Co-ordinates	Cr	Zr	Ti	Zr/Ti
MCHa	Animal Creek greywacke	DH MCH-1, 562–570 m	CP891912	350	190	2350	0.080
MCHb	Animal Creek greywacke	DH MCH-1, 570–580 m	CP891912	290	180	2800	0.064
MCHc	Animal Creek greywacke	DH MCH-1, 580–590 m	CP891912	390	170	2500	0.068
MCHd	Animal Creek greywacke	DH MCH-1, 590–606 m	CP891912	330	200	2900	0.070
J635	Animal Creek greywacke	Cradle Mountain Link Road	CP909985	490	165	2398	0.069
J631	Black Marsh Road greywacke	Cobbers Road North	DQ019080	350	240	3777	0.064
J637	Black Marsh Road greywacke	Beecroft DH No. 1, 125 m	CQ995059	850	185	1978	0.094
J014	Vitric tuff	Black Marsh Road quarry	DQ026106	120	200	1079	0.185
J632	Tuffaceous siltstone	Black Marsh Road quarry	DQ027107	81	200	1079	0.185
J629	Tuffaceous siltstone	Upper River Road area	DQ030060	210	140	6535	0.021
J630	Tuffaceous siltstone	Upper River Road area	DQ024059	57	260	1619	0.161
J634	Tuffaceous siltstone	Ring Road	DQ044122	19	250	2518	0.099

Chemical analyses performed by Department of Mines, Launceston Laboratories

Table 4
TRACE ELEMENT ASSAYS FROM XENOLITHIC MAFIC DYKES AND HELLYER BASALTS IN THE HELLYER TAILINGS DAM CANAL AREA

Sample	Description	Location	Cr	Ni	Ti	Zr	Ba	As	Y
427927	Xenolithic mafic dyke	DH MAC-15 81.7 m	35	95	1.7%	350	230	6	40
427937	Xenolithic mafic dyke	DH MAC-15 44.1–46.2 m	80	140	1.78%	370	590	4	45
427942	Xenolithic mafic dyke	DH MAC-15 79.6–82.6 m	400	195	1.33%	310	140	10	45
427854	Xenolithic mafic dyke	West end of canal exposure	95	–	1.9%	400	<10	6	40
427855	Xenolithic mafic dyke	West end of canal exposure	75	–	1.78%	400	<10	5	45
427865	Hellyer basalt	East end of canal exposure	870	–	4300	170	60	4	–
427851	Hellyer basalt	Central part of canal exposure	820	–	3300	150	320	20	20
427853	Hellyer basalt	60 m north of canal exposure	1000	–	6000	200	65	12	25
427943	Hellyer basalt	DH MAC-15 82.6–91.6 m	930	285	5300	140	170	12	30

Assays by Analabs for Aberfoyle Ltd. Drill core data from fillet grinds.

Hellyer mine is of considerable interest to exploration geologists and to regional geologists generally. A considerable amount of information is now available from drilling by the Department of Mines (partly for the Sub-Basalt Drilling Program and partly for recent stratigraphic investigations for the Mt Read Volcanics mapping project) and by companies – particularly the Panfin joint venture partners and Aberfoyle Exploration. Eight SBDP holes (2, 4, 6, 7, 9, 10, 14, 15) in the area of interest are shown on the reconstruction map (fig. 19), together with four Panfin holes (see fig. 5 for details), two Aberfoyle holes (Mac 20 and 22), and the most recent Mines Department hole (MXRD-1). In addition, several small outcrops of Palaeozoic rocks in 'windows' through the basalt, recently mapped by Aberfoyle Resources (McNeill, 1989*a*, 1989*b*), provide further constraints and are also shown.

The map (fig. 19) shows a possible reconstruction of the sub-basalt geology which accounts for all the known data. The known surface geology of the area is also included, together with the major mapped structures to show their possible continuity. It must be emphasised that the sub-basalt data is sparse in most areas, that the actual sub-basalt geology is undoubtedly more complex than shown, and that other interpretations are possible.

Some significant features of the sub-basalt geology are listed below.

(1) Equivalents of the Que–Hellyer Volcanics are present west of Mt Cattley. These are considered to occupy the axial region of the Black Marsh syncline, which appears to plunge to the south in this area. Some possibility exists for these volcanics to occur in the northern part of this structure, which appears to plunge north, but this has not been shown on the map.

(2) Extensive areas of Denison Group, Gordon Group and Siluro–Devonian rocks occur to the north, east and south of Moory Mount, suggesting the presence of NE-trending folds and NW-trending cross-faults and folds.

(3) There appears to be a large area occupied by the 'lower vitric tuff sequence' to the south of Two Hummocks. Some possibility exists that younger rocks, such as the Animal Creek Greywacke, occur in this area west of SBDP-15.

(4) A continuation of the Henty Fault is postulated to the NNE of Mt Cripps, possibly extending to beneath the Denison Group east of Two Hummocks.

STRUCTURAL GEOLOGY

Introduction

The Cradle Mountain Link Road–Mt Tor area lies at the junction of two of the major structural trends in Tasmania, where the N-S trends of the West Coast Range–Dundas Trough area intersect, or merge with, the E-W trends of the Fossey Mountains Trough. The area has been the subject of fairly detailed structural analysis by Seymour (1980, 1989; Williams and Seymour, 1989) which has resulted in subdivision of the Devonian fold trends into four main sequential phases:

D_1 = E-W folds

D_2 = NE-SW folds

D_3 = N-S folds

D_4 = NW-SE folds

Detailed structural analysis has not been attempted during the present study because of time constraints. However, the mapping has been more detailed than in any previous study, and has provided additional data on fold locations and trends as well as delineating a number of major stratigraphic boundaries which help to clarify some of the structural relationships. Compilation of the sub-basalt data has also helped in delineating some major structures, as shown on the structural compilation map (fig. 19). Major and minor structures mapped from surface exposures are shown on this map, as well as some representative bedding and cleavage readings.

Folding

Rock distribution in the area is largely controlled by a series of major folds, and to a lesser extent by faults. The dominant fold system comprises NE-trending (030°–045°T) upright to steeply-inclined folds with horizontal to moderately plunging hingelines. The larger of these folds (e.g. Black Bluff Range anticline, Belvoir syncline, Cattley syncline – fig. 19) extend for over 20 km along strike, and have half-wavelengths of the order of 2–3 kilometres. In the Que–Hellyer area, smaller folds on a similar north-east trend have half-wavelengths of the order of 0.5–1 km.

The longest of the Que–Hellyer folds, the Que syncline, swings into a N-S trend as it is traced south of Mt Charter. Similarly, some of the major folds in the Black Bluff Range area (particularly the Black Bluff Range and Belvoir structures) swing into an ENE and then E-W trend as they are traced northwards. This swing in trend is clearly shown by more recent mapping to the east of Black Bluff (Pemberton and Vicary, 1989). By contrast, the Black Marsh syncline, developed in Cambrian rocks west of the Black Bluff Range, appears to swing into a NNW trend when traced northwards towards Two Hummocks. It is notable in this area, however, that the major Cambrian lithological trends are truncated on a regional unconformity surface at the E-W trending base of the Denison Group siliciclastics, suggesting that at least some folding of the Cambrian sequence occurred prior to deposition of the siliciclastics.

A series of smaller-scale folds (half-wavelengths of 200–400 m) trending parallel to the major north-east trend (≈040°) occurs in Denison Group rocks about 4 km SSE of Mt Tor. Folds at a small Cambrian window 2 km SW of Black Bluff have a slightly more easterly trend (≈050°), as do small folds near Lake Lea.

Overprinting the NE-trending folds is a later set of smaller, less continuous, NW-trending folds, the interaction producing dome and basin structures in places. Good examples of this occur just west of Hellyer mine, and in Tor Creek just east of Mt Tor. The Cambrian windows on the Black Bluff Range are probably also related, at least in part, to cross folding on this trend. The NW folds, and associated faults, are most prominently developed in a zone north of Mt Cripps, where a belt of Denison Group siliciclastics and younger rocks extends north-westerly towards Moory Mount. This belt has the form of a complex syncline plunging shallowly to the NW or NNW. Available evidence suggests that this zone of cross-structures does not extend eastwards into the Mt Beecroft area, but may be truncated or terminated against the postulated extension of the Henty Fault.

Folds of N-S trend are notably rare in the area, the known examples being two small folds to the north-west and south-west of Black Bluff, another in Cambrian rocks south-west of Mt Tor, and one at Mt Cripps.

East-west oriented folds are also rare, the most notable example being the large syncline occupied by Ordovician limestone in the Loongana–Two Hummocks area (partly off the map). A small fold on this trend is present just west of Black Bluff.

Analysis of sub-areas

Four sub-areas have been designated in the area covered by Maps 7 and 8 to facilitate more detailed analysis (fig. 20). They are based on major lithological boundaries (mainly top and bottom of Denison Group, and Precambrian margin), and are not meant to be structural domains as such.

SUB-AREA 1 – MT CATTLEY – TWO HUMMOCKS

This sub-area encompasses the Cambrian rocks in the Mt Cattley–Two Hummocks area. Mapping clearly indicates a major structural discordance between the generally N-trending Cambrian rocks and the E-W trending Denison Group between Mt Tor and Two Hummocks (fig. 19). A central major synclinal structure, the Black Marsh syncline, is evident, with its axial region occupied by the Animal Creek Greywacke correlate. This syncline plunges gently southwards (≈20°) in the southern part of the area, where the axial region is occupied by correlates of the QueHellyer Volcanics, Que River Shale and Southwell Subgroup. Limited evidence suggests a gentle northerly plunge in the northern part of the area.

A NNE to N-trending anticlinal structure, with steep to vertical limb dips, has been mapped to the east of the Black Marsh syncline near Mt Cattley, and again in the Leven River west of Mt Tor.

A stereoplot of 184 bedding readings from this sub-area is shown in Figure 21a, b. The plot does not define a simple great circle distribution, but rather suggests folding about axes trending approximately NNE and ENE (both plunging gently north-east). Examination of Map 8 suggests that bedding related to the mapped NNE-trending folds swings into a NNW to north-west trend about a broad fold axis trending approximately ENE and passing just south of Mt Tor. This later fold axis probably corresponds to the broad anticlinal bend shown by the Denison Group siliciclastics around the western flanks of Mt Tor. There does not appear to be any cleavage development associated with this fold.

A stereoplot of 35 cleavages from Sub-area 1 (fig. 22) indicates a predominance of cleavages oriented NNW to north-west, but with a range from NNE to WNW. The data suggest that the measured dominant cleavages are mainly related to the NW-oriented cross-folding.

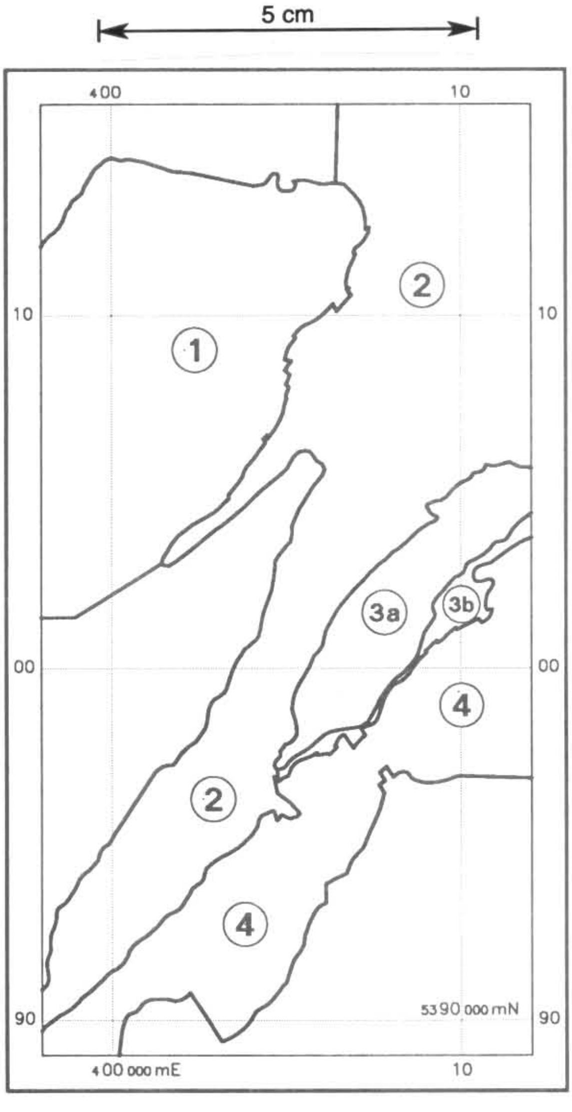


Figure 20. Map showing sub-areas used for structural analysis.

SUB-AREA 2 – BLACK BLUFF RANGE

A major anticline-syncline couple, trending about 035°, dominates the Denison Group rocks on the Black Bluff Range (fig. 19). This is reflected in the stereoplot of 500 bedding readings (fig. 23a, b), which shows a broad band oriented NW-SE across the plot. The data have a bilateral distribution about a great circle, indicating shallow plunges to 035° and 215°.

Cleavages in the siliciclastic rocks in this sub-area are generally poorly developed and difficult to measure, and too few data were available to warrant plotting. Measured cleavages on Maps 7 and 8 are mainly of either NE-SW orientation, related to the major fold axes, or of N-S orientation, presumably related to (?later) folds of that orientation. A third group of cleavages, of NW-SE orientation, is evident in the northern part of the area, and is related to the NW-trending cross-folds.

SUB-AREA 3a – VALE OF BELVOIR

The Gordon Group limestone occupying the core of this large synclinal structure outcrops only poorly. Available bedding and cleavage data suggest that the fold is asymmetrical (oversteepened from the west), with the fold axis located closer to the western side of the valley. A stereoplot of the limited bedding data is shown in fig. 24, and suggests a statistical fold axis plunging 5° to 031°. A rather angular closure to the syncline is apparent at the southern end of the Vale of Belvoir, where the structure is complicated by the interaction of NW-trending cross-folds and faults.

SUB-AREA 3b – DENISÒN GROUP ON BONDS RANGE

A number of small, NE-trending folds have been mapped in the shallow cover of Denison Group siliciclastics on Bonds Range. Bedding data from this area (fig. 25) define an essentially horizontal statistical fold axis trending 041°. A dome-shaped window of Cambrian rocks near Bonds Hill indicates modification of the structure by later cross-folding, probably on a north-west trend.

SUB-AREA 4 – BACK PEAK–IRIS RIVER

This sub-area encompasses the Cambrian rocks in the Back Peak–Iris River area, bounded by the Precambrian basement to the east and the Denison Group siliciclastics to the west. The Cambrian sequence sits unconformably on the Precambrian basement, and generally dips and faces away from it.

The stereoplot of 89 bedding readings from this sub-area (fig. 26) defines a statistical fold axis plunging 55° towards 344°. The data from the Iris River area only (i.e. east of the obvious constriction of the Cambrian belt at Etchells Creek) show a trend closer to WNW-SSE, and suggest a statistical fold axis plunging 47° to 031° (fig. 26).

The data indicate that the rocks in the area have been folded about a broad anticline plunging to the NNW. This fold coincides with the change in trend of the Precambrian margin from NNE to E-W, suggesting that the fold represents a fold of the basement as well as of the cover rocks. The 50° plunge of the fold is much steeper than any of the plunges recorded for other major folds in the area (usually less than 20°), and this suggests that the Cambrian beds had been steepened prior to the Devonian folding.

A stereoplot of 25 cleavages recorded in the Back Peak and Sticht Range Beds (fig. 27) shows the predominant cleavage direction to be NNW (about 345°), parallel to the major fold axis described above but probably mainly due to the Devonian north-west cross-folding.

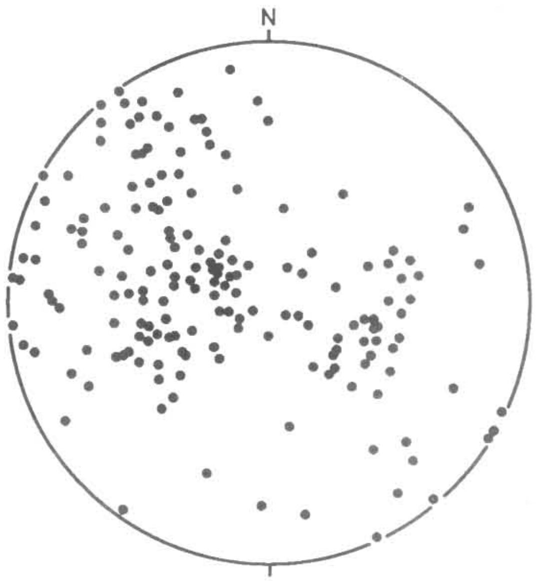


Figure 21a. Stereoplot of 184 poles to bedding, Sub-area 1.

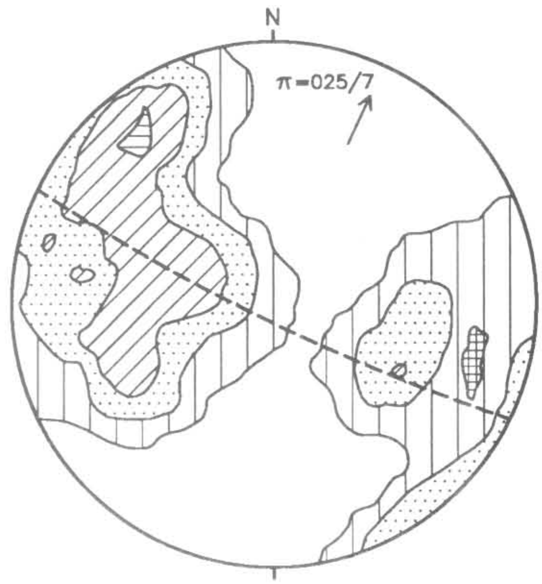


Figure 21b. Contoured plot of poles to bedding, Sub-area 1.

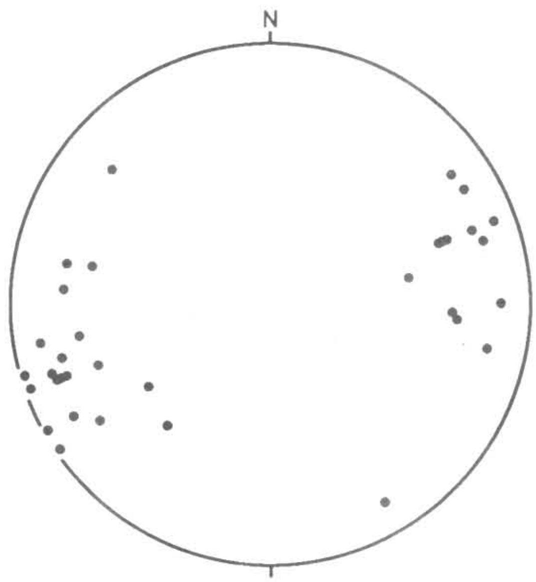


Figure 22. Stereoplot of 35 poles to cleavage, Sub-area 1.

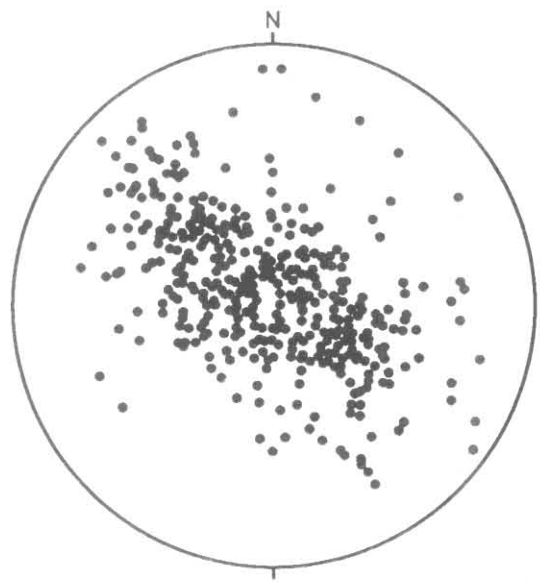


Figure 23a. Stereoplot of 500 poles to bedding, Sub-area 2.

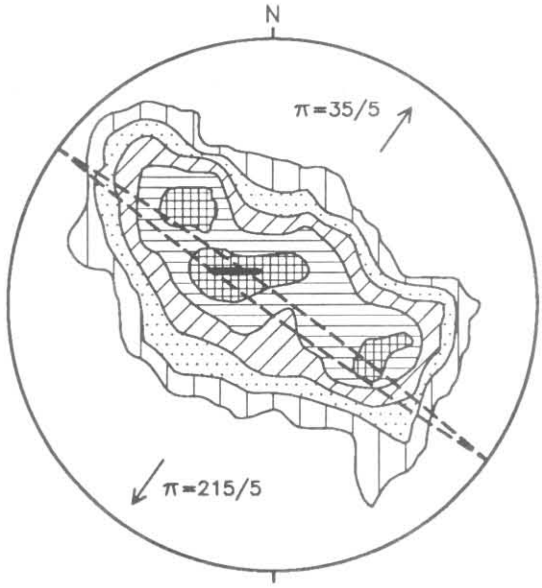


Figure 23b. Contoured plot of poles to bedding, Sub-area 2.

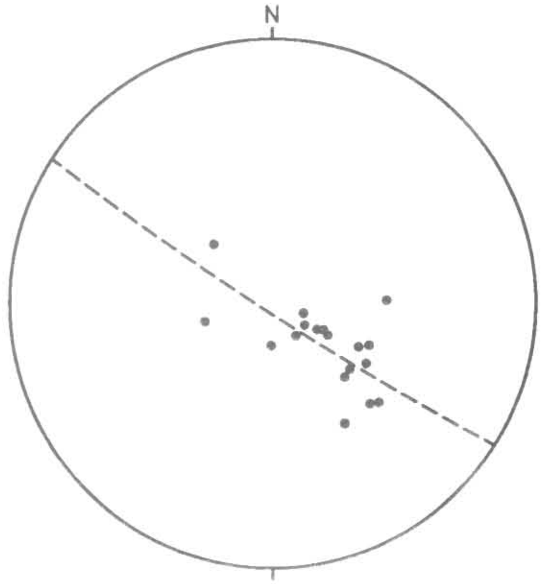
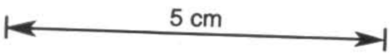


Figure 24. Stereoplot of 18 poles to bedding, Sub-area 3a.



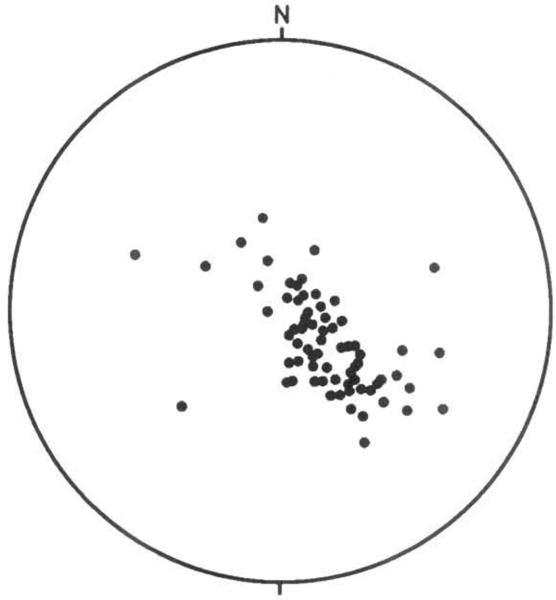


Figure 25. Stereoplot of 98 poles to bedding, Sub-area 3b.

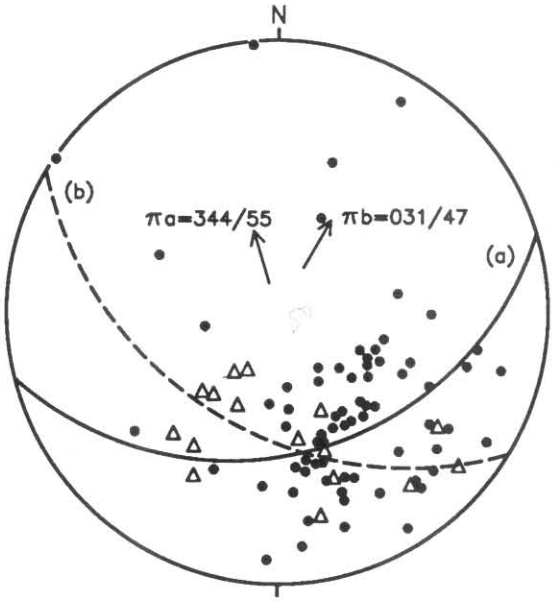


Figure 26. Stereoplot of 89 poles to bedding, Sub-area 4. Triangles denote readings from Iris River area.

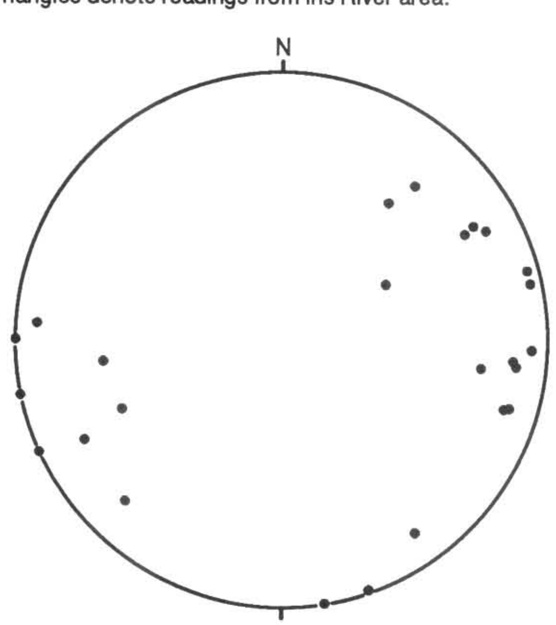


Figure 27. Stereoplot of 25 poles to cleavage, Sub-area 4.

5 cm

Sequence of fold trends

The study of fold trends reported here is insufficient to clearly determine the sequence of development of the various trends, since cleavage over-printing relationships have not been examined. However, the following observations can be made.

(1) The NNE-trending folds appear to be the earliest in this area.

(2) There is a suggestion of overprinting of these by NE folds in the head of Cattley Creek and on the Mt Tor anticlinal structure, but this is unconfirmed.

(3) The NW-trending folds clearly overprint the NNE folds, and are associated with numerous faults.

(4) Some minor N-S folds are probably later than the NNE folds, but again this is unconfirmed.

(5) The relationship of the E-W folds to the other fold trends is not really clear, since they are mostly off the map. The merging of the NE trends with E-W trends around Black Bluff may indicate that the two trends are more or less contemporaneous.

Faulting

Some 70 faults have been mapped on Maps 7 and 8 (not including the Que–Hellyer area), and the rose diagram (fig. 28) clearly shows the dominance of NW to NNW-oriented structured. These late faults are clearly associated with the widespread cross-folding in the same direction. Displacements on the faults are mostly small (a few hundred metres or less), and most of the faults appear to be steep. Examples of both north-side-up and south-side-up displacements are present, and both sinistral and dextral movements could be represented.

A significant fault on the north-west trend forms the southern boundary of the Sticht Range Beds and Back Peak Beds near Mt Remus, and it is likely that this fault was an active basin-margin structure during deposition. Several other NW-trending faults in this area also coincide with major thickness changes in the Cambrian sequence, suggesting contemporaneous movement.

Several faults with north-east trend are also present. One of these, at Mt Tor, is associated with the wedging out and disappearance of several units in the lower part of the Denison Group, suggesting it was an active structure in the late Cambrian-early Ordovician.

THE HENTY FAULT

The continuation or otherwise of the enigmatic NNE-trending Henty Fault from the Que River mine area has been the subject of considerable speculation. A zone of strongly cleaved, folded and lineated rocks (mainly greywacke and shale) marks it in the vicinity of the Sharks Fin (Komyshan, 1986). However, recent mapping by Aberfoyle geologists to the east of the Que River mine, and by M. Vicary in the Cradle Mountain Link Road area (Map 7), clearly shows that the fault zone does not continue northwards to the Link Road as suggested by Komyshan (1986).

Rather, it seems that the structure is displaced on, or replaced by, the ENE-trending Mt Cripps fault, which intersects it just east of the Que River mine (fig. 19). Air-photo interpretation by the authors, and some reconnaissance mapping by A. McNeill (pers. comm.), indicates that the latter fault probably swings into a north-east trend at Mt Cripps, where it truncates SE-trending bedding in the siliciclastic sequence before disappearing under Tertiary basalt. Since the fault is a major structure, it is likely that it continues to the north or north-east beneath the basalt cover.

Drilling carried out since the production of Maps 7 and 8 has shown that equivalents of the Que–Hellyer

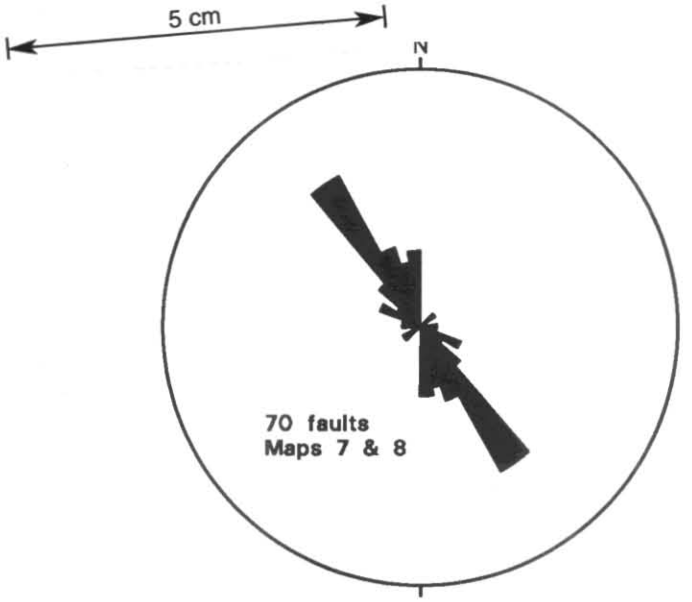


Figure 28. Rose diagram of fault orientations, Maps 7 and 8.

Volcanics occur in the basalt-covered southern part of the Black Marsh syncline, overlying the Animal Creek Greywacke. Since the Que–Hellyer Volcanics and Animal Creek Greywacke do not appear to be present east of the Black Marsh syncline, it is suggested herein that a major fault lies along, or close to, the poorly exposed eastern margin of the Animal Creek Greywacke sequence in the syncline, and this fault has tentatively been connected with the Henty Fault at Mt Cripps (fig. 19). The position of this postulated fault is poorly defined, however, and on present evidence it could lie up to a kilometre east of the greywacke margin.

This postulated sub-basalt position for the Henty Fault extension is in agreement with the palaeogeographic relationship between the fault and the Que–Hellyer Volcanics suggested by Corbett (1986) and Corbett and Komyshan (1989) – namely, that the basaltic-andesitic volcanics developed as large lenses within tensional openings associated with early movements on the fault. Splay faults, such as the Mt Charter Fault, may also have functioned as important controls on this early basin development.

Although the Henty Fault is considered to be initially a Cambrian structure, there has clearly been much Devonian movement on it, as evidenced by the fact that Ordovician and Siluro–Devonian rocks are affected by the fault between Tullah and the Sharks Fin. A five-stage movement history, including pre-Devonian thrusting, has been deduced by Berry (1989) from studies of the fault in the Tullah–Mt Farrell area. In the present area, it seems likely that some of the unusual fold trends and localised effects in the Sharks Fin and Mt Cripps areas are due to Devonian movements on the fault system.

SUMMARY, SYNTHESIS AND DISCUSSION

General

MRVP Maps 7 and 8 straddle most of the width of the Mt Read Volcanics belt north of Hellyer mine, from the Precambrian basement in the east to the sediment-dominated sequences in the west. There is considerable cover by younger siliciclastic rocks in the central part of the area, and difficulties remain in correlating the west-facing sequences in the east with the folded sequences in the west. Difficulties involved with correlating beneath the extensive cover of Tertiary basalt in the west have to some extent been overcome by the use of sub-basalt drilling information.

Some revision to previous stratigraphic nomenclature has been necessary in this report. The lower part of the sequence overlying the Central Volcanic Complex, previously referred to as the lower tuffaceous part of the Animal Creek Greywacke (Komyshan, 1986; Corbett and Komyshan, 1989), is herein designated as a separate unit – informally referred to as the 'lower vitric tuff sequence' pending formal naming. The term 'Animal Creek Greywacke' is restricted to the distinctive bedded greywacke sequence.

Cambrian volcanic and sedimentary Sequences

'LOWER VITRIC TUFF SEQUENCE'

This widespread unit of interbedded vitric tuff, tuffaceous siltstone, sandstone and shale, with intercalated quartz-phyric tuffs and coarse mass-flow units, is probably at least 600 m thick. It is known to extend from east of Mt Block to Two Hummocks. It appears to overlie the Central Volcanic Complex (CVC) in the main, but a partially interfingering relationship is also possible. Abundant dacite intrusives occur within the upper part of the sequence at Black Harry Road, but these are geochemically distinct from the CVC rocks and are more akin to the dacites in the Que–Hellyer Volcanics.

ANIMAL CREEK GREYWACKE *(sensu stricto)*

This unit extends at least 30 km from south of Mt Charter to the Two Hummocks area, and is of the order of 350 m thick. The typical sandstones consist predominantly of Precambrian detritus, but the upper and lower contacts are gradational into tuffaceous rocks. An 11-metre volcaniclastic unit marks its contact with the overlying Que–Hellyer Volcanics in the Middlesex Road drill hole.

Assays of the micaceous greywackes from several different areas show surprisingly high chrome values, in the range 300-800 ppm, comparable with the values shown by basalts and dolerites. The source of the detrital chromite present in the sandstones, and the reasons for its concentration, are uncertain. There are no obvious chromite sources, such as ultramafic-mafic complexes, associated with the likely Tyennan Precambrian source rocks to the east, the known ultramafic rocks being in the opposite direction to the west and south-west. However, Berry and Crawford (1988) have postulated that much of the Tyennan region may originally have been covered with large allochthonous ultramafic sheets (of which the preserved complexes to the west represent remnants), and such sheets represent a possible source for the chromite detritus. Further studies are necessary to determine the nature of the chromite and the likely source rocks, and to determine whether other similar Precambrian-derived sandstone units (e.g. Sticht Range Beds, Stitt Quartzite, Miners Ridge Sandstone) are also chromite-enriched.

QUE–HELLYER VOLCANICS

This andesitic-basaltic sequence, which hosts the Que River and Hellyer massive sulphide deposits, is now known to be present in the Black Marsh syncline, 10 km north-east of Hellyer. The sequence in the latter area is known only from drill holes, with a complete intersection of 242.3 m obtained in MXRD-1. The intersected sequence consists almost entirely of pillowed, massive and brecciated andesite-basalt flows (mostly fine-grained rather than obviously feldspar-phyric), with no obvious equivalents of the dacites which mark the host horizon at Que River. However, an 'andesitic volcaniclastic wacke' unit, 0.3 m thick, which has been identified by W. Herrmann (pers.comm.) 170 m below the top of the andesitic sequence, appears to divide the sequence into geochemically distinct units which may correspond to the upper and lower parts of the Que–Hellyer sequence.

Fillet grind assay data for MXRD-1 became available in the final stages of writing of this report, and are listed in Table B4 of Appendix B. Several points of interest can be seen from these data:

(1) The 'andesitic wacke' unit (at 525.2 m) is notably enriched in Pb (463 ppm) compared to all other rocks in the section. In thin section (J852) this unit is actually a volcaniclastic siltstone, and is rich in microfossils (radiolaria and sponge spicules).

(2) The andesites-basalts above this siltstone can be subdivided into four distinct geochemical units (fig. 29):
Unit 1 (525.2–460 m) has a low Zr/Ti ratio (averaging 0.018), high Cr (360–658 ppm), low Y (13–19 ppm) and high Mg (average 4.5%);
Unit 2 (460–430 m) has high Zr/Ti (averaging 0.038), variable Cr (138–408 ppm), moderate to high Y (18–24 ppm), and low Mg (2.92%);
Unit 3 (420–390 m) has Zr/Ti averaging 0.028, high Cr (403–474 ppm), low Y (15–18 ppm) and high Mg (average 4.5%);

Unit 4 (390-360 m) has Zr/Ti averaging 0.025, moderate Y (14–19 ppm) and low Mg (average (2.6%).
When compared with fillet grind data from DH MCH-1 (Corbett and Komyshan, 1989) these four units are geochemically comparable with the upper basalts and andesites of the Que–Hellyer Volcanics.

(3) The lower andesites-basalts below the siltstone (525.5 m–597.8 m) have similar Zr/Ti ratios to the lower basalt (195.7–354.3 m) from MCH-1 (0.030 for MXRD-1 and 0,028 for MCH-1), and similar low Cr (22–51 ppm for MXRD-1 and 50–75 ppm for MCH-1).

The Que–Hellyer Volcanics can be seen to lens out rapidly to the north-west of Hellyer mine, where only a thin, discontinuous sliver of basalt separates the Que River Shale from the underlying Animal Creek Greywacke. This implies that the andesites and basalts were erupted in a fairly narrow, trough-like feature roughly 5 km wide and at least 20 km long.

QUE RIVER SHALE

This distinctive pyritic-carbonaceous shale unit, which blankets the Que–Hellyer Volcanics from south-west of Mt Charter to north of Hellyer mine, is also present in the Black Marsh syncline area. It is 50 m thick in MXRD-1, and separated from the underlying andesites-basalts by a polymict epiclastic breccia similar to that reported in the Hellyer area (Corbett and Komyshan, 1989). The thickness of shale, and the paucity or absence of coarse-grained units or volcanic rocks within it, suggests a major hiatus in volcanic (and tectonic?) activity following the andesitic volcanism and preceding the felsic volcanism of the Southwell Subgroup.

The fillet grind assay data from MXRD-1 (Appendix B) indicate a remarkable consistency in composition throughout the shale.

SOUTHWELL SUBGROUP

The Southwell Subgroup marks a return to active, pumice-rich, quartz-phyric felsic volcanism after the Que River Shale hiatus, and contains abundant mass-flow breccias and tuffaceous rocks intercalated with turbidite-type greywackes and siltstones. The sequence is lithologically similar to much of the 'lower vitric tuff sequence'. Flow-banded, glassy felsic lavas, associated with similar-looking pumice-rich tuffs, occur in the upper, easternmost part of the sequence on the Cradle Mountain Link Road and on the Ring Road, suggesting that the sequence is becoming more proximal to the east.

'TYNDALL GROUP CORRELATES'

The youngest volcanic sequence west of the Black Bluff Range appears to constitute a new and slightly different cycle of volcanism. In the most complete section available, on the Link Road, it commences with a local unit of siliciclastic conglomerate, sandstone and siltstone, containing rounded boulders of Precambrian quartzite. This is followed by a sequence of quartz-feldspar-phyric crystal tuffs, crystal-lithic tuffs and tuffaceous sandstones with minor andesites, welded ignimbrites and fossiliferous shales. The tuffs include distinctive pink and green banded units which are essentially identical to those which characterise the lower part of the Tyndall Group at Queenstown (Corbett *et al.*, 1974), but the base of the group is poorly defined and may include equivalents of part or all of the Southwell Subgroup as well. The age of the fauna in the fossiliferous shales is latest Middle Cambrian, similar to that of the Comstock Tuff fauna.

The minor andesitic lavas in the Link Road section are lithologically and chemically comparable to andesites of the Que–Hellyer Volcanics, suggesting the possibility of a 'failed cycle' of Que–Hellyer type at this level.

The upper part of the Link Road sequence comprises several hundred metres of volcaniclastic conglomerate and sandstone. Much of the conglomerate is of boulder grade, and implies considerable erosion of a nearby volcanic pile. Andesite clasts are abundant, but also present are clasts of quartz-feldspar-biotite porphyry, a porphyry type known only to the east and typified by the large body on Bonds Range. This implies that the Bonds Range porphyry had been emplaced and unroofed by this stage, which in turn implies that the Back Peak and Sticht Range Beds (which are intruded by the porphyry) are older than the volcaniclastic sequence.

The volcaniclastic conglomerate sequence is well developed along the entire western margin of the Black Bluff Range from Mt Tor to Mt Cripps, and is also present on the northern side of Black Bluff. However, it appears to be absent or only minimally developed along the eastern side of the range, where the younger siliciclastic sequence sits directly on the Bonds Range porphyry in most places. This distribution suggests that the volcaniclastic debris represents an 'apron' of coarse erosional detritus fringing the outer side of a high area formed by the main volcanic pile and the Bonds Range porphyry.

The apparent absence in the Mt Cattley–Mt Tor area of the lower part of the Tyndall Group sequence (the banded crystal tuffs etc.) suggests that these rocks were deposited in more restricted basins or belts than were the volcaniclastic conglomerates. Such a basin or belt could lie to the east of the Mt Cattley exposures, beneath the area of extensive siliciclastic cover. Baillie (in Seymour, 1989) describes 'agglomerates' and tuffs from the Native Track Tier area (north of Map 8) which he regards as being identical to the Comstock Tuff.

VOLCANIC ROCKS IN 'WINDOWS' ON THE BLACK BLUFF RANGE

The volcanic rocks exposed in the series of windows along the Black Bluff Range consist largely of glassy, flow-like rocks associated with pumice-bearing tuffs, volcaniclastic conglomerates and sandstones, and minor andesites. The presence of welded shard textures in at least one of the flow rocks suggests that the rocks are mainly densely welded ignimbrites rather than lavas, and implies a largely subaerial environment. The welded tuffs, andesites and volcaniclastic sediments are very similar to those in the Tyndall Group correlates in the Cradle Mountain Link Road area, while the pumice-bearing tuffs closely resemble those those from the upper part of the Southwell Subgroup.

Thus the windows exposures probably represent the proximal equivalents of the upper Southwell–lower Tyndall rocks, on or near the main axis of the original volcanic belt.

STICHT RANGE BEDS

The Sticht Range Beds correlates form the basal unit of the Mt Read Volcanics sequence on the eastern side. They rest unconformably on the Precambrian basement, and are predominantly of Precambrian derivation. They consist largely of fine- to medium-grained sandstones, suggesting a relatively low-energy depositional environment compared to that of the conglomerate-rich sequence of the type area (Corbett, 1982; Baillie, 1989*a*). The Beds are discontinuous along the Precambrian margin, and wedge out completely to the north-east of Etchells Creek. Marked thickness changes are associated with several NW-trending faults, and deposition appears to have occurred in a series of small, fault-controlled basins.

Correlation of the Sticht Range Beds with units in the western part of the Mt Read belt remains uncertain.

BACK PEAK BEDS

The Back Peak Beds comprise up to 1000 m of mainly fine-grained, shard- and pumice-rich tuffs and tuffaceous sediments, interbedded with the siliceous Sticht Range Beds at the base and also showing marked thickness changes associated with NW-trending faults. Their distribution suggests they have filled in and 'topped up' the initial basins, and smoothed off the original basement topography.

The apparent paucity of coarse-grained units and absence of proximal-type volcanics (lavas etc) suggests that deposition of the Back Peak Beds took place some distance from the main volcanic belt, perhaps mainly by fall-out from ash-cloud eruptions. The abundance of fine ash and pumice suggests a possible relationship to the 'lower vitric tuff sequence' to the west of Black Bluff Range.

The intrusive Bonds Range porphyry forms the upper contact of the Back Peak Beds, and the nature of the original overlying sequence is uncertain. The closest rocks stratigraphically are some quartz-feldspar-phyric crystal-vitric-lithic tuffs near the western margin of the porphyry in the Vale River 'window'.

Cambrian intrusive events

BONDS RANGE PORPHYRY

This sill-like body of quartz-feldspar-biotite ± hornblende porphyry extends for at least 55 km along strike, from south of the Fury River to Lake Cethana, and is 2–3 km wide. This makes it probably the largest Cambrian intrusive body in the State. It is comparable in size to the larger Devonian granitoid bodies in western Tasmania, and has a granitic composition, suggesting that it should have a similar influence on the gravity field. It lies along, or parallel to, the Precambrian-Cambrian margin, and is one of a series of such porphyry bodies and related granitic rocks (including the Murchison Granite) marking the eastern side of the Mt Read Volcanics belt from Elliott Bay to Sheffield (Corbett and Turner, 1989). The porphyry, and its numerous apophyses, directly intrudes the Precambrian rocks in many areas, providing further confirmation that the eastern part of the Mt Read belt was erupted on Tyennan basement.

DOLERITE IN MXRD-1 – CORRELATE OF MT CHARTER DOLERITES

The 67 m-thick dolerite sill intersected in MXRD-1 occupies a similar stratigraphic position to dolerites in the Mt Charter area. A preliminary plot of Ti-Zr values from the fillet grind assays (Appendix B) gives a field of values close to that of the Mt Charter dolerite (fig. 29).

As noted by Corbett and Komyshan (1989), the general geochemical and alteration features shown by the Mt Charter dolerites suggest a relationship to the calc-alkaline basalts and andesites of the Que–Hellyer Volcanics. The dolerites possibly represent the final phase of magmatic activity associated with this volcanism. They do not appear to be related to other mafic bodies in the Leven River or Black Bluff Range areas (fig. 29).

MAFIC INTRUSIVES IN THE LEVEN RIVER AREA

Several altered tholeiitic mafic intrusives occur within the upper Southwell Subgroup and lower Tyndall Group correlates in the Level River area, and represent a complex late Cambrian (or possibly younger) phase of mafic activity which is difficult to relate to any other event.

The largest body, the Ring Road metadolerite, is a chlorite-carbonate-epidote-sericite-altered rock with ophitic to porphyritic (plagioclase-pyroxene-phyric) texture and basalt-andesite composition. It is notably enriched in Ti and Zr, and plots in a distinct field, well removed from the other tholeiites, on the Ti-Zr diagram (fig. 29).

The superficially similar northern metadolerite body is an intensely epidote-quartz-actinolite-altered rock with subophitic texture in plagioclase and pyroxene, and an andesitic to basaltic composition. It has moderate Ti and Zr levels (fig. 29), and the two analysed samples show a remarkably close correspondence to the Tertiary basalt on the trace element discrimination diagrams. However, the degree of alteration suggests a pre-Tertiary, probably pre-Devonian age, and the alteration assemblage is typical of Cambrian mafic rocks.

The metadolerites are not related to the Mt Charter dolerites, which appear to be calc-alkaline in character. There may be a relationship to the abundant tholeiitic dykes which intrude the Central Volcanic Complex in the Mt Read area, particularly near the Henty Fault, and which appear to be related to gabbros and extrusive basalts in the western part of the Henty Fault Wedge (Corbett, 1989). However, most of these rocks have lower Ti and Zr values than the metadolerites (fig. 29).

The abundant epidote alteration which characterises the northern metadolerite is reminiscent of that affecting the stratigraphically lower samples of Tor Creek basalts (J297, V349). However, the Ti values of the latter are considerably lower.

Further study is required to determine the significance and relationships of these enigmatic mafic bodies. Analysis of rare earth elements appears to be a logical first step.

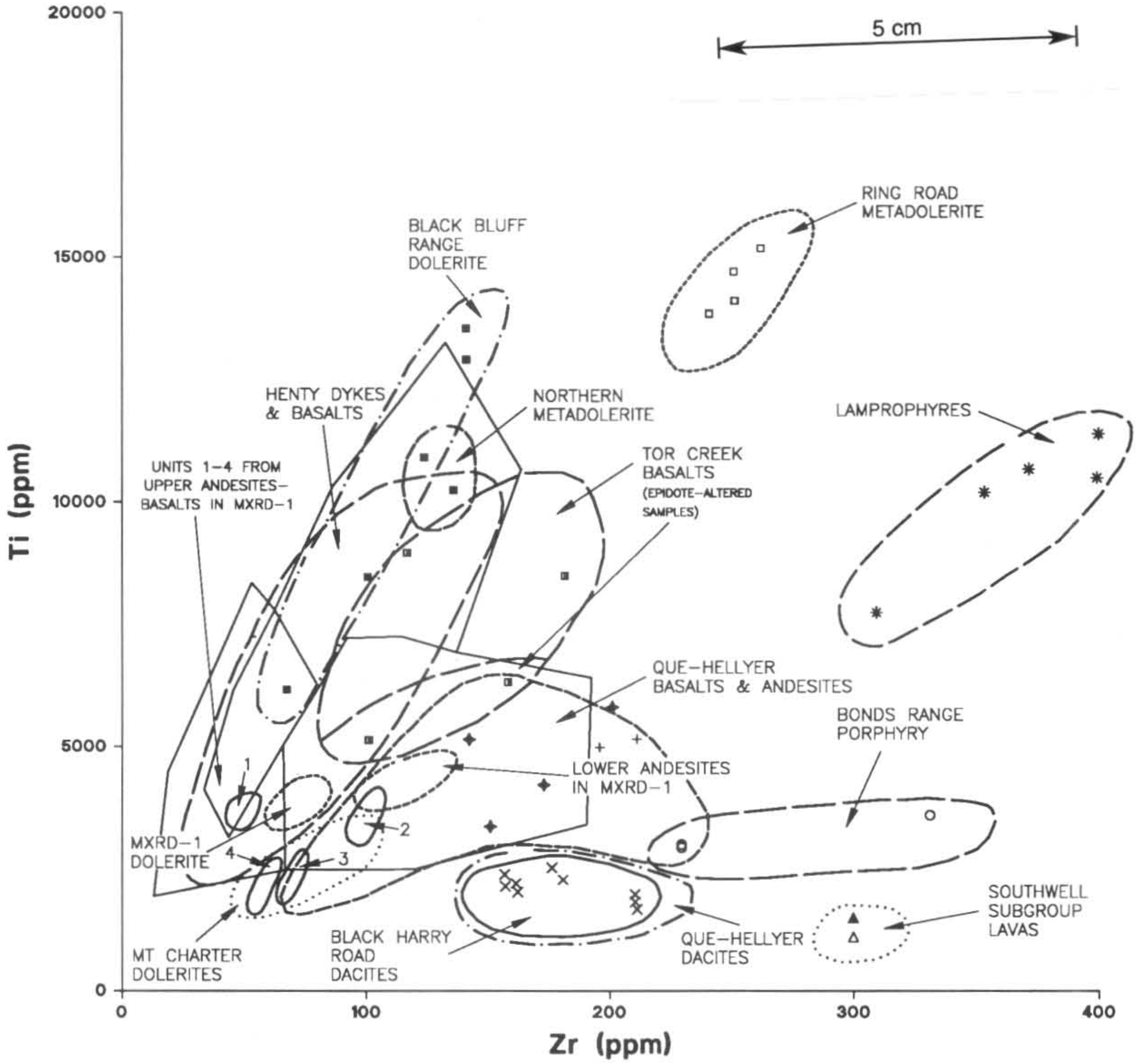


Figure 29. Ti-Zr plot showing fields of major rock units. Additional data from Corbett and Komyshan (1989) and Corbett (1989).

Mafic volcanics and intrusives on the Black Bluff Range

The basalts and dolerites mapped within the siliciclastic sequence on the Black Bluff Range during the present study represent a new magmatic phase in Tasmanian geology. The rocks are tholeiitic and not related to the Mt Read Volcanics. The basalts are latest Cambrian to early Ordovician in age, as indicated by the host sediments. Although a minimum K-Ar mineral age of 329±4 Ma (Carboniferous) has been obtained from the dolerite, alteration and strain effects are seen in thin section, and the body appears to have been affected by the same folding and faulting which affect the host rocks. These factors suggest that a pre-Devonian age is likely for the dolerite, and a genetic link to the basalts seems likely. However, further studies are necessary to confirm this.

The Tor Creek basalts occur as small flows and larger plug-like bodies, in a matrix of volcaniclastic sandstone, close to the base of the Moina Sandstone correlate. The uppermost flows are strongly oxidised and cleaved, such that they resemble red shales, and can easily be overlooked in mapping. The lower bodies are more massive, and are pale green in colour due to the abundant epidote. The relationship between the upper and lower basalts remains uncertain.

The presence of tholeiitic basalts, and possibly related dolerite intrusives, within the Denison Group sequence, may reflect a rifting environment associated with deposition of the siliciclastic conglomerates and sandstones.

Denison Group siliciclastics – a syn-tectonic sequence?

The Denison Group sequence has an apparently conformable contact with the underlying volcaniclastic conglomerate sequence (Tyndall Group correlates) between Mt Tor and Mt Cripps, but elsewhere has an erosional, disconformable contact, with varying degrees of angular discordance, on the underlying Cambrian rocks. Angular discordance is particularly apparent between Two Hummocks and Mt Tor, where the E-W striking siliciclastics truncate the generally NNW- to NW-trending, Cambrian units. At various places, the siliciclastics rest directly on most of the major units in the Cambrian sequence, including the 'lower vitric tuff sequence' (Two Hummocks), Animal Creek Greywacke (east of Two Hummocks), Southwell Subgroup (Leven River, and probably also in Black Bluff Range

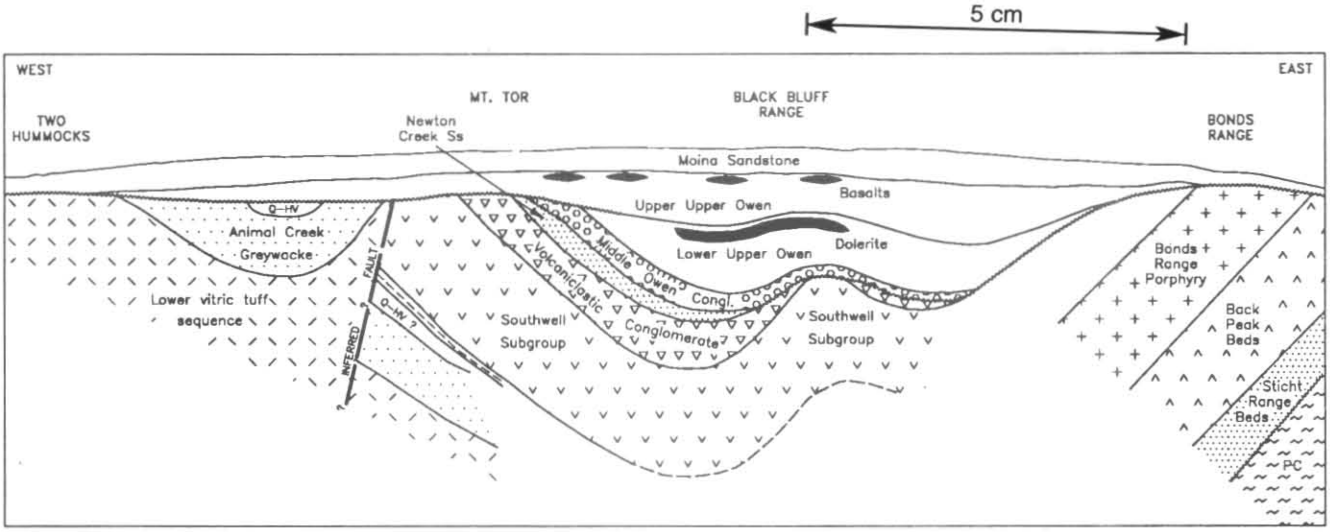


Figure 30. Diagrammatic cross-section from Two Hummocks to Bonds Range showing inferred relationships within Cambro-Ordovician sequence at about Moina Sandstone time. Not to scale.

windows), Bonds Range porphyry (Bonds Range), and Tyndall Group volcaniclastics. This implies folding, uplift and considerable erosion of the Cambrian rocks prior to, and probably during, deposition of the siliciclastics. These relationships are expressed diagrammatically in Figure 30.

Syn-depositional tectonism is also suggested by the internal angular unconformities and erosional disconformities within the siliciclastic sequence. Erosional breaks, associated with the introduction of coarser conglomerate, occur at the base of the Middle Owen Conglomerate correlate, at the base of the Upper Pink Sandstone, and at the base of the Moina Sandstone correlate. Some angular discordance is associated with the base of the Middle Owen at Mt Tor, but the most pronounced break is that at the base of the UpperPink Sandstone, which is associated with widespread angular discordance. This is particularly apparent at Mt Tor, where the unit truncates the underlying Middle Owen Conglomerate and Newton Creek Sandstone correlate. The unit continues north-west from Mt Tor to rest directly on successively older Cambrian units, including the Animal Creek Greywacke and 'lower vitric tuff sequence' at Two Hummocks (fig. 30). The implication of this relationship is that some folding and uplift of the Cambrian and early siliciclastic sequences occurred immediately prior to deposition of the Upper Pink Sandstone unit.

The unconformity at the base of the Upper Pink Sandstone also marks the introduction of abundant detrital chert to the sequence, in additional to the ubiquitous Precambrian quartzite detritus. The clasts of fine-grained, apparently unstrained, pink to greenish-grey chert occur throughout the Upper Pink Sandstone sequence above this level, but appear to be absent or rare below it. A similar phenomenon has been observed in many other areas at or about this level, e.g. Mt Murchison–Mt Farrell (McNeill, 1987), Tyndall Range (Corbett and Jackson, 1987), Mt Lyell–Mt Owen (Corbett *et al.*, 1989). The unconformity at this level appears to correspond to the well-known Haulage Unconformity at Queenstown (Corbett *et al.*, 1974; Wade and Solomon, 1956).

The chert does not appear to be of Precambrian origin. The only known chert-rich source rocks are in the older Cambrian sequences in the Waratah–Sheffield area (e. g. Barrington Chert), and to a lesser extent in the Mt Read Volcanics at Queenstown (Comstock Chert and related bodies). It is possible, therefore, that the tectonic event responsible for the unconformity resulted in significant uplift of Cambrian sequences west of the siliciclastic belt.

The stratigraphy of the siliciclastic sequence on the Black Bluff Range (fig. 8) can be matched to that in the Queenstown–Mt Murchison area (see references above), except for the absence of any equivalents of the Lower Owen Conglomerate. The apparent lateral persistence of the units for over 90 km is rather surprising, considering the variable shallow-marine to probably non-marine facies involved, and implies some overall tectonic control. A cyclical character is evident in the sequence (fig. 8), with three (and possibly four) cycles introduced by an erosion surface, followed by a conglomerate (possibly non-marine in some cases), passing up into mainly shallow-marine sandstone and, granule-pebble conglomerate with a variable proportion of siltstone and shale. It is likely that each cycle has been initiated by a tectonic event.

The axis of maximum thickness of the siliciclastic sequence lies along the Black Bluff Range, as is evident from the cross-sections on Maps 7 and 8 (see also fig. 30). This axis appears to have moved eastwards with time, as the lower members (Newton Creek, Middle Owen) have their maximum development on the western flanks (Mt Cattley–Mt Tor area), while the upper members (which constitute the bulk of the sequence) have their maximum thickness along the crestal part of the range. To the east, a ridge of Bonds Range porphyry appears to have formed a topographic margin to the basin.

An inversion of topography appears to have occurred along the central part of the range, where windows of the underlying volcanics are now exposed along an anticlinal crest corresponding to the highest part of the range.

No obvious tectonic control for the depositional basin is apparent, although the inferred major fault west of Mt Cattley and Mt Tor (the possible continuation of the Henty Fault) could well have influenced the early basin development (fig. 30). Uplift of the Cambrian sequence in this area, probably associated with folding and faulting, may have caused the basin axis to migrate eastwards and resulted in truncation of earlier units by the later parts of the siliciclastic sequence. The Upper Pink Sandstone (and Moina Sandstone) transgressed this basin margin to rest directly on the Cambrian rocks to the west.

Mineralisation and prospectivity

Confirmation of the presence of a significant thickness of Que–Hellyer Volcanics beneath the Tertiary basalt 10 km north-east of Hellyer mine represents a significant upgrade of the prospectivity of the Mt Cattley area, and raises the possibility of discovery of further Hellyer-type massive sulphide deposits. The large synclinal structure containing the volcanics continues northwards through the Cattley area, disappearing again under Tertiary basalt near the Black Marsh Road. Suggestions of a change to northerly plunge in this area could mean that further sub-Tertiary occurrences of the Que–Hellyer Volcanics are possible. The postulated extension of the Henty Fault in this area also raises the possibility of fault-related mineralisation such as occurs in the Tullah–Henty area.

A number of mineral occurrences and prospects are located near the eastern margin of the Bonds Range porphyry, either within basal Cambrian rocks or Precambrian basement. An association with smaller porphyry intrusions and/or NW-trending cross-faults is evident for some of these. Indications of both Cambrian mineralisation and a later Devonian granite-related overprint (e.g. tourmaline, tungsten, molybdenum) are present. Of particular interest is the breccia-related mineralisation at Anio Creek containing 1.9 g/t gold and 11 g/t silver in one sample, and associated with significant untested EM anomalies. Further examination of this prospect is warranted since, apart from any commercial considerations, it could provide a useful genetic model for application in other areas.

Gold mineralisation occurs within the Bonds Range porphyry at Ten Mile Creek, associated with hematitic stockwork veining, and in alluvial deposits probably derived from the porphyry at Bonds Hill.

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APPENDIX A
Original major element chemical analyses, with descriptive notes

	RING ROAD METADOLERITE				NTHN M D	BLACK BLUFF RANGE DOLERITE				TOR CREEK BASALTS			
Sample No.	J036	J035	J078	J059	J075	V280	V281	V205	V206	VP5	VP3	J297	V349
Major elements (mass%)													
SiO_2	52.23	52.51	52.97	54.25	53.57	46.32	49.00	55.75	57.72	45.60	51.17	48.73	51.81
TiO_2	2.21	2.31	2.42	2.24	1.58	2.07	1.00	1.36	2.20	1.32	1.35	0.83	0.97
Al_2O_3	14.17	14.78	15.67	14.77	16.77	33.56	16.15	23.90	21.88	15.80	19.37	17.01	17.37
Fe_2O_3	2.45	2.64	4.13	2.20	2.93	1.68	2.03	2.36	2.36	11.86	11.76	1.98	1.78
FeO	8.76	8.63	9.02	9.24	7.63	0.71	7.77	0.71	0.70	3.55	2.47	6.40	5.80
MnO	0.14	0.13	0.10	0.08	0.13	0.01	0.16	0.01	0.01	0.10	0.04	0.14	0.12
MgO	3.33	3.34	3.89	3.87	5.92	0.83	7.56	1.00	1.08	6.04	3.54	7.39	6.28
CaO	6.10	3.29	0.76	1.69	0.88	0.22	10.03	0.06	0.08	0.10	0.27	10.97	5.21
Na_2O	3.66	2.50	3.54	5.18	2.96	0.27	2.64	0.08	0.08	0.04	0.15	2.34	5.13
K_2O	2.13	3.10	2.02	0.66	0.26	9.66	0.38	11.16	10.28	4.69	5.45	0.63	0.46
P_2O_5	0.23	0.28	0.30	0.24	0.15	0.27	0.13	0.16	0.19	0.10	0.23	0.23	0.34
SO_3	<0.05	0.16	0.07	0.32	<0.05	0.02	0.12	0.02	0.03	0.07	<0.05	0.31	0.07
CO_2	0.13	0.72	0.33	0.79	0.14	–	–	–	–	–	–	–	0.05
H_2O^+	3.12	4.41	5.03	4.25	6.25	–	–	–	–	–	–	–	3.44
H_2O^-	–	–	–	–	–	–	–	–	–	–	–	–	–
LOI	2.28	4.17	4.36	4.01	5.54	4.36	1.70	2.91	2.95	5.26	4.36	2.53	2.89
Total	97.69	97.68	99.18	98.43	98.32	99.96	98.55	99.46	99.53	94.46	100.16	99.18	98.83

Sample No.	Description	Location	AMG Ref.
Ring Road metadolerite			
J036	Dolerite	Leven River	DQ051132
J035	Dolerite	Leven River	DQ052130
J078	Dolerite	Ring Road area	DQ051127
J059	Dolerite	Ring Road area	DQ053122
Northern metadolerite			
J075	Dolerite	North of Ring Road	DQ061135
Black Bluff Range dolerite			
V280	Dolerite-chilled margin	Rocky Mount area	DP047005
V281	Fresh dolerite	Rocky Mount area	DP041994
V205	Altered dolerite	Mackintosh Creek	DP033989
V206	Altered dolerite	Mackintosh Creek	DP033989
Tor Creek basalts			
VP5	Cleaved hematitic basalt	Alps Road	DQ097123
VP3	Cleaved hematitic basalt	Tor Creek	DQ094133
J297	Basalt with epidote alteration	Alps Road	DQ096121
V349	Basalt with epidote alteration	Loongana Mill Creek area	DQ108133

Samples VP5 and VP3 were collected by D. Seymour

	TERTIARY BASALT	ANDESITES		BONDS RANGE PORPHYRY			FELDSPAR-HORNBLENDE PORPHYRY		LAVA – RING ROAD	LAVA – SOUTHWELL SUB-GROUP
Sample No.	V284	V049	V196	V152	V125	J158	J245	V179	J281	V078
Major elements (mass%)										
SiO_2	50.56	57.60	61.54	66.09	69.81	69.09	72.73	73.97	71.34	77.36
TiO_2	1.72	0.78	0.82	0.49	0.59	0.48	0.26	0.21	0.23	0.18
Al_2O_3	13.58	15.48	14.46	14.15	14.72	13.82	13.87	13.16	12.97	10.98
Fe_2O_3	2.02	2.27	3.01	2.04	0.58	1.03	0.97	1.20	0.74	5.07
FeO	9.35	5.12	5.09	2.60	2.49	2.83	1.51	0.73	2.59	0.11
MnO	0.15	0.10	0.72	0.08	0.05	0.07	0.01	0.01	0.04	0.01
MgO	8.19	4.50	2.56	3.03	1.74	2.53	0.89	0.40	0.60	0.53
CaO	8.14	1.86	0.45	3.27	2.00	1.87	0.08	0.05	0.75	0.04
Na_2O	3.19	4.00	3.41	1.79	1.72	2.69	3.39	2.53	2.49	0.53
K_2O	0.83	3.79	3.53	4.34	4.33	4.62	5.34	6.50	5.53	3.37
P_2O_5	0.30	0.23	0.20	0.15	0.11	0.15	0.08	0.06	0.08	0.06
SO_3	0.06	0.09	<0.05	0.16	<0.05	0.24	<0.05	<0.05	<0.05	<0.05
CO_2	–	1.06	1.40	0.14	0.06	0.02	0.09	0.09	1.61	0.06
H_2O^+	–	3.28	2.69	2.00	1.56	1.88	1.49	1.14	1.42	2.20
H_2O^-	–	–	–	–	–	–	–	–	–	–
LOI	0.40	3.77	3.53	2.30	1.34	1.59	1.41	1.15	2.74	2.25
Total	98.43	99.50	99.32	98.03	99.48	100.77	100.54	99.97	100.10	100.49

Sample No.	Description	Locality	AMG Reference
Tertiary basalt			
V284	Basalt	Cradle Mountain Link Road	DQ040008
Andesite			
V049	Andesite	Cradle Mountain Link Road	CP958988
V196	Andesite	Cattley Creek Window	DQ059032
Bonds Range porphyry			
V152	Quartz-feldspar-biotite± hornblende porphyry	Cradle Mountain Link Road	DP086988
V125	Quartz-feldspar-biotite± hornblende porphyry	Anio Creek	CP984892
J158	Quartz-feldspar-biotite± hornblende porphyry	Fury River, 2 km south of Anio Creek	CP967879
Feldspar-hornblende pophyry			
J245	Feldapar-hornblende-phyric lava	Upper River Road	DQ021059
V179	Pink feldspar-phyric lava	Leven River	DQ018055
Felsic lavas			
J281	Feldspar-phyric lava	Ring Road	DQ056119
V078	Hematitic rhyolite	2 km north of Cradle Mountain Link Road	CQ972011

APPENDIX B
Drill logs and accessory data for drill holes at Black Harry Road (BLHY-1), Beecroft Road (BTRD-1) and Middlesex Road (MXRD-1)

Drill log of Black Harry Road drill hole (BLHY-1)

The Black Harry Road drill hole was proposed to investigate an occurrence of feldspar-phyric lavas, tentatively correlated with the Central Volcanic Complex, in the Black Harry Road area.

The hole was drilled by the Department of Mines. Down hole surveys and fillet grind assays were done by Aberfoyle Resources. The support of A. W. McNeill during this project is gratefully acknowledged.

DIAMOND DRILL CORE RECORD		BLHY–1 (BLACK HARRY ROAD)		
PROJECT: Mt Read Volcanics		SURVEY DATA (Aberfoyle)		
OBJECTIVE: To investigate the relationship between the Animal Creek Greywacke and a probable occurrence of the Central Volcanic Complex at Black Harry Road		DEPTH (m)	INCLIN-ATION (°)	AZIMUTH (°) mag.
PROPOSED BY: M. J. Vicary, K. D. Corbett		Collar	-70	348°21′
LOGGED BY: M. J. Vicary (with additional information by A. W. McNeill, Aberfoyle)		150	-70	335
LOCATION: Black Harry Road, off Murchison Highway		488.8	-59.3	334
MAP SHEET: Mackintosh – 44 (8014N)				
AMG CO-ORDINATES: 390326.46 mE 5399479.95 mN				
COLLAR R.L.: 685.83 m	TOTAL DEPTH: 488.8 m			
COLLAR DIP: -70°00′	AZIMUTH: 348°21′ (magnetic)			
DATE COMMENCED: 24.4.1989	DATE COMPLETED: 28.7.1989			
DRILL RIG: Longyear 44 No.1				
DRILL CREW: Craig Mitchell				
HOLE SIZE HQ to 43.7 m: NQ to 488.8 m				

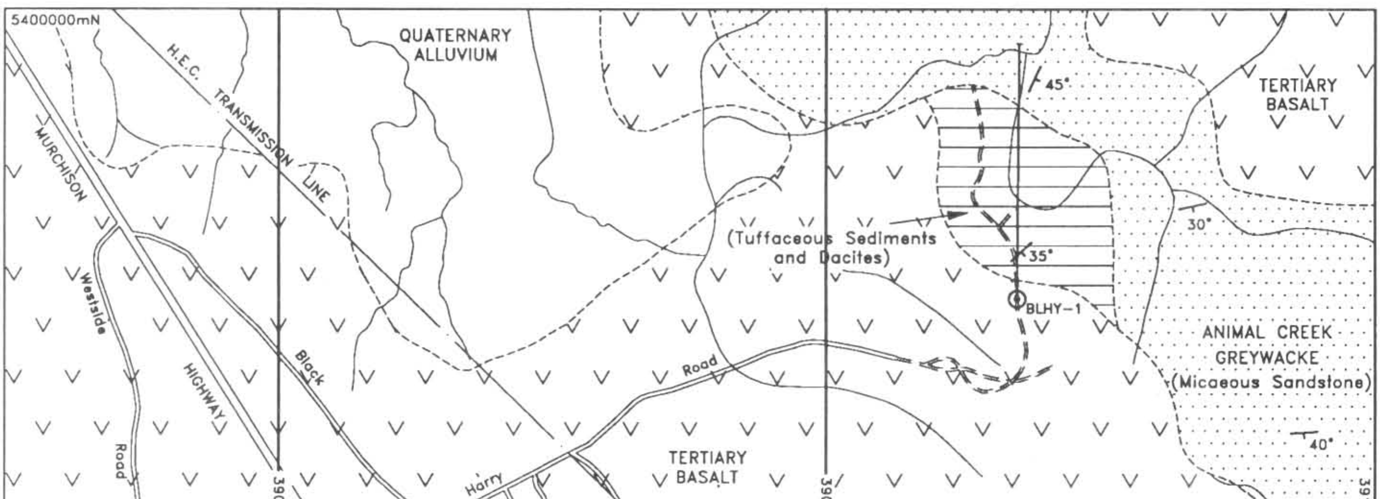


Figure B1. Location and geology of Black Harry Road drill hole.

DRILL CORE GEOLOGICAL RECORD – HOLE BLHY-1, BLACK HARRY ROAD

Depth (m)	Description	Sample and depth	Preparation*
0–8.4	Vesicular/amygdaloidal Tertiary basalt with minor thin sediment horizon at base		
8.4–120.66	Massive feldspar-phyric dacite with minor brecciated zones. Generally porphyritic with sericitic and chloritic feldspar laths, up to 2 mm, but may be aphyric. Contains irregular patches of chlorite, vugh-like cavities, and minor hematite and chlorite-quartz veins. Zone of broken core with minor micaceous sandstone at 16.60–22.60 m.	BH-1 (20.8 m) 515670 (70.45 m) BH-2 (70.45–70.76 m) BH-3 (106.88–107.20 m)	T T G T, G
120.66–147.2	Predominantly interbedded black micaceous sandstone and siltstone with minor green chloritic pumice horizons, and vitric tuff. Individual pumiceous layers are up to 5 m thick with pumice clasts up to 40 mm. Bedding core angle 70° at 126.5 m.	515675 (123.45 m) BH-4 (134.17–134.20 m)	T T
147.2–149.23	Massive feldspar phyric dacite with minor brecciation at base. Upper contact is marked by 40 mm wide quartz vein.	BH-5 (148.05–148.73 m)	T, G
149.23–150.98	Interbedded black micaceous sandstone and siltstone with minor pumiceous layers.		
150.98–163.45	Massive feldspar phyric dacite with minor brecciation. Possible flow banding at 151 m.	BH-6 (158.29–158.69 m) 515671 (158.7 m)	G T
163.45–182.45	Predominantly interbedded thinly laminated black siltstone and sandstone and minor tuffaceous siltstone and sandstone. Black siltstone horizons are frequently slumped. Minor mass flow horizons with dacitic and pumice clasts at base. Grading in coarse clastic horizons suggests up hole facing. Core Orientation at 166.45 Radial angle = 258°. Core axis intersection = 52°. Small intrusive feldspar-quartz phyric dyke at 163.83–164.03 m.	BH-7 (163.84–163.91 m) 515672 (171.0 m)	T T
182.45–187.22	Graded mass flow unit with pebble-sized dacitic clasts in a grey black feldspathic tuffaceous matrix at base. This unit progressively grades upwards to siltstone grade at top. Bedding/core angle 40° at 182.7 m.	515673 (186.0 m)	T
187.72–196.95	Interbedded tuffaceous sandstone and siltstone. Bedding/core angle 70° at 187.9 m and 65° at 195.4 m.		
196.95–201.50	Coarse mass flow breccia with dacitic, vitric tuff and black siltstone clasts with minor interbedded tuffaceous siltstone units. Bedding/core angle 80°at 201.1 m.	515674 (200.25 m)	T
201.50–220.92	Tuffaceous siltstone. Bedding core angle 60°at 216.6 m.	515676 (205.86 m) 515677 (217.45 m)	T T
220.92–245.20	Predominantly massive to brecciated feldspar phyric dacite. Upper contact is most likely intrusive with sheared thin pale yellow selvage. Possible flow banding at 221.20 m. Sediment horizon at 239.72–240.30 m	BH-9 (221.28–221.37 m) BH-8 (232.60–232.88 m) BH-10 (240.3 m)	T T, G T
245.20–246.35	Coarse subangular blocks of dacite, vitric tuff and shale in dark silty matrix. Mass flow.		
246.35–260.70	Massive dacite with minor brecciation	BH-11 (251.60–251.95 m)	T, G
260.70–276.97	Predominantly tuffaceous siltstone with minor mass flow unit (263.42–263.55 m). Bedding/core angle 53° at 263.55 m	515678 (263.45 m)	T
276.97–277.39	Dacite	BH-12 (276.98–277.39 m)	T, G
277.39–290.65	Interbedded tuffaceous siltstone and sandstone. Bedding/core angle 60° at 277.87 m	515679 (286.95 m)	T, G
290.65–291.47	Mass flow horizon		
291.47–302.05	Interbedded tuffaceous siltstone and sandstone	BH-13 (305.34305.64 m)	T, G

Depth (m)	Description	Sample and depth	Preparation*
302.05–313.88	Massive dacite with minor brecciation and flow banding. Carbonate veining common and possible carbonate filled vesicles. Chlorite alteration at base.		
313.88–333.80	Predominantly tuffaceous siltstone/vitric tuff with minor mass flow horizons. Tuffaceous siltstone contains large devitrification nodules up to 120 mm and progressively grades down hole to tuffaceous sandstone. Bedding/core angle 65° at 330.50 m		
333.80–350.14	Thinly laminated black shale. Commonly fractured with large breccia forming carbonate veins up to 100 mm. Pyrite common along bedding and in discordant veins. Bedding/core angle 68° at 349.41 m		
350.14-355.84	Intrusive (?) flow banded dacite with pink hydrothermal colouring. Minor brecciation.	BH-14 (352.06-352.43 m)	T, G
355.84–365.30	Thinly laminated black shale and tuffaceous siltstone. Minor polymict mass flow breccia. Bedding core angle 69° at 358.90 m		
365.30–365.86	Dacite		
365.86–367.16	Thinly laminated black shale		
367.16–378.14	Interbedded dark vitric tuff/tuffaceous siltstone. Devitrification structures up to 140 mm. Bedding/core angle 70° at 374.80 m		
378.14–382.92	Polymict mass flow breccia with cobble grade dacite clasts and irregular shale rip-ups.		
382.92–384.90	Vitric tuff/tuffaceous siltstone. Bedding/core angle 60° at 384.55 m.		
384.90–387.00	Polymict mass flow breccia. Clasts of vitric tuff up to 300 mm. Dacite and black shale clasts also present. Bedding/core angle 70° at 387.00 m		
387.00–396.44	Vitric tuff/tuffaceous siltstone. Bedding/core angle 65° at 395.00 m.		
396.44–396.95	Interbedded black shale, tuffaceous sandstone and vitric tuff.		
396.95–413.25	Interbedded thinly laminated to massive yellow to black tuffaceous siltstone/vitric ash. Devitrification nodules common. Minor units of tuffaceous sandstone. Bedding/core angle 80° at 409.70 m	515676A (397.9 m)	T
413.25–465.90	Graded mass flow unit. 413.25–439.00 m: massive grey to yellow brown tuffaceous siltstone with abundant devitrification nodules, grades into fine-grained tuffaceous sandstone at 439.00 m. 445–460 m: poorly bedded fine to medium grained tuffaceous sandstone. Irregular colour banding/blotches and devitrification nodules common. 460–464.64 m: medium to coarse grained tuffaceous sandstone. Colour banding parallel to bedding present. Bedding/core angle 80°at 461.70 m. 464.64–465.90 m: coarse tuffaceous sandstone to granule pebble polymict mass flow breccia with pumice and/or feldspar-phyric lava clasts up to 15 mm. Pink lava and black shale rip-up clasts also present. Base erosional into underlying black tuffaceous siltstone.	515677A (426.5 m) 515678A (462.5 m) BH-15 (465.71–465.75 m)	T T T
465.90–470.60	Interbedded black to grey tuffaceous siltstone/vitric ash.		
470.60–488.83	Massive to well bedded grey to yellow grey fine tuffaceous siltstone/vitric ash. Core orientation at 484.8 m; radial angle = 006°; core axis intersection = 52°. Core orientation at 488.5 m; radial angle = 355°; core axis intersection = 62°.		
488.83	EOH		

* T = thin section, G = whole rock analysis

Table B1.
FILLET GRIND ASSAYS FOR Cu, Pb, Zn, Ba, As, Cr, Zr AND Ti, BLACK HARRY ROAD DRILL HOLE

Interval (m)	Metal content (g/t)								Comments
	Cu	Pb	Zn	Ba	As	Cr	Zr	Ti	
0–9.9	50	30	205	200	22	350	210	12250	Tertiary basalt
9.9–20	30	55	110	150	8	20	230	1650	dacite
20–30	75	30	130	230	28	25	230	1650	
30–40	90	10	170	140	19	30	220	1500	
40–50	15	5	135	130	14	15	230	1600	
50–60	20	10	120	150	15	10	250	1700	
60–70	10	10	60	160	17	20	230	1600	
70–80	10	0	75	160	8	0	220	1550	
80–90	15	0	120	160	13	5	210	1550	
90–100	10	0	80	190	20	15	220	1600	
100–110	10	0	55	200	15	7	220	1600	
110–120.6	10	10	55	180	30	0	220	1550	
120.6–132.5	15	30	90	260	26	130	260	2100	micaceous sandstone and siltstone
132.5–142.5	40	20	100	280	28	60	270	1900	
142.5–147.5	45	60	105	320	47	90	240	2450	
147.5–149.7	10	10	60	300	18	0	230	2150	dacite
149.7–150.9	45	45	330	240	35	110	190	2400	micaceous sandstone
150.9–161.2	10	25	170	230	22	9	170	1850	dacite
161.2–171.9	110	55	190	290	28	65	240	2350	black shale
171.9–181.9	65	25	70	320	35	95	250	2450	
181.9–187.7	40	20	70	310	19	85	280	2200	mass flow
187.7–197.1	40	50	105	250	18	45	250	1700	tuffaceous siltstone
197.1–201.5	35	20	85	230	16	80	210	1800	mass flow
201.5–211.5	20	20	100	230	14	45	200	1750	tuffaceous siltstone
211.5–220.9	10	15	30	230	24	35	190	2050	
220.9–231	25	15	55	330	14	10	150	2000	dacite
231–241	15	10	30	360	4	10	160	1900	
241–251	15	15	30	270	5	30	160	1800	
251–261	15	20	45	320	3	10	160	1850	
261–271	40	20	40	190	8	35	190	2150	tuffaceous siltstone
271–279.7	25	15	35	200	6	30	210	2350	dacite
279.7–285	15	15	40	190	11	55	250	2900	tuffaceous siltstone
285–290.55	30	15	50	190	9	60	300	3050	mass flow
290.55–296.8	20	20	60	210	10	80	280	3100	tuffaceous siltstone
296.8–302.15	15	15	35	200	11	40	220	2050	
302.15–313.9	15	30	110	270	14	35	180	1950	dacite
313.9–323.9	15	15	65	260	10	70	240	2250	tuffaceous siltstone
323.9–333.85	20	15	55	230	7	85	300	2750	
333.85–343.45	85	75	145	270	39	85	160	2950	black shale
343.45–350.1	90	50	115	240	31	130	130	2950	
350.1–355.8	25	10	80	320	3	15	160	1900	dacite
355.8–365.3	50	45	205	310	22	65	180	295	black shale
365.3–373.45	35	100	200	320	14	25	270	2950	tuffaceous siltstone
373.45–379	35	40	120	350	6	20	290	3000	
379–387	70	50	205	360	13	20	240	2950	mass flow
387–397	40	50	240	270	11	10	310	2900	interbedded tuffaceous siltstone and sandstone
397–407	30	35	140	280	10	30	310	2800	
407–417	35	20	85	240	10	20	300	2650	
417–427	15	5	75	220	5	6	320	2350	
427–437	10	20	60	240	4	0	300	2350	
437–447	20	15	65	220	4	5	310	2300	
447–459.5	20	15	70	210	6	75	290	2400	
459.5–465.9	30	45	180	230	12	0	230	3050	coarse tuffaceous sandstone
465.9–470.6	40	55	210	220	17	25	210	1850	tuffaceous siltstone
470.6–EOH	30	10	100	180	6	8	230	1400	
Detection limit	5	5	5	10	1	5	5	50	

Analyses performed by Analabs on fillet grinds done for Aberfoyle.

Table B2
SELECTED ASSAYS FOR GOLD AND SILVER FROM FILLET GRINDS, BLACK HARRY ROAD DRILL CORE

Ag and Au were analysed for all intervals, but values for most intervals were below the detection limits of 0.5 g/t Ag and 0.008 g/t Au. Values for the following intervals were above the detection limit for Au and Ag.

Interval (m)	Concentration (g/t)	Element
142–147.5	0.009	Au
365.3–373.45	0.013	Au
387.0–397.0	1.0	Ag
397.0–407.0	1.0	Ag
407.0–417.0	1.0	Ag
417.0–427.0	0.011	Au
459.5–465.9	0.012	Au

Analyses performed by Analabs on fillet grinds done for Aberfoyle.

Table B3
ORIGINAL MAJOR ELEMENT CHEMICAL ANALYSES OF DACITES FROM THE BLACK HARRY ROAD DRILL HOLE

	BH-2	BH-3	BH-5	BH-6	BH-8	BH-11	BH-12	BH-13	BH-14
SiO_2	68.83	67.30	70.99	68.66	66.02	65.27	69.58	65.99	66.43
TiO_2	0.30	0.28	0.40	0.36	0.34	0.34	0.37	0.35	0.37
Al_2O_3	13.66	13.45	15.23	13.33	13.13	13.09	13.12	13.25	13.18
Fe_2O_3	0.64	0.64	0.77	0.90	0.45	0.71	0.40	1.29	0.52
FeO	4.60	5.50	1.00	3.40	3.00	3.00	3.00	3.00	3.60
MnO	0.21	0.40	0.05	0.10	0.11	0.13	0.08	0.09	0.09
MgO	0.76	0.86	0.94	1.45	1.14	1.15	0.89	1.72	1.70
CaO	0.08	0.33	1.18	2.29	3.90	4.15	2.65	3.10	3.09
Na_2O	1.32	0.68	0.29	0.26	1.90	1.54	1.66	1.43	1.42
K_2O	3.42	3.73	4.22	3.14	2.94	3.06	3.01	3.01	3.02
P_2O_5	0.20	0.19	0.24	0.23	0.26	0.25	0.18	0.23	0.22
SO_3	0.25	0.25	0.31	0.33	0.25	0.25	0.65	0.06	0.06
CO_2	2.66	3.57	1.50	2.84	4.71	5.42	2.79	3.86	3.89
H_2O^+	2.23	2.34	2.36	2.80	2.12	1.59	1.90	2.53	2.44
H_2O^-	-	-	-	-	-	-	4.62	-	-
LOI	4.48	5.40	3.87	5.39	6.60	6.78	-	6.08	5.95
Total	99.16	99.52	99.48	100.09	100.27	99.95	100.28	99.91	100.03

Analyses by Department of Mines Launceston Laboratories

Drill log of Beecroft Road drill hole (BTRD-1)

DIAMOND DRILL CORE RECORD		BTRD–1 (BEECROFT ROAD)		
PROJECT: Mt Read Volcanics		SURVEY DATA (Aberfoyle)		
OBJECTIVE: To obtain bedding orientation from Cambrian greywackes		DEPTH (m)	INCLIN-ATION (°)	AZIMUTH (°) AMG
PROPOSED BY: K. D. Corbett, J. Pemberton		79	72	288
LOGGED BY: J. Pemberton		135	73	294
LOCATION: 4 km west of Mt Cattley, near Beecroft Road				
MAP SHEET: St Valentines – 36 (8015N)				
AMG CO-ORDINATES: 39648 mE 5405761 mN				
COLLAR R.L.: 680.9 m	TOTAL DEPTH: 138.28 m			
COLLAR DIP: 70°	AZIMUTH: 290° (true)			
DATE COMMENCED: 21.8.1989	DATE COMPLETED: 15.9.1989			
DRILL RIG: Warman 1000				
DRILL CREW: Ross Stevens and Les Newman				
HOLE SIZE Precollared to 78 m NQ to EOH				

DRILL CORE GEOLOGICAL RECORD – HOLE BTRD-1, BEECROFT ROAD

Depth (m)	Description
0–78	Precollared through Tertiary basalt with minor thin sediment horizon at base
78–88.83	Massive Tertiary basalt to 85 m then highly amygdaloidal to base
88.83–118.48	Red to khaki vesicular basalt (Cambrian) from 105.6–105.9 less weathered light green basalt
118.48–120.28	Broken zone with core loss
120.28–127.00	Brown weathered volcaniclastic breccia showing graded bedding indicating up-hole facing. Clasts (to 30 mm at base) of basic volcanics and sediments
127.00–128.78	Grey weathered crystal-lithic tuff – clasts of andesite and vesicular basalt. Crystals of quartz and feldspar to 2 mm
128.78–138.28	Interbedded sequence of micaceous greywacke, siltstone and black shale Core orientation at 132.85 m – dip 34° towards 054° 137.9 m – dip 21° towards 104°
	EOH

Drill log of Middlesex Road drill hole (MXRD-1)

DIAMOND DRILL CORE RECORD	MXRD–1 (MIDDLESEX ROAD)		
PROJECT: Mt Read Volcanics	SURVEY DATA		
OBJECTIVE: To intersect complete sequence of Que–Hellyer Volcanics beneath Tertiary basalt	DEPTH (m)	INCLINATION (°)	AZIMUTH (°) AMG
PROPOSED BY: K. D. Corbett, J. Pemberton	246	59	022
LOGGED BY:	414	56.5	023
LOCATION: 4 km west of Mt Cattley, near Middlesex Road	520	54	025
MAP SHEET: St Valentines – 36 (8015N)	738	42.5	031
AMG CO-ORDINATES: 399555 mE 5404657 mN			
COLLAR R.L.: 674.2 m TOTAL DEPTH: 750 m			
COLLAR DIP: 70° AZIMUTH: 020° (true)			
DATE COMMENCED: 12.4.1990 DATE COMPLETED: 9.8.1990			
DRILL RIG: Precollared by Longyear 38, diamond drilling by Warman 1000			
DRILL CREW: Warman: R. Stevens, S. Mueller. Longyear: D. Whamond, K. Barrett.			
HOLE SIZE Precollared to 86 m: NQ to 417.4 m			

SUMMARY DRILL CORE GEOLOGICAL RECORD – HOLE MXRD-1, MIDDLESEX ROAD
(partly after A. McNeill and W. Herrmann)

Depth (m)	Description
0–184.6	Tertiary basalt and sediment
184.6–225.2	Interbedded fine-grained greywacke, shale and minor grit. Core orientation at 214.5 m – strike 320°, dip 40°S
225.2–292.4	Dolerite intrusive. Chilled vesicular top and chilled base. T.S. J844 at 254.9 m
292.4–305.0	Quartz-feldspar-phyric volcaniclastic with sericitic fiamme and lava clasts. Black shale matrix at base
305.0–352.6	Massive black shale with scattered pyrite framboids to 20 mm in diameter
352.6–355.5	Interbedded fine-medium lapilli volcaniclastic and black shale. Abrupt faulted contact?
355.5–525.2	Vesicular, brecciated (hyaloclastic and hydraulic) andesitic-basaltic lava. Interpillow pyrite and ash-rich sediment
525.2–525.5	Andesitic volcaniclastic wacke
525.5–597.6	Vesicular, massive to brecciated basalt lava. Variably carbonate-veined. Carbonate-sericite altered below 565.5 m to base
597.6–608.4	Pumiceous fine lapilli volcaniclastic. Some fuchsite spotting between 597.6 m and 599 m. Feldspar-phyric with rare felsic lava and shale clasts. Pyritic at base. Minor ash-rich interbeds and fine-grained micaceous greywacke
608.4–750.0	Micaceous greywacke with interbeds of grey-black shale and minor ash-rich volcaniclastic. Greywacke beds to 8 m thick and facing up-hole EOH

Table B4
FILLET GRIND ASSAYS FROM MIDDLESEX ROAD DRILL HOLE MXRD-1

Interval (m)	Cu	Pb	Zn	Ba	Cr	Zr	Ti	Y	Nb	Mn	Fe	Mg	Ca	Na	K	Rock type
184.6–190.6	120	<100	2034	534	111	117	6223	35	12	742	6.83	1.16	0.292	0.045	2.23	greywacke and shale
190.6–200	87	<100	154	509	112	86	5353	29	<10	1580	5.83	1.66	3.25	0.083	2.47	
200–210	96	<100	116	519	103	92	4608	26	<10	1415	5.05	1.74	4.07	0.058	2.71	
210–220	82	<100	86	420	86	92	4331	26	<10	1109	5.52	1.88	3.99	0.059	2.74	
220–225.2	83	<100	171	399	96	94	4036	27	<10	970	5.02	1.75	3.98	0.053	3.07	
225.2–230	6	<100	72	317	95	69	3820	19	10	770	5.57	3.73	6.54	0.869	2.14	dolerite
230–240	5	<100	95	847	103	74	4206	22	<10	618	5.28	5.76	3.72	2.27	0.97	
240–250	5	<100	133	860	127	77	4223	22	<10	758	5.29	5.32	4.08	3.34	0.73	
250–260	6	<100	89	769	119	75	4252	22	<10	701	5.53	4.94	4.52	3.43	0.49	
260–270	7	<100	122	751	122	64	3723	20	<10	774	4.91	4.51	6.26	3.36	0.97	
270–280	6	<100	154	706	120	68	4039	22	<10	841	5.52	4.54	5.46	3.06	1.07	
280–290	7	<100	94	414	113	68	4126	22	<10	841	5.15	4.30	6.31	3.21	0.58	
290–292.4	6	<100	84	585	108	71	3962	26	<10	1178	4.51	3.10	9.43	1.91	1.75	
292.4–297	9	<100	51	322	11	63	937	24	<10	593	1.25	0.42	3.91	1.99	2.16	felsic volcaniclastic
297–301.5	17	<100	59	351	13	88	1365	29	<10	717	1.37	0.605	3.59	1.53	2.49	
301.5–305	56	<100	117	532	29	128	2038	37	<10	631	3.58	0.972	3.30	0.405	2.86	
305–310	80	172	673	578	101	112	3455	25	<10	752	6.02	1.35	2.14	0.078	2.48	black shale
310–320	67	<100	305	551	89	98	3098	25	<10	708	4.75	1.45	2.55	0.079	2.27	
320–330	57	<100	192	721	95	111	3354	24	<10	621	3.86	1.55	2.94	0.179	2.60	
330–340	60	<100	298	840	92	108	3712	24	<10	409	3.92	1.37	2.50	0.251	2.50	
340–350	56	<100	254	901	89	117	3663	25	<10	432	3.75	1.32	2.90	0.260	2.54	
350–352.6	128	100	404	1099	107	142	3627	28	<10	454	4.83	1.37	2.63	0.766	2.79	volcaniclastic breccia
352.6–355.5	24	<100	216	1891	30	235	3478	41	12	263	3.55	1.35	1.60	0.799	4.46	
355.5–360	72	<100	268	935	44	154	4138	29	<10	347	5.01	2.27	2.54	2.38	1.96	andesite-basalt
360–370	83	<100	234	540	338	64	2501	17	<10	1060	5.61	2.26	9.29	2.44	0.82	
370–380	133	<100	220	269	417	48	2189	14	<10	1079	5.37	2.68	10.34	2.91	0.13	
380–390	101	<100	251	333	414	69	2551	19	<10	1276	4.75	2.86	10.62	2.96	0.05	
390–400	95	<100	274	947	474	80	2817	18	<10	1339	5.89	4.17	7.10	2.05	0.42	
400–410	83	<100	204	883	442	75	2620	16	<10	1358	5.56	4.97	7.99	1.96	0.32	
410–420	111	<100	253	1238	403	65	2374	15	<10	1461	5.15	4.51	12.15	1.77	0.28	
420–430	80	<100	400	664	207	59	2363	16	<10	1310	5.28	3.19	9.05	2.96	0.33	
430–440	79	<100	321	896	408	86	2530	18	<10	1000	4.92	2.63	7.95	2.45	0.83	
440–450	34	<100	218	1288	138	108	2566	23	<10	1484	4.71	2.58	10.93	2.08	0.63	
450–460	50	112	437	1033	214	119	3075	24	<10	1085	5.78	3.56	6.59	1.97	1.19	
460–470	66	100	413	753	529	53	3053	15	<10	900	6.33	5.25	3.24	2.53	0.58	
470–480	113	<100	164	783	360	47	2602	14	<10	1309	5.38	2.93	8.78	2.78	0.35	
480–490	65	<100	260	653	536	62	3317	14	<10	1179	6.16	5.01	6.46	2.27	<0.05	
490–500	63	<100	302	1325	521	63	3321	19	<10	1311	5.91	4.86	7.72	2.16	<0.05	
500–510	68	<100	206	1669	469	55	2941	16	<10	1361	5.60	5.11	8.08	2.03	0.11	
510–520	136	<100	261	4690	658	48	2797	13	<10	1570	6.12	4.27	7.06	1.34	0.34	
520–525.2	124	<100	203	1238	611	50	2623	13	<10	1464	5.63	4.07	9.74	1.36	0.20	
525.2–525.5	119	463	165	495	130	97	3214	22	<10	983	5.07	2.11	4.73	0.89	1.90	andesitic wacke
525.5–530	47	<100	168	521	51	143	4579	25	<10	889	5.47	2.24	4.63	1.28	1.96	andesite-basalt
530–540	65	<100	137	515	43	127	4204	23	<10	1192	5.28	2.17	6.07	0.76	1.98	
540–550	26	<100	161	524	48	138	4286	22	11	1317	5.44	2.63	5.23	0.60	2.15	
550–560	34	<100	160	402	40	127	4075	23	<10	1087	4.94	2.09	6.92	1.11	1.55	
560–570	20	<100	217	316	34	135	4238	23	10	962	5.29	2.54	6.17	1.45	1.21	
570–580	18	<100	129	365	28	127	3846	23	<10	1042	4.80	2.46	6.29	0.848	1.86	
580–590	13	<100	121	430	27	100	3621	21	<10	1286	5.25	2.13	6.06	0.715	2.20	
590–597.8	12	<100	65	545	22	89	3498	20	<10	1903	4.49	2.29	5.00	0.364	2.90	
597.8–598	22	<100	50	400	68	74	2558	20	<10	2429	3.43	1.72	5.89	0.061	2.16	greywacke
598–603	27	<100	65	543	90	95	2584	24	<10	1753	3.32	1.74	4.16	0.145	3.01	felsic tuff-sandstone
603–608.4	31	<100	95	530	78	105	2611	24	<10	1284	3.76	2.06	3.52	0.324	2.65	
608.4–610.2	39	181	230	570	45	142	2646	320	15	533	2.66	1.26	2.09	0.086	2.74	siltstone
610.2–620	25	<100	567	340	224	85	1818	16	<10	1127	2.95	2.34	3.75	0.074	1.83	greywacke-siltstone
620–626.7	28	<100	263	376	182	101	2098	17	<10	1360	3.70	2.95	3.56	0.08	2.04	
626.7–628.3	44	235	248	826	45	191	3837	36	15	516	3.42	2.17	1.55	0.104	4.45	pumice breccia
628.3–630	30	<100	119	332	193	83	1831	14	12	1244	3.66	3.09	4.50	0.077	1.70	greywacke-siltstone
630–636	22	<100	140	270	219	71	1712	14	<10	983	3.07	2.29	3.58	0.059	1.40	
636–646.5	22	141	182	382	225	97	2103	18	<10	1334	3.54	2.72	4.54	0.072	2.12	
646.5–650	28	<100	62	239	304	43	1421	15	<10	1687	2.89	2.65	5.69	0.056	1.45	
650–660	22	<100	83	290	233	77	1596	13	<10	1282	3.12	2.82	4.90	0.064	1.55	
660–670	40	<100	194	297	221	70	1680	12	<10	938	2.40	2.18	3.89	0.056	1.48	
670–680	40	<100	140	219	203	62	1447	14	<10	1367	2.66	2.51	5.10	0.058	1.40	
680–690	30	<100	204	229	246	76	1746	13	<10	1129	3.41	2.87	4.10	0.072	1.33	
690–700	26	<100	101	252	208	86	1913	15	<10	1049	3.59	2.89	3.98	0.066	1.49	
700–710	26	<100	104	248	276	79	1893	14	<10	1139	2.95	2.53	4.29	0.078	1.62	
710–720	19	<100	262	282	250	92	2076	14	<10	1021	3.45	2.99	3.55	0.115	1.63	
720–730	33	100	403	246	265	82	2014	14	<10	979	3.22	2.91	3.76	0.145	1.47	
730–740	36	100	392	302	239	92	2276	16	<10	971	3.63	3.14	3.55	0.103	1.84	
740–750	35	<100	117	413	248	97	2150	16	<10	1379	3.46	3.04	4.04	0.073	1.88	
Detection	5	100	5	5	10	5	10	1	10	15	0.01	0.002	0.005	0.005	0.05	
Units	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	%	%	%	%	%	
Method	201	201	201	201	201	201	201	201	201	201	201	201	201	201	201	

Note: all gold values <0.04 ppm; all silver values <5 ppm. Assays by Analabs for Outokumpu Exploration Aust.

5 cm

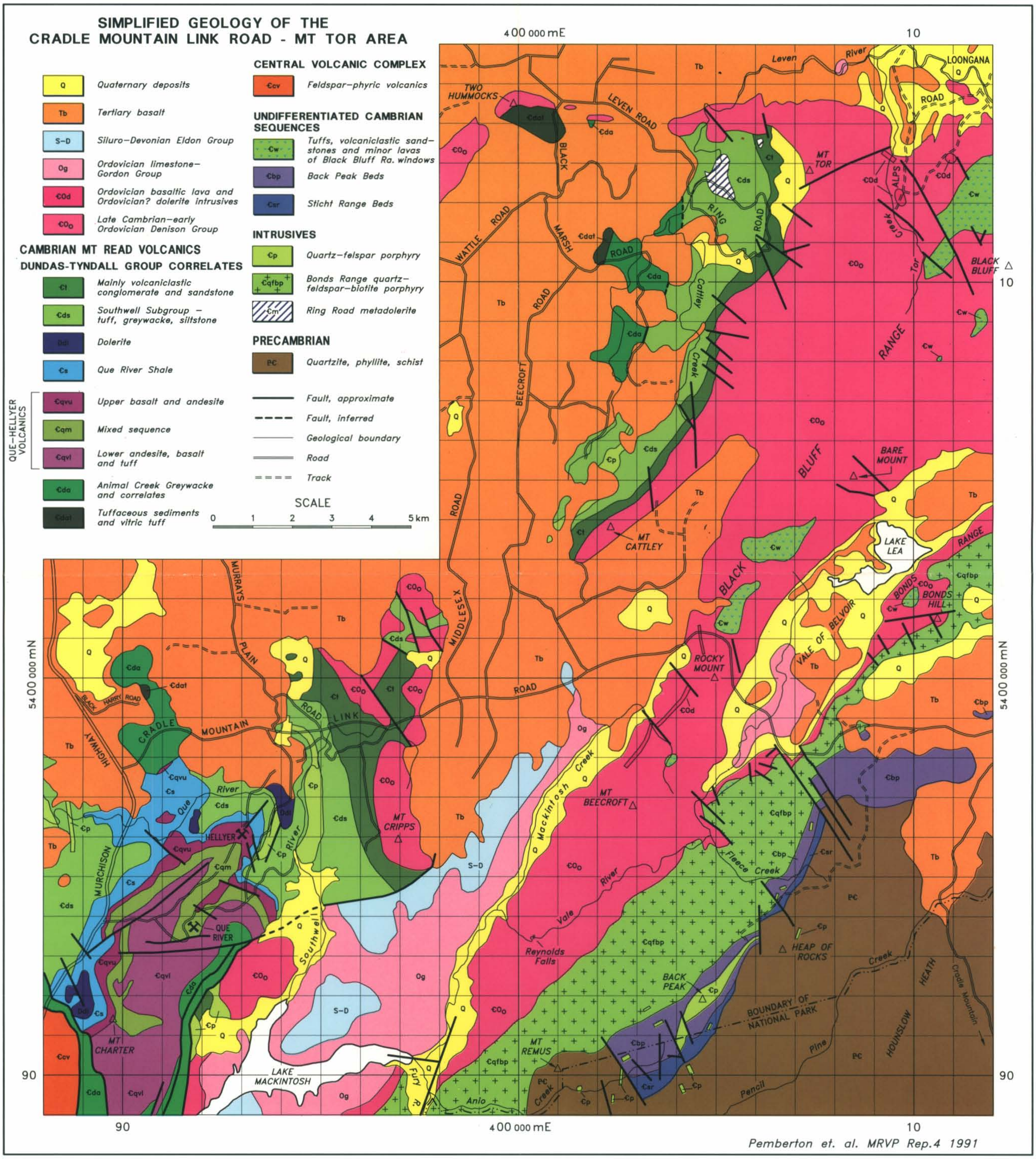


FIGURE 1.

MRV4

5 cm

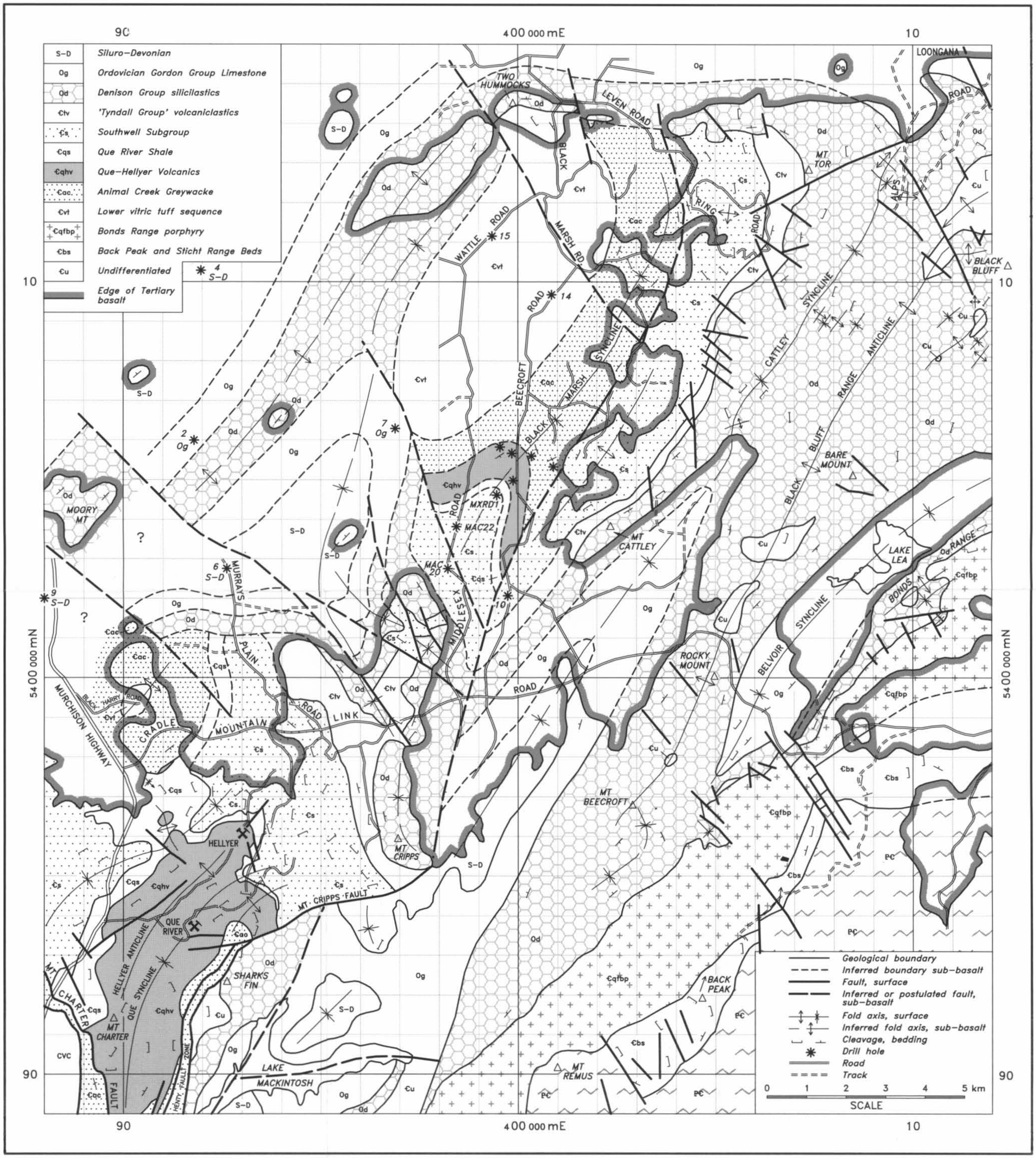
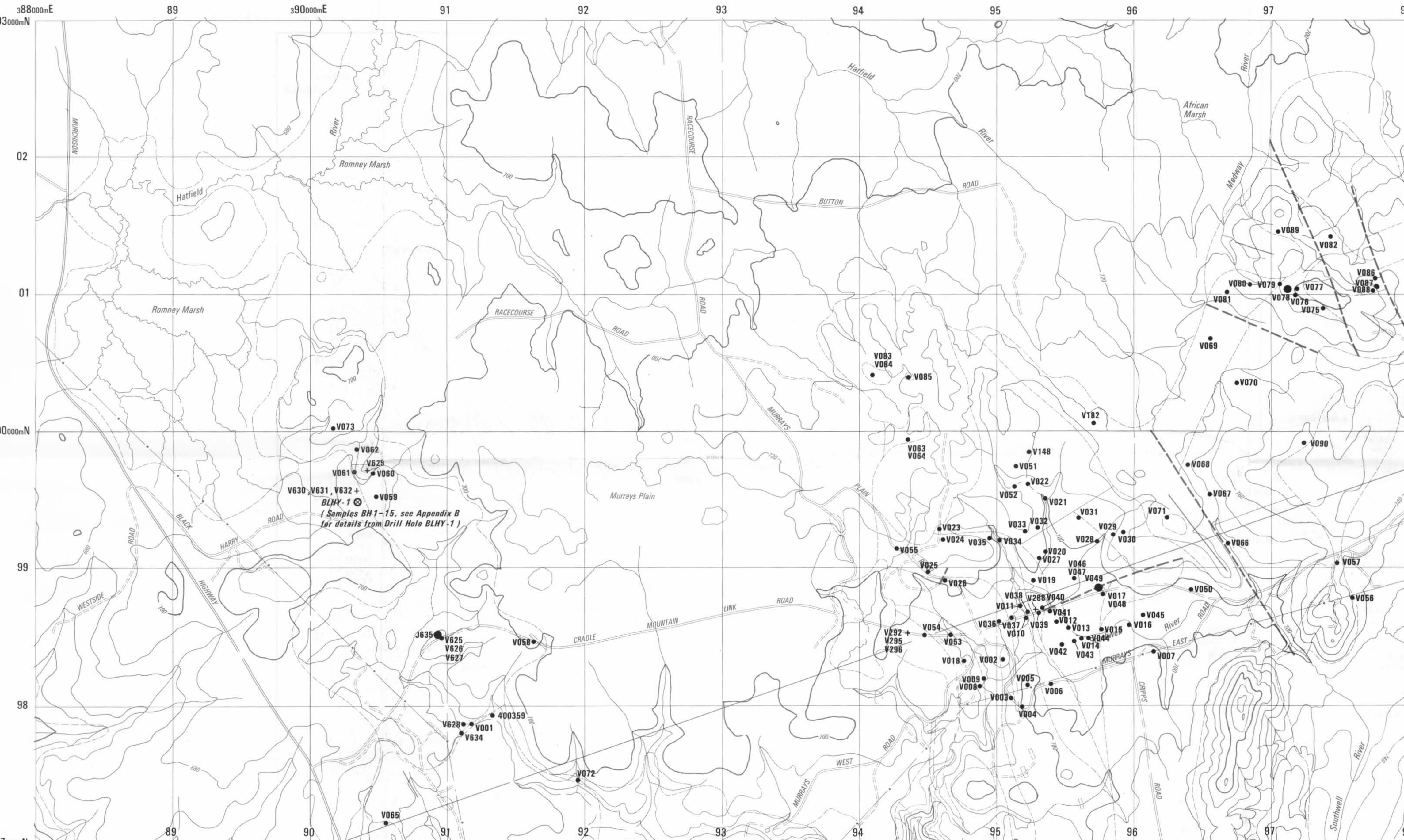


FIGURE 19. SUB-BASALT MAP AND STRUCTURAL MAP OF THE HELLYER - TWO HUMMOCKS - BLACK BLUFF RANGE AREA

Pemberton et al. MRVP Geol. Rep.4 1991.

MRV4



GEOLOGICAL SURVEY OF TASMANIA — DEPARTMENT OF MINES — HOBART

MT READ VOLCANICS PROJECT 1988

SAMPLE LOCALITY MAP OF THE BACK PEAK — CRADLE MOUNTAIN LINK ROAD AREA (M.R.V.P. MAP 7)

1 0.5 0 1 2 km

SCALE 1 : 25 000

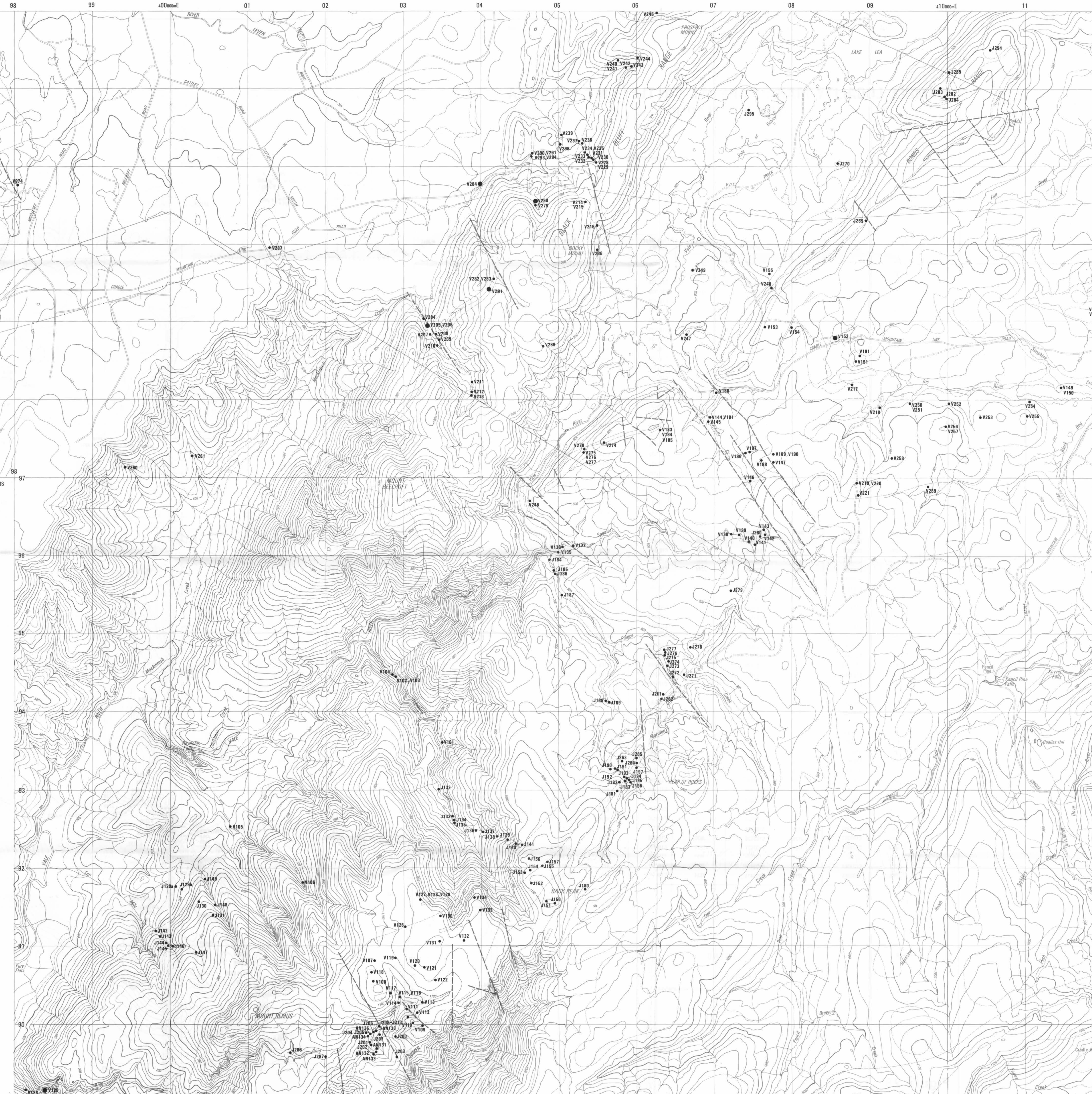
Field No.	Mines Dept. Cat No.	Field No.	Mines Dept. Cat No.	Field No.	Mines Dept. Cat No.	Field No.	Mines Dept. Cat No.	Field No.	Mines Dept. Cat No.	Field No.	Mines Dept. Cat No.	Field No.	Mines Dept. Cat No.	Field No.	Mines Dept. Cat No.	Field No.	Mines Dept. Cat No.
V001	C103001	V041	C103041	V081	C103081	V131	C103131	V206	C103206	V250	C103250	V630	C104332	J187	C103587	J277	C103477
V002	C103002	V042	C103042	V082	C103082	V132	C103132	V207	C103207	V251	C103251	V631	C104333	J188	C103588	J278	C103478
V003	C103003	V043	C103043	V083	C103083	V133	C103133	V208	C103208	V252	C103252	V632	C104334	J189	C103589	J279	C103479
V004	C103004	V044	C103044	V084	C103084	V134	C103134	V209	C103209	V253	C103253	J129a	C103529	J190	C103590	J280	C103480
V005	C103005	V045	C103045	V085	C103085	V135	C103135	V210	C103210	V254	C103254	J129b	C103601	J191	C103591	J282	C103482
V006	C103006	V046	C103046	V086	C103086	V136	C103136	V211	C103211	V255	C103255	J130	C103530	J192	C103592	J283	C103483
V007	C103007	V047	C103047	V087	C103087	V137	C103137	V212	C103212	V256	C103256	J131	C103531	J193	C103593	J284	C103484
V008	C103008	V048	C103048	V088	C103088	V138	C103138	V213	C103213	V257	C103257	J132	C103532	J194	C103594	J285	C103485
V009	C103009	V049	C103049	V089	C103089	V139	C103139	V214	C103214	V258	C103258	J133	C103533	J195	C103595	J286	C103486
V010	C103010	V050	C103050	V090	C103090	V140	C103140	V215	C103215	V259	C103259	J134	C103534	J196	C103596	J287	C103487
V011	C103011	V051	C103051	V101	C103101	V141	C103141	V216	C103216	V260	C103260	J135	C103535	J197	C103597	J294	C103494
V012	C103012	V052	C103052	V102	C103102	V142	C103142	V217	C103217	V261	C103261	J136	C103536			J295	C103495
V013	C103013	V053	C103053	V103	C103103	V143	C103143	V218	C103218	V274	C103274	J137	C103537			J635	C104843
V014	C103014	V054	C103054	V104	C103104	V144	C103144	V219	C103219	V275	C103275	J138	C103538	J200	C103600	AN131	C104831
V015	C103015	V055	C103055	V105	C103105	V145	C103145	V220	C103220	V276	C103276	J139	C103539	J201	C103401	AN132	C104832
V016	C103016	V056	C103056	V106	C103106	V146	C103146	V221	C103221	V277	C103277	J140	C103540	J202	C103402	AN133	C104833
V017	C103017	V057	C103057	V107	C103107	V147	C103147	V224	C103224	V278	C103278	J141	C103541	J203	C103403	AN134	C104834
V018	C103018	V058	C103058	V108	C103108	V148	C103148	V225	C103225	V279	C103279	J142	C103542	J204	C103404	AN135	C104835
V019	C103019	V059	C103059	V109	C103109	V149	C103149	V228	C103228	V280	C103280	J143	C103543	J205	C103405	AN136	C104836
V020	C103020	V060	C103060	V110	C103110	V150	C103150	V229	C103229	V281	C103281	J144	C103544	J206	C103406	400359	C400359
V021	C103021	V061	C103061	V111	C103111	V151	C103151	V230	C103230	V282	C103282	J145	C103545	J207	C103407		
V022	C103022	V062	C103062	V112	C103112	V152	C103152	V231	C103231	V283	C103283	J146	C103546	J208	C103408		
V023	C103023	V063	C103063	V113	C103113	V153	C103153	V232	C103232	V284	C103284	J147	C103547	J209	C103409		
V024	C103024	V064	C103064	V114	C103114	V154	C103154	V233	C103233	V285	C103285	J148	C103548	J210	C103410		
V025	C103025	V065	C103065	V115	C103115	V155	C103155	V234	C103234	V286	C103286	J149	C103549	J211	C103411		
V026	C103026	V066	C103066	V116	C103116	V180	C103180	V235	C103235	V287	C103287	J150	C103550	J212	C103412		
V027	C103027	V067	C103067	V117	C103117	V181	C103181	V236	C103236	V288	C103288	J151	C103551	J213	C103413		
V028	C103028	V068	C103068	V118	C103118	V182	C103182	V237	C103237	V289	C103289	J152	C103552	J261	C103461		
V029	C103029	V069	C103069	V119	C103119	V183	C103183	V238	C103238	V290	C103290	J153	C103553	J262	C103462		
V030	C103030	V070	C103070	V120	C103120	V184	C103184	V239	C103239	V291	C103291	J154	C103554	J263	C103463		
V031	C103031	V071	C103071	V121	C103121	V185	C103185	V240	C103240	V292	C103292	J155	C103555	J264	C103464		
V032	C103032	V072	C103072	V122	C103122	V186	C103186	V241	C103241	V293	C103293	J156	C103556	J265	C103465		
V033	C103033	V073	C103073			V187	C103187	V242	C103242	V294	C103294	J157	C103557	J269	C103469		
V034	C103034	V074	C103074	V124	C103124	V188	C103188	V243	C103243	V295	C103295	J180	C103580	J270	C103470		
V035	C103035	V075	C103075	V125	C103125	V189	C103189	V244	C103244	V296	C103296	J181	C103581	J271	C103471		
V036	C103036	V076	C103076	V126	C103126	V190	C103190	V245	C103245	V625	C104327	J182	C103582	J272	C103472		
V037	C103037	V077	C103077	V127	C103127	V191	C103191	V246	C103246	V626	C104328	J183	C103583	J273	C103473		
V038	C103038	V078	C103078	V128	C103128			V247	C103247	V627	C104329	J184	C103584	J274	C103474		
V039	C103039	V079	C103079	V129	C103129	V204	C103204	V248	C103248	V628	C104330	J185	C103585	J275	C103475		
V040	C103040	V080	C103080	V130	C103130	V205	C103205	V249	C103249	V629	C104331	J186	C103586	J276	C103476		

5 cm

LEGEND

- • Thin section.
- ● Thin section and chemical analysis.
- + Hand sample only
- ⊙ Drill hole

5 cm



MR/4

Figure 2A

5356

SAMPLE LOCALITY MAP OF THE MT. CATTLEY–MT. TOR AREA (M.R.V.P. MAP 8)

1 0.5 0 1 2 km

SCALE 1 : 25 000

Field No.	Mines Dept. Cat No.	Field No.	Mines Dept. Cat No.	Field No.	Mines Dept. Cat No.	Field No.	Mines Dept. Cat No.
J001	C103301	J066	C103366	J216	C103416	J636	C104844
J002	C103302	J067	C103367	J217	C103417	J637	C104845
J003	C103303	J068	C103368	J218	C103418	V091	C103091
J004	C103304	J069	C103369	J219	C103419	V092	C103092
J005	C103305	J070	C103370	J220	C103420	V093	C103093
J006	C103306	J071	C103371	J221	C103421	V094	C103094
J007	C103307	J072	C103372	J222	C103422	V095	C103095
J008	C103308	J073	C103373	J223	C103423	V096	C103096
J009	C103309	J074	C103374	J224	C103424	V097	C103097
J010	C103310	J075	C103375	J225	C103425	V098	C103098
J011	C103311	J076	C103376	J226	C103426	V099	C103099
J012	C103312	J077	C103377	J227	C103427	V100	C103100
J013	C103313	J078	C103378	J228	C103428	V156	C103156
J014	C103314	J079	C103379	J229	C103429	V157	C103157
J015	C103315	J080	C103380	J230	C103430	V158	C103158
J016	C103316	J081	C103381	J231	C103431	V159	C103159
J017	C103317	J082	C103382	J232	C103432	V160	C103160
J018	C103318	J083	C103383	J233	C103433	V161	C103161
J019	C103319	J084	C103384	J234	C103434	V162	C103162
J020	C103320	J085	C103385	J235	C103435	V163	C103163
J021	C103321	J086	C103386	J236	C103436	V164	C103164
J022	C103322	J087	C103387	J237	C103437	V165	C103165
J023	C103323	J088	C103388	J238	C103438	V166	C103166
J024	C103324	J089	C103389	J239	C103439	V167	C103167
J025	C103325	J090	C103390	J240	C103440	V168	C103168
J026	C103326	J091	C103391	J241	C103441	V169	C103169
J027	C103327	J092	C103392	J242	C103442	V170	C103170
J028	C103328	J093	C103393	J243	C103443	V171	C103171
J029	C103329	J094	C103394	J244	C103444	V172	C103172
J030	C103330	J095	C103395	J245	C103445	V173	C103173
J031	C103331	J096	C103396	J246	C103446	V174	C103174
J032	C103332	J097	C103397	J247	C103447	V175	C103175
J033	C103333	J098	C103398	J248	C103448	V176	C103176
J034	C103334	J099	C103399	J249	C103449	V177	C103177
J035	C103335	J100	C103400	J250	C103450	V178	C103178
J036	C103336	J101	C103501	J251	C103451	V179	C103179
J037	C103337	J102	C103502	J252	C103452	V192	C103192
J038	C103338	J103	C103503	J253	C103453	V193	C103193
J039	C103339	J104	C103504	J254	C103454	V194	C103194
J040	C103340	J105	C103505	J255	C103455	V195	C103195
J041	C103341	J106	C103506	J256	C103456	V196	C103196
J042	C103342	J107	C103507	J257	C103457	V197	C103197
J043	C103343	J108	C103508	J258	C103458	V198	C103198
J044	C103344	J109	C103509	J259	C103459	V199	C103199
J045	C103345	J110	C103510	J260	C103460	V200	C103200
J046	C103346	J111	C103511	J266	C103466	V201	C103201
J047	C103347	J112	C103512	J267	C103467	V202	C103202
J048	C103348	J113	C103513	J268	C103468	V203	C103203
J049	C103349	J114	C103514	J281	C103481	V226	C103226
J050	C103350	J115	C103515	J288	C103488	V227	C103227
J051	C103351	J116	C103516	J289	C103489	V262	C103262
J052	C103352	J117	C103517	J290	C103490	V263	C103263
J053	C103353	J118	C103518	J291	C103491	V264	C103264
J054	C103354	J119	C103519	J292	C103492	V265	C103265
J055	C103355	J120	C103520	J293	C103493	V266	C103266
J056	C103356	J121	C103521	J296	C103496	V267	C103267
J057	C103357	J122	C103522	J297	C103497	V268	C103268
J058	C103358	J123	C103523	J298	C103498	V269	C103269
J059	C103359	J124	C103524	J300	C103500	V270	C103270
J060	C103360	J125	C103525	J629	C104837	V271	C103271
J061	C103361	J126	C103526	J630	C104838	V272	C103272
J062	C103362	J127	C103527	J631	C104839	V273	C103273
J063	C103363	J128	C103528	J632	C104840	V349	C104051
J064	C103364	J214	C103414	J633	C104841	VP3	R001616
J065	C103365	J215	C103415	J634	C104842	VP5	R001618

LEGEND

- Thin section.
- Thin section and chemical analysis.

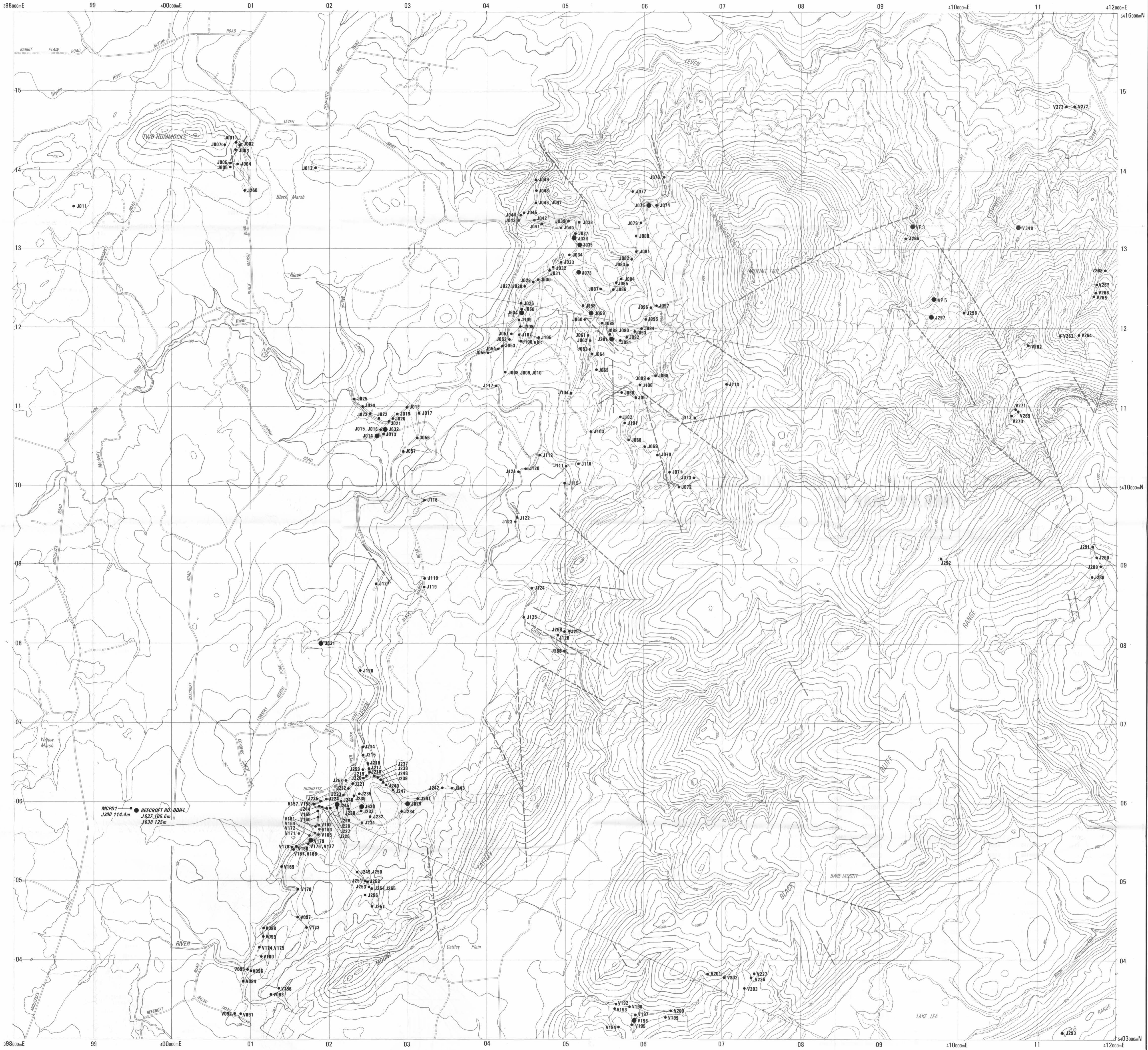


Figure 2B