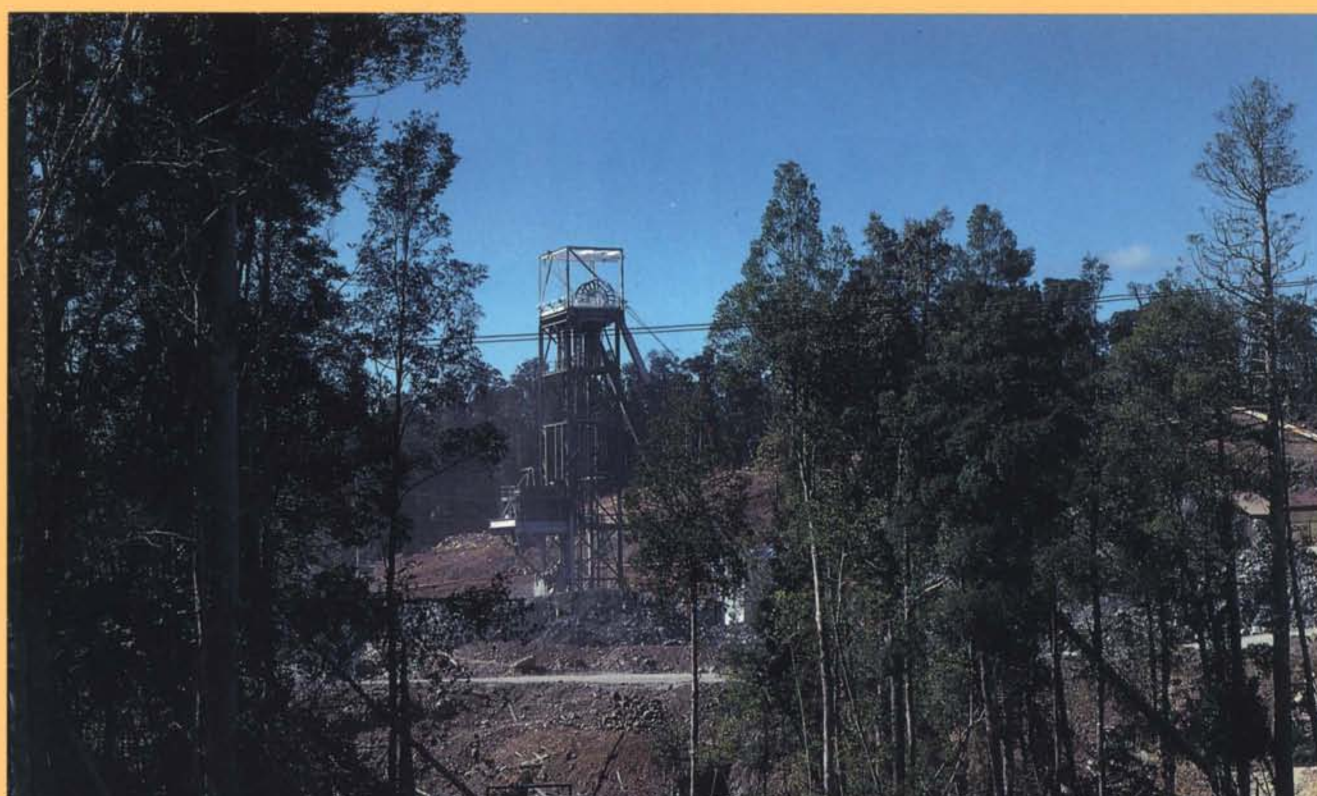
MT READ VOLCANICS PROJECT
GEOLOGICAL REPORT 1

GEOLOGY OF THE HELLYER – MT CHARTER AREA



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COVER PHOTOGRAPH

Que River mine headframe.

M. J. Dix

TASMANIA DEPARTMENT OF MINES

1989

M.R.V. PROJECT

MT READ VOLCANICS PROJECT GEOLOGICAL REPORT 1

Geology of the Hellyer – Mt Charter area

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INTRODUCTION

Scope of study

This report describes the rock sequences and related features of the geology of the Hellyer mine - Mt Charter area, western Tasmania. This area was mapped by P. Komyshan as Map 1 of the Mt Read Volcanics Project in 1985-1986 (Komyshan, 1986*a*). The report, which should be read in conjunction with that map, was compiled and written by K. D. Corbett, partly from notes prepared by P. Komyshan prior to his departure from the Department of Mines in September 1986. Additional information and revisions to the geology arising from further mapping in the area north of Hellyer (mainly by M. Vicary), and from assessment of Departmental and company drilling in the Mt Charter area, have been incorporated. A new section dealing with the geochemistry of the rocks has been added.

The Mt Read Volcanics Project was initiated in July 1985 by the Department of Mines, with a grant from the Federal Government, and comprises geological, geophysical and geochemical studies of the Mt Read Volcanics belt aimed at promoting the prospectivity of the belt, improving the scientific data base, and making exploration more efficient. The geological mapping program is supervised by K. D. Corbett, and is a continuation of a systematic mapping project on the Mt Read Volcanics initiated by him in 1974.

The Hellyer-Mt Charter area is part of an undulating plateau at average elevation of about 700 m, covered by dense rainforest vegetation. The plateau falls steeply to the east to the valley of the Southwell River and Lake Mackintosh. The Murchison Highway transects the central part of the area, and the new Cradle Mountain Link Road, in the early stages of clearing and formation during the mapping by P. Komyshan, transects the northern part. Rock exposure in the area has been greatly improved over recent years by the construction of roads, tracks and costeans associated with development of the Que River and Hellyer mines and the related exploration, by the construction of a major HEC transmission line through the area, and by the construction of a number of forestry roads.

Mapping by P. Komyshan was carried out in the six month period from November 1985 to April 1986, using contoured base maps at 1:10 000 scale and colour air photographs. Mapping was concentrated on the highly complex sequence between Mt Charter and the Hellyer mine, and is less detailed in the areas west of the Murchison Highway and east of the Southwell River. Some Aberfoyle Exploration diamond drill holes were examined for stratigraphic relationships, and brief visits were made to the two mines to examine underground exposures. However, a detailed assessment of underground geology and mineralisation at the mines is beyond the scope of this study.

Thin sections of over 150 rock samples from the area have been examined, and brief descriptions of some of these have been included. An exhaustive petrological study was not attempted, however, and many of the mineral identifications remain tentative.

Chemical assays of major and trace elements for 44 rocks have been obtained, mainly from the Launceston Laboratories of the Department of Mines, and these are discussed in a separate section.

Locations for petrological and geochemical samples are shown on Figure 2. All samples are held at the Department of Mines.

Previous work

Significant mineralisation within the mapped area was discovered only recently, and little early geological work was carried out because of the remoteness and difficulty of access. The earliest reports are those of Henderson (1937, 1938) on the Gold Hill prospect, one kilometre north of the present Que River mine. The area was mapped by the Department of Mines as part of the Mackintosh Sheet in the early 1960s (Barton, *et. al.*, 1966), and further mapping was carried out by P. L. F. Collins and incorporated in the Mackintosh Explanatory Report (Collins *et. al.*, 1981).

A number of unpublished exploration reports describe exploration activity in the area during the last fifteen years or so, associated with the discovery of the Que River and Hellyer deposits. The regional geology is best described in those reports by Young (1977) and Shaw (1984). The case history of the discovery of the Que River deposit is presented by Webster and Skey (1979), and the geology of the mine is described by Duggan (1980), Young (1980), Wallace and Green (1982) and Wallace (1984, 1989). The case history of the discovery of the Hellyer deposit is given by Sise and Jack (1984), and the geophysical aspects are dealt with by Eadie *et al.* (1984). Descriptions of the mineralisation have been given by McArthur (1986, 1989).

Nomenclature

Nomenclature for the volcanic rocks has proved a problem in this area because of the widespread alteration. General terms have mostly been based on silica percentages according to previous usage (Corbett, 1979) : basalt <53% SiO_2, andesite 53–63%, dacite 63–69%, rhyodacite 69–73%, rhyolite >73%. Silica values may vary widely in the altered rocks, however, and classification of these has generally been made using the Zr/TiO_2–Nb/Y diagram of Winchester and Floyd (1977) together with other criteria such as Ti/Zr ratio and Cr values.

The general term 'tuff' is used for any rock composed dominantly of volcanic fragments less than 4 mm in diameter, and 'breccia' or 'agglomerate' is used for rocks containing greater than 30% of fragments larger than 4 mm.

Acknowledgements

Grateful acknowledgement is made to the staff of Aberfoyle Resources (particularly D. Jack, A. M. Hespe, A. McNeill and D. Wallace) and Mackintosh Mines (particularly G. McArthur) for considerable assistance and many helpful discussions over several years, and for donation of the lower 200 metres of drill hole MCH-1 and associated data to the Department as a reference section. Joe Stolz of the Geology Department, University of Tasmania, kindly made available four analyses of drill core from the Mt Charter holes.

The sterling support given by Grant Eagling as a field assistant to P. Komyshan during the very strenuous field program is gratefully acknowledged. The outstanding contribution made by the Cartographic Section of the Department has ensured a high quality of map production and diagram preparation. The staff at the Launceston Laboratories are thanked for providing the many geochemical and assay data, as is Jane Mackey for her efficient preparation of the many thin sections.

CAMBRIAN STRATIGRAPHY AND PETROLOGY

Introduction and general setting

The Cambrian Mt Read Volcanics form a complex N-S belt, 10-20 km wide, extending from Elliott Bay on the south-west coast through Queenstown, Rosebery and the Hellyer area to near Deloraine in the north. The volcanic sequence is host to the base metal sulphide mines at Mt Lyell, Rosebery, Hercules, Que River and Hellyer, and to many smaller prospects (Corbett, 1981; Corbett and Solomon, 1989). The belt is flanked to the west by Cambrian sedimentary sequences, and to the east by Precambrian rocks of the Tyennan Region.

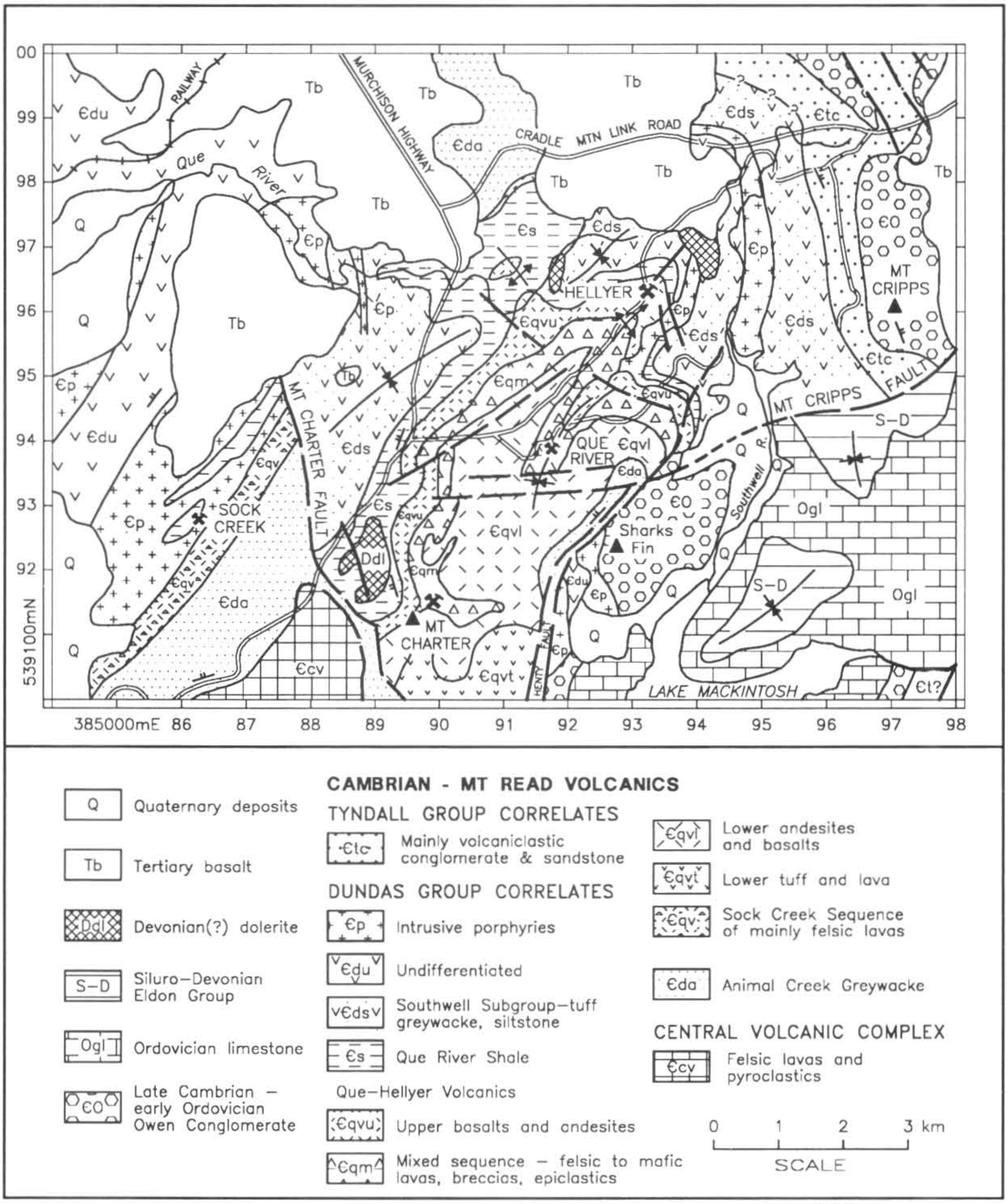

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Figure 1. Simplified geological map of the Hellyer–Mt Charter area (revised after Komyshan, 1986*a*)

The NNE-trending Henty Fault Zone obliquely bisects the Mt Read belt from south of Mt Read to north of Tullah. To the north-west of this fault, a Central Volcanic Complex of massive felsic lavas and pyroclastics (hosting the Rosebery and Hercules orebodies) is overlain, in places unconformably, by a volcano-sedimentary sequence containing Middle to Late Cambrian fossils. This latter sequence, which includes volcanic rocks forming part of the Mt Read belt, is referred to as the Dundas Group and correlates (Corbett, 1986; Corbett and Lees, 1987). To the east and south of the Henty Fault, a similar Central Volcanic Complex is overlain by a volcano-sedimentary sequence referred to as the Tyndall Group.

Mapping by Corbett and McNeill (1986) and Komyshan (1986*a*) has shown that the Henty Fault extends north from Tullah to a point east of the Que River mine as a major zone of sheared and lineated rocks up to several hundred metres wide. A less prominent zone of faulting and cleavage development extends further north to the Hellyer Portal area, and was also thought to be present on the Cradle Mountain Link Road by Komyshan. On this basis, the Henty Fault Zone was shown as extending through the Hellyer Portal and across the Link Road to the top of the map sheet (Komyshan, 1986*a*). However, subsequent excavations and improvement of exposure on the Link Road clearly show that no major fault zone is present in this area (mapping by M. Vicary for the MRV Project), and further work by Aberfoyle geologists in

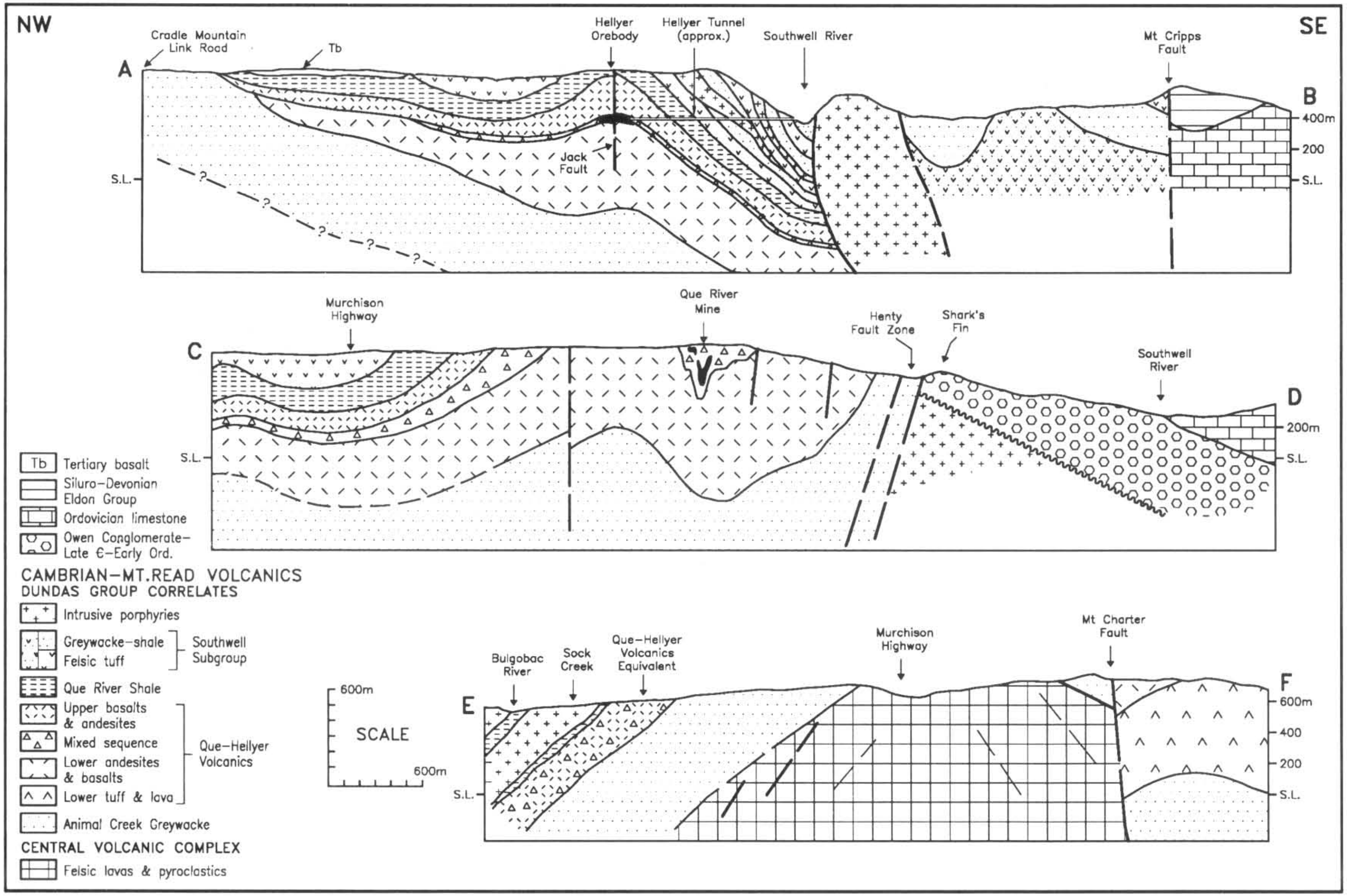

Figure 3. Geological cross-sections of the Hellyer–Mt Charter area (see fig. 2 for location of cross-sections)

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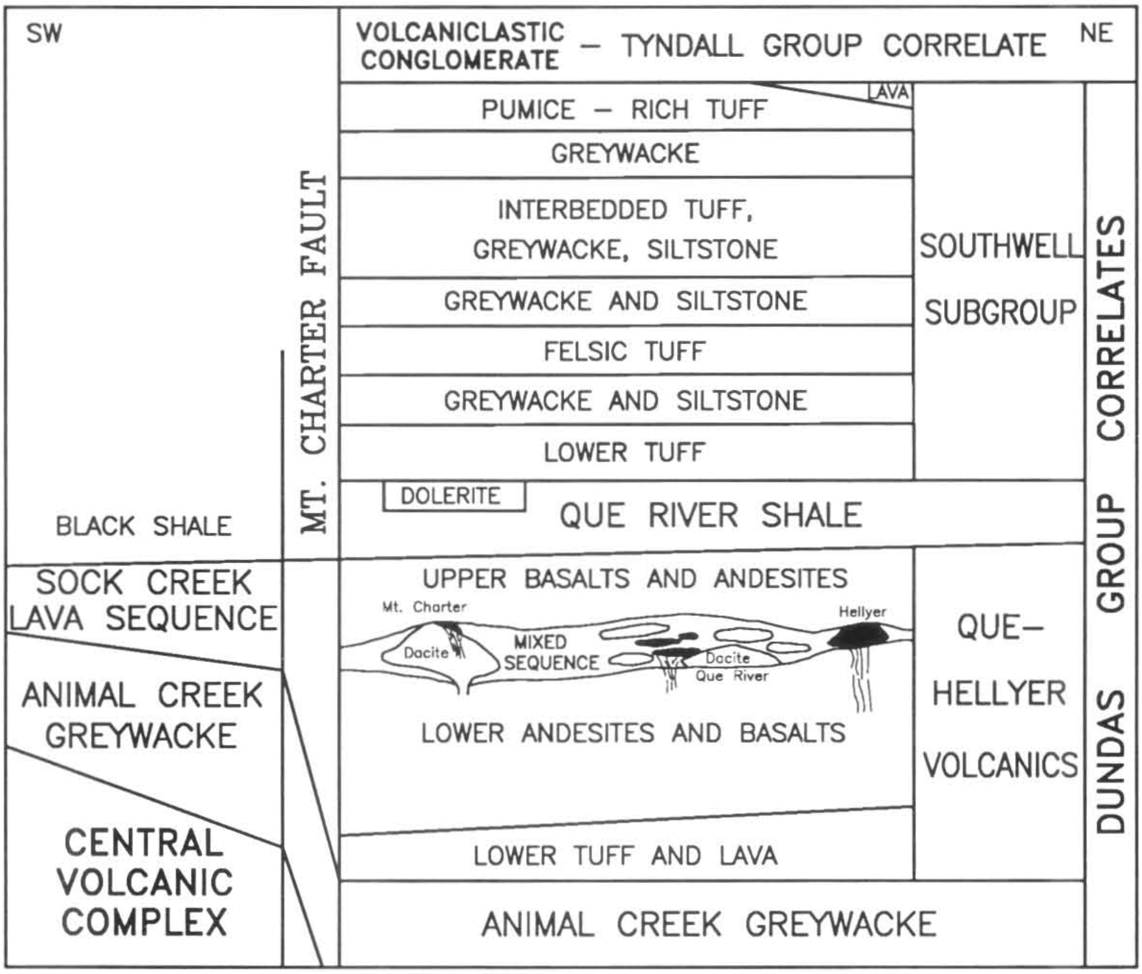

Figure 4. Stratigraphic diagram for the Dundas Group correlates in the Que–Hellyer area

the Hellyer Portal area has also shown that this is not the site of a major structure (A. McNeill, pers. comm.). It is now considered most likely that the major fault zone has either been transferred to, or displaced by, the ENE-directed Mt Cripps Fault, which intersects the Henty Fault east of the Que River mine. Air-photo interpretation indicates that the Mt Cripps Fault swings into a more northerly orientation near Mt Cripps, where it apparently truncates the Owen Conglomerate sequence before disappearing under Tertiary basalt. This revised interpretation is shown on the simplified geological map given in Figure 1.

The MRV Project mapping has also shown that the Central Volcanic Complex west of the Henty Fault terminates in a north-plunging anticlinal nose near Mt Charter. In this area it underlies, and is wrapped around by, a greywacke-rich unit which forms the basal part of a thick volcano-sedimentary sequence which outcrops extensively to the north and west. This volcano-sedimentary sequence contains Middle Cambrian fossils at the Que River bridge on the Murchison Highway (Gee, *et. al*., 1970), and is clearly referable to the Dundas Group. The sequence of andesitic and basaltic rocks containing the Que River and Hellyer orebodies (Que-Hellyer Volcanics) occurs as a lens within this volcano-sedimentary sequence, overlying the basal greywacke, and hence is also regarded as part of the Dundas Group and correlates (Corbett, 1986).

The sequence east of the postulated northern extension of the Henty Fault beyond the Hellyer Portal includes rocks which are lithostratigraphic correlates of the Tyndall Group (particularly the volcaniclastic sequence near Mt Cripps), and all of this section was referred to as Tyndall Group correlates by Komyshan (1986*a*, *b*). This correlation has been reviewed, however, in the light of the improved exposures on the Cradle Mountain Link Road and the revised interpretation of the Henty Fault position, and it is now suggested that only the volcaniclastic unit can be clearly referred to as a Tyndall Group correlate. The lower part of this eastern sequence, comprising mainly interbedded felsic tuffs and greywackes, has a gradational relationship with the Dundas Group correlates further west, and is herein incorporated into a new subdivision of the Dundas Group referred to as the Southwell Subgroup. This Subgroup encompasses that part of the sequence above the Que River Shale and below the Tyndall Group volcaniclastics.

The Cambrian sequence is overlain by siliciclastic conglomerate and sandstone, correlated with the late Cambrian-early Ordovician Owen Conglomerate, at Mt Cripps and the Sharks Fin. These rocks are overlain by Ordovician limestone and Siluro-Devonian clastics in the south-east corner of the map sheet.

The general stratigraphic relationships are shown by the cross-sections (fig. 3) and the stratigraphic diagram (fig. 4).

Central Volcanic Complex

Terminology for this unit, previously referred to as the Central Volcanic Sequence, has recently been reviewed, and the term Central Volcanic Complex has been considered to be more appropriate (Corbett and Solomon, 1989; Corbett and McNeill, 1988).

The complex sequence consists mostly of fine-grained, sericitic, feldspar-phyric or feldspar-quartz-phyric volcanics, and is exposed along the HEC transmission line and associated tracks south-west of Mt Charter. The rocks are pale pink to fawn, cream or pale greenish-grey in colour, and commonly massive in appearance. Rock types include flow-banded and vesicular lavas, pumice-bearing tuffs, vitric tuffs, vitric-crystal tuffs, and minor breccias. The rocks appear to be predominantly of rhyolitic to dacitic composition.

The lavas are typically fine-grained rocks with small albite phenocrysts and glomerocrysts (usually partially sericitised) and, in some cases, sparse embayed quartz phenocrysts, in a sericite-altered quartzo-feldspathic groundmass with minor chlorite and opaques. Remnant spherulite texture is apparent in the groundmass in some cases. Tuffs containing sericite (± chlorite)-altered pumice clasts up to 30 mm long, commonly forming a eutaxitic foliation, in a quartzo-feldspathic matrix with preserved shard shapes and small albite crystals, possibly represent ignimbrites, and are common in parts of the sequence. Fine-grained ash-like vitric tuffs occur in the south-western part of the mapped area. Further descriptions of the sequence and its extensions into the Mt Block area to the south are given in reports by McNeill (1986, 1989).

Dundas Group Correlates

The Dundas Group succession (fig. 4) commences with the Animal Creek Greywacke, followed by the basaltic-andesitic sequence of the Que-Hellyer Volcanics. The latter are represented by only a relatively thin unit of mainly felsic lava in the Sock Creek area on the south-western side of the Mt Charter Fault. Overlying the Que-Hellyer Volcanics is a unit of black pyritic shale containing late Middle Cambrian fossils and referred to as the Que River Shale. Above this is a thick sequence of alternating to interbedded felsic (quartz-feldspar-phyric) tuff, greywacke and siltstone referred to as the Southwell Subgroup. The Tyndall Group correlates overlie this Subgroup.

DUNDAS GROUP CONTACTS, FAULTS, AND DEPARTMENTAL DRILLING IN THE MT CHARTER AREA

In an effort to resolve the nature of several important contacts, faults and sequences in the Mt Charter area, the Department of Mines drilled 4 diamond drill holes in the period June 1986-April 1987. The locations of these holes are shown on the geological map (fig. 5), and cross-sections for the three most significant holes are shown in Figures 6, 7, 8. Drill hole MCH-3 intersected the contact between the Animal Creek Greywacke and Central Volcanic Complex, MCH-2A intersected the Mt Charter Fault between the Animal Creek Greywacke and Que-Hellyer Volcanics, and MCH-1 penetrated the complete sequence of Que-Hellyer Volcanics from the Que River Shale above to the Animal Creek Greywacke below. The lower 200 m of MCH-1 was drilled

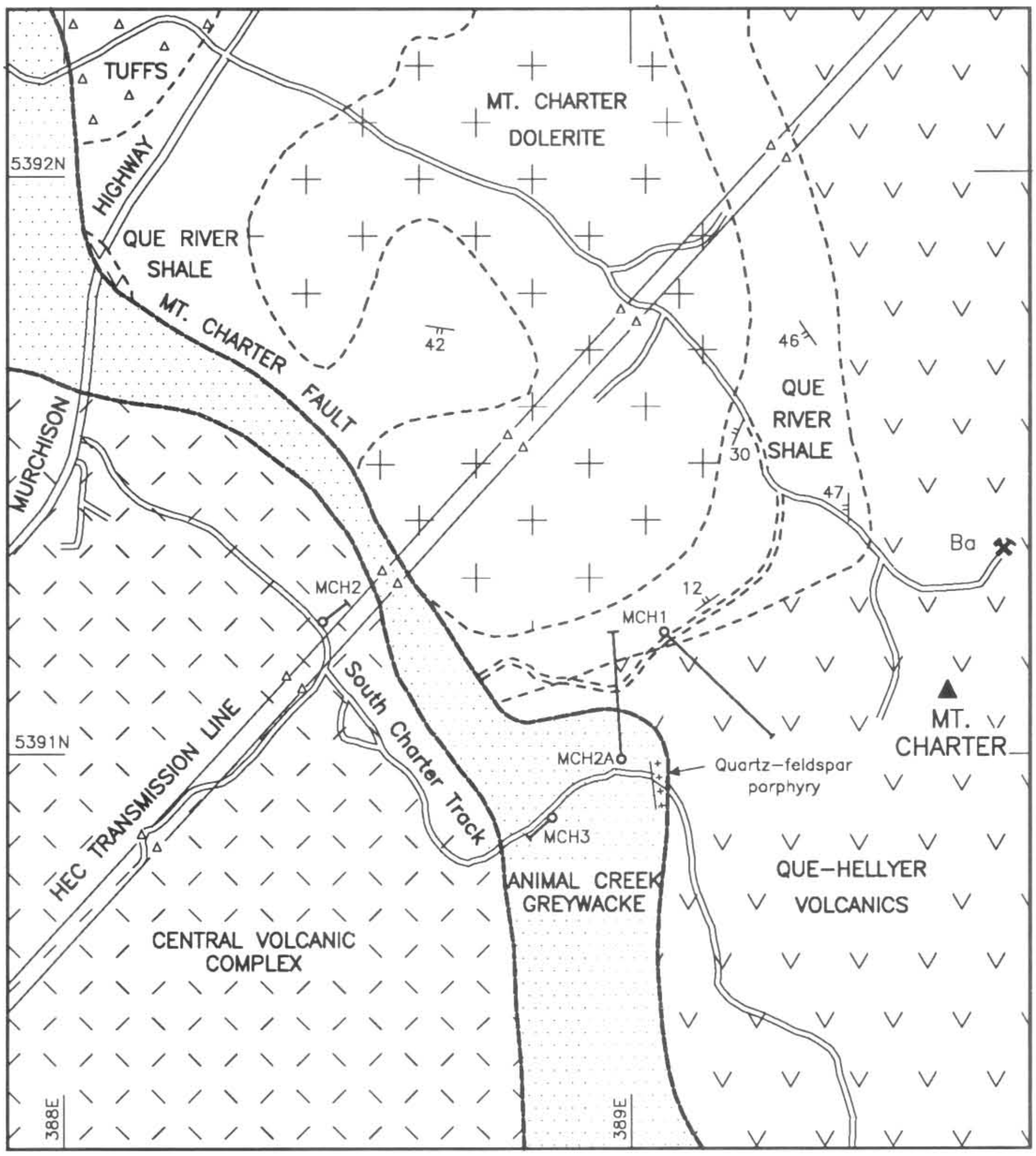

Figure 5. Locations of drill holes in the Mt Charter area

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by Aberfoyle and kindly donated to the Department. The fourth hole, MCH-2, was aborted within the Central Volcanic Complex. Detailed logs of the drill holes are given in Appendix B.

The contact between the Central Volcanic Complex and overlying Animal Creek Greywacke is generally poorly exposed, but has been mapped as a fault (Komyshan, 1986*a*) because of the evidence for shearing, facturing and quartz-veining in the few areas where outcrop is present. Units within the Central Complex are apparently truncated against the contact near the Murchison Highway, suggesting either a faulted relationship or an erosional disconformity-unconformity. Bedding in the Animal Creek Greywacke dips and faces away from the contact in most areas (see also Corbett and McNeill, 1988), suggesting that the contact could be an original depositional surface which has been affected by some later shearing movement related to the contrast in competencies of the units during folding. Mapping by McNeill in the area south of Mt Charter and east of Mt Block (Corbett and McNeill, 1986) indicates that the contact in this area is formed by a N-S trending fault which also truncates units in the Animal Creek Greywacke sequence.

Drill hole MCH-3, collared within the Animal Creek Greywacke on the South Charter track, was designed to test the nature of this contact. It was angled at -60° towards the contact, which it intersected at 36 m depth, indicating that the contact surface dips north-east at about 30° (fig. 6). The contact was marked by a 100 mm-wide zone of vein quartz. The sandstone immediately above the contact was very broken, and the rhyolitic lavas of the Central Complex below the contact were strongly cleaved.

The dip of the Animal Creek Greywacke - CVC contact surface is identical to the regional plunge of the Devonian folds in the area (see Structural Geology section) and strongly suggests modification by shearing, faulting and quartz vein development during the Devonian folding episode, which produced the N-plunging anticlinal structure. It is considered unlikely that the contact represents a major, low-angle thrust fault or a folded fault of some kind, although neither of these possibilities can be discounted without further work and drilling.

Drill hole MCH-2A penetrated some 276 m of Animal Creek Greywacke before crossing the Mt Charter Fault position and entering the middle part of the Que-Hellyer Volcanics. Details of this hole, and of MCH-1, are discussed in later sections.

ANIMAL CREEK GREYWACKE

This unit was defined by Collins (in Collins *et. al*, 1981) as the sequence of greywacke, siltstone and vitric tuff cropping out along the Murchison Highway for about 4 km north of Animal Creek, bounded to the east by the Central Volcanic Sequence and to the west by the felsic lava unit on the eastern side of Bulgobac Plain (Sock Creek lava unit of this report). The present mapping shows the unit to be continuous around the 'nose' of Central Volcanic Complex rocks at Mt Charter, and to underlie the Que-Hellyer Volcanics in a large syncline SE of Mt Charter (Corbett and McNeill, 1986). It is also found underlying the Que-Hellyer Volcanics east of the Que River mine near the Henty Fault Zone, in the Department of Mines' MCH-1 drill hole west of Mt Charter (fig. 4), and in at least two other drill holes west of Que River mine and Hellyer mine (Aberfoyle geologists, pers. comm.). It also occurs at the western end of the Cradle Mountain Link Road (fig. 2), where recent mapping by M. Vicary (Mt Read Volcanics Project) and Aberfoyle geologists shows it to be separated from the overlying Que River Shale by only a very thin wedge of basalt (10 m or less) representing the Que-Hellyer Volcanics (fig. 3).

The Animal Creek Greywacke is of the order of 500-600 m thick in the Murchison Highway-Sock Creek area, where it dips fairly uniformly west at 35-45° and faces west. A general two-fold subdivision into a lower tuffaceous part and an upper micaceous part is possible here, and also in the area east of Mt Block (McNeill, 1989; Corbett and McNeill, 1986). The lower part of the sequence on the Murchison Highway consists of grey to buff-coloured vitric tuff and lesser vitric-crystal tuff interbedded with tuffaceous greywacke and greywacke of mixed volcanic-Precambrian provenance. The rocks are well-bedded except for some relatively massive tuff units. A thin section (P206) from a greywacke near the Highway consists of quartzite grains (about 40%), phyllite and quartz-mica schist grains (about 20%), detrital mica (about 10%), feldspar grains and minor opaques in a fine-grained matrix of quartz, sericite and carbonate. This rock is somewhat atypical in being predominantly of Precambrian derivation.

The upper part of the sequence consists of interbedded grey to brown-coloured greywacke, sandy siltstone, black shale and minor vitric tuff and crystal-vitric tuff. The sandstones typically show muscovite flakes on fresh or weathered surfaces, and are quartz-rich, ranging from quartz-wacke to lithic-wacke in composition. Graded bedding is evident in many of the greywacke beds, which are interpreted as turbidites.

The sequence is markedly thinner in the vicinity of Mt Charter, where it is 'sandwiched' between the Mt Charter Fault and the CVC contact and the beds are tightly folded, cleaved and disrupted (e.g. in drill holes MCH-2A and MCH-3).

In the Sharks Fin area, south-east of the Que River mine, a similar sequence of micaceous greywacke, siltstone and shale, of the order of 200 m thick, dips and faces west and is conformably overlain by the Que-Hellyer Volcanics. Some tuffs and minor basalts which occur in the upper part of this sequence possibly belong to the lower unit of the Que-Hellyer Volcanics as defined herein, but have been included in the greywacke sequence for mapping purposes. The sequence is bounded to the east by, and partly incorporated within, the Henty Fault Zone, the boundaries of which are somewhat gradational. There is apparent continuity along the fault zone to the south with the belt of Animal Creek Greywacke which extends around the large synclinal structure to the Mt Charter area (Corbett and McNeill, 1986). The sequence also abuts the northern continuation of the Farrell Slates within the fault zone, but the contact relationship is unclear and may be faulted.

The typical greywackes in the Sharks Fin area are bluish- grey when fresh, weathering to white or pale brown. Beds are up to several metres thick and are commonly graded, with sole marks and flame structures at the base and an upper interval of cross-lamination. Detrital components are mainly Precambrian-derived quartzite and phyllite grains, muscovite flakes, and minor volcanic material. Interbedded with the greywackes are minor, brown to green, laminated silstone beds up to 200 mm thick, and minor feldspar-rich crystal-vitric tuff units. A thin flow of vesicular basaltic lava, about 10 m thick, occurs within the sequence 1.2 km ESE of Que River mine. In thin section (P145) the basalt consists of plagioclase phenocrysts and partly altered clinopyroxene phenocrysts in a sub-trachytic groundmass of plagioclase, chlorite and pumpellyite. Vesicles are filled with chlorite, quartz, calcite, epidote and prehnite. Tuffaceous rocks predominate towards the top of the sequence, and include quartz-feldspar-phyric crystal-vitric and vitric-crystal tuffs, some of which show alteration to sericite and minor fuchsite. A three metre thick bed of tuffaceous shale marks the top of the sequence on a four wheel drive track west of the Sharks Fin.

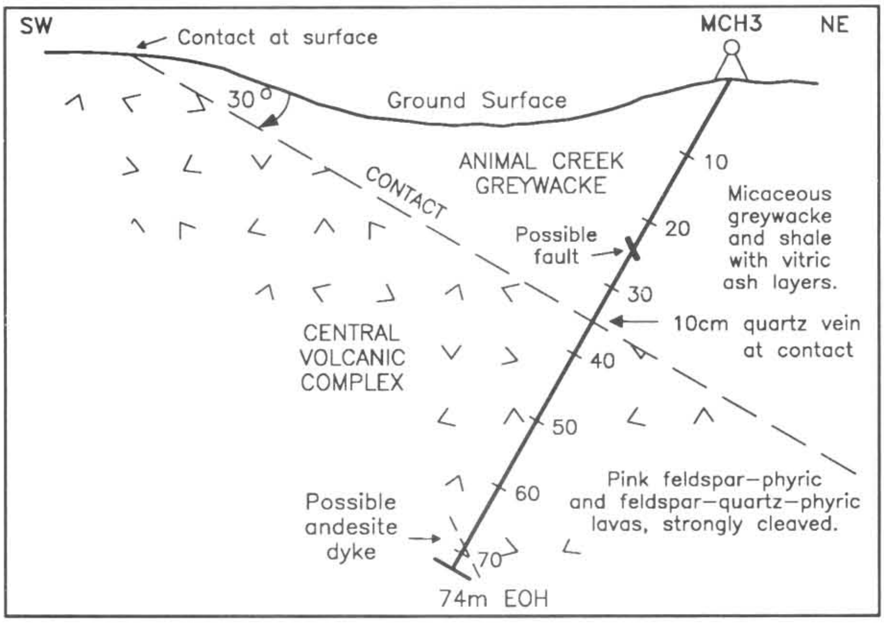


Figure 6. Cross-section of drill hole MCH-3

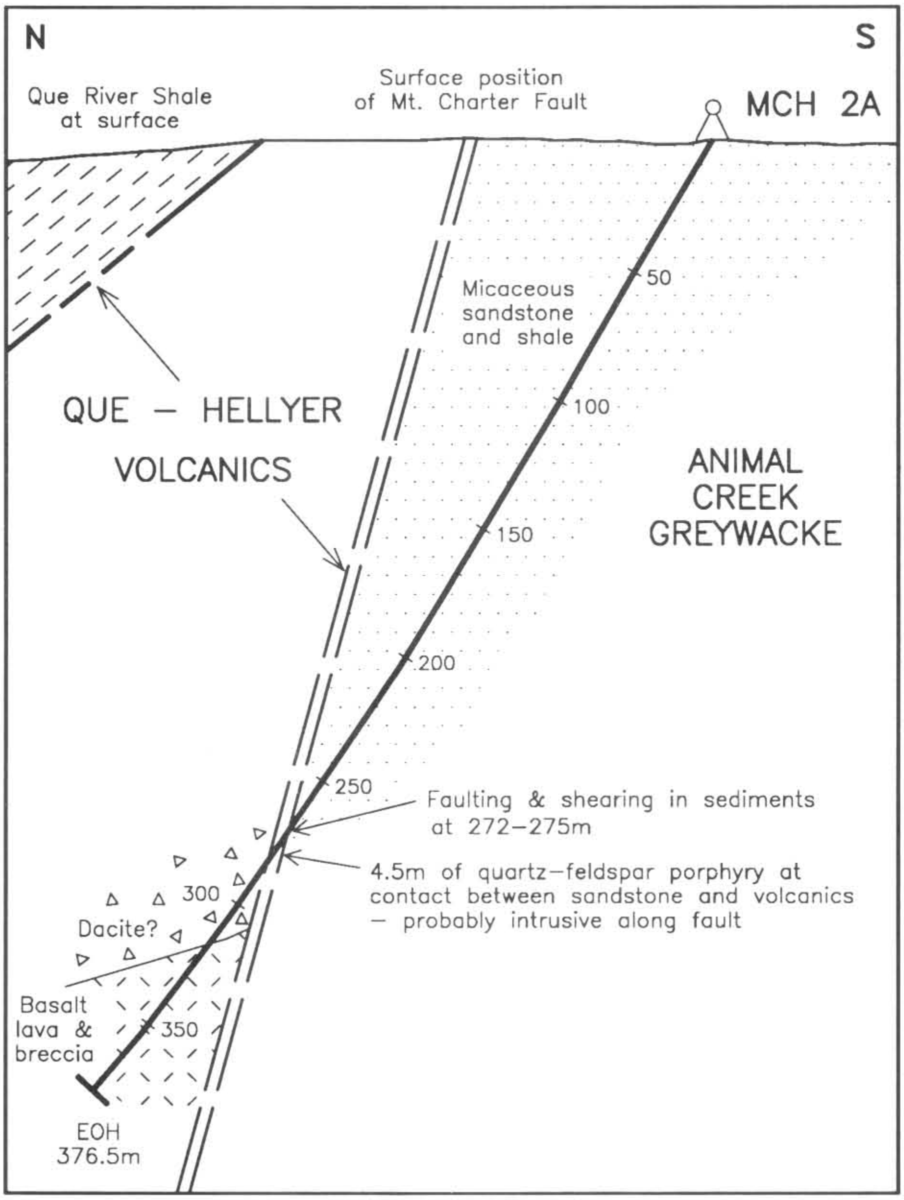
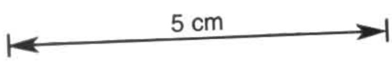


Figure 7. Cross-section of drill hole MCH-2A



Within the Henty Fault Zone the greywacke sequence is highly cleaved, lineated and strongly sericitised. A thin section (P134) of one sample shows a penetrative alignment of chlorite and sericite overprinting a silicified, quartz-veined rock of uncertain origin. In sample (P167), a probable vitric-crystal tuff, broken remnants of quartz and feldspar crystals occur in a highly cleaved, completely sericitised matrix. These rocks may be termed cataclasites. An unusual feldspar-chlorite-magnetite-phyric rock occurs within the greywacke sequence in the fault zone at the northern end of the Sharks Fin. In thin section (P146), zoned plagioclase phenocrysts and glomerocrysts, 0.2-1.0 mm long, are variably sericitized and chloritised and rimmed by felted sericite. Magnetite grains are abundant, forming up to 5% of the rock, and appear to be a primary constituent. One isolated quartz phenocryst is also present. The groundmass consists of quartz, sericite and chlorite and has a faint snowflake texture. The rock is quartz-veined, and may originally have been an andesite or dacite lava.

Recent mapping by M. Vicary (Vicary and Pemberton, 1988) shows that the greywacke sequence exposed along the western part of the Cradle Mountain Link Road is also a correlate of the Animal Creek Greywacke. This sequence of pale-weathering quartz-rich micaceous sandstone and siltstone dips and faces to the south-east in the southern part of the area, and is overlain, apparently conformably, by the Que River Shale, with only a thin sliver or lens of basalt representing the Que-Hellyer Volcanics. Although the contact with the Que River Shale shows silicification and quartz-veining in one area, further examination suggests it is mainly a conformable sedimentary boundary.

QUE-HELLYER VOLCANICS

The Que-Hellyer Volcanics may be defined as that sequence of andesitic to basaltic volcanics with minor felsic volcanics and sedimentary rocks lying between the micaceous Animal Creek Greywacke below and the Que River Shale above, and exposed in the vicinity of the Que River and Hellyer mines and Mt Charter. The sequence has a maximum thickness of possibly 1000 m in the Que River mine area, but appears to thin dramatically to the west, north-west, and south-west. Total thickness of the complete section in the drill hole MCH-1 west of Mt Charter is of the order of 480 m.

The sequence has been subdivided into four units (figs. 4, 8): (1) lower tuff and lava, comprising interbedded tuff, tuffaceous sandstone and siltstone with minor intercalated basaltic, andesitic and felsic lava; (2) lower andesites and basalts; (3) mixed sequence of felsic to mafic lava, epiclastic breccia, tuff and minor sedimentary rocks; (4) upper basalts and andesites.

Lower tuff and lava

This unit is exposed only in the area south-east of Mt Charter, where it occupies the core of a large N-plunging syncline and extends onto the next map sheet to the south (Corbett and McNeill, 1986; McNeill, 1989). Thickness of the sequence is difficult to estimate because of the paucity of dip readings, but appears to be of the order of 200-300 m. The equivalent unit in MCH-1 is only about 60 m thick (fig. 8), indicating a considerable thinning to the west. The unit also appears to thin northwards, and may be represented by only a few tens of metres or less of tuff and minor basalts in a gradational zone between the Animal Creek Greywacke and the lower andesites east of Que River mine.

The unit consists of felsic tuff with minor intercalated felsic lava and a unit of basaltic lava with associated basaltic tuffs. The contact with the Animal Creek Greywacke is conformable and possibly interfingering. The felsic tuffs and lavas are grey to pink or green when fresh, weathering to cream or white. Most of the rocks are vitric-crystal tuffs and crystal-vitric-lithic tuffs, while the lava units are relatively minor and are typically flow-banded, feldspar-phyric, and of rhyolitic-dacitic composition. The rocks are generally strongly cleaved and chlorite-carbonate-altered, with up to 5% disseminated pyrite. Original textures are difficult to recognise.

A thin section (P178) of a crystal-vitric-lithic tuff shows anhedral (broken) to euhedral phenocrysts of plagioclase and quartz, up to 1.5 mm across, in a chlorite-sericite matrix. Large areas of mosaic quartz appear to be replacements of original altered lithic clasts. The rock has a well-developed spaced, anastomosing, brown seam cleavage.

A thin section from a pale grey vesicular, feldspar-phyric lava (P182) shows sericite-chlorite pseudomorphs of feldspar up to 2 mm in length, set in a dusty brown groundmass with a partially developed snowflake texture. Spotty chlorite and sericite alteration occurs throughout the groundmass. Vesicles are mostly elongate, up to 1.5 mm long, and filled with a mosaic of quartz and minor sericite. The rock also contains very finely disseminated pyrite (1-5%), and has a well developed, spaced, anastomosing, brown to black seam cleavage. Fractures perpendicular to the cleavage contain sericite, pumpellyite and phrehnite oriented parallel to the cleavage.

The basaltic unit is of the order of 100 m thick, and is described by McNeill (1989) as consisting of vesicular, dark grey to green, plagioclase-clinopyroxene-phyric lavas with interbedded basaltic crystal-lithic tuff and vitric tuff. Some of the lavas are autobrecciated (pillow breccias?), with pale cherty material filling the interstices between clasts. Vesicles are strongly flow-oriented in some flows, and are filled with quartz, calcite and epidote. The basaltic flow sequence appears to grade southwards into massive, coarser grained doleritic rock which transects the Animal Creek Greywacke contact and is probably an intrusive feeder. A chemical analysis (A317) from this basaltic unit, supplied by A. McNeill from the area south of the map sheet [CP904892], is given in Table 1 and discussed in the Geochemistry Section.

The sequence correlated with the lower tuff and lava in the MCH-1 drill hole (fig. 8) comprises a lower unit of some 40 m of andesitic crystal-lithic tuff and tuffaceous sandstone, with a 2 m thick basalt flow in the central part, and an upper unit (about 20 m thick) of andesitic and basaltic lavas and breccias (including a 2 m thick unit of distinctive, pale coloured, quench-fragmented basalt which resembles a felsic lava) with a 5 m thick tuffaceous siltstone bed at the top. The sequence is gradational through well-bedded tuffaceous sandstone and siltstone to the bedded quartzose-micaceous sandstone and siltstone of the underlying Animal Creek Greywacke.

Lower andesites and basalts

This unit crops out mainly on the rugged eastern slopes of the plateau and also along the HEC transmission line west and south-west of Que River mine. It appears to be of the order of 400-500 m thick east of Que River mine, but is only about 260 m thick in drill hole MCH-1 (fig. 8). The rocks at surface are generally deeply weathered to a reddish-brown clayey soil, and fresh outcrop is rare.

The unit as intersected in drill hole MCH-1 comprises a lower section of andesite lava and breccia (80 m) followed by basalt lava and breccia (20 m), andesitic breccia and tuff (18 m), micaceous sandstone (5 m), and a thick upper basalt (140 m). The lower andesitic section consists of about equal proportions of massive lava and breccia, typically in units 10-20 m thick. The lava is typically pale grey to mid-grey or greenish-grey in colour, vesicular in patches, with visible feldspar phenocrysts. The breccias contain clasts from a few

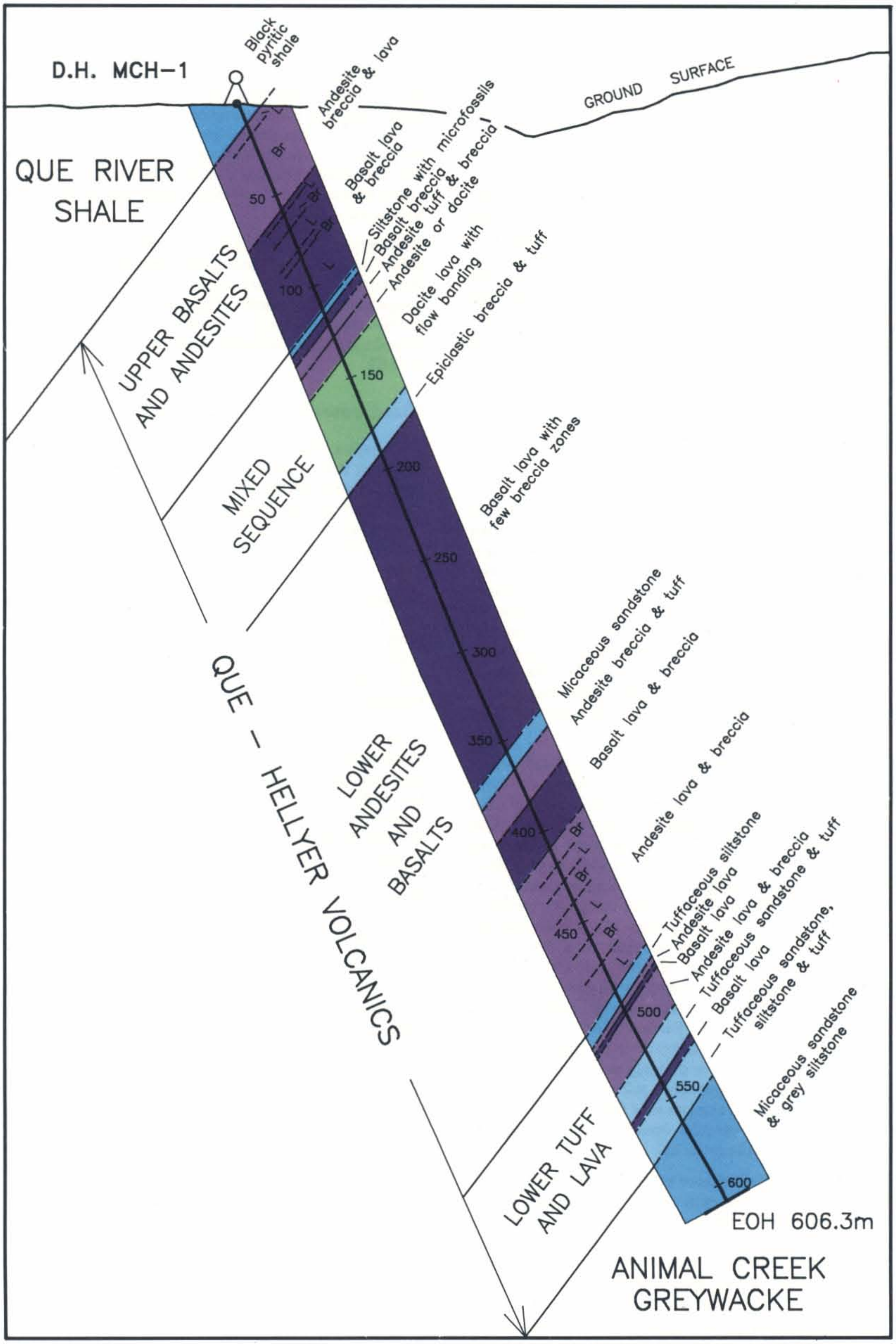


Figure 8. Cross-section of drill-hole MCH-1, showing complete sequence of Que-Hellyer Volcanics

5 cm

mm to more than 100 mm across, often with darker centres and paler rims. Relict perlitic texture is evident in many clasts e.g. Plate 1*b*, and is commonly best developed at the margins. The matrix between the clasts is cherty and fine-grained in some cases, and may be inter-pillow material. Thin sections of the andesites (57446-57450, see Appendix B) typically show sericitised albite phenocrysts and a few chlorite pseudomorphs of ferromagnesian phenocrysts in a very fine-grained, variably altered (chlorite-carbonate-sericite), quartzo-feldspathic groundmass (plate 1*a*-*b*).

The central basalt unit and the thick upper basalt show the typical characteristics of the Que-Hellyer basalts generally, i.e. they are fine-grained, even-textured, dark-coloured, non-porphyritic rocks in hand specimen, commonly with abundant vesicles. Thin sections of the basalts (56826, 56827, 56831-56833) typically show abundant small vesicles, with fillings of chlorite, pumpellyite, quartz, carbonate and epidote, in a non-porphyritic to micro-porphyritic groundmass of plagioclase microlaths and granular subhedral to euhedral clinopyroxene (mainly augite, often partially altered to epidote or pumpellyite, Plate 2*a*-*b*). Flow texture is commonly evident as an alignment of vesicles and microlaths. The lack of phenocrystic texture in hand specimen, and the abundance of pyroxene, are the main distinguishing features from the andesites. There is a notable paucity or lack of opaque minerals in the basalts.

The sandstone intersected in the central part of this unit is a massive, grey, micaceous quartzwacke with some minor intercalation of laminated siltstone. Some graded bedding is apparent in the sandstone, with uphole facing. The sandstone is predominantly of Precambrian derivation, and is virtually identical to the Animal Creek Greywacke. The presence of this sedimentary unit suggests a hiatus in the volcanism, at least locally, during which time turbidity currents from more distant sources were able to enter the basin. The general paucity of such sedimentary units throughout the sequence suggests that the basaltic-andesitic volcanism was fairly continuous and rapid.

Field mapping has not differentiated the thick basaltic unit of the lower andesites and basalts, possibly due to paucity of outcrop and/or to lateral wedging of the unit. The basalt is not present below the mixed sequence at either the Hellyer or Que River mines. Field outcrops seen of the lower sequence are of andesitic to basaltic lavas and breccias, ranging from bluish-green to very pale grey in colour. Thin sections of lavas (P149, P180, P190) show phenocrysts and glomerocrysts of plagioclase (about 15%), and phenocrysts of clinopyroxene (about 10%) up to 0.6 mm diameter, in a fine-grained trachytic groundmass of plagioclase, chlorite and pumpellyite. Vesicles are commonly present, up to 5 mm long, and filled with quartz, chlorite, carbonate and occasionally pumpellyite. Sample P166 is a vesicular porphyritic basalt with phenocrysts of plagioclase and pyroxene. Sample P177 is a highly vesicular basalt with plagioclase and clinopyroxene micro-phenocrysts. The vesicles include small, elongate ones filled with Fe-Mg-rich chlorite, and larger irregular ones filled with intergrown quartz and pumpellyite (plate 2*a*).

The upper part of the sequence west of Que River mine is rich in andesitic (?) breccias consisting of rounded, pale grey to white clasts, up to 100 mm across, in a dark green matrix. The pale clasts are of vesicular porphyritic andesite (?), with plagioclase and clinopyroxene phenocrysts in a fine-grained, pilotaxitic, dusty brown groundmass. Diffuse margins to many of the clasts suggest interaction with the interstitial 'matrix'. The darker 'matrix' between the clasts is also vesicular in some cases, and consists of disoriented plagioclase and pyroxene crystals in a base of plagioclase, chlorite and prehnite. The igneous nature of the 'matrix' indicates that the breccias are blocky lava flows. Breccias formed by other processes, including quench brecciation and pyroclastic eruptions, also appear to be present.

A unit of prominently feldspar-phyric andesite lava or breccia, 50-100 m thick, forms a semi-continuous stratigraphic horizon in the footwall position of the Que River and Hellyer orebodies. A thin section of this unit (P049) from the HEC transmission line shows feldspar phenocrysts and lithic fragments pseudomorphed by chlorite, sericite and carbonate, in a fine-grained groundmass of mosaic quartz, sericite, chlorite and disseminated pyrite. Sample P130 from near Que River mine has similarly been totally altered to quartz, sericite and pyrite. Vesicles in the rock are now filled with quartz and pyrite.

Thin sections (P179, P162) from near the top of the unit east of Mt Charter contain relatively fresh phenocrysts of twinned plagioclase 0.1-2.0 mm long, together with prehnite-pumpellyite pseudomorphs of ferro-magnesian phenocrysts, and rare quartz phenocrysts, in a pilotaxitic, plagioclase-rich groundmass. Embayed quartz phenocrysts are more common in P162.

Mixed sequence or mine sequence

The complex, lithologically variable unit containing the Que River and Hellyer orebodies varies in thickness from a few metres to about 300 m, and is particularly distinguished by the presence of felsic lavas and polymict epiclastic breccias. Also within the sequence are andesitic and basaltic lavas and breccias, finer-grained tuffs, and minor bedded sedimentary rocks.

At Hellyer mine, the sequence is represented by only a thin unit (10 m) of epiclastic breccia, tuff and minor shale which partly overlaps the massive sulphide body (McArthur, 1986). In the vicinity of Que River mine, the unit is of the order of 120 m thick and contains three separate felsic lava bodies separated mainly by andesitic tuffs and breccias. In the Portal road area, 2 km north-east of Que River mine, the unit is approximately 250 m thick and consists of a basal basaltic-andesitic epiclastic horizon interbedded with thin basaltic to andesitic lava flows, overlain by a massive felsic lava body which is in turn overlain by polymict epiclastic breccias with intercalated basalt flows. On the Farrell-Waratah transmission line, the unit is about 200 m thick and consists of several felsic lava flows intercalated with andesitic tuffs and breccias and overlain by epiclastic breccia. Pyrite-sericite alteration is pervasive in the sequence around the Que River and Hellyer mines, and has destroyed primary textures and mineralogies to the point where identification of original rock types is not possible in some areas.

At Mt Charter, the mixed sequence is about 200 m thick and comprises a basal epiclastic horizon followed by a massive felsic lava body, with minor breccia intercalations, overlain locally by a massive barite-pyrite body. A somewhat similar sequence is evident in drill hole MCH-1 (fig. 8), where the sequence is about 70 m thick and comprises a lower unit of epiclastic breccia and tuff (about 15 m) followed by a 35 m thick dacite lava, followed by about 20 m of mixed basaltic and andesitic breccias capped by a one metre-thick bed of laminated tuffaceous siltstone. Sponge spicules and probable radiolaria are preserved within the siltstone (thin section 56819), and confirm that marine conditions prevailed during deposition of the sequence.

Because of the complexities of the sequences, and the difficulties of correlation, the mixed sequence is described in terms of the major individual rock types.

(a) Felsic lavas ('dacites')

The felsic rocks occur both as massive, lens-shaped or bulbous bodies, probably representing lava domes, and as thin, tabular concordant bodies representing flows. A few cross-cutting dykes are also known. The rocks typically weather to white, cream or pink colours, being pale grey to mid-grey when fresh. A close association between some dome-like bodies and epiclastic breccias rich in clasts of the lava is evident in several places, and suggests that eruption and/or erosion of the domes was responsible for some of the breccia units. The felsic rocks are typically fine-grained, and commonly flow-banded. Some varieties are vesicular and/or spherulitic. Patches of autobrecciation texture occur in some units, associated with flow-banding, while some flows appear to be more or less brecciated throughout. Probable flow-top breccias occur in the Mt Charter area. A dacite intrusive which cross-cuts PQ lens in the Que River mine (D. Wallace, pers. comm.) may represent a feeder dyke for the domes and flows in this area.

The felsic lava in drill hole MCH-1 is a mid-grey to pale grey, feldspar-phyric, sparsely-vesicular rock resembling some of the andesite lavas, and was only positively identified as a dacite after examination of geochemical data. The rock is flow-banded over much of its thickness, and this may also be a distinguishing feature from the more mafic rocks. Thin sections (56823, 56824) show plagioclase phenocrysts partially altered to sericite, muscovite and pumpellyite, in a pale felsitic groundmass showing spherulite or snowflake texture (plate 3). Vesicles are filled with quartz, albite and muscovite. The unusual muscovite alteration is also apparent in thin sections (57362, 57363) of the equivalent unit intersected in drill hole MCH-2A (fig. 7).

Thin sections of the least altered felsic lavas (P041, P199) from 2 km north-east of Que River mine contain euhedral plagioclase phenocrysts (5%), 0.2-2.0 mm long, which have been partially or totally replaced by carbonate, sericite-carbonate, or sericite-quartz. The groundmass, which varies from spherulitic to snowflake-textured, is extensively sericitised and carbonate altered. Sample P081 contains chlorite-sericite-opaque pseudomorphs of glomerophyric feldspar (0.2-2.0 m diameter) and minor quartz phenocrysts (less than 0.4 mm across), in a highly altered quartz-sericite-carbonate groundmass. Most of the felsic lavas (e.g. P074, P075) are extensively sericite-chlorite-altered. Secondary mosaic quartz may form up to 50% of the groundmass, and has completely obliterated the primary texture in sample P158. Cleavages are usually strongly developed.

In the Que River Mine area, Young (1977, 1980) divided the felsic lavas into non-porphyritic and porphyritic types. In thin section (P138) the non-porphyritic dacite is a fine-grained, flow-banded rock with sparse sericitised feldspars in a spherulitic groundmass. The porphyritic dacite (P137) consists of quartz-sericite pseudomorphs of feldspar phenocrysts (0.1-2.0 mm) in a partly-spherulitic groundmass altered to quartz, sericite and minor chlorite. The rock is cut by quartz-sericite and carbonate-pyrite zoned veins.

(b) Basaltic-andesitic lavas and lava breccias

Basaltic to andesitic lavas occur as thin (2-20 m) flows, often pillowed or pillow-brecciated, intercalated with epiclastic breccias. Up to five separate flows occur in some areas, e.g. near the Haulage Road 2 km north-east of Que River mine. The mafic flows are usually extensively altered, particularly to carbonate and fuchsite, or pyrite and sericite, and in places may only be recognised by the presence of abundant large vesicles. These vesicles are concentrated at pillow margins in some flows. Alteration and bleaching produces a pale grey to almost white colouration in some cases. Elsewhere, the fresh rocks are pale green to dark green in colour, and weather to a red-brown soil.

A pillowed to pillow-brecciated flow on the Haulage road 1.5 km north-east of Que River mine has an inter-pillow matrix of pale grey, fine-grained cherty material. In thin section (P093, P094) the 'matrix' has a very fine-grained pilotaxitic texture which appears to be chilled against the margins of the coarsely vesicular clasts. The clasts are extensively altered to carbonate-sericite-chlorite-quartz and minor pumpellyite. Vesicles are chlorite-carbonate filled.

Other thin sections of basalts (P091, P102) show extensive alteration to carbonate, quartz, sericite and pumpellyite. In sample P196, the elongate to irregular to ellipsoidal vesicles show zoned fillings of quartz, chlorite-carbonate, sericite, and pumpellyite-chlorite.

(c) Epiclastic breccias and other sediments

Massive polymict to monomict breccias and minor bedded volcaniclastic sandstone-siltstone occur irregularly throughout the mixed sequence. When freshly exposed, the polymict breccias are impressive, multi-coloured rocks in which clasts, up to 200 mm across, of grey to pink dacite are usually prominent, together with clasts of basalt-andesite, altered dacite, and base metal sulphide. The dacite clasts are commonly angular, and some show arcuate and concave surfaces suggestive of a hyaloclastic origin. The breccia units are up to tens of metres thick and appear to be mainly mass-flow deposits. Some of the flows were probably initiated by hyaloclastic disintegration of the margins of dacite domes or flows. Hydrothermal alteration of the breccias is ubiquitous, with pyrite-sericite, fuchsite-sericite-carbonate, and quartz-carbonate-sericite being the common assemblages.

The basal epiclastic unit in the Haulage Road section consists dominantly of basaltic-andesitic clasts, and grades upwards to sandstone rich in basaltic detritus. Epiclastic units higher in the sequence are dominated by dacite clasts and also contain abundant detrital quartz grains. Angular to sub-rounded clasts of massive pyrite and banded sulphide, ranging in size from a few millimetres to nearly one metre in length, occur in the upper units. These clasts are commonly rimmed by pyrite. Distinctive pale green wispy fiamme-like clasts are common in the upper units. In thin section (P096) these wispy fragments consist entirely of sericite, and may represent original pumice. Small arcuate features of similar composition may represent glass shards.

In the Mt Charter area, the epiclastic unit at the base of the mixed sequence (P161) contains clasts of sericitised dacite, unaltered basalt, and micaceous greywacke. Thinner epiclastic units occurring within the large dome-like mass of dacite are composed essentially of dacite clasts, and tend to be narrow (less than 10 m across) and limited in extent.

In drill hole MCH-1, the basal epiclastic unit of the mixed sequence is a massive to faintly bedded rock containing bright pink clasts of albitised lava (probably dacite) up to 100 mm across, and dark green-grey clasts, in a tuffaceous matrix. Andesitic and basaltic breccias and tuffs occur near the top of the sequence, and include units with abundant small clasts of perlitically cracked andesite lava (e.g. thin sections 56821, 56822).

A thick (approximately 100 m) epiclastic sequence exposed along the HEC powerline one kilometre NNW of Mt Charter consists predominantly of sub-angular pink clasts of partially-altered dacite, up to 200 mm across, with a few basaltic clasts. This unit possibly represents a debris-flow fan derived from the adjacent dacite dome.

Samples collected from the Haulage Road show strong carbonate-sericite-quartz alteration. In P044 carbonate has totally replaced clasts and matrix in some areas. In sample P103, carbonate forms about 50% of the rock, the remainder consisting of secondary mosaic quartz and fuchsite. A strongly developed stylolitic cleavage is present. In sample P104 quartz and pyrite rim a probable dacite lava clast.

Samples from north-west of Que River mine, in the vicinity of the footwall alteration zone of the Hellyer mineralisation,

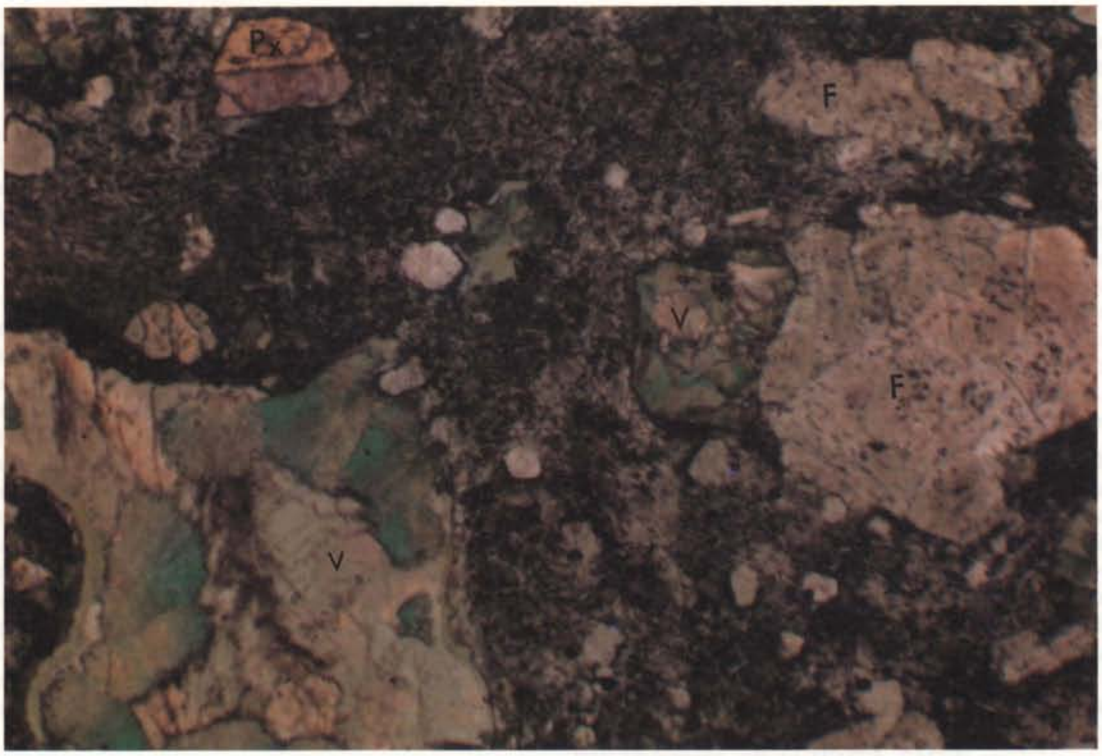


Plate 1a. Photomicrograph of vesicular porphyritic andesite from lower part of Que–Hellyer Volcanics – sample P180 from east of Mt Charter. Note vesicles (V) filled with fibrous blue-green pumpellyite and clear quartz; plagioclase phenocrysts (F); sparse pyroxene phenocrysts (Px); groundmass of feldspar microlaths and fine-grained chlorite. Plane light. Field dimensions 3.5 × 2.5 mm.

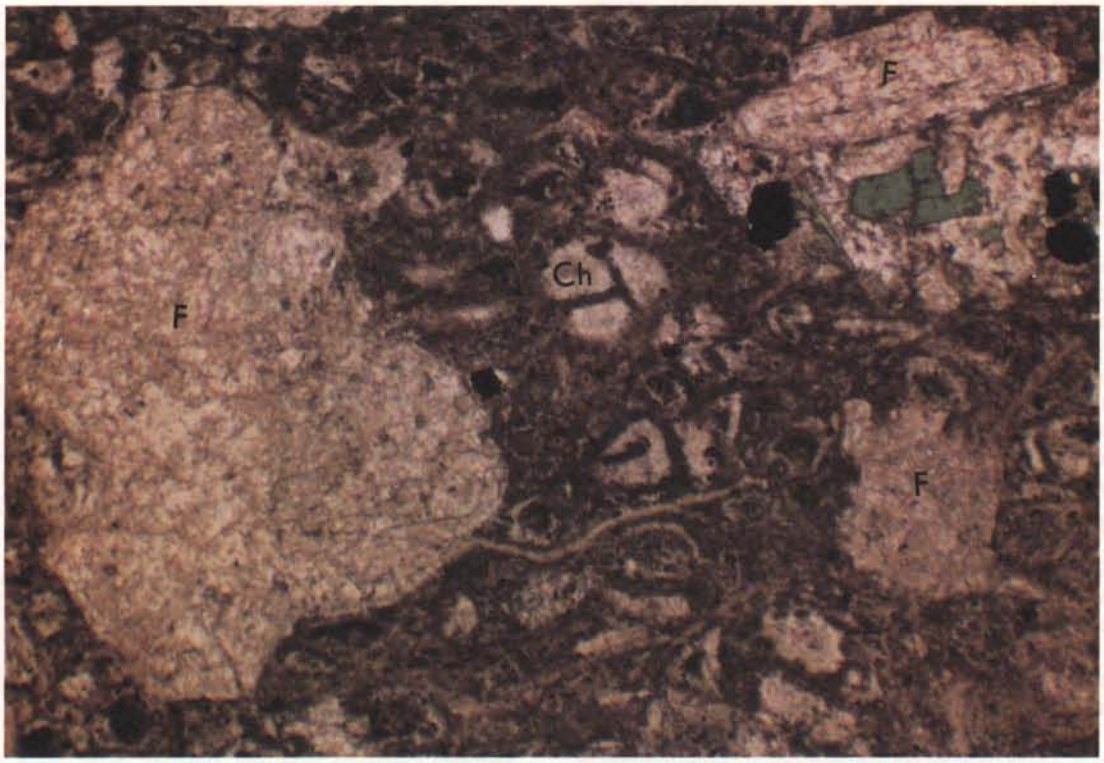


Plate 1b. Porphyritic andesite clast from andesitic breccia in lower part of Que–Hellyer Volcanics – sample 57447 from 428.0 m in drill hole MCH-1. Note sericite-altered plagioclase phenocrysts (F); green chlorite pseudomorphs after ferromagnesian minerals; leucoxenised opaque grains; small bodies of secondary chert (Ch) – mainly after feldspar; groundmass of quartz, sericite and chlorite showing remnant perlitic texture. Plane light. Field dimensions 3.5 × 2.5 mm.

Plate 2a. Vesicular aphyric basalt from lower part of Que–Hellyer Volcanics – sample P177 from South Mt Charter track. Note large vesicle (V) filled with clear quartz and fibrous brown-green pumpellyite; small vesicles (V) filled with chlorite; groundmass of feldspar microlaths, small pyroxene crystals, and chlorite. Plane light. Field dimensions 3.5 × 2.5 mm.

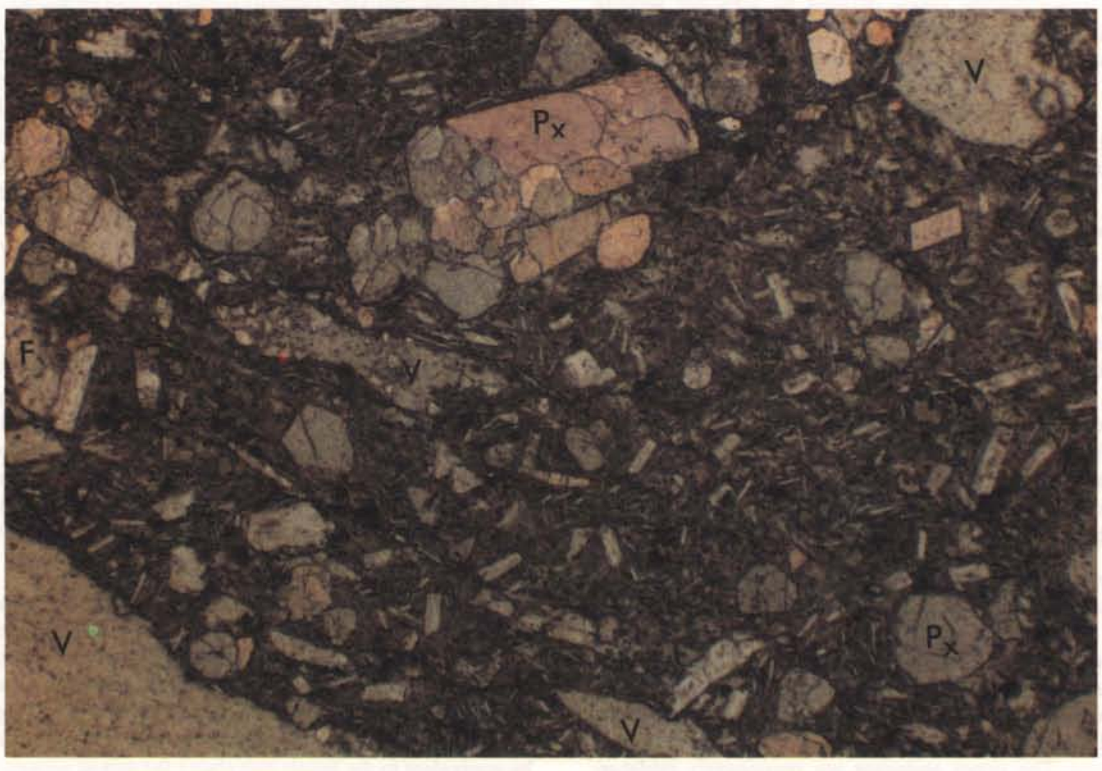


Plate 2b. Micro-porphyritic basalt from upper part of the Que–Hellyer Volcanics – sample 56817 from 83.0 m in drill hole MCH-1. Note micro-phenocrysts of pyroxene (Px); chlorite-filled elongate vesicles (V); groundmass of feldspar microlaths, pyroxene and chlorite. Plane light. Field dimensions 3.5 × 2.5 mm.

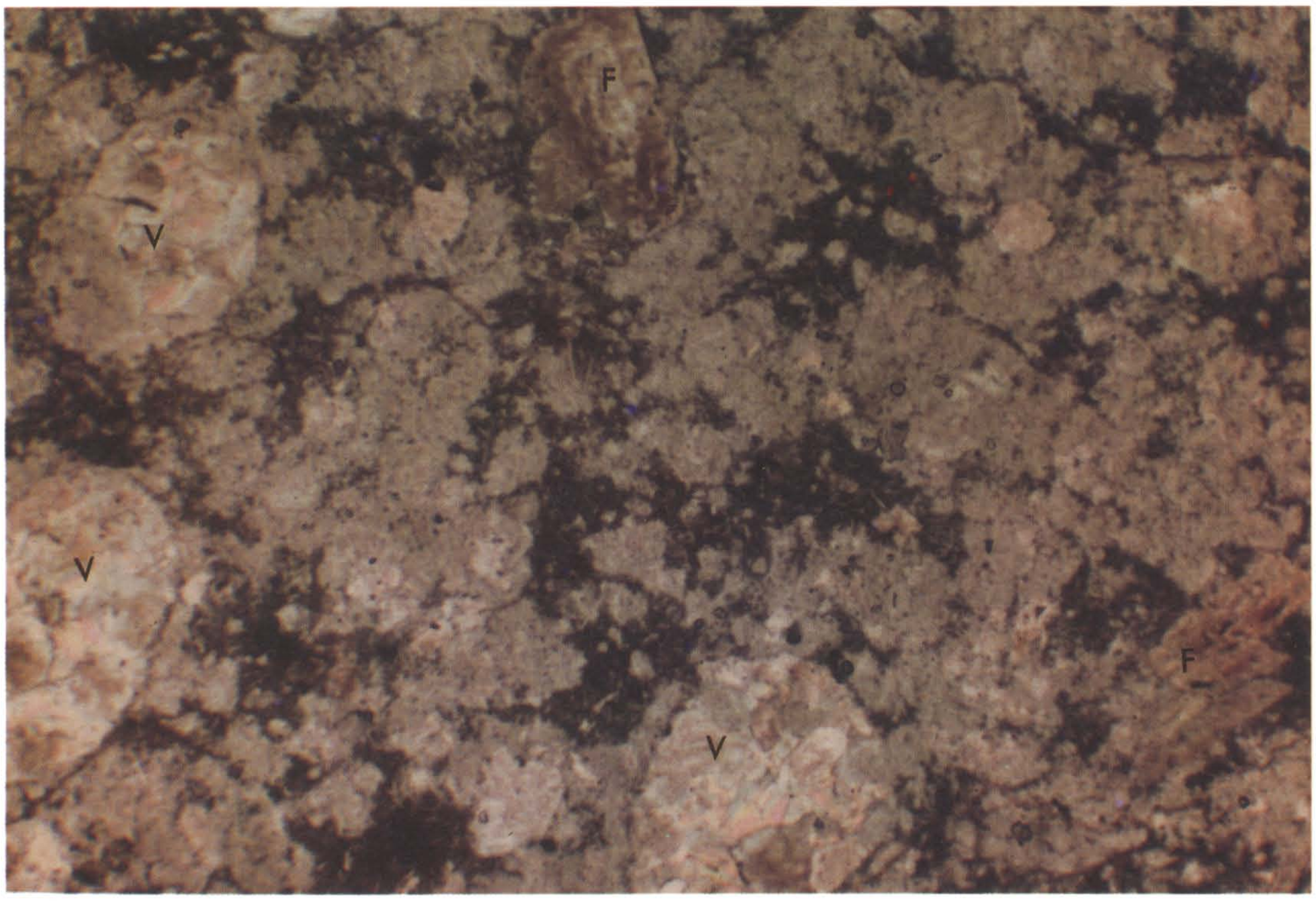


Plate 3. Vesicular dacite from mixed sequence of Que–Hellyer Volcanics – sample 56823 from 154.8 m in drill hole MCH-1. Note rounded vesicles (V) with infilling of quartz and muscovite; feldspar phenocrysts (F); quartzo-feldspathic groundmass showing incipient spherulitic texture and chlorite-rich interstices. Plane light. Field dimensions 3.5 × 2.5 mm.

show intense pyrite-sericite alteration. A thin section (P099) shows relict dacitic clasts defined by stronger sericite alteration than that shown by the matrix. The rock is highly strained, with a penetrative cleavage, strong elongation fabric, and the development of porphyroblastic quartz. The matrix consists mainly of felted sericite and mosaic quartz. Quartz overgrowths or 'beards' occur on pyritic grains, which constitute 5-10% of the rock.

Upper basalts and andesites

This upper sequence is of the order of 100-200 m thick, and ranges from basalt-dominated to andesite-dominated. A succession of basalt flows and breccias, 220 m thick, forms the entire sequence above the Hellyer orebody (McArthur, 1986), while andesites appear to predominate west of Que River mine. The sequence in drill hole MCH-1 (fig. 8) is about 90 m thick, and comprises an upper unit of andesite lavas and breccias (40 m) and a lower unit of basalt lavas and breccias (50 m). A thin epiclastic breccia horizon occurs at the top of the sequence in some areas.

The upper sequence basalts in MCH-1 are generally similar to those lower in the sequence. Thin sections (56817, 56818) show a well-developed micro-porphyritic texture with abundant fresh euhedral-subhedral augite and less abundant plagioclase crystals in a microlath-rich groundmass showing flow texture (plate 2*b*). Sparse, elongate vesicles are filled with chlorite or chlorite-carbonate. Opaque grains are scarce or absent. The upper andesites are prominently feldspar-phyric, with sparse chlorite-opaque- pseudomorphed ferromagnesian phenocrysts also present in some cases, and have felsitic groundmasses with microlath textures in some samples. Micro-phenocrysts of quartz occur in some samples.

Fresh field outcrops of the upper sequence are rare. A typical andesite lava from west of Mt Charter (P217) shows perlitic cracks, and contains rounded feldspar phenocrysts (up to 2 mm) and minor embayed quartz phenocrysts in a trachytic-textured groundmass. Feldspar laths to 0.4 mm, and fine-grained pyroxene partially altered to chlorite and sericite, occur in the groundmass. Rare, quartz-filled vesicles also occur. By comparison, sample P173, a similar trachytic andesite lava from near the Mt Charter barite body, is strongly chlorite-sericite-altered. A breccia (P218) from near the base of the sequence on the South Charter track shows clasts of vesicular lava with plagioclase phenocrysts in a fine-grained, strongly flow-textured feldspathic groundmass. Although initially identified as an andesite by Komyshan, this rock shows patches of quartz-muscovite alteration similar to that seen in the mixed sequence dacites in drill holes MCH-1 and MCH-2A, and its geochemical characteristics also indicate that it is probably a dacite.

A lens-shaped body of basaltic lava occurs at the base of the upper sequence 1.3 km north-west of Mt Charter, and is texturally similar to the lower basalts. In thin section (P194), phenocrysts and glomerocrysts of zoned clinopyroxene constitute about 30% of the rock, and occur with minor chlorite-sericite-altered feldspars in a dusty brown chlorite-altered groundmass. Minor quartz-chlorite-filled vesicles are also present.

The major basalt unit in the northern part of the area, informally referred to as the Hellyer basalt, has a maximum thickness of about 220 m at Hellyer mine, where it directly overlies the mixed sequence and Hellyer orebody. The basalt thins to the south, above a northwards-thickening wedge of andesitic rocks, and appears to wedge out. It may, however, be equivalent to the basalt unit above the mixed sequence in drill hole MCH-1.

The basalt is generally highly vesicular, and ranges from massive to pillowed and pillow-brecciated. Minor black shale and black chert occur within the basalt sequence, and irregular intermixing of basalt and cherty shale, to form 'peperitic' texture, is evident in some areas, particularly at the upper contact with the Que River Shale. The cherty inter-pillow material, when seen in thin section (P027), contains diffuse rounded clasts of mica-rich siltstone in a matrix of mosaic quartz with minor sericite, chlorite and pyrite.

The freshest basalt seen in the field varies from dark green to an unusual very pale green colour, and is commonly flecked with bright green fuchsite alteration. In thin section (MR437), the least altered basalt contains euhedral micro-phenocrysts and glomerocrysts of twinned clinopyroxene (20-30%) and sparse, subhedral, partly sericitised plagioclase micro-phenocrysts. The dusty brown groundmass is partly chlorite-sericite-altered, and rich in granular pyroxene and microlaths of feldspar. Patches of the groundmass are completely replaced by carbonate. Vesicles are chlorite-filled. A highly vesicular basalt (P045) has circular vesicles up to 5 mm diameter with zonal infillings of quartz, carbonate and minor chlorite. Phenocrysts of zoned feldspar, up to 3 mm long, are pseudomorphed by sericite and chlorite, and contained within a highly altered groundmass of chlorite, sericite and mosaic quartz.

Basalt samples from closer to the Hellyer orebody (within 300 m) are extensively altered (e.g. P029, P116), with sericite 'ghosts' of feldspars being the only recognisable phenocrysts. The groundmass is strongly albitised, with minor sericite, chlorite and carbonate. Vesicles are filled with chlorite, albite and prehnite. Samples from further afield (e.g. P053, P117) are dominantly carbonate-altered, with associated sericite, chlorite and minor prehnite-pumpellyite. The carbonate is present throughout the groundmass (up to 30% of the rock), and also occurs within vesicles and veins.

A discontinuous unit of polymict breccia occurs at the top of the Que-Hellyer Volcanics along the western contact against the Que River Shale. Although Collins (in Collins *et. al*, 1981) included this unit in the Que River 'Beds', its general similarity with other epiclastic units in the Que-Hellyer Volcanics, and its contrasting character with the fine-grained Que River Shale, indicates that it is better included with the Que-Hellyer Volcanics. The unit is up to 20 m thick, and occurs in three areas between Mt Charter and the Que River.

As exposed in a quarry west of the Que River mine [CP900945], the breccia consists of angular to rounded clasts, up to 100 mm long, mostly of grey felsic lava and tuff, but also including vesicular basalt, pumice-like material, altered pyritic volcanics and massive pyrite, in a sericitic matrix containing disseminated pyrite. In thin section (P050) the felsic clasts include some with highly irregular, wispy shapes as though still plastic when deposited. Other felsic clasts display perlitic cracks filled with pyrite, and thin elongate vesicles, and resemble some varieties of the felsic lava from the Sock Creek area described below. Some vesicular basaltic-andesitic fragments appear to have been moulded against other clasts. Pyrite occurs as irregular clasts up to 10 mm across, as disseminations in the matrix, and as rims and fracture fillings on many lithic clasts. Concentric growths of pyrite, chlorite and sericite appear to fill irregular cavities between clasts in some places. Sericite alteration is ubiquitous, and sericite overgrowth on pyrite is common. Sample P051, from the same quarry, is a very altered carbonte-chlorite-sericite rock in which the original breccia texture has been obliterated, and only sparse quartz phenocrysts and feldspar pseudomorphs remain.

An exposure of the unit on a four-wheel drive track near Mt Charter [891912] shows an epiclastic breccia containing small to large clasts of weathered basalt-andesite and silty sediment.

CORRELATE OF QUE-HELLYER VOLANICS IN THE SOCK CREEK AREA

The stratigraphic position of the Que-Hellyer Volcanics on the south-west side of the Mt Charter Fault is occupied by a unit of mainly felsic lava with intercalated epiclastic breccia, tuff, sandstone and siltstone. The unit is best exposed on tracks in the vicinity of the Sock Creek prospect, and is of the order of 200 m thick. It appears to conformably overlie the Animal Creek Greywacke, and is overlain by pyritic black shale correlated with the Que River Shale. Large intrusive bodies of quartz-feldspar porphyry intrude the latter. The felsic lava unit strikes NE-SW and dips north-west. It has been traced along strike to the Boco Siding area (Corbett and McNeill, 1986), giving a total strike length of at least 9 km.

The typical felsic lava is variably flow-banded and vesicular, and weathered to a creamy fawn or pale brown colour. Sparse phenocrysts of feldspar and quartz are present, and a sugary granular texture is evident on some weathered surfaces. Vesicules range from ovate to strongly elongated (up to 100 mm long). In thin section (P209) the well aligned elongate vesicles are filled with chlorite and quartz, and are up to 4 mm in length but only 0.2 mm in width. The flow-textured groundmass of small albite laths, sericite and chlorite is overprinted by spherulitic texture, the spherulites having a core of clear quartz (resembling small anhedral phenocrysts) and a prominent chlorite-rich rim.

In sample P189, phenocrysts and glomerocrysts of plagioclase (to 1.2 mm) occur in a fine-grained, strongly flow-textured groundmass rich in feldspar laths. A modified perlitic texture is present, with chlorite growth along and inwards from the perlitic cracks.

The lavas show breccia texture in places, with rounded, pink-rimmed clasts in a pale grey, siliceous matrix. A thin section (P208) shows the clasts to have a very pronounced, large-scale perlitic cracking texture (possibly the 'ocellar' texture referred to by Collins (in Collins, *et. al*. 1981), and the matrix to consist of perlitic fragments sutured by mosaic quartz, as though quenched in situ. The lava has micro-phenocrysts of plagioclase and abundant, elongate, chlorite-filled small vesicles in the typical flow-textured, fine-grained feldspathic groundmass.

The middle part of the lava sequence north-east of Sock Creek prospect comprises some 40-50 m of weathered clastic rocks, including micaceous grit or breccia, tuffaceous siltstone, feldspar-phyric crystal tuff, and pumice-rich tuff. The breccia unit contains clasts of felsic lava, chert and siltstone, and resembles some of the epiclastic breccias in the mixed sequence at Mt Charter and north-east of Que River mine.

QUE RIVER SHALE

A distinctive unit of black pyritic siltstone and shale overlies the Que-Hellyer Volcanics and is overlain conformably and gradationally by felsic tuffs of the Southwell Subgroup. The shale unit was described by Gee *et. al*. (1970) as the Que River Beds, based on exposures along the Murchison Highway north and south of the Que River bridge. The present mapping has further delineated the unit and clarified its upper and lower boundaries, such that formal definition as a formation is now possible.

The Que River Shale is defined as that unit of black and grey siltstone and shale with minor greywacke and tuff, conformably overlying the Que-Hellyer Volcanics and conformably overlain by felsic tuffs of the Southwell Subgroup in the area between the Murchison Highway and Hellyer Mine. The formation is of the order of 150 m thick on the Murchison Highway, but appears to thin eastwards and may wedge out completely in the Southwell River area south-east of Hellyer mine (A. McNeill, pers. comm.). A fossil assemblage including agnostid trilobites, hydroids, dendroids, inarticulate brachiopods and sponge spicules, occurs near the Que River bridge and indicates a late Middle Cambrian age (Gee, *et. al*., 1970).

The typical rock type is a black to grey fine-grained micaceous carbonaceous rock with faint to prominent lamination marked by thin, paler silty bands, and a more or less well developed fissility parallel to bedding. Some outcrops are bleached to pale grey or even white. Pyrite is common as lenticular nodules parallel to bedding, as films on joints and bedding surfaces, as framboids, as disseminated small cubes, and as replacements of sponge spicules. Units of fine-grained cherty vitric ash are interbedded with the shale in places, and rare beds of greywacke sandstone and coarse to fine epiclastic tuff also occur. The top of the formation in the Hellyer Haulage Road section is marked by interbedding of black shale with coarse, graded epiclastic tuffs of the Southwell Subgroup, while the base is marked by irregular intermixing with the top of the underlying basalt. The shale in this area is intruded by two sub-concordant felsic porphyry bodies, and elsewhere is intruded by several bodies of (?)Devonian dolerite. Towards the Cradle Mountain Link Road, north-west of Hellyer mine, the Que River Shale conformably overlies Animal Creek Greywacke, with only a thin intervening sliver or lens of Que-Hellyer Volcanics.

Two chemical analyses of the shale given by Gee *et. al.* (1970) show fairly siliceous composition (68.9 and 72.9% SiO_2) with a relatively minor carbonaceous component (0.95 and 1.82% organic carbon).

A correlate of the Que River Shale occurs in the Sock Creek area, south-west of the Mt Charter Fault, where it overlies the felsic lava unit. Pyritic black shale and grey siltstone in this area occur within several narrow strips or bands separated by sub-concordant bodies of intrusive quartz-feldspar porphyry. The shales are micaceous and finely laminated, and contain up to 5% pyrite as disseminations and nodules. Small-scale soft-sediment deformation structures are apparent in places. Well-bedded quartz-feldspar-phyric tuffs are intercalated with the shale in the upper part of the sequence as exposed. Mapping further to the south-west, in the Boco-Pinnacles area, suggests that the shale unit loses its identity and grades laterally into a mixed sequence of shale, greywacke and felsic tuff (Corbett and McNeill, 1986).

SOUTHWELL SUBGROUP

The Southwell Subgroup may be defined as that sequence of felsic tuff, greywacke and siltstone, with minor felsic lava, conformably overlying the Que River Shale in the vicinity of Hellyer mine, and conformably overlain by volcaniclastic rocks correlated with the Tyndall Group on Murrays East Road [CP95259820] and the Cradle Mountain Link Road [CP95259870]. This area encompasses the headwaters of the Southwell River. The sequence dips and faces east to north-east, and appears to be of the order of 1200-1400 m thick, although thickness estimates are complicated by the presence of a number of intrusive porphyry bodies. The sequence consists generally of alternating tuff-rich units and greywacke-siltstone-rich units, and in the type area may be subdivided into seven sub-units as follows: (1) lower tuff; (2) greywacke and siltstone; (3) felsic tuff; (4) greywacke and siltstone; (5) interbedded tuff, greywacke and siltstone; (6) greywacke and siltstone on Murrays Road; (7) upper pumice-rich tuff and minor lava.

Lower tuff unit

This unit is of the order of 300 m thick and is best exposed on the Hellyer Haulage Road. It also occurs to the north of Hellyer Mine, and on the Murchison Highway south of Que River bridge. Graded, pumice-bearing, quartz-feldspar-phyric crystal-vitric-lithic tuff in beds up to 10 m thick, separated by thin (<0.2 m) intervals of black shale and siltstone, are typical of the sequence, but intervals of up to 10 m thickness of siltstone and greywacke also occur, as well as units up to 20 m thick of bedded crystal-vitric tuff.

The base of the unit in the Haulage Road section is a graded lithic tuff bed, about 8 m thick, with an irregular erosional contact on the underlying Que River Shale. Flame structures of shale penetrate the tuff in places, and clasts of black shale up to 0.5 m long are prominent in the lower 3 m of the bed. Distinctive lime-green pumice clasts are a feature of this and other units, and are strongly elongated parallel to bedding. Many have flame-like ends like fiamme. The pumice clasts show reverse size grading in the lower 2 m of the bed, being up to 0.1 m long near the base of the bed but increasing to 1-2 m in length about 2 m above the base. The pumice clasts contain large quartz and feldspar crystals in a sericitic groundmass and are similar in composition to more equidimensional, angular lithic clasts of cream to pink quartz-feldspar porphyry which also occur in the lower part of the bed. Large quartz and feldspar grains are prominent in the matrix of the tuff. Lithic clasts, pumice clasts and quartz crystals become progressively less prominent in the upper part of the bed, where there is gradation through crystal-vitric tuff to fine-grained, well-bedded vitric tuff and finally to grey-black siltstone.

The presence of an erosional base and ripped-up shale clasts, together with the overall grading of the unit, indicate that the tuff bed was deposited by a bottom-hugging mass-flow, while the abundance of juvenile pumice clasts suggests the flow was initiated by a pyroclastic eruption. Many other mass-flow beds of similar type and composition occur within the unit, indicating that similar eruptive events occurred repeatedly.

Thin sections of typical crystal-vitric tuffs from the unit (P064-P069) show large rounded phenocrysts of embayed quartz (0.2-4 mm diameter) with underlose extinction and 'perlitic' cracks, smaller angular quartz phenocrysts with straight extinction, and sericite-carbonate-altered phenocrysts and glomerocrysts of plagioclase. Also present are pumice clasts, up to 10 mm or more in length, showing flame-like ends and a strong internal sericite fabric which shows compaction effects against external phenocrysts and lithic clasts. Vesicles are preserved in some pumice clasts. The matrix material consists largely of angular, arcuate and Y-shaped shards and small uncompacted to partially compacted pumice clasts. Sericite and carbonate alteration of the matrix is extensive. Large areas of the matrix are replaced by carbonate clots in sample P069.

A bedded crystal-vitric tuff outcropping near the Hellyer core shed [932971] shows pink and green colour banding and resembles the Comstock Tuff. In thin section (P026) it consists of an aggregate of angular quartz grains (to 1.2 mm) and sericite-carbonate-altered feldspars (to 1.2 mm) in a poorly sorted matrix of pumice clasts and shards. The greenish bands appear to be due to the presence of up to 10% chlorite replacing the matrix. Sample P010 from further north-west shows extensive replacement of the matrix by an albite mosaic.

The tuffs and agglomerates of the unit are compositionally similar to the large quartz-feldspar porphyry intrusive bodies which intrude the sequence west of the Murchison Highway. A sample (P212) of crystal-rich tuff occurring within a quartz-feldspar porphyry body near Sock Creek prospect contains about 80% feldspar and quartz crystals, together with clasts of quartz-feldspar porphyry. The large (up to 4 mm) rounded and embayed quartz crystals are apparently identical to the quartz phenocrysts in the surrounding porphyry. The abundant porphyries in this area may indicate a volcanic source area for many of the tuffs.

Sequence above the lower tuff and below the greywacke on Murrays Road

The lower tuff unit on the Hellyer Haulage Road is overlain by a unit dominated by interbedded greywacke and siltstone, of the order of 250 m thick, and thence by a unit dominated by bedded to massive quartz-feldspar-phyric felsic tuffs about 200 m thick. Overyling this is another greywacke-rich unit which crops out some 200 m west of the Hellyer Portal (Komyshan, 1986*a*), and this is followed by a more complex, but rather poorly exposed, sequence of mixed greywacke, siltstone, tuff and mass-flow breccia extending from the Hellyer Portal northwards along the Southwell River gorge on the western side of a large intrusive porphyry body. Outcrops of the latter sequence also occur on the Cradle Mountain Link Road west of the intrusive porphyry body.

The greywacke-siltstone units within this part of the sequence are typically well-bedded (beds 0.1 to 3 m thickness), with abundant graded bedding in the coarser units indicating an origin from turbidity currents. Most beds are of sand to silt grade, with conglomeratic beds (granule to pebble grade) being rare. The greywackes are blue-grey when fresh, weathering to brown or fawn colours. A thin section (P020) of a coarse-grained bed shows poorly-sorted, matrix-supported angular clasts (0.1-2.0 mm) consisting mainly of Precambrian-derived quartzite and micaceous graphitic schist. The fine-grained matrix consists of detrital mica, chlorite, pumpellyite, sericite, and minor quartz, with overprinting carbonate.

In sample P070, the clasts (up to 2.0 mm in length) are subrounded, and composed of graphitic schist-phyllite (10-20%), feldspar-phyric basalt (5-10%), siltstone (50%), volcanic quartz (10%), and feldspar (5%). The subordinate matrix consists of chlorite, sericite and carbonate. In places a stylolitic cleavage is developed parallel to bedding, between the closely packed clasts.

A sample of siltstone (P084) consists of minor detrital quartz (to 0.1 mm) and mica in a matrix of mosaic quartz and sericite. Primary (?) and secondary coarse-grained carbonate constitutes about 40% of the rock.

Greywacke-siltstone unit on Murrays Road

This unit outcrops on Murrays Road and the Cradle Mountain Link Road, its western contact being formed by the intrusive quartz porphyry body. It is of the order of 150-200 m thick, and consists of coarse-grained to conglomeratic greywacke interbedded with siltstone, black shale and minor tuff.

The greywacke beds are up to 2 m thick, and are commonly graded. They weather to brown or purplish-brown colours, the fresh rock being blue-grey. Thin-bedded lithic sandstone units, often cross-bedded, occur in places. Rip-up shale clasts up to 0.1 m long occur in the lower part of some coarser units, together with subrounded to subangular clasts to pebble size (0.1 mm-10 mm). Clasts are predominantly of Precambrian derivation, consisting of quartzite, phyllitic quartzite and quartz-mica schist, with lesser proportions of chlorite-mica schist and graphitic phyllite. Muscovite is a common detrital component, and twinned feldspar, opaques, and minor perovskite also occur. Rare clasts of felsic tuff are also present. Specimen P017 contains rare clasts of trachytic basalt. Finer-grained matrix components are mainly quartz, sericite and chlorite. Siltstones and finer-grained sandstones are similar in composition but with a higher proportion of muscovite and sericite in the matrix.

The greywacke unit has an interfingering relationship with the overlying pumice-rich tuff.

Upper pumice-rich tuff unit

This unit is of the order of 450 m thick, and is exposed along Murrays Road (East) and the Cradle Mountain Link Road, and on logging roads and tracks south-west of Mt Cripps. It consists largely of pumice-bearing quartz-feldspar-phyric crystal-lithic-vitric tuff and breccia, with some vitric tuff, rhyolitic lava, and minor greywacke. The typical tuff or breccia has a characteristic pink and green splotchy coloration due to the presence of clasts of pumice, tuff and lava which are either dark green and chloritic or bright pink due to secondary albitisation. The matrix is typically green and chlorite-rich. The pumice clasts commonly have irregular, fiamme-like shapes, and may form a weak to strong eutaxitic foliation. Clasts range from a few mm to 60 mm in length.

A typical crystal-vitric-lithic tuff (P001) from the sequence consists mainly of rounded quartz phenocrysts (to 3 mm diameter) and plagioclase grains in a matrix of chlorite-sericite-altered pumiceous material, including non-compacted and partially compacted pumice clasts. The feldspars are partially replaced by granular carbonate and prehnite- pumpellyite. Scattered lithic fragments are mainly of vitric-crystal tuff. Sample P005 is a vitric-crystal tuff consisting of sparse, small phenocrysts of quartz in a recrystallised quartz-sericite-rich matrix of small pumice clasts and shards. Sample P006 contains abundant lithic clasts, mainly of vitric-crystal tuff (ignimbrite?), partly affected by prehnite-pumpellyite alteration, and quartz-sericite-altered pumice clasts, in a matrix which has recrystallised to a quartz-feldspar mosaic.

Several tabular bodies, up to 150 m thick, of cream to pale brown coloured felsic lava occur within this unit, the most prominent being at the top of the unit on Murrays East Road. The lava is feldspar-phyric, and shows prominent fine-scale flow banding in many outcrops. Autobrecciation texture also occurs. A thin section (P046) shows medium-grained plagioclase phenocrysts aligned by flow in a quartz-sericite groundmass.

Tyndall Group correlates

A distinctive sequence of purple-weathering volcaniclastic conglomerate, sandstone, siltstone and minor crystal tuff occurs on the western slopes of Mt Cripps and on Murrays Road East and the Cradle Mountain Link Road, and is correlated with the Tyndall Group of the Queenstown area (Corbett, *et. al.*, 1974; Corbett, 1979). The sequence is of the order of 500-600 m thick, and appears to conformably overlie the pumice-rich tuff unit of the Southwell Subgroup. The beds dip moderately to steeply east, and face east, although occasional westerly dips indicate some minor folding.

Much of the sequence consists of graded to non-graded units, 1-30 m thick, of pebble-cobble-boulder conglomerate interbedded with lithic sandstone and minor siltstone. The lower part of the sequence on Murrays East Road consists of poorly exposed reddish-weathering crystal and crystal-lithic tuff and associated tuffaceous sandstones.

Clasts in the conglomerates are generally rounded to well-rounded, and composed predominantly of Cambrian volcanics. Typical clast types are quartz-feldspar porphyry, quartz-feldspar-biotite porphyry, quartz-phyric tuff and agglomerate, fine-grained rhyolitic lava, and less common andesite and basalt. Clasts of Precambrian-derived quartzite and phyllite occur rarely throughout the sequence, and are more common towards the top. Detrital chromite(?) was noted in a sandstone unit beside Mackintosh Road.

A thin section (P105) of a sandstone shows it to be clast-rich and moderately well sorted. Clasts consist largely of flow-textured basalt and andesite, with minor vesicular basalt and felsic tuff. Large feldspar crystals, angular volcanic quartz grains and hematite grains are common. Chlorite replaces much of the matrix, and pseudomorphs some feldspar crystals. Hematite forms rims on, and partially replaces, some of the lithic clasts and feldspar grains. The abundant hematite is responsible for the purple colouration of the sequence.

The sequence is overlain, apparently conformably, by siliciclastic pebble conglomerate, correlated with the Owen Conglomerate, at an exposure on the Cradle Mountain Link Road.

Cambrian intrusive rocks

Two types of felsic intrusive rocks have been mapped within the area: coarse-grained quartz-feldspar porphyries, and finer grained spherulitic quartz porphyries. The former occur predominantly west of the Murchison Highway, and the latter mainly to the east of the highway.

QUARTZ-FELDSPAR PORPHYRY

Two major NNE-trending sub-concordant bodies of quartz-feldspar porphyry intrude the Dundas Group sequence in the Sock Creek area, and are probably part of a single larger composite body extending south into the Bulgobac-Boco area. The bodies occur mainly within the Que River Shale correlates, near the contact with the underlying felsic lava unit, and contain xenoliths of shale.

Several bodies of similar porphyry are exposed in the bed of the Que River, further north, where they intrude mainly into the felsic tuff sequence above the Que River Shale. The westernmost of the latter bodies contains what appear to be mega-xenoliths of greywacke up to 20 m across, while a centrally located body is flow-banded and has an apparently gradational contact with the compositionally similar pumice-rich tuff. A small 2 m wide body further east occurs near the contact of the Que River Shale and overlying tuff and is associated with hornfelsing of the sediments.

The porphyry is characterised by large rounded quartz phenocrysts (to 5 mm diameter) and large feldspar laths (up to 4 mm length). In thin section (P073) the quartz phenocrysts are typically scalloped and embayed, occurring as single crystals and as glomerocrysts. The variably twinned and zoned feldspar phenocrysts and glomerocrysts are partially to completely altered to chlorite and sericite. The fine-grained groundmass (<0.1 mm) consists of quartz, feldspar, sericite and chlorite, with minor apatite and zircon.

A small body of quartz-feldspar porphyry crops out on the South Charter track near the position of the Mt Charter Fault, and another similar body has been intersected on the fault in drill hole MCH-2A (fig. 7). A thin section of the latter body (57361) shows numerous embayed quartz phenocrysts (to 2 mm), and less abundant altered feldspar phenocrysts, in a pink, very fine-grained, carbonate-altered quartzo-feldspathic groundmass containing small blebs of mosaic quartz. The rock is fractured, quartz-veined and cleaved, and shows disseminated pyrite mineralisation. It is geochemically similar to the other quartz-feldspar porphyry intrusives.

SPHERULITIC QUARTZ PORPHYRY

This type occurs as abundant small dykes and as larger sub-concordant bodies which appear to be concentrated in the general vicinity of the Que River and Hellyer mines and near the Henty Fault. The larger bodies are up to 500 m wide and form prominent ridges and hills, while the smaller bodies commonly form waterfalls where they intersect creeks. The porphyry is fine-grained and pale pink to orange-coloured when fresh, the larger bodies tending to weather to a pale cream colour. Weathered surfaces commonly show a sugary texture due to the abundant small spherulites, and small quartz phenocrysts are also usually apparent. Flow-banding, generally parallel to the intrusive contacts, is common, and well-developed columnar jointing perpendicular to contacts is present in some bodies.

A number of the larger porphyry bodies appear to have preferentially intruded along sedimentary units (shale and/or greywacke), and may locally appear to be concordant 'flows'. However, cross-cutting contacts indicating an intrusive origin have been found for most bodies.

A typical porphyry body intrudes and partly hornfelses the Que River Shale on the Hellyer Haulage Road. The contacts are faulted in places, and slightly discordant to bedding in the shale. A thin section (P061) of the shale-porphyry contact shows an irregular contact, with flame-like projections of porphyry into siltstone. A narrow (<2 mm) chilled margin is evident to the porphyry, which has a concentration of pyrite grains within the basal 20 mm. The upper part of this body is columnar jointed. The body intrudes the Que River Shale for about 2 km of strike length, then cross-cuts the stratigraphy to intrude the lower part of the Southwell Subgroup.

Thin sections (P029, P048, P060) from several of the larger quartz porphyry bodies show scalloped and embayed quartz phenocrysts (0.1-2.5 mm diameter), minor feldspar phenocrysts pseudomorphed by sericite, and pyrite (<2%). Quartz phenocrysts tend to be less prominent (<0.1 mm diameter) in the smaller dykes. The groundmass, consisting of quartz, sericite, chlorite and minor carbonate, shows well-developed spherulitic or snowflake texture. In sample (P083) spherulites up to 0.5 mm diameter are evenly developed throughout the groundmass, and quartz phenocrysts have spherulitic rims.

Alteration of the porphyries varies from extensive sericitisation to carbonate-sericite alteration. The sericite forms a prominent cleavage fabric often cross-cut by darker brown to grey seams of stylolitic cleavage.

A sample of flow-banded quartz porphyry (P059) is atypical in containing elongate, ovate, strongly aligned vesicle to vein-like features which average 0.4 mm in width and 0.8 to 5.0 mm in length. These unusual 'vesicles' are filled with quartz of undulose extinction, and in places appear to be partially embayed.

A number of quartz porphyry bodies occur within or adjacent to the Henty Fault Zone. In sample (P170) many of the quartz phenocrysts are extensively brecciated and rimmed by quartz-sericite overgrowths. The crystal fragments retain the extinction of the original crystal, and are annealed by a matrix of quartz and sericite. In the Sharks Fin area, a similar sheared quartz porphyry is extensively veined and altered by hematite, magnetite and minor pyrite.

MINERALISATION AND ALTERATION IN THE QUE-HELLYER VOLCANICS

Mineralisation

The Que-Hellyer Volcanics are host to the massive sulphide orebodies at Que River and Hellyer mines. The multiple sulphide lenses at Que River, the single massive sulphide lens at Hellyer, and the barite-pyrite body at Mt Charter, all occur within the 'mixed sequence' as defined herein.

The Que River mineralisation, discovered in 1974, has been described by Webster and Skey (1979), Young (1980), Collins *et. al.* (1981), Wallace and Green (1982), and Wallace (1984, 1989), and is summarised below. The mineralisation consists of 5 sub-parallel, N-S striking lenses with sub-vertical dip, and extends over an indicated strike length of about 700 metres. Although the lenses were initially interpreted as forming a simple west-facing sequence (e.g. Webster and Skey, 1979), the presence of a tight syncline within the mine area, causing repetition of some lenses, was suggested by Young (1980) and has been confirmed by the present mapping (see cross-section, fig. 3) and by detailed underground studies (McGoldrick and Large, 1986; Wallace, 1989).

Two major types of mineralisation occur at Que River – the copper-rich S lens, and the lead-zinc-rich PQ and P North lenses. S lens occurs 120 m east of PQ lens, and consists of pyrite with accessory chalcopyrite, sphalerite, galena and trace tetrahedrite. This lens actually outcrops at surface, where it overlies a fractured felsic lava body carrying disseminations, aggregates, veins and stringers of pyrite and base metal sulphides. PQ lens, the largest of the two economic Pb-Zn lenses, is 600 m long, 150 m deep and 9 m wide, plunging 15°N. In cross-section it ranges from a typical ellipse to a W- or Y-shaped body. PQ and P North lenses consist of massive to partly bedded sphalerite, galena and pyrite, with minor amounts of chalcopyrite and silver-bearing tetrahedrite. Gold and arsenic occur in trace amounts. Gangue minerals are mainly sericite, carbonate, quartz and minor barite. The sulphide lens is underlain by a wide zone of pyrite-chalcopyrite stringer-vein mineralisation which also contains minor sphalerite, galena and barite. This stringer mineralisation, accompanied by extensive sericite-chlorite alteration, occurs to the west and east of PQ lens.

Production at Que River mine to the end of 1986 has been 0.8 million tonnes of ore at a grade of 14.9% Zn, 8.3% Pb, 0.4% Cu, 223 g/t Ag and 3.9 g/t Au (Wallace, in Corbett and Solomon, 1989).

The Hellyer massive sulphide body was discovered in 1983, following drilling of a UTEM geophysical anomaly (Sise and Jack, 1984; Skey, 1984). The body is entirely sub-surface (fig. 3) and contains at least 15 million tonnes at 13% Zn, 7% Pb, 0.4% Cu, 160 g/t Ag and 2.3 g/t Au (McArthur, 1986). The body has a N-S strike length of over 750 m, is 200 m wide, and 75 m deep. It lies in the axial plane of a broad anticline plunging 20-30° to the NNE, and is cut by, and partly displaced on, the vertical Jack Fault (McArthur, *op. cit.*). A well-developed stringer zone beneath the orebody lies adjacent to the Jack Fault, which appears to have provided plumbing for the hydrothermal system. The orebody rests on the feldspar-phyric footwall andesite, and is overlain by a unit of epiclastic breccia, with minor vitric ash and shale, which thins out over the thickest part of the sulphide lens. Above this is some 220 m of basalt, including pillowed and pillow-brecciated flows, followed by the Que River Shale.

At Mt Charter, a banded barite-pyrite body, approximately 50 m thick, directly overlies the felsic lava mass. Veins of barite and minor pyrite extend as stringers into the underlying lava, and along strike from the barite body. Although it is not clear whether the banding is primary or secondary, the barite-rich body is considered to be syngenetic.

Fillet grind assays of core through a complete section of the Que-Hellyer Volcanics in drill hole MCH-1 are given in Appendix B. These give an indication of background levels of Cu, Pb, Zn, Ag, Au, As, Ba and other elements for this sequence.

Alteration

The Que-Hellyer sequence has undergone regional prehnite-pumpellyite facies metamorphism, probably in the Devonian. These minerals, with rare actinolite, are observed in the andesitic-basaltic rocks away from the areas of significant Cambrian hydrothermal alteration.

Hydrothermal alteration associated with the massive sulphide mineralisation at Que River and Hellyer is quite extensive, particularly in rocks of the mixed sequence. The various styles, mineralogies and chemical features of the alteration at Que River have been described by Young (1980), Whitford and Wallace (1984), Wallace (1984), Whitford (1984) and Offler and Whitford (1986), and a brief account of the Hellyer footwall alteration zone is given by McArthur (1986, 1989). A full assessment of the alteration is beyond the scope of this report, and only a brief account of field observations is presented.

The most prominent alteration products are sericite, fuchsite, carbonate, silica and to a lesser extent chlorite and minor albite. The footwall rocks of the Hellyer and Que River massive sulphide deposits are pervasively sericitised and pyritie-mineralised. Quartz vein stringers are associated with this alteration, particularly at Hellyer. Within this alteration zone, original textures are difficult to recognise in hand specimen. In thin section the altered rocks consist of a felted mass of sericite within a mosaic quartz matrix. The sericite is typically illite, hydromuscovite and chrome muscovite (Young, 1980).

The western limb of the syncline between Hellyer and Que River, and the western limb of the anticline immediately west of Que River and the Mt Charter area, are also extensively sericitised. Away from these areas, alteration is less obvious in the field. However, in thin sections, rocks from the mixed sequence show extensive carbonate-sericite degradation of original phenocrysts and matrix. Fuchsite-carbonate alteration within basaltic lavas, breccias and epiclastics is common, the abundance of fuchsite (Cr-rich sericite) probably reflecting the Cr-rich nature of the host rocks. Although chlorite alteration is less prominent, chlorite does occur as an accessory with sericite and carbonate within basaltic and andesitic volcanics.

Sericite-fuchsite and carbonate alteration also persists into the hanging-wall pillow lavas above the Hellyer massive sulphide, indicating that hydrothermal activity continued well after mineral deposition had ceased, probably by percolation through inter-pillow areas (McArthur, 1986).

POST-CAMBRIAN ROCKS

Owen Conglomerate (Late Cambrian-Early Ordovician)

Siliciclastic conglomerate and sandstone correlated with the Owen Conglomerate (Denison Group) occurs in the Mt Cripps area and at the Sharks Fin. The sequence has not been examined in detail, and correlation of individual units with sequences elsewhere has not been attempted.

In the Mt Cripps area, the sequence dips moderately to steeply east, and has an apparently conformable contact with the underlying volcaniclastic conglomerate. The sequence in this area consists mostly of pink pebble to pebble-cobble conglomerate with some interbedded sandstone and minor units with boulder-grade clasts.

The sequence also dips generally east in the Sharks Fin area, where it rests with probable unconformity on intrusive quartz porphyry. A small inlier of highly sheared siliciclastic conglomerate occurs within the Henty Fault Zone 2 km due east of the Que River mine.

Gordon Group Limestone and Siluro-Devonian Eldon Group

Ordovician limestone of the Gordon Group is exposed at the southern end of Mackintosh Road, south of Mt Cripps, in an area of rugged topography and dense rainforest. The limestone is also exposed around the northern shores of Lake Mackintosh (Barton, *et. al*, 1966), but was not examined in detail.

Grey to fawn-weathering sandstone and siltstone of the Siluro-Devonian Eldon Group sequence conformably overlies the limestone in the cores of broad synclinal folds south of the Mt Cripps Fault. These rocks include fossiliferous beds and friable, weathered horizons, but have not been mapped in detail.

Devonian(?) dolerite intrusions

Several intrusive bodies of massive grey dolerite have been mapped around the outcrop margins of the Que-Hellyer Volcanics, either within the Que River Shale or slightly above this level. The largest body lies one kilometre west of Mt Charter, and appears from surface mapping and geophysical surveys (A. M. Hespe, pers. comm.) to be a tabular sill-like body in the central part of the Que River Shale. The sub-surface form of the other smaller bodies, which occur to the west and east of Hellyer mine, is not known.

The dolerite weathers to form a distinctive brown, clay-rich soil in which rounded boulders of fresh rock are dispersed. The rock has been described as resembling the Jurassic dolerite seen elsewhere in the State (Barton, *et. al*, 1966; Collins, *et. al*, 1981). However, an age of 396 ± 10 Ma has been obtained (K-Ar on pyroxene) from Amdel by Aberfoyle geologists (A. M. Hespe, pers. comm.), indicating that the rock is either Devonian or older.

Collins (in Collins *et. al.*, 1981) describes a sample from near Mt Charter as being medium-grained, with sub-ophitic texture of plagioclase and pyroxene in a groundmass of chlorite, actinolite, sphene, K-feldspar, quartz and opaques. A sample (P011) from 1.5 km west of Hellyer mine is a medium-grained rock composed dominantly of altered plagioclase laths, subhedral clinopyroxene grains (about 15%), and pools of green chlorite. The texture is intergranular to intersertal, with the pyroxene grains (probably augite) ranging in size from <0.1 mm to small phenocrysts and glomerocrysts up to 1.0 mm. The plagioclase has been extensively altered to sericite, with minor carbonate and chlorite, such that crystal boundaries have been obscured over much of the slide. Chlorite occurs as irregular pools up to 0.3 mm across, commonly associated with fibrous actinolite, irregular carbonate grains, and blebs of epidote. Minor opaque oxide is also present. The degree of alteration is similar to that seen in many Cambrian mafic intrusives, and is clearly greater than that exhibited by the Jurassic dolerites.

The geochemistry of the dolerites is discussed in a later section, where it is shown that one of the mapped dolerite bodies (2.75 km WNW of Hellyer) is most probably a Tertiary basalt.

Tertiary basalt

Extensive flows of Tertiary basalt blanket low hills and plateau-like areas to the north and northwest of Hellyer mine, west of the Murchison Highway, and east of Mt Cripps. The base of the basalt sequence lies at an altitude of 650-700 m in most areas. The basalt typically exhibits large-scale columnar jointing in road cutting exposures. A chemical analysis of a Tertiary basalt (originally collected as a Devonian(?) dolerite) is discussed in Section 5.

Quaternary deposits

Several small patches of poorly sorted diamictite, considered to represent Pleistocene till, occur on the Haulage Road just northeast of Que River mine. They contain clasts of Precambrian quartzite, Devonian granite and Cambrian volcanics, suggesting a probable source in the Granite Tor area. House-size erratics of Owen Conglomerate occurring in the upper part of the Southwell River are also considered to be of glacial origin. Large boulders of Devonian(?) granite occurring near the road junction 1.5 km south-west of Mt Cripps [CP965946] must also be of glacial derivation, and suggest a considerable thickness of ice in the Southwell valley. A large area of fluvioglacial (and glacial?) deposits, including clays, sands and gravels (to boulder grade), occupies the lower reaches of the Southwell Valley.

GEOCHEMISTRY

Introduction

Analyses of major and trace elements of 44 rocks from the Hellyer-Mt Charter area are given in Table 1, together with average values for the particular groups and some trace element ratios. The major element values shown have been recalculated volatile-free to 100% from the original analyses. Original values, sample locations, and notes are given in Appendix A, and the sample locations are plotted on Figure 2. The following discussion refers to the recalculated values only.

Thirty-five of the analysed rocks are from the Que-Hellyer Volcanics, comprising one andesite-basalt from the lower tuff and lava unit, nine rocks from the lower andesites and basalts, four andesites-basalts from the mixed sequence, twelve dacites from the mixed sequence, seven rocks from the upper basalts and andesites, and two felsic lavas from the Sock Creek area. Also included are five felsic intrusives from the Dundas Group, three Devonian(?) dolerites, and one basaltic rock originally mapped as Devonian(?) dolerite but which is almost certainly a Tertiary basalt.

Most of the rocks sampled, particularly those from the Que-Hellyer Volcanics, are somewhat altered, as evident by the moderate to high ignition loss values (mostly between 2% and 10%), and variable alkali values. Many of the rocks sampled from the mixed sequence have been affected to some extent by the hydrothermal alteration associated with the massive sulphide mineralisation, and some were analysed to assist in determining their original nature, e.g. whether andesite or dacite.

Considerable reliance has been placed on trace element values and ratios in classifying some of the rocks, particularly using the relatively immobile elements such as Ti, Zr, Nb, Y, and Cr. A discrimination plot using Ti and Zr is given in Figure 9 (after Pearce and Cann, 1973), Figure 10 is a plot of SiO_2 *vs* K_2O, and Figure 11 is a plot of Zr/TiO_2 *vs* Nb/Y (after Winchester and Floyd, 1977).

Geochemical features of the Que-Hellyer Volcanics

GENERAL FEATURES

The Ti-Zr plot (fig. 9) shows all of the Que-Hellyer Volcanics samples plotting either within the calc-alkaline basalt field of Pearce and Cann (1973), or just below this field in the case of the felsic rocks. The suite defines a strong sub-horizontal trend of increasing Zr with relatively constant Ti, typical of calc-alkaline rocks, with no indication of a tholeiitic trend. Whitford *et. al.* (1983) and Whitford and Wallace (1984) used similar evidence to conclude that the suite is of calc-alkaline type.

It is notable that the bulk of the andesite-basalt samples plot in the lower part of the calc-alkaline basalt field, reflecting the generally low Ti content of the Que-Hellyer rocks in comparison to calc-alkaline suites elsewhere. Average TiO_2 values for calc-alkaline andesites (56-63% SiO_2) quoted by Ewart (1982) range from 0.73 to 1.03%, for basaltic andesites (52-56%) 0.83 to 1.31% and for basalts (<52% SiO_2) 0.85 to 1.97%. By comparison, average values for Que-Hellyer andesites (15 samples) are 0.61%, for basaltic andesites (3 samples) 0.69%, and for basalts (one sample) 0.59%.

'Misfit' samples indicated by the plot are P218, an 'andesite' from the upper basalts and andesites which appears to be a dacite; P202, a dacite plotting with the andesite-basalt group; and the two Sock Creek felsic lavas (P186, P209), which are notably higher in Ti than the other dacites.

The K_2O-SiO_2 plot (fig. 10) shows a considerable spread of K_2O values for each of the SiO_2 groups. The majority of

Table 1

WHOLE-ROCK CHEMICAL ANALYSES OF 44 ROCKS FROM THE HELLYER–MT CHARTER AREA

	QUE–HELLYER VOLCANICS															
	LOWER TUFF	**LOWER ANDESITES AND BASALTS**										MIXED SEQUENCE ANDESITES				
	A317	MC1/D	MC2A/B	P193	MC2A/A	P135	P160	P149	P150	P166	Average values	P102	P196	P101	P194	Average values
SiO_2	62.73	55.06	55.44	55.96	58.93	59.18	59.69	60.58	62.84	65.31	59.22	56.57	57.97	58.57	58.62	57.93
TiO_2	1.05	1.04	0.53	0.50	0.51	0.53	0.46	0.55	0.55	0.24	0.55	0.68	0.71	0.62	0.69	0.68
Al_2O_3	15.85	16.58	14.67	16.20	13.68	15.48	16.34	15.28	13.53	11.76	14.84	17.60	18.22	16.38	16.24	17.11
Fe_2O_3	1.00	10.27*	1.45	2.57	7.68*	1.89	2.37	1.43	0.98	1.44	1.73	2.14	1.01	1.71	1.57	1.61
FeO	7.16	-	6.84	5.68	-	5.78	5.00	6.00	3.92	4.06	5.33	7.98	6.58	6.93	5.80	6.82
MnO	0.18	0.24	0.37	0.34	0.27	0.16	0.16	0.26	0.16	0.15	0.23	0.16	0.14	0.29	0.16	0.19
MgO	2.26	4.71	8.42	4.88	6.69	4.10	5.59	4.38	4.04	5.47	5.36	3.16	2.99	3.31	5.71	3.79
CaO	5.45	6.47	7.22	9.50	7.35	9.12	6.66	6.50	6.96	7.09	7.43	6.70	7.09	7.79	8.22	7.45
Na_2O	2.60	3.57	2.73	3.68	3.57	2.28	2.13	3.23	2.97	3.80	3.11	1.64	1.45	0.62	1.86	1.39
K_2O	1.47	1.70	2.09	0.39	1.08	1.31	1.32	1.52	3.63	0.59	1.51	2.79	3.25	3.24	0.92	2.55
P_2O_5	0.25	0.38	0.24	0.30	0.24	0.17	0.28	0.27	0.42	0.09	0.27	0.58	0.59	0.54	0.21	0.48
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	-
LOI	2.95	2.52	3.77	3.72	6.11	3.44	3.55	2.60	2.27	1.91	-	10.32	10.83	11.77	3.01	-
Ba	910	-	1350	690	-	510	1100	910	1600	330	927	940	930	860	660	848
Rb	56	44	43	28	25	58	46	67	130	32	53	100	115	125	52	98
Sr	320	562	310	580	347	400	560	650	380	200	443	120	135	85	660	250
Y	29	29	29	67	25	19	17	17	16	7	25	25	22	25	18	23
Nb	10	12	13	6	12	5	5	6	6	<3	7	10	9	8	8	9
Zr	145	142	165	125	146	105	120	135	140	45	125	180	185	160	130	164
Co	17	-	28	32	-	22	25	24	17	23	24	27	14	14	24	20
Ni	5	-	130	115	-	32	49	52	35	99	73	14	10	14	45	21
Cr	90	-	600	560	-	280	220	210	210	520	371	23	29	26	320	100
V	210	-	180	250	-	240	230	250	195	210	208	290	290	250	260	273
Sc	28	-	27	34	-	27	25	28	32	27	29	24	25	20	28	24
Cu	49	61	82	66	11	62	57	180	48	82	72	17	67	11	57	38
Pb	8	52	13	530	209	11	7	11	18	19	97	5	12	5	35	14
Zn	110	*230	110	500	59	79	97	300	84	54	168	63	89	31	110	73
Ti/Zr	43	44	19	19	24	21	30	23	24	32	26	23	23	23	32	25
Cr/Y	3	-	21	8	-	15	13	12	13	74	22	1	1	1	18	5
Co/Ni	3.4	-	0.2	0.3	-	0.7	0.5	0.5	0.5	0.2	0.4	2.0	1.4	1.0	0.5	1.0

* Total Fe expressed as Fe_2O_3.
Major element values have been re-calculated volatile-free. Analyses MC1/D and MC2A/A kindly supplied by A. J. Stolz (University of Tasmania, Geology Department), all others by Department of Mines, Launceston Laboratories.

Table 1 (continued)
WHOLE-ROCK CHEMICAL ANALYSES OF 44 ROCKS FROM THE HELLYER–MT CHARTER AREA

	QUE–HELLYER VOLCANICS																						
	MIXED SEQUENCE DACITES													UPPER BASALTS AND ANDESITES								SOCK CREEK	
	MC2A/C	P200	MC1/C	P088	P202	P191	P192	P220	P199	P211	P198	P222	Average values	MC1/B	MR437	P116	P177	P218	P097	P115	Average values	P186	P209
SiO_2	68.35	70.90	71.11	72.18	72.09	73.43	73.76	75.27	76.55	77.51	78.61	80.38	74.18	48.07	56.41	59.87	58.55	60.84	61.87	64.97	58.65	72.65	74.51
TiO_2	0.38	0.32	0.39	0.27	0.62	0.28	0.26	0.41	0.26	0.29	0.31	0.28	0.34	0.59	0.56	0.75	0.50	0.36	0.63	0.32	0.53	0.61	0.62
Al_2O_3	16.23	16.17	14.94	13.98	20.82	14.80	14.45	16.14	13.52	15.90	15.00	13.99	15.50	17.96	12.99	17.23	14.46	19.07	16.71	14.43	16.12	15.62	14.32
Fe_2O_3	1.25	0.98	4.76*	3.07	0.30	2.10	2.01	2.32	0.66	1.41	0.86	0.87	1.44	11.28*	0.81	2.58	1.08	1.44	10.99	1.13	3.01	1.43	0.18
FeO	4.07	2.45	-	2.93	0.37	0.79	1.86	1.17	1.09	0.37	0.43	0.67	1.47	-	8.25	4.34	5.35	7.07	3.43	8.63	6.18	0.96	1.34
MnO	0.12	0.11	0.09	0.39	0.01	0.04	0.05	0.13	0.10	0.01	0.01	0.01	0.09	0.28	0.20	0.07	0.76	0.22	0.04	0.49	0.29	0.04	0.04
MgO	1.52	1.24	0.94	0.80	0.19	0.05	0.31	0.40	0.41	0.15	0.03	0.03	0.51	8.96	8.29	5.08	6.07	3.64	3.02	6.73	5.97	0.55	0.27
CaO	0.69	2.99	0.68	2.51	0.02	0.35	0.24	0.14	2.74	0.04	0.08	0.03	0.88	8.12	8.05	6.23	6.63	0.56	0.15	0.37	4.30	0.19	0.31
Na_2O	4.83	1.18	5.10	1.41	0.41	5.35	2.57	0.52	1.90	0.19	1.30	0.34	2.09	2.80	2.84	0.53	4.12	5.24	0.49	2.43	2.64	6.00	7.34
K_2O	2.49	3.57	2.20	2.37	5.14	2.74	4.45	3.37	2.73	4.10	3.30	3.37	3.32	1.39	1.24	2.91	2.35	1.45	2.49	0.43	1.75	1.84	0.94
P_2O_5	0.07	0.09	0.08	0.09	0.03	0.07	0.04	0.13	0.08	0.03	0.07	0.03	0.07	0.55	0.36	0.41	0.13	0.11	0.18	0.07	0.26	0.11	0.13
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
LOI	1.71	5.63	2.04	5.27	3.28	1.64	2.35	3.82	4.64	2.86	2.63	2.97	-	3.59	4.16	9.71	3.60	4.26	7.65	5.73	-	2.16	0.89
Ba	1300	730	-	550	630	1800	2300	1650	500	420	670	640	1017	-	1130	670	1550	1050	6900	260	1927	880	250
Rb	92	150	72	82	125	81	135	140	99	145	115	115	113	33	32	93	85	73	93	32	63	65	105
Sr	200	26	187	53	66	260	210	42	135	11	39	32	105	768	610	120	280	240	34	98	307	145	7
Y	30	19	36	25	21	28	26	28	17	21	26	23	25	29	17	23	54	16	31	16	27	32	30
Nb	15	8	14	8	9	7	6	7	8	9	8	11	9	10	6	11	5	7	9	4	7	10	12
Zr	230	140	223	140	170	165	175	135	150	160	170	185	162	137	150	160	95	200	170	85	142	750	135
Co	7	5	-	8	11	8	7	11	6	<4	<4	7	7	-	36	34	23	9	33	35	28	7	4
Ni	14	5	-	5	<3	4	<3	11	4	3	3	6	5	-	85	45	55	24	150	125	81	<3	3
Cr	64	125	-	46	74	82	47	110	82	39	42	82	72	-	430	420	410	31	770	680	457	40	62
V	19	260	-	20	30	31	28	66	26	39	31	23	52	-	310	280	230	91	280	195	231	41	6
Sc	<10	35	-	14	11	15	14	17	11	12	12	<10	13	-	32	39	33	15	40	28	31	15	<10
Cu	10	12	6	11	10	9	20	8	9	12	8	10	10	85	110	39	8	8	99	68	60	7	10
Pb	<4	26	4	6	9	8	9	5	7	7	8	12	9	5	7	32	8	<4	11	9	11	5	6
Zn	33	11	46	28	26	37	150	37	17	16	26	26	38	84	75	92	760	74	140	160	198	59	11
Ti/Zr	10	14	10	12	22	9	9	18	10	11	11	9	13	26	22	28	32	11	22	23	22	5	28
Cr/Y	2	7	-	2	3	3	2	4	5	2	2	4	3	-	25	18	8	2	25	43	20	1	2
Co/Ni	0.5	1.0	-	1.6	-	2.0	-	1.0	1.5	-	-	1.2	1.3	-	0.4	0.07	0.4	0.4	0.2	0.3	0.4	-	1.3

* Total Fe expressed as Fe_2O_3.
Major element values have been re-calculated volatile-free. Analyses MC1/C and MC1/B kindly supplied by A. J. Stolz (University of Tasmania, Geology Department), all others by Department of Mines, Launceston Laboratories.

Table 1 (continued)
WHOLE-ROCK CHEMICAL ANALYSES OF 44 ROCKS FROM THE HELLYER–MT CHARTER AREA

	FELSIC INTRUSIVES					DEVONIAN(?) DOLERITES				TERTIARY BASALT
	P221	MR435	P201	P210	MC2A/D	P021	P011	P216	Average values	P219
SiO_2	73.83	78.36	82.59	75.14	75.29	52.83	52.92	53.35	53.06	50.41
TiO_2	0.17	0.12	0.12	0.26	0.24	0.36	0.62	0.50	0.49	1.54
Al_2O_3	15.71	12.21	13.48	13.57	12.85	16.15	14.69	13.96	14.93	14.65
Fe_2O_3	4.02	0.52	0.34	0.85	0.86	1.17	1.03	0.76	0.98	3.10
FeO	1.02	1.01	0.51	1.80	1.54	6.49	7.46	7.29	7.08	8.87
MnO	0.01	0.06	0.01	0.06	0.07	0.15	0.16	0.16	0.16	0.20
MgO	0.24	0.49	0.40	0.33	1.70	8.06	10.48	10.99	9.84	8.09
CaO	0.02	3.04	0.03	0.14	3.16	12.44	8.23	10.48	10.38	8.90
Na_2O	0.04	1.60	0.11	4.18	0.23	1.72	2.65	1.35	1.91	3.36
K_2O	4.92	2.56	2.39	3.63	3.89	0.52	1.62	0.98	1.04	0.62
P_2O_5	0.02	0.03	0.02	0.04	0.17	0.11	0.14	0.18	0.14	0.26
Total	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	-	100.00
LOI	2.23	4.44	3.28	1.24	4.95	0.19	3.29	2.81	-	1.09
Ba	730	360	590	1650	670	165	800	390	452	340
Rb	175	79	34	89	155	48	61	59	56	37
Sr	7	72	170	130	28	125	370	270	255	320
Y	39	34	34	23	27	10	16	12	13	17
Nb	15	10	10	7	12	<3	8	4	5	11
Zr	290	120	720	175	180	58	94	82	78	115
Co	4	8	5	5	<4	42	37	36	38	49
Ni	9	7	<3	<3	7	105	165	140	137	190
Cr	70	140	79	110	69	155	790	820	588	390
V	6	11	33	26	10	280	250	230	253	195
Sc	<10	<10	14	<10	<10	40	34	30	35	23
Cu	13	24	12	9	11	47	57	21	42	48
Pb	7	120	7	9	5	4	6	10	7	<4
Zn	74	290	120	35	17	62	77	75	71	110
Ti/Zr	4	6	1	9	8	37	40	37	38	80
Cr/Y	2	4	2	5	3	16	49	68	44	23
Co/Ni	0.4	1.1	-	-	-	0.4	0.2	0.3	0.3	0.3

Major element values have been re-calculated volatile-free. Analyses by Department of Mines Launceston Laboratories. See Appendix A for original analyses and locality notes.

rocks, however, are in either the medium-K or the high-K categories as defined by Ewart (1982). The spread of K_2O values is considered to be at least partly due to hydrothermal alteration effects.

Recalculated SiO_2 values for the Que-Hellyer rocks range from 48% to 80%, and the samples appear to form two fairly distinct groups: a lower-SiO_2 group in the 48-63% range (with two samples at 65%), and a higher SiO_2-group in the 71-80% range (with one at 68%). The presence of this apparent SiO_2 gap in the 63-71% SiO_2 range confirms the field impression that the Que-Hellyer Volcanics are bimodal in character, a feature previously noted by Komyshan (1986*b*).

An unexpected feature of the chemical data is the paucity of rocks with less than 53% SiO_2 in the Que-Hellyer sequence. Only one sample (MC1/B), from the upper basalt in drill hole MCH-1, is a true basalt in this sense. Samples from the thick lower basalt in the Mt Charter drill holes (MC1/D, MC2A/B, MC2A/A) have 55% to 59% SiO_2, and samples of the 'Hellyer basalt' above the Hellyer ore body (MR437, P116, P095, P117) have 56% to 65% SiO_2. These relatively high silica values in rocks which petrographically resemble basalts and are otherwise similar to the low-SiO_2 sample, strongly suggest that the rocks have had silica added during alteration and/or metamorphism. Evidence for such secondary silicification is widespread in the form of veinlets and vesicle fillings of quartz.

The Zr/TiO_2-Nb/Y plot (fig. 11) was devised by Winchester and Floyd (1977) for use with altered or metamorphosed rocks. The compositional fields have been defined using fresh volcanic suites, and some overlap of field boundaries is to be expected. The Zr/TiO_2 ratio represents a differentiation index, and the Nb/Y ratio an alkalinity index. The latter is

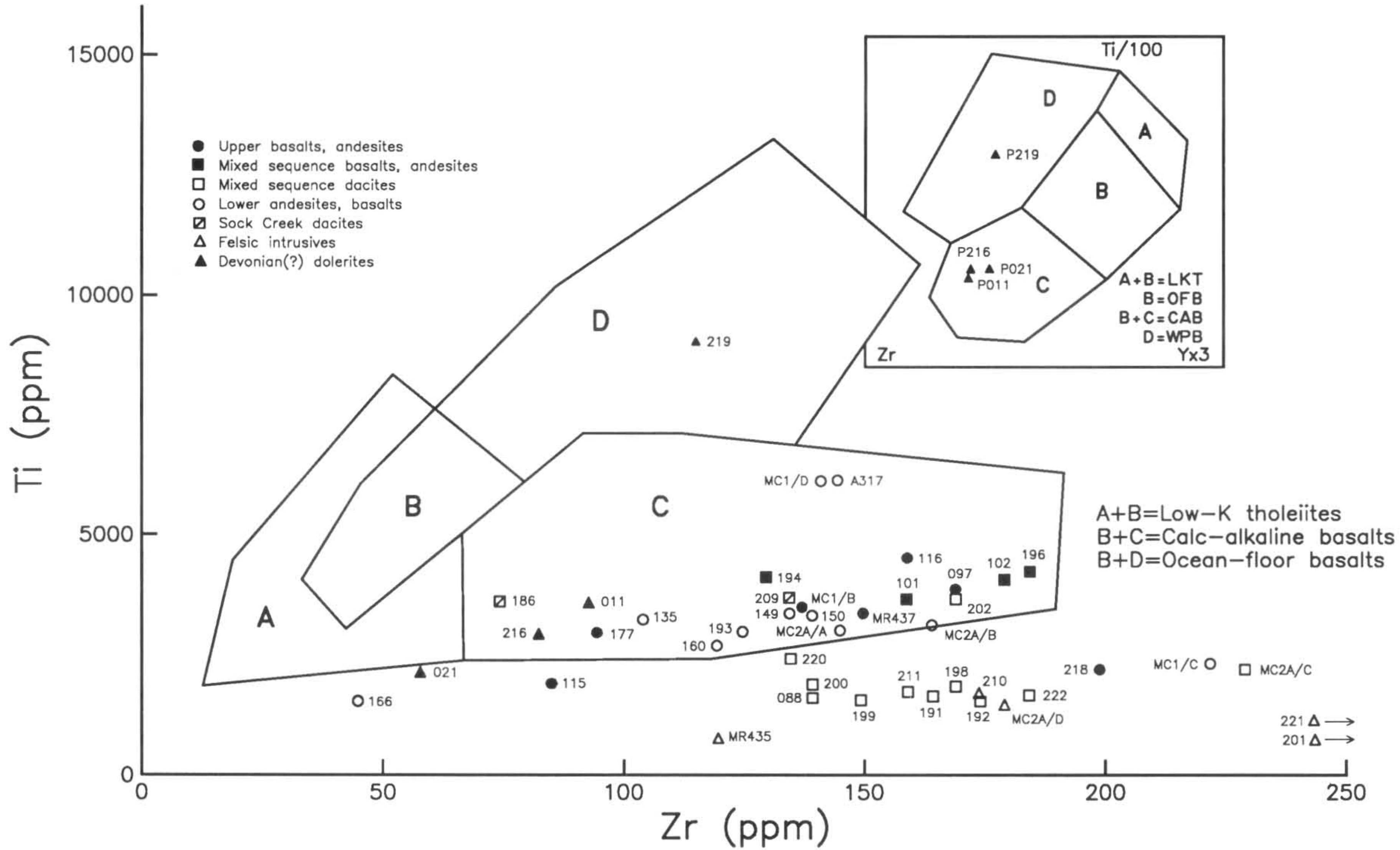


Figure 9. Plot of Ti *vs* Zr for all analysed samples, and part of Ti/100–Zr–Y× 3 triangular diagram for Devonian(?) dolerite samples. Fields after Pearce and Cann (1973). Note that the prefix 'P' has been omitted from most sample numbers.

5 cm

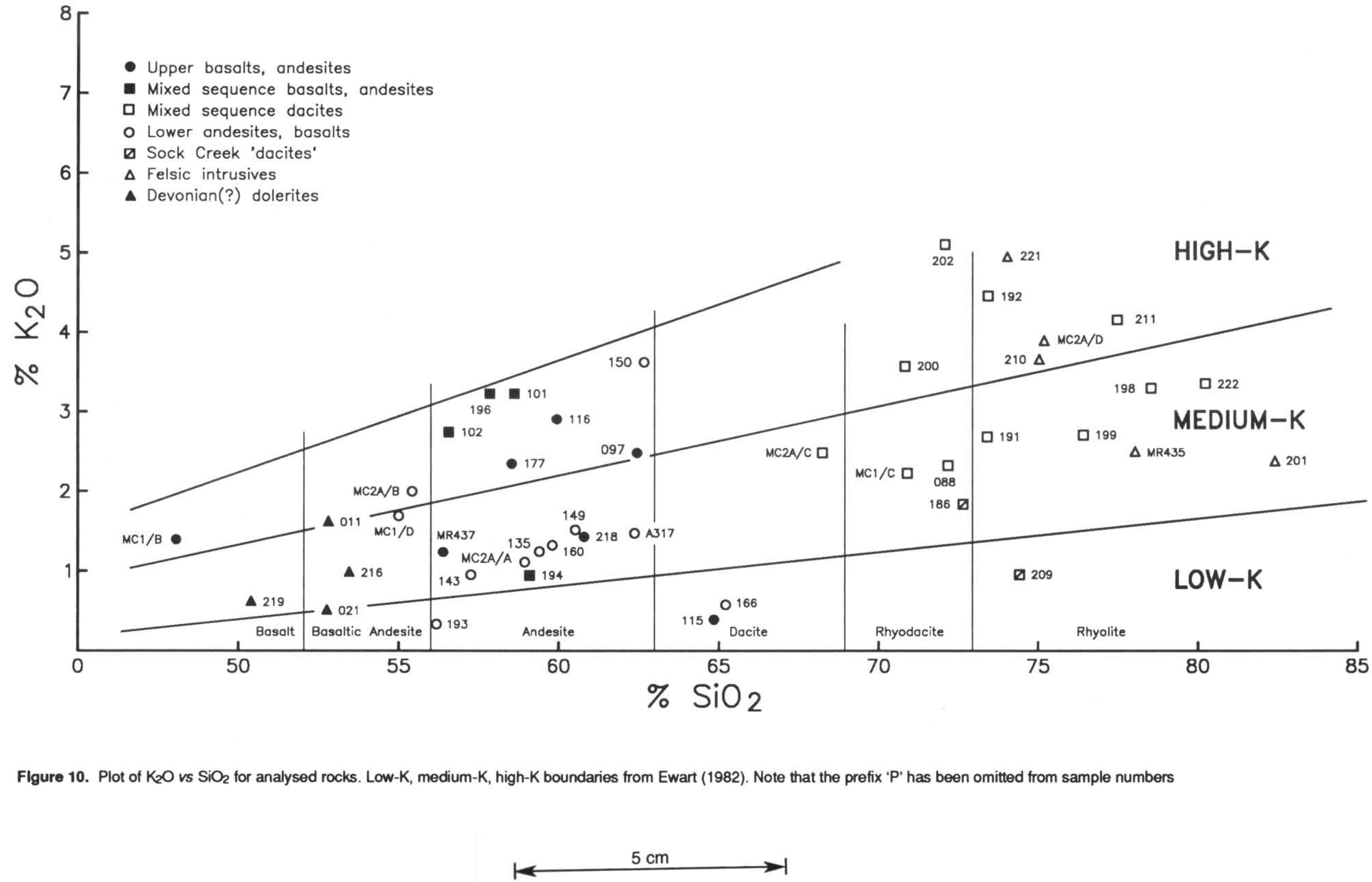


Figure 10. Plot of K_2O *vs* SiO_2 for analysed rocks. Low-K, medium-K, high-K boundaries from Ewart (1982). Note that the prefix 'P' has been omitted from sample numbers

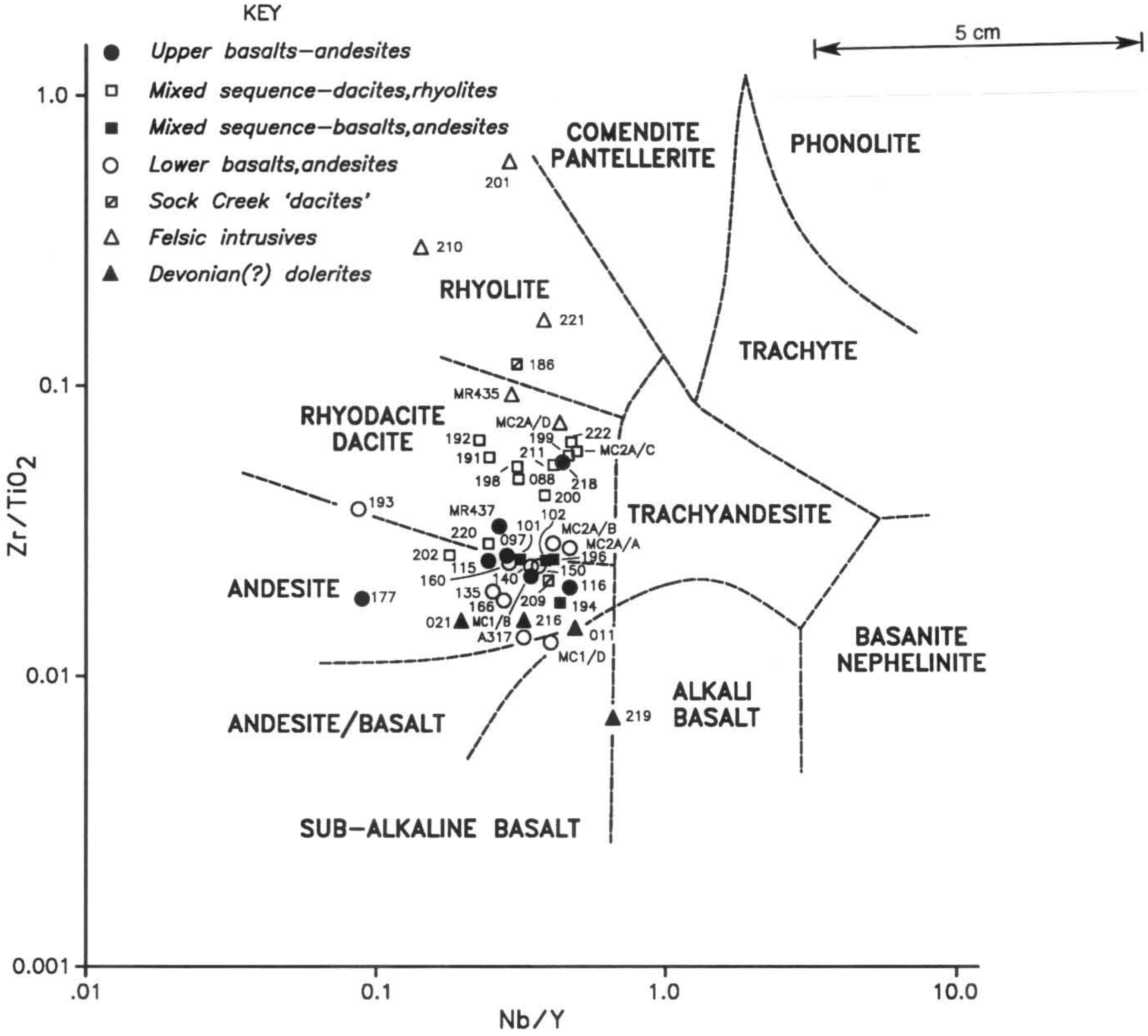


Figure 11. Plot of Zr/TiO_2 *vs* Nb/Y for analysed rocks. Fields after Winchester and Floyd (1977)

particularly useful in distinguishing sub-alkaline (including calc-alkaline) rocks from the alkaline and strongly alkaline series. All samples from the Que-Hellyer Volcanics plot within the sub-alkaline fields. The andesitic-basaltic rocks plot as a fairly tight group within the andesite field, overlapping slightly with the dacite field. Only one sample (MC1/D) plots within the andesite/basalt field, and there are none within the basalt field.

A distinct compositional gap is evident between the andesitic-basaltic group and the high-silica rocks, which plot in the central to upper part of the dacite/rhyodacite field. The field term 'dacite' would seem to be appropriate for the felsic lavas, despite the relatively high SiO_2 values. None of the rocks are rhyolites according to the plot, although one of the Sock Creek lavas and three of the felsic intrusives plot in the rhyolite field.

'Misfit' samples on Figure 11 are P218, the 'andesite' from the South Charter track, which is almost certainly a dacite (probably from the mixed sequence, which was not recognised in the field in this area); P202, a 'dacite' from the Hellyer footwall alteration zone, which appears to be an andesite; P220, a 'dacite' from the Farrell-Waratah transmission line, which appears to be an altered andesite; and P209, one of the Sock Creek lavas, which plots as an andesite.

GEOCHEMICAL FEATURES OF THE BASALTS AND ANDESITES

Some general feautres of the basalts and andesites evident from the analyses in Table 1 are as follows:

(1) TiO_2 values around 0.5% (highest value 1.05% in the lowermost stratigraphic unit), with slightly higher values (average 0.60%) in the mixed sequence andesites. These values are slightly lower than those for average calc-alkaline rocks, as previously mentioned.

(2) Alumina values around 13-16%, with only two rocks having greater than 18% Al_2O_3.

(3) Soda-potash ratios greater than 1 for the lower and upper groups, but less than 1 for the mixed sequence andesites, probably reflecting Na_2O-depletion associated with the widespread hydrothermal alteration in this sequence.

(4) P_2O_5 values are about average for calc-alkaline rocks (Ewart, 1982) in the lower and upper groups (average 0.27 and 0.26%), but notably higher in the mixed sequence (average 0.48%), where three of the four samples have greater than 0.5%.

(5) Chrome values are generally high to very high, averaging 371 ppm in the lower group, 100 ppm in the mixed sequence, and 457 ppm in the upper group. Five samples have greater than 500 ppm Cr. Average Cr values quoted by Ewart (1982) for calc-alkaline andesites (56-63% SiO_2) and basalts (<52% SiO_2) are 50-100 ppm, 60-210 ppm, and 70-270 ppm respectively. The apparent depletion in Cr in the mixed sequence andesites is evident when Cr/Y ratios are compared (table 1), the lower and upper groups having average ratios of 22 and 20, while the mixed sequence has an average ratio of 5 and three samples have a ratio of 1.

(6) Ti/Zr ratios have average values of 26, 25 and 22 for the three groups, compared with 13 for the dacites.

(7) Co/Ni ratios average 0.4, 1.0 and 0.4 for the three groups, compared with 1.3 for the dacites.

GEOCHEMICAL FEATURES OF THE MIXED SEQUENCE DACITES

Some general features of the dacites may be summarised as follows:

(1) Silica values between 68 and 80%, averaging 74% SiO_2.

(2) TiO_2 values between 0.27 and 0.4%. Sample P202 with 0.62% is probably an andesite, as discussed previously.

(3) Alumina values between 13 and 20% (average 15.5%).

(4) Soda and potash values highly variable (averages 2.1% and 3.3% respectively), with Na_2O/K_2O ratios generally less than 1.

(5) Ti/Zr ratios around 9-12 (the average value of 13 on Table 1 is influenced by the two high values for P202 and P220, which are probably andesites, as discussed previously).

(6) Chrome values around 40-80 ppm (average 72 ppm Cr), and Cr/Y ratios around 2-4.

(7) Co/Ni ratios between 1 and 2 (average 1.3).

THE SOCK CREEK LAVAS

The two Sock Creek lavas differ somewhat from one another in their chemistry, and also show some differences from the mixed sequence dacites. They plot near the low-K to medium-K boundary on the K_2O-SiO_2 diagram (fig. 10), and their K_2O contents (1.84 and 0.94%) are markedly lower than those of the mixed sequence dacites (average 3.32%). By contrast, their soda values (6.0 and 7.34% Na_2O) are much higher than those of the mixed sequence dacites (average 2.1%), and again suggests that there has been considerable Na_2O depletion associated with hydrothermal alteration in the latter rocks.

Both of the Sock Creek samples plot with the general andesite group, rather than with the dacites, on the Ti-Zr diagram (fig. 9), reflecting their relatively high TiO_2 contents (0.61 and 0.62%) by comparison with the dacites (average 0.34%). On the Zr/TiO_2-Nb/Y discrimination diagram (fig. 11), one of the samples (P186) plots within the rhyolite field (a consequence of the very high Zr content – 750 ppm), and the other (P209) in the andesite field (because of its relatively low Zr content – 135 ppm). Both samples have relatively low Cr values, and their Cr/Y and Co/Ni ratios are similar to the dacites.

Felsic intrusives

The felsic intrusives analysed comprise three spherulitic quartz porphyries (P221, MR435, P201), one quartz-feldspar porphyry from near Sock Creek (P210), and the probably-intrusive quartz-feldspar porphyry body from drill hole MCH-2A (MC2A/D). The strong chemical similarity of MC2A/D with the porphyry from Sock Creek (except for Na_2O-depletion in the former), and their close correlation on the diagrams (particularly fig. 9, 10), supports the conclusion that the drill hole sample belongs with the Cambrian intrusives.

The five samples plot either within or close to the rhyolite field on the discrimination diagram (fig. 11), indicating that they are more differentiated than the other groups. They are medium-K to high-K rocks according to Figure 10, with 2.5-5% K_2O. Their TiO_2 values are lower than for most of the dacites, with the spherulitic quartz porphyries (average 0.14%) being lower than the quartz-feldspar porphyries (0.25%). Soda values are generally low, and distinctly lower than K_2O values, except in the case of P210 from Sock Creek, which has 4.18% Na_2O. A parallel may be seen with the Na_2O-rich Sock Creek lavas.

Ti/Zr ratios for the five samples range from 1 to 9 (average 5), somewhat lower than those for the dacites (average 13). Cr/Y ratios average 3, identical with those of the dacites.

Devonian(?) dolerites and Tertiary basalt

Samples of dolerite were collected by Komyshan from each of the four bodies mapped as Devonian(?) dolerite. It is clear from the chemical data, however, that sample P219 is quite distinct from the other three samples. P219 is from a low hill of outcrop 3 km WNW of Hellyer mine, abutting the Tertiary basalt plateau. Examination of a thin section sample collected from this area indicates that the outcrop is part of the Tertiary basalt sequence, and this explains its distinct geochemical features.

On the Ti-Zr diagram (fig. 9), the three dolerites plot within or close to the calc-alkaline basalt field, whereas the Tertiary basalt sample plots on a tholeiite trend in the ocean-floor basalt field. The inset on Figure 9 shows the Pearce and Cann (1973) fields from the Ti/100-Zr-Y×3 triangular plot, with the three dolerites plotting within the calc-alkaline basalt field and the Tertiary basalt plotting within the within-plate basalt field. The clear distinction is also evident on the Zr/TiO_2-Nb/Y diagram (fig. 11), where the three dolerites plot in the sub-alkaline andesite to andesite/basalt fields, and the Tertiary sample on the boundary of the alkali basalt field at a much lower differentiation level. Other differences evident from the analyses include less Na_2O in the dolerites (average 1.91% versus 3.36% for the Tertiary sample), more K_2O (1.04 versus 0.62%), lower Nb values (5 ppm versus 11 ppm) and Zr values (78 ppm versus 115 ppm), higher Cr values (588 ppm versus 390 ppm) and Y values (250 ppm versus 195 ppm), lower Ti/Zr ratios (38 versus 80) and higher Cr/Y ratios (44 versus 23).

The three dolerite samples plot within the general grouping defined by the basalts and andesites of the Que-Hellyer Volcanics in all three diagrams (fig. 9, 10, 11). General similarities with the Que-Hellyer rocks are evident from Table 1 in Al_2O_3 values, Na_2O/K_2O ratios, Rb and Sr values, the high Cr contents (average 588 ppm in the dolerites), the high Ti/Zr ratios (average 38 for the dolerites), high Cr/Y ratios, and Co/Ni ratios around 0.3. These initial data suggest that there may be a genetic relationship between the dolerites and the Que-Hellyer basalts and andesites. The dolerites show chlorite-epidote-actinolite-carbonate alteration typical of other Cambrian rocks in the area, suggesting that they were affected by the Devonian deformation and metamorphism. The K-Ar mineral age of 396 ± 10 Ma recorded from the dolerite at Mt Charter (A. M. Hespe, pers. comm.) is a minimum age only, and could well record the Devonian re-setting of an earlier Cambrian age. Such re-setting is common in western Tasmania (Adams, *et. al.* 1985).

STRUCTURAL GEOLOGY

Folding in the Que-Hellyer area

Stereonet plots of poles to cleavage and bedding in the area are given in Figures 12 and 13. Devonian folding is evident as broad, NE-trending folds which decrease in wavelength from about 2 km to about 500 m approaching the Henty Fault. Cleavage associated with these folds is poorly developed west of the Murchison Highway, but is prominent and axial planar to the folds east of the highway (fig. 12). In the Hellyer mine area, the major NE-plunging anticlinal structure is clearly outlined by the Que River Shale and by units within the Que-Hellyer Volcanics. Poles to bedding plots of the Hellyer mine area (fig. 13f) indicate an axial trace of 040° and plunge of 30°.

The presence or absence of a synclinal axis through the Que River mine area has been the subject of some debate (Young, 1980). Regionally, a syncline is clearly evident in sedimentary rocks to the south of Mt Charter (McNeill, 1986), and also to the north-east of Que River mine. Rocks of the mixed sequence clearly define a fold axis enclosing the Que River mine, and tight parasitic folding is evident in the felsic lavas and massive sulphide lenses of this sequence. McGoldrick and Large (1988) interpreted the PQ sulphide lens as being complexely folded and thickened in a synclinal fold axis about a major dacite wedge. This was supported by metal zonation within the sulphide lens and by the presence of footwall stringer style mineralisation to the east and west of the syncline.

Synclinal folding at Que River mine is also indicated by flow banding within the felsic lavas of the mixed sequence. A plot of poles to flow banding (fig. 14) clearly delineates eastern and western limbs dipping at 70-80° above a fold axis trending 010-023° with a northerly plunge of 0-20°.

The NE-trending folds have been overprinted by smaller wavelength (less than 400 m) NW-trending folds which have a strongly developed axial planar cleavage. The interaction of the two fold phases has resulted in small dome and basin structures in some areas, e.g. the basalt 'window' 2 km west of Hellyer Mine.

A third cleavage of north to NNE trend related to the Henty Fault Zone, and cross-cutting the NE-trending folds, is discussed later.

Henty Fault Zone (HFZ)

This major fault zone trends generally NNE, and consists of a zone 100-300 m wide of highly cleaved, lineated sediments and volcanic rocks. Deformation and alteration appear to be considerably greater to the south of the E-W trending Mt Cripps Fault (i.e. around The Sharks Fin and south thereof), and work subsequent to the original mapping suggests that the fault zone shown extending through the Hellyer Portal area may be a splay structure, with the major movement being deflected along the Mt Cripps Fault.

In the Sharks Fin area, the fault zone rocks are strongly sericitised and locally silicified. Hematite-magnetite veins and pervasive hematite alteration within a quartz porphyry body one kilometre north of The Sharks Fin are also associated with the Henty Fault. To the north of the area of intersection with the Mt Cripps Fault, the rocks within the fault zone are generally strongly cleaved but relatively unaltered. Minor sericite-fuchsite(?) alteration of felsic tuff was noted in preliminary excavations on the Cradle Mountain Link Road, and the fault zone was extrapolated to this point.

Slickensides on fault surfaces within the fault zone indicate a number of movement directions, with strike-slip and reverse movement being most common. Folds are common within the fault zone, and are generally tight and variably plunging, with variable axial planes. Bedding within the fault zone, although generally parallel to the fault trend, may diverge at moderate angles. Dips are steep and commonly overturned. Plots of poles to bedding within the fault zone give concentrations at 170/82 and 190/80 (fig. 13*h*).

Schistosity in the fault zone is generally sub-vertical, and mostly ranges from 170 to 190° AMG in strike, sub-parallel to bedding (fig. 12*f*). Cleavage development on this trend is strongly evident up to one kilometre distance from the fault zone on either side (fig. 12*a, g, h*), becoming more intense as the fault zone is approached. This cleavage cross-cuts the NE-trending fold structures, but its relationship to the NW-trending structures is not known.

Minor faulting associated with the Henty Fault is also strongly developed up to one kilometre on either side of the main fault. Three major trends are apparent (fig. 15), partially corresponding to the cleavage trends in the fault zone.

The latest movement on the Henty Fault is clearly post-Cambro-Ordovician and later than NE-trending fold structures which are probably Devonian in age. The Henty Fault is a fundamental structure in the Mt Read Volcanics belt. Corbett and Lees (1987) have suggested that the localisation of basaltic and gabbroic dykes along the North Henty Fault and southern part of the Henty Fault (Mt Read area) indicates that the fault was active during the Cambrian. In the Hellyer-Mt Charter area, the apparent localisation of quartz porphyry intrusive bodies by fractures associated with the Henty Fault also suggests that the fault was active in the Cambrian. The porphyry bodies are cleaved and affected by later movements and deformation on the Henty Fault.

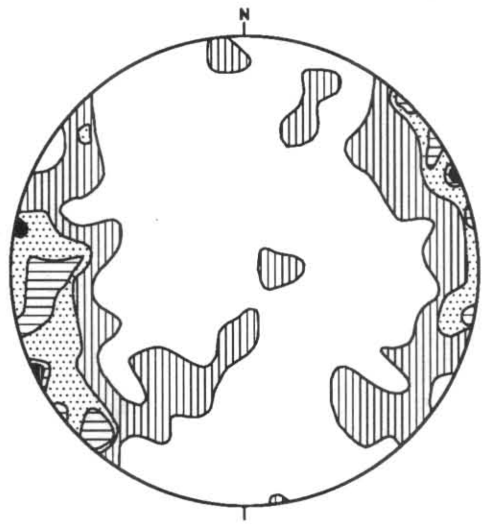
The Que River and Hellyer massive sulphide bodies are both located approximately one kilometre from the HFZ. Footwall alteration zones of the two orebodies are steeply to vertically dipping (cross-cutting stratigraphy), and strike approximately NNE. Faulting on a NE to NNE trend has also influenced the location of the Hellyer orebody (the Jack Fault of McArthur, 1986). It is suggested that fractures associated with the Henty Fault system localised the transportation of hydrothermal fluids and acted as feeder zones during deposition of the massive sulphides. Hydrothermal activity along these fractures persisted well after deposition of the sulphides, as evidenced by sericite-fuchsite alteration extending at least 200 m into the hangingwall of the orebodies.

The Mt Charter Fault

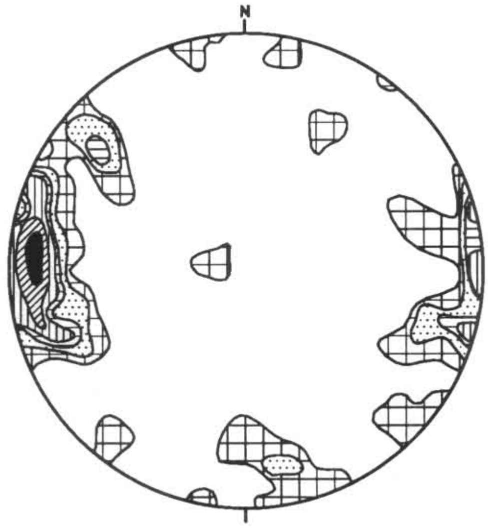
The NNW- to NW-trending Mt Charter Fault forms the southern boundary to the bulk of Que-Hellyer Volcanics in the Mt Charter area. The fault shows a number of fairly sharp changes in trend – mostly well controlled from surface costean exposures – suggesting that it has been affected by later deformations. The north-western extremity of the fault is located in thickly-forested, poorly-accessible country west of the Murchison Highway, and its position has not been accurately fixed in this area.

Where exposed, the fault zone is typically evident as a zone of brecciation, clay pug development, and sericitisation up to several metres wide. Intense minor faulting and shearing related to the fault may extend up to 50 m on either side of the main fault zone.

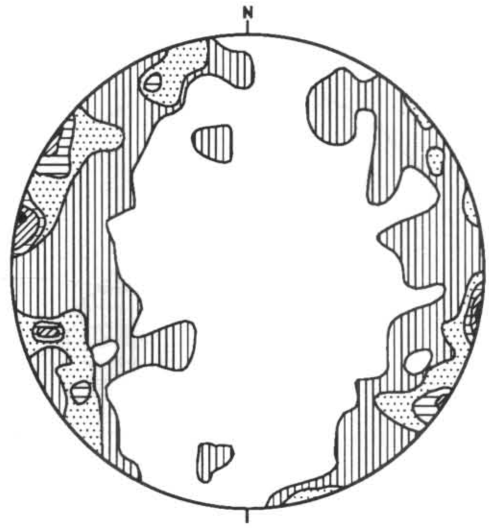
Drill hole MCH-2A (fig. 5, 7) was drilled to determine the attitude and nature of the Mt Charter Fault in the vicinity of the South Charter track. The hole penetrated some 275 m of Animal Creek Greywacke, and intersected some 4.5 m of quartz-feldspar porphyry at the position of the Mt Charter



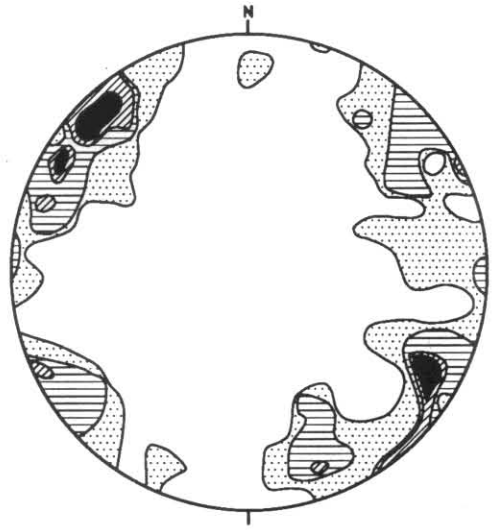
(a) Sub-area A. Contours at 1, 3, 5, 7%; 99 points



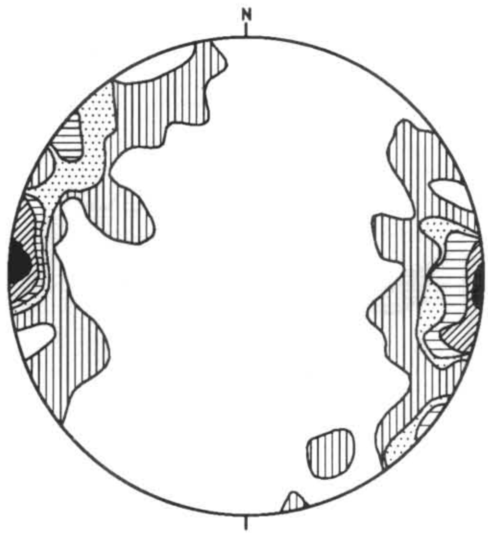
(b) Sub-areas C and F. Contours at 1, 3, 5, 7, 10%; 103 points



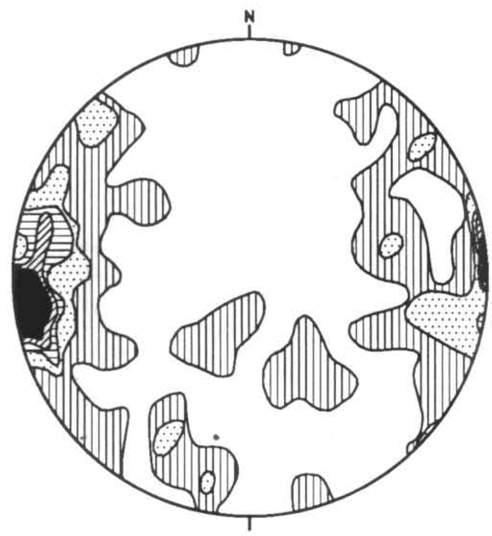
(c) Sub-area D. Contours at 1, 3, 5, 7, 10%; 74 points



(d) Sub-area E. Contours at 1, 3, 5, 7, 10, 15%; 54 points



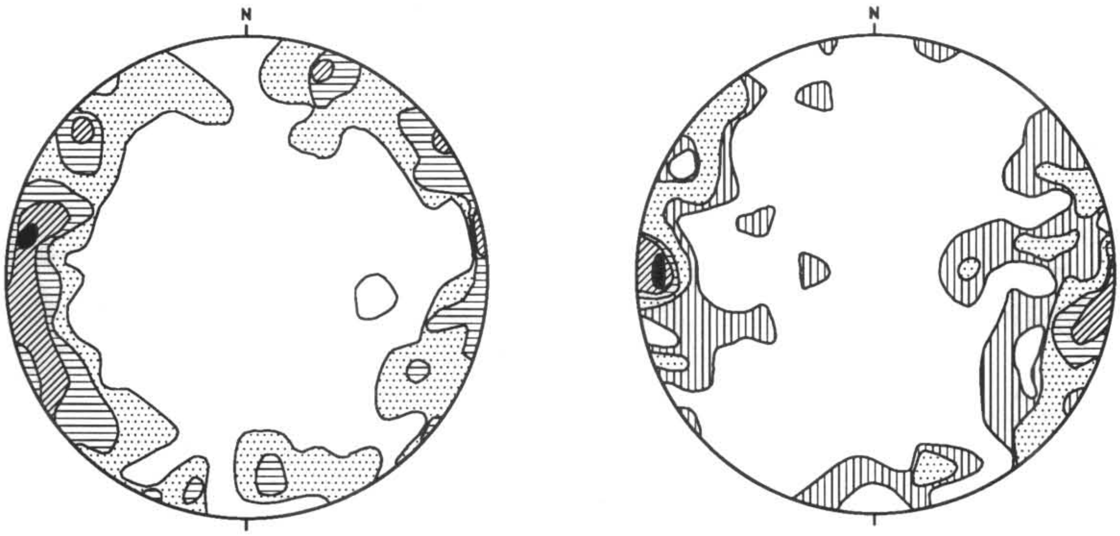
(e) Sub-area G. Contours at 1, 3, 5, 7%; 68 points.



(f) Sub-area H. Contours at 1, 3, 5, 7, 10%; 102 points

Figure 12. Stereoplots of poles to cleavage (continued on following page). Sub-areas are shown on page 35.

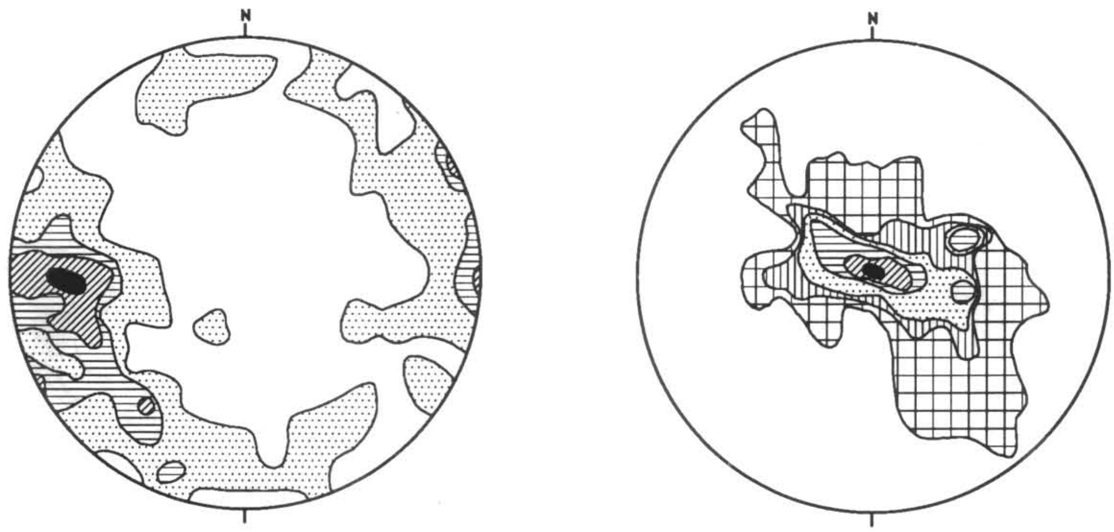
5 cm



(g) Sub-area J. Contours at 1, 3, 5, 7%; 113 points

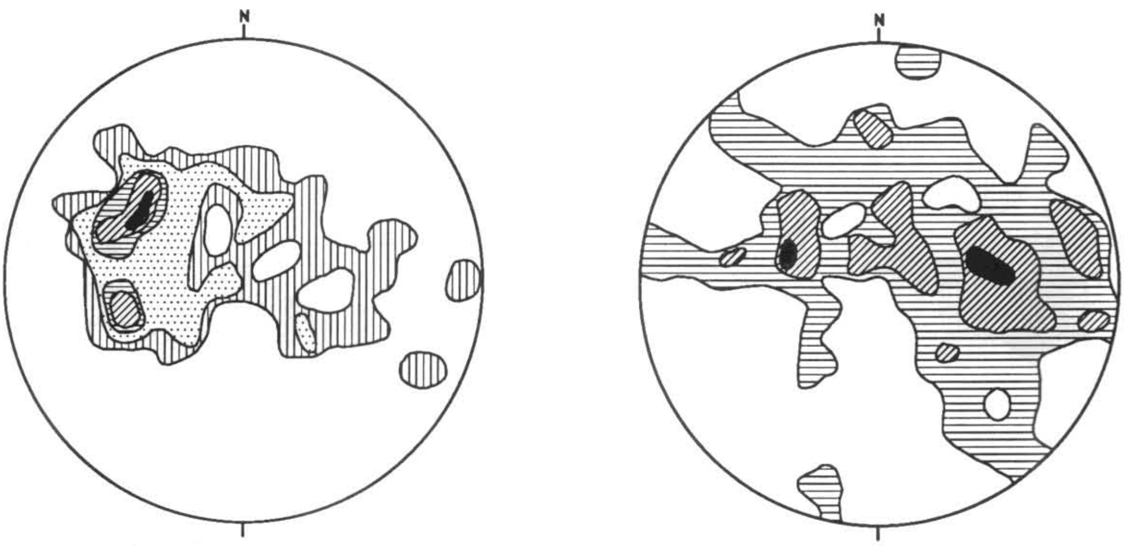
(h) Sub-area K. Contours at 1, 3, 5, 7, 10%; 68 points

Figure 12. Stereoplots of poles to cleavage (continued from previous page). Sub-areas are shown onpage 35.



(a) Sub-area A. Contours at 1, 3, 5, 7,%; 123 points

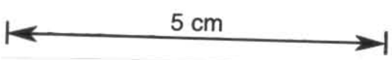
(b) Sub-area B. Contours at 1, 3, 5, 7, 10%; 53 points

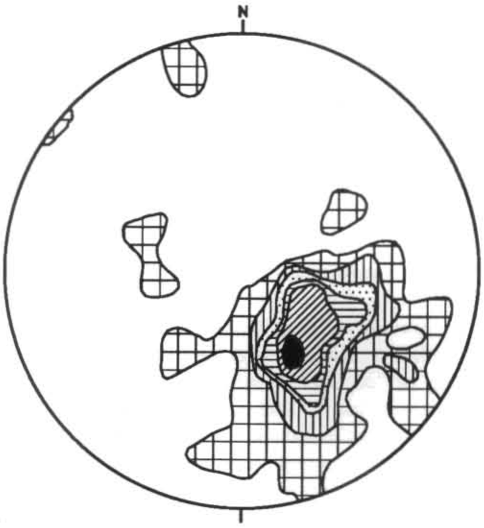


(c) Sub-area C. Contours at 1, 3, 5, 7, 10, 15%; 120 points

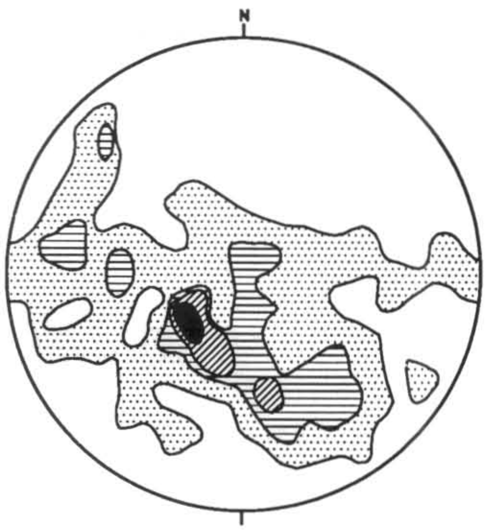
(d) Sub-area D. Contours at 1, 3, 5%; 91 points

Figure 13. Stereoplots of poles to bedding (continued on following page). Sub-areas are shown on page 35.

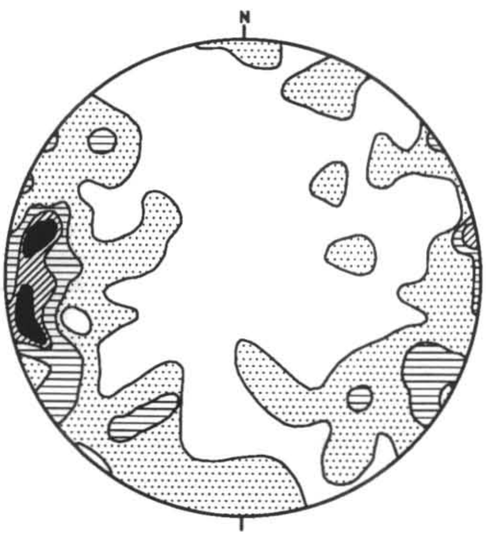




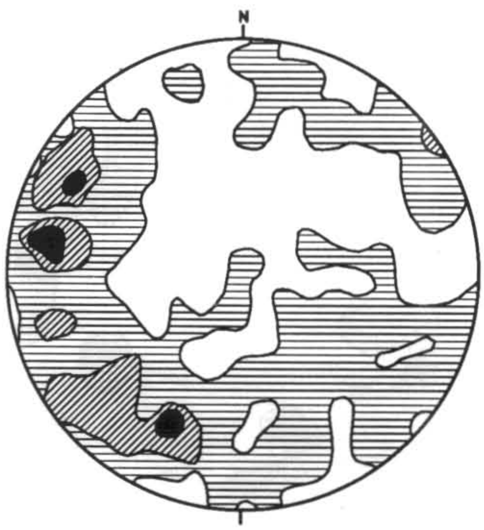
(e) Sub-area E. Contours at 1, 3, 5, 7, 10, 15%; 89 points



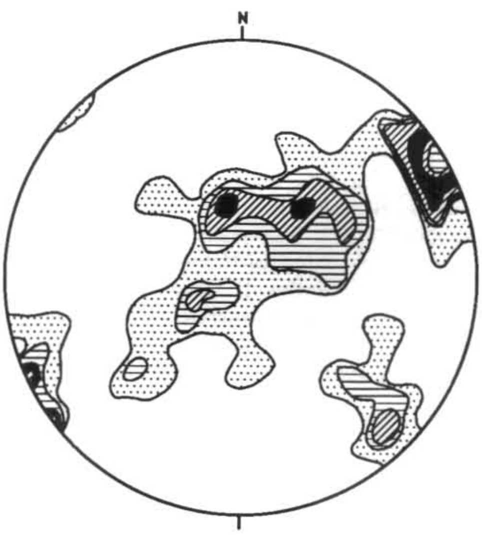
(f) Sub-area F. Contours at 1, 3, 5, 7%; 130 points



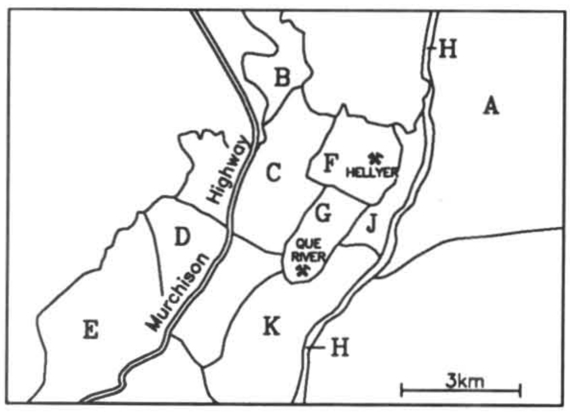
(g) Sub-area H. Contours at 1, 3, 5, 7%; 131 points



(h) Sub-area J. Contours at 1, 3, 5%; 195 points



(i) Owen Conglomerate, whole area. Contours at 1, 3, 5, 7%; 51 points



STRUCTURAL SUB-AREAS

Figure 13. Stereoplots of poles to bedding (continued from previous page).

5 cm

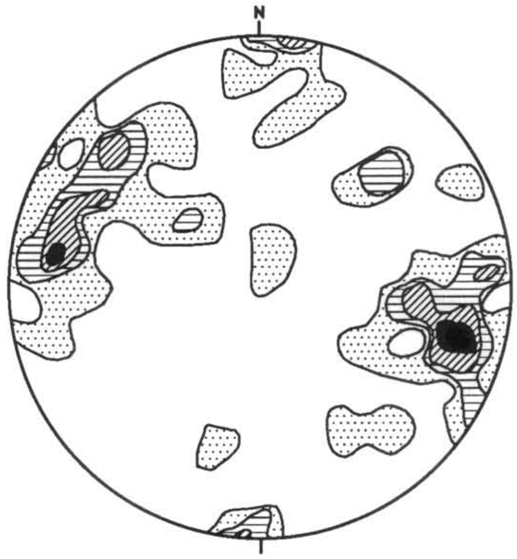


Figure 14. Stereoplot of poles to flow banding in lava, Sub-area G. Contours at 1, 3, 5, 7%; 61 points.

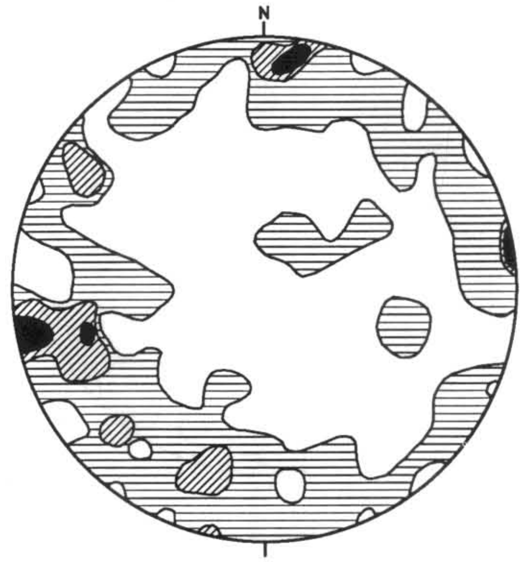


Figure 15. Stereoplot of poles to fault planes, whole area. Contours at 1, 3, 5%; 80 points.

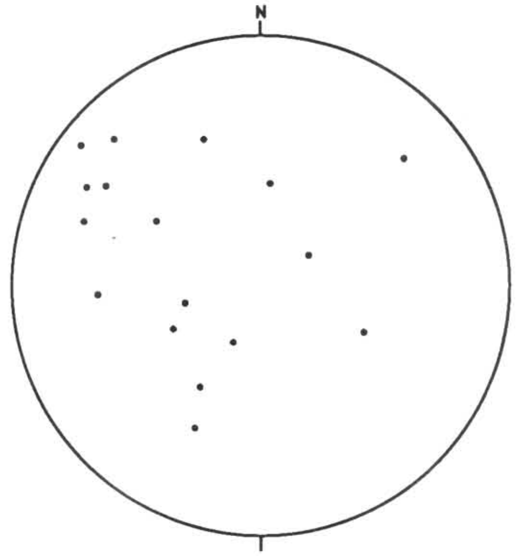


Figure 16. Stereoplot of fold hinge-line plunges, whole area. Seventeen points.

5 cm

Fault, before entering the Que-Hellyer Volcanics on the north side. The porphyry body has an irregular, welded contact against shale of the Animal Creek Greywacke, and contains a 300 mm-long inclusion of black shale, also with irregular, welded contacts. The nature of the contacts strongly suggests that the porphyry has intruded the shale. The contact between the porphyry body and a lava unit of the Que-Hellyer Volcanics is marked by an unbroken, unsheared quartz-carbonate vein, 50 mm wide.

The lack of intense shearing or brecciation within the porphyry body, and the welded, intrusive nature of its contacts, strongly suggests that it intruded up the fault zone after the initial fault movements. This may have had the effect of sealing or locking the original fault plane, such that subsequent movements were accommodated by shears within the Animal Creek Greywacke. A significant fault zone with puggy clay development and associated quartz-veining occurs within the greywacke one metre uphole from the porphyry body, and another probable fault zone one metre or so further uphole (see logs, Appendix B). A small body of similar quartz-feldspar porphyry was noted cropping out on the South Charter track near the position of the Mt Charter Fault 100 m east of the MCH-2A collar position, and may well be continuous with that intersected in the drill hole.

Extrapolation of the intersection position of the Mt Charter Fault in MCH-2A to the surface position of the fault (fig. 7) indicates a northerly dip of about 70° for the fault plane. The fault in this area has an E-W trend (fig. 5), and there is a possibility that it represents a secondary cross-fault which has offset the original NNW-trending structure. However, the lack of evidence for any continuation of the cross-fault (e.g. it does not appear to affect the Central Volcanic Complex boundary), and the occurrence of quartz-feldspar porphyry on the fault in the drill intersection and also further east on surface, strongly suggests that the trend change is due to folding of the original structure.

A sub-vertical or steep northerly dip for the Mt Charter Fault suggests it is a normal fault associated with tensional subsidence of the basin containing the Que-Hellyer Volcanics. The pronounced thickness change in the Que-Hellyer Volcanics across the fault – from 500 m or more in the vicinity of Mt Charter to 200 m or less in the Sock Creek area – strongly suggests that the structure was active during eruption and deposition of the Que-Hellyer sequence.

SYNTHESIS AND DISCUSSION

1. A complete and well exposed section of the younger part of the Mt Read Volcanics, between the Central Volcanic Complex below and the Owen Conglomerate above, is available in the Mt Charter-Hellyer-Mt Cripps area. The major part of the sequence is correlated with the Dundas Group, and has been subdivided into four main units – Animal Creek Greywacke at base, Que-Hellyer Volcanics, Que River Shale, and Southwell Subgroup at the top. A volcaniclastic conglomerate-sandstone sequence correlated with the Tyndall Group occurs between the Southwell Subgroup and the Owen Conglomerate.

2. The Central Volcanic Complex in the area is dominated by massive felsic lavas and pyroclastics, including fiamme-bearing units resembling ignimbrites. Sedimentary rocks are absent, and the sequence may be largely subaerial.

3. The Animal Creek Greywacke comprises several hundred metres of greywacke, shale and vitric ash, indicating a major change in conditions from the active, possibly subaerial, volcanism of the Central Complex. Much of the greywacke is quartz-mica-rich and of Precambrian derivation, implying a significant

hiatus in volcanism when the marine basin was flooded with Tyennan detritus carried by turbidity currents. The micaceous quartzwacke sequence may correlate with other quartzwacke units known from the lower part of the Dundas Group, e.g. the Stitt Quartzite of the Rosebery area, and the quartzwacke- conglomerate unit on Howards Road south-west of Mt Read (Corbett and Lees, 1987). Similar micaceous quartzwacke occurs in parts of the Farrell Slates belt near Tullah (mapping by Corbett in Corbett and McNeill, 1986; McNeill, 1989).

4. The Que-Hellyer Volcanics developed as a large lens within the lower part of the Dundas Group correlates, with evidence of an axis of maximum thickness (possibly one kilometre) extending from east of Mt Charter through the Que River and Hellyer mines. The sequence thins dramatically to the north-west, where it is represented by only 10 m or less of basalt near the Cradle Mountain Link Road, and also to the south-west, where it is represented by only 200 m or so of mainly felsic lava in the Sock Creek area. The deepest part of the basin of accumulation was bounded by the Mt Charter Fault to the south-west, and probably by the Henty Fault to the east. Formation of this basin may well have been related to tensional opening associated with early movements on the Henty Fault system (Corbett, 1986). The occurrence of pillow lavas within the sequence, of sedimentary intercalations, including siltstone with marine microfossils, of abundant breccias of various kinds (including pillow breccias and hyaloclastic breccias), and of massive sulphide lenses, all indicate that the basin remained marine throughout its development.

5. The lower tuff and lava unit of the Que-Hellyer Volcanics has its thickest development in the south-east corner of the basin, and there is some evidence that thickness maxima for successive units migrated from here to the NNW. Thus the basin may have opened progressively in that direction. The lower unit includes flows of felsic, feldspar-phyric lava resembling those of the Central Complex (although chemical comparison has not been attempted), and also flows and dykes of basalt.

6. The bulk of the Que-Hellyer Volcanics comprises roughly equal proportions of 'basalt' and 'andesite'. The abundance of lava flows and coarse breccias indicates a proximal environment, and it is likely that much of the original volcanoes or volcanic centres has been preserved. The 'basalts' are typically massive, grey-green vesicular, fine-grained rocks, with micro-phenocrysts of plagioclase and clinopyroxene in a groundmass rich in plagioclase microlaths and granular pyroxene. The 'andesites' by comparison have visible feldspar phenocrysts but few, if any, ferromagnesian phenocrysts, in a felsitic groundmass with little or no pyroxene but often showing perlitic texture. Vesicle fillings include quartz, carbonate, chlorite, pumpellyite and epidote. Geochemically, the bulk of the rocks are calc-alkaline andesites and basaltic andesites, with true basalts (<53% SiO_2) being extremely rare. The basaltic rocks are notably Cr-rich, with up to 600 ppm Cr, and have Ti/Zr ratios of greater than 20. Dolerite bodies intruding the Que River Shale have geochemical and petrological similarities with the basalts, and may be genetically related to them.

7. The mixed sequence containing the Hellyer and Que River orebodies is distinguished by the presence of flows and domes of calc-alkaline dacite-rhyodacite, with associated 'epiclastic' breccia deposits and minor tuffs and sedimentary rocks. Although the dacites weather to white or pink colours at surface, they are grey when fresh, commonly feldspar-phyric, and may be difficult to distinguish from andesites in drill core. Flow-banding, lack of ferromagnesians, felsitic groundmass with strong flow-texture and spherulite-snowflake development, and sericite-muscovite alteration, are useful distinguishing features. Geochemical data, and particularly such features as Ti/Zr ratios, may be needed to resolve the issue.

   The reason for eruption of dacites at this level is unknown. Wheller and Varne (1986) describe a stratovolcano of similar stratigraphy, and suggest a mechanism whereby fractional crystallisation near the walls of the magma chamber leads to early production of siliceous magmas which erupt in a caldera-forming event, to be followed by extrusion of post-caldera basalts from the undifferentiated core liquids. A similar caldera-forming eruption history has been suggested for the dacitic volcanics associated with the Japanese Kuroko deposits (Ohmoto and Takahashi, 1983). Such a mechanism might be relevant to the Que-Hellyer Volcanics, with the implication that the dacite lavas and fragmentals, and the associated orebodies, might be related to an event involving rapid magma chamber depletion and associated subsidence. On the other hand, the occurrence of dacitic lavas in the 'overflow' situation outside the main basin at Sock Creek might suggest that the eruption of the dacites coincided with a period of less active subsidence, when the Mt Charter Fault scarp was overtopped. A period of relative quiescence is also suggested by the formation and preservation of the massive sulphide orebodies.

8. The strong stratigraphic control of the Que River and Hellyer orebodies within the dacite-rich mixed sequence emphasises the remarkable parallel with the Kuroko deposits of Japan. The stratigraphy of the Hokuroko basin (Tanimura *et. al*, 1983) may be summarised as follows: (i) basal unit of andesitic lavas, breccias and tuffs with intercalations of sandstone, conglomerate and mudstone (200-600 m); (ii) basaltic lavas and breccias (including pillow lavas) with minor mudstone and tuff (up to 650 m); (iii) unit of felsic lava flows and domes with associated breccias, tuffs and minor mudstone, containing massive sulphide lenses in upper part (300-600 m); (iv) alternating tuff and mudstone with local basalt lavas (150 m); (v) upper unit of interbedded pumice-rich felsic tuff and mudstone, with minor dacitic lavas (40-250 m). Most of the sequence was deposited in deep water (2.5 km or more, Guber and Merrill, 1983) within a volcano-tectonic depression within which smaller caldera structures formed as a result of the felsic volcanism. The sequence is topped with shallow marine to non-marine coarse- to fine-grained sediments and subaerial volcanics.

9. The known hydrothermal deposits of Hellyer, Que River and Mt Charter are spaced at exactly 3 km intervals along a NNE line corresponding roughly to the thickest part of the sequence. If the spacing is significant, a further deposit might be expected in the vicinity of the Cradle Mountain Link Road - Murrays Road junction. Unfortunately, at this point the mixed sequence probably lies more than 800 m below surface.

10. Growth faults which were active during the Que-Hellyer volcanism may well have provided conduits for hydrothermal fluids, as in the case of the Jack Fault at Hellyer, and recognition of other such faults could be important for exploration. The Mt Charter Fault was almost certainly active at this time, as indicated by thickness changes across it and by the

occurrence of felsic intrusives along it, and must be considered a significant target. Minor galena-sphalerite-chalcopyrite mineralisation is present in basalt near this fault in drill hole MCH-2A (Appendix B).

11. The occurrence of a major belt of dacitic-andesitic lavas in the Sock Creek-Boco area significantly increases the known area of prospective Que-Hellyer Volcanics. The Sock Creek belt is as yet poorly known because of limited exposure, but contains at least some epiclastic breccias and tuffs similar to those associated with the Que River and Hellyer deposits.

12. The basaltic-andesitic volcanism and associated tectonism of the Que-Hellyer area appears to have ceased abruptly in the late Middle Cambrian, and, after some local erosion and clastic deposition to produce the lenses of polymict breccia, was followed by a prolonged quiescent period when the Que River Shale was deposited. This black, pyritic, micaceous shale appears to have blanketed much or all of the volcanic pile, reaching a thickness of at least 150 m on the western flank but possibly thinning to zero in some areas to the east.

    The similarity between the Que River Shale and the Farrell Slates, which occur within the Henty Fault Zone from the vicinity of Mt Charter southwards, has led to speculation that the two are equivalent. The Farrell Slates abut correlates of the Animal Creek Greywacke on an unknown boundary within the fault zone east of Mt Charter. Further work is required to resolve these relationships, but it seems likely that the Farrell Slates are at least partly equivalent to the Animal Creek sequence. If correlates of the Que River Shale are also represented in the Farrell Slates, then it must be assumed that the Que-Hellyer Volcanics have wedged out in this position, since no equivalents are known within the Farrell sequence. Such wedging out would not be unexpected, however, considering the lens-like nature of the Que-Hellyer sequence to the north-west, and hence the possible presence of Que River Shale within the Farrell Slates remains an open question.

    The faunal age of the Que River Shale (late Middle Cambrian, Undillan stage) indicates correlation with the Hodge Slate of the type Dundas Group section, but appears to be slightly older than the basal Tyndall Group fauna from Queenstown (Jago and Brown, 1989).

13. The volcanism which followed the Que River Shale, in the Southwell Subgroup, was quite unlike the Que-Hellyer volcanism, being wholly felsic in character and dominated by mass-flows of quartz-feldspar-phyric detritus from outside the basin. The felsic detritus included large juvenile pumice clasts in many cases, suggesting that many of the mass-flows were initiated by explosive, possibly subaerial, eruptions. A probable source area to the east is indicated by the concentration of pumice-rich tuffs in the upper unit in the Murrays Road area, and by the occurrence of felsic lavas within this unit, and a possible source area to the west is suggested by the abundance of quartz-feldspar porphyries in the Sock Creek area. Many of the turbidity currents entering the basin carried Precambrian-derived detritus.

14. Several phases or types of intrusive activity occurred after and/or during deposition of the Southwell Subgroup. Perhaps the earliest is represented by the dolerite bodies occurring within the Que River Shale or just above this level in the Southwell Subgroup. These may represent the final stages of magmatism related to the Que-Hellyer Volcanics. Quartz-feldspar porphyry intrusives are particularly abundant west of the Murchison Highway, and also occur along the Mt Charter Fault. The similarity of these to the detritus in the Southwell Subgroup suggests they may, in part, represent the roots of contemporaneous volcanoes. Spherulitic quartz porphyry intrusives are notably abundant in the Hellyer-Southwell River area, and along and adjacent to the Henty Fault Zone in the Sharks Fin area. This suggests a probable relationship to tectonism associated with the Henty Fault, and there may be a connection to the bend or displacement of the Henty structure where it meets the Mt Cripps Fault.

15. The volcaniclastic conglomerate sequence at Mt Cripps has been correlated with the Tyndall Group in this paper. It should be noted, however, that the Tyndall Group as defined at Queenstown (Corbett, *et. al*., 1974) includes a significant sequence of volcanic rocks (including quartz-rich tuffs) below the upper volcaniclastic unit, and that fossils from the base of the group are only fractionally younger than those of the Que River Shale. It could be argued, therefore, that the entire Southwell Subgroup is also a correlate of the Tyndall Group.

    The Dundas and Tyndall Groups were defined in different areas, on opposite sides of the Henty Fault, the Dundas Group being predominantly sedimentary in its type area, and the Tyndall Group predominantly volcanic or volcaniclastic. The age range for the Dundas Group is middle Middle Cambrian (or possibly older) to middle Late Cambrian, whilst that for the Tyndall Group (on very sparse evidence) is late Middle Cambrian to middle Late Cambrian. The Hellyer-Mt Cripps region represents the first area in which detailed mapping has shown lithostratigraphic correlates of both groups to be present in the same sequence, creating something of a terminological dilemma. The Dundas Group term has precedence, but the Tyndall Group term is retained for the distinctive volcaniclastic sequence which is characteristic of the Tyndall Group but not of the Dundas Group.

    The thickness of volcaniclastic detritus (>500 m of mostly rounded clasts to boulder size) indicates a major period of erosion of the pre-existing volcanic pile. The presence of basaltic-andesitic clasts suggests that some of the Que-Hellyer Volcanics may have been exposed to erosion, but most of the detritus appears to be felsic in character. Clasts of quartz-feldspar-biotite porphyry were probably derived from the very large body of the distinctive porphyry which occurs further to the east in the Fury River-Bond Range area (work by M. Vicary and J. Pemberton for the Mt Read Project). Clasts of Precambrian detritus from the Tyennan region were also incorporated in the deposit. The volcanic detritus was ultimately buried beneath a flood of Precambrian-derived siliciclastic gravel and sand constituting the Owen Conglomerate.

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APPENDIX A

Original whole-rock chemical analyses of major elements, with descriptive notes

	A317	MC1/D	MC2A/B	P193	MC2A/A	P135	P160	P149	P150	P166	P102
SiO_2	60.89	53.66	53.39	53.79	55.33	57.32	57.61	58.98	61.39	64.03	50.72
TiO_2	1.02	1.01	0.51	0.48	0.48	0.53	0.44	0.54	0.54	0.24	0.61
Al_2O_3	15.38	16.16	14.14	15.57	12.85	15.08	15.78	14.89	13.23	11.54	15.79
Fe_2O_3	0.97	10.01*	1.40	2.46	7.20*	1.80	2.29	1.39	0.96	1.41	1.92
FeO	6.94	-	6.58	5.45	-	5.51	4.83	5.84	3.83	3.99	7.16
MnO	0.17	0.23	0.36	0.33	0.25	0.15	0.15	0.26	0.16	0.15	0.14
MgO	2.19	4.59	8.12	4.68	6.28	3.91	5.40	4.26	3.95	5.37	2.84
CaO	5.29	6.31	6.95	9.12	6.91	8.70	6.45	6.33	6.80	6.96	6.01
Na_2O	2.53	3.48	2.63	3.53	3.35	2.16	2.06	3.15	2.91	3.73	1.47
K_2O	1.43	1.66	2.01	0.37	1.01	1.24	1.27	1/47	3.55	0.58	2.50
P_2O_5	0.24	0.37	0.23	0.28	0.23	0.16	0.27	0.26	0.41	0.09	0.52
H_2O^+	2.51	-	3.66	2.72	-	3.04	2.98	2.32	1.48	2.03	3.56
CO_2	0.68	-	0.18	0.86	-	0.31	0.09	0.14	0.27	0.11	6.45
SO_3	-	-	-	-	-	-	-	-	-	-	-
S	-	-	-	0.14	-	-0.10	0.26	0.20	0.11	0.07	0.07
Total	100.24	100.05	100.16	99.78	99.58	100.01	99.88	100.03	99.59	100.30	99.76
LOI	-	2.57	-	-	5.69	-	-	-	-	-	-

	P196	P101	P194	MC2A/C	P200	MC1/C	P088	P202	P191	P192	P220
SiO_2	51.66	51.64	57.30	67.18	66.89	69.67	68.34	69.71	72.18	72.00	72.36
TiO_2	0.63	0.55	0.67	0.37	0.30	0.38	0.26	0.60	0.28	0.26	0.41
Al_2O_3	16.26	14.46	15.19	15.95	15.26	14.63	13.25	20.14	14.57	14.11	15.52
Fe_2O_3	0.90	1.51	1.52	1.23	0.93	4.37*	2.91	0.29	2.07	1.97	2.23
FeO	5.87	6.12	5.67	4.00	2.31	-	2.78	0.36	0.78	1.82	1.13
MnO	0.13	0.26	0.16	0.11	0.10	0.09	0.37	0.01	0.04	0.05	0.13
MgO	2.67	2.92	5.56	1.50	1.17	0.92	0.76	0.19	0.05	0.30	0.39
CaO	6.33	6.88	8.00	0.68	2.83	0.67	2.38	0.02	0.35	0.24	0.14
Na_2O	1.29	0.55	1.81	4.75	1.12	4.99	1.34	0.40	5.27	2.51	0.50
K_2O	2.90	2.86	0.90	2.45	3.37	2.16	2.25	4.97	2.70	4.35	3.24
P_2O_5	0.53	0.48	0.21	0.07	0.09	0.08	0.09	0.03	0.07	0.04	0.13
H_2O^+	2.61	3.33	2.86	2.12	2.06	-	2.61	2.67	1.11	1.80	2.82
CO_2	8.11	8.28	0.16	-	3.40	-	2.04	0.16	0.18	0.17	0.09
SO_3	-	-	-	-	-	-	-	-	-	-	-
S	0.09	0.07	0.08	-	0.11	-	0.08	0.06	0.07	0.14	0.06
Total	99.98	99.91	100.09	100.41	99.94	99.34	99.46	99.61	99.72	99.76	99.15
LOI	-	-	-	-	-	1.38	-	-	-	-	-

* Total Fe expressed as Fe_2O_3

Lower tuff and lava

A317 - basalt, 2 km SSE of Mt Charter [CP904892]

Lower andesites and basalts

MC1/D - basalt, drill hole MCH-1, 265 m (see figs 5, 8). Analysis provided by A.J. Stolz, Geology Department, University of Tasmania.

MC2A/B - basalt, drill hole MCH-2A, 312 m (see figs 5, 7).

P193 - basalt, costean 1 km N of Mt Charter [CP901923]

MC2A/A - basalt, drill hole MCH-2A, 352 m. Analysis provided by A.J. Stolz.

P135 - andesite, ridge south of Switchback on Haulage Road [CP929941]

P160 - andesite, track east of Mt Charter [CP905915]

P149 - andesite, Que River Portal [CP915933]

P150 - andesite, 300 m east of Que River Portal [CP918932]

P166 - 1.5 km NE of Mt Charter [CP914921]

Mixed sequence andesites

P102 - andesite, Haulage Road [CP926945]

P196 - andesite, Haulage Road [CP925944]

P101 - andesite, Haulage Road [CP926945]

P194 - andesite, transmission line 1.2 km north of Mt Charter [CP896925]

Mixed sequence dacites

MC2A/C - grey lava, drill hole MCH-2A, 290 m (see figs 5, 7)

P200 - dacite, Haulage Road [CP930944]

MC1/C - flow-banded grey lava, drill hole MCH-1, 176 m (see figs 5, 8). Analysis provided by A. J. Stolz

P088 - dacite, road west of Switchback [CP929944]

P202 - dacite, 1.5 km NNE of Que River mine [CP921951]

P191 - dacite, costean 1 km north of Mt Charter [CP901925]

P192 - dacite, costean 1 km north of Mt Charter [CP901925]

P220 - dacite, Farrell-Waratah transmission line road [CP916950]

	P199	P211	P198	P222	MC1/B	MR437	P116	P177	P218	P097	P115
SiO_2	72.99	75.30	76.52	77.97	46.34	54.07	54.03	56.42	58.21	57.13	61.24
TiO_2	0.25	0.28	0.30	0.27	0.57	0.54	0.68	0.48	0.35	0.58	0.30
Al_2O_3	12.86	15.44	14.61	13.59	17.32	12.45	15.57	13.95	18.27	15.43	13.59
Fe_2O_3	0.63	1.37	0.84	0.85	10.88*	0.78	2.33	1.04	1.38	10.15	1.07
FeO	1.04	0.36	0.42	0.65	-	7.90	3.92	5.16	6.77	3.17	8.14
MnO	0.10	0.01	0.01	0.01	0.27	0.19	0.06	0.73	0.21	0.04	0.46
MgO	0.39	0.15	0.03	0.03	8.63	7.95	4.59	5.86	3.49	2.79	6.35
CaO	2.61	0.04	0.08	0.03	7.83	7.72	5.63	6.39	0.54	0.14	0.35
Na_2O	1.81	0.18	1.27	0.33	2.70	2.72	0.48	3.97	5.02	0.45	2.29
K_2O	2.60	3.98	3.22	3.27	1.34	1.19	2.63	2.27	1.39	2.30	0.41
P_2O_5	0.08	0.03	0.07	0.03	0.53	0.35	0.37	0.13	0.11	0.17	0.07
H_2O^+	1.42	2.31	1.90	2.33	-	2.88	3.40	2.27	3.27	4.74	4.70
CO_2	2.93	0.15	0.23	0.14	-	0.36	4.67	0.81	0.07	0.66	1.48
SO_3	-	-	-	-	-	-	2.03	-	-	-	-
S	0.08	0.06	0.06	0.07	-	0.05	0.61	0.08	0.08	0.41	0.13
Total	99.79	99.66	99.56	99.57	100.04	99.13	101.00	99.56	99.16	98.16	100.58
LOI	-	-	-	-	3.63	-	-	-	-	-	

	P186	P209	P221	MR435	P201	P210	MC2A/D	P021	P011	P216	P219
SiO_2	71.07	73.85	72.17	74.86	79.88	74.20	71.57	52.73	51.16	51.84	49.86
TiO_2	0.60	0.61	0.17	0.11	0.12	0.26	0.23	0.36	0.60	0.49	1.52
Al_2O_3	15.28	14.19	15.36	11.67	13.03	13.40	12.21	16.12	14.20	13.57	14.49
Fe_2O_3	1.40	0.18	3.93	0.50	0.33	0.84	0.82	1.17	1.00	0.74	3/.07
FeO	0.94	1.33	1.00	0.97	0.49	1.78	1.46	6.48	7.22	7.09	8.78
MnO	0.04	0.04	0.01	0.06	0.01	0.06	0.07	0.15	0.16	0.16	0.20
MgO	0.54	0.27	0.24	0.47	0.39	0.33	1.62	8.04	10.14	10.68	8.00
CaO	0.19	0.30	0.02	2.91	0.03	0.14	2.99	12.42	7.96	10.18	8.80
Na_2O	5.87	7.28	0.04	1.53	0.11	4.13	0.22	1.72	2.56	1.31	3.32
K_2O	1.80	0.93	4.81	2.45	2.31	3.58	3.70	0.52	1.57	0.95	0.61
P_2O_5	0.11	0.13	0.02	0.03	0.02	0.04	0.16	0.11	0.14	0.18	0.26
H_2O^+	1.59	0.80	2.59	1.28	2.86	1.10	2.71	0.72	3.30	2.79	0.83
CO_2	0.28	0.14	0.08	2.31	0.14	0.17	1.67	0.22	0.22	0.11	0.43
SO_3	-	-	-	-	-	-	-	-	-	-	-
S	0.07	0.07	0.06	0.09	0.06	0.07	0.30	0.08	0.07	0.08	0.09
Total	99.78	100.12	100.50	99.24	99.78	100.10	99.73	100.83	100.30	100.17	100.26
LOI	-	-	-	-	-	-	-	-	-	-	-

* Total Fe expressed as Fe_2O_3

Mixed sequence dacites (continued)

P199 - dacite, Haulage Road at Switchback [CP930944]

P211 - altered dacite, Hellyer footwall zone 2 km NNE of Que River mine [CP927955]

P198 - dacite, Haulage Road just south of Switchback [CP928944]

P222 - dacite, Farrell-Waratah transmission line road [CP915952]

Upper basalts and andesites

MC1/B - basalt, drill hole MCH-1, 69.5 m (see figs 5, 8). Analysis provided by A.J. Stolz.

MR437 - basalt, Farrell-Waratah transmission line road [CP913959]

P116 - basalt pillow lava beneath Que River Shale, Hellyer Tunnel

P177 - basalt, South Charter track [CP891908]

P218 - grey lava, andesite or dacite, near South Charter track [CP891910]

P097 - basalt, 1 km west of Hellyer Portal [CP933951]

P115 - basalt, Haulage Road [CP932947]P177 - basalt, South Charter track [CP891908]

P218 - grey lava, andesite or dacite, near South Charter track [CP891910]

P097 - basalt, 1 km west of Hellyer Portal [CP933951]

P115 - basalt, Haulage Road [CP932947]

Sock Creek lavas

P186 - dacite, access track to Sock Creek [CP871928]

P209 - spherulitic vesicular lava, access track to Sock Creek [CP868928]

Felsic intrusives

P221 - spherulitic porphyry near Murrays Road [CP948980]

MR435 - spherulitic porphyry dyke, Hellyer Tunnel 289 m from portal.

P201 - spherulitic porphyry, 500 m NW of Switchback [CP930951]

P210 - quartz-feldspar porphyry near Sock Creek prospect [CP866928]

MC2A/D - quartz-feldspar porphyry on Mt Charter Fault, drill hole MCH-2A, 276.1 m, (see figs 5, 7)

Devonian (?) dolerites

P021 - 800 m NE of Hellyer [CP942965]

P011 - 1.5 km west of Hellyer [CP919965]

P216 - 1 km west of Mt Charter [CP890918]

Tertiary basalt (?)

P219 - 2.75 km WNW of Hellyer [CP906970]

APPENDIX B

Drill logs from Departmental drill holes in the Mt Charter area

The accompanying drill logs are for holes MCH-1, MCH-2A and MCH-3. The locations of the holes are shown on Figure 5 (p. 9), and cross-sections in Figures 6-8. The lower 200 m of MCH-1 was drilled by Aberfoyle Resources and kindly donated to the Department to serve as a reference section for the Que-Hellyer Volcanics.

Also included are fillet grind assays for the elements Cu, Pb, Zn, Ag, Au, Ni, As, Ba, Cr, Zr, Ti; done by Analabs for Aberfoyle Resources, for the complete MCH-1 core. Thin sections from this core and from MCH-2A, produced by Central Mineralogical Services for Aberfoyle Resources, are listed in the logs and are held by the Department.

MCH-1 – MT CHARTER

DIAMOND DRILL CORE RECORD	MCH–1 (MT CHARTER)		
PROJECT: Mt Read Volcanics	SURVEY DATA (Aberfoyle)		
OBJECTIVE: Stratigraphic section of the Que-Hellyer Volcanics and test of Hellyer ore position	DEPTH (m)	INCLINATION (°)	AZIMUTH (°)
PROPOSED BY: K. D. Corbett, P. Komyshan	0	67	133.7
LOGGED BY: K. D. Corbett	50	67.7	134
LOCATION: 500 m west of Mt Charter	100	68.1	134
MAP SHEET: Mackintosh – 44 (8014N)	150	68.3	133
AMG CO-ORDINATES: 389066.0 mE 5391201.9 mN	200	68	133
COLLAR R.L.: 754.4 m TOTAL DEPTH: 606.3 m	250	66.9	132.5
COLLAR DIP: -67° AZIMUTH: 133.7°	300	66	132.5
DATE COMMENCED: 30.6.1986 DATE COMPLETED: 26.9.1986	350	65.2	131.5
DRILL RIG: Longyear 38 No.2	400	64.8	130.5
DRILL CREW: Whamond and Barrett (Department of Mines).	450	64.4	130.5
Bottom 200 m drilled by Aberfoyle	500	63.2	131.5
HOLE SIZE:	550	61.6	133.5
HQ to 33 m	600	59.8	137
NQ to 532 m	606.3	59.5	137
BQ to end of hole			

DRILL CORE GEOLOGICAL RECORD – HOLE MCH-1 MT CHARTER

Depth (m)	Description	Sample and depth
0–10.6	Black pyritic shale and laminated siltstone – Que River Shale. Pyrite nodules on bedding planes. Bedding-core angles 55° at 7 m, 60° at 8.7 m. Interpenetrating contact with bleached, pale grey andesite below, with patches of dark cherty shale persisting to 12 m.	TS 56813 at 9.0 m
10.6–17.2	Andesite lava, prominently feldspar-phyric, pale to mid-grey, flow-banded in places. Flow-banding-core angles 60° at 14.5 m, 85° at 16.5 m.	TS 56814 at 14.4 m
17.2–57.7	Andesite breccia, pale grey, with abundant feldspar-phyric clasts. Patchy dark and light coloration becomes prominent below 20 m.	TS 56815 at 18.9 m TS 56816 at 36.0 m
57.7–65.0	Basalt lava, mid-grey, fine-grained, fairly massive and uniform. Few dark cherty bands and patches may be inter-pillow sediments. Prominently vesicular in parts.	
65.0–68.0	Basalt breccia, clasts up to 0.1 m, some inter-pillow cherty material.	
68.0–82.0	Mainly massive basalt lava, core very broken and quartz-veined in sections.	
82.0–84.0	Basalt breccia.	TS 56817 at 83.0 m
84.0–115.1	Mainly massive vesicular basalt to non-vesicular basalt, fine-grained, even-grained, mid-grey, broken in patches, some veins, some cherty inter-pillow material towards base.	TS 56818 at 109.9 m
115.1–116	Siltstone-shale, laminated, grey-black, with thin sandstone bands. Sharp contact with overlying basalt has angle of 50° to core axis. Bedding-core angle 55° at 115.6 m, 50° at 116 m. Irregular contact on underlying basalt breccia. Sponge spicules and radiolaria (?) in thin section at 115.2 m.	TS 56819 at 115.2 m TS 56820 at 115.8 m
116.0–121.5	Basalt breccia, broken and weathered, with empty vesicles and cavities, some grey shale-chert patches.	
121.5–130	Andesite(?) tuff and breccia, mostly small rather vague clasts and dark splotches; feldspar-rich. Patch of bedded sandy tuff at 127.3–127.8 m, with bedding-core angle 80°.	TS 56821 at 122.1 m TS 56822 at 127.4 m
130–141	Puggy fault zone at 141 m. Grey, sparsely feldspar-phyric rock, slightly wispy texture in places. Could be lava, either andesite or dacite.	
141–143	Pale grey to cream-coloured breccia, probably silicified. Darker clasts in pale matrix. Probably the top of dacite lava unit. Broken and weathered around 143 m.	
143–178	Dacite lava, pale to mid-grey, feldspar-phyric, flow-banded in many places. Banding-core angles 70° at 149 m, 60° at 151 m, 55° at 159 m, 45° at 165 m, 45° at 167 m.	TS 56823 at 154.8 m TS 56824 at 173.0 m
178–188.0	Epiclastic breccia, pink and green coloured, with pink (dacite?) clasts from few millimetres to more than 0.1 m. Some faint banding.	TS 56825 at 182.0 m
188.0–188.6	Tuff, bedded, grey-pink, sandy to fine-grained. Bedding-core angle 50°.	
188.6–196.2	Epiclastic breccia with some pink clasts, some dark green clasts, clasts down to few millimetres in size. Irregular contact with underlying basalt is sub-parallel to core axis.	
196.0–354.3	Basalt lava, massive, grey, fine-grained, even-grained, with sparse patches of breccia texture. Strongly vesicular in places. Abundant epidote as veins, blebs and vesicle-fillings in places. A few patches of pink albite alteration. Also veins and blebs of carbonate and chlorite. Rock is bleached almost to white for about 0.5 m at 241 m, with gradational change to grey-green colour on either side. Other bleached zones at 263 m and 272 m. Strongly sheared, cleaved and broken zone 294-296 m. Many white carbonate (± quartz) veins are perpendicular to core axis, range in width from 1–100 mm, most less than 10 mm. Another very broken zone at 347–349 m within otherwise very massive basalt.	TS 56826 at 241.6 m TS 56827 at 249.5 m
354.3–359.7	Sandstone, grey, massive, micaceous, quartz-rich. Resembles Animal Creek Greywacke. Contact with overlying basalt shows some downward penetration of wisps of chilled glassy basalt, but overall is ~ 85° to core axis. Good graded bedding at base of sand layer at 357 m shows up-hole facing, is exactly 90° to core axis. Another bedding in laminated silty unit at 356.8 m has angle of 65° to core axis. Contact with underlying andesite breccia has angle of about 70° with core axis.	TS 56828 at 356.0 m
359.7–379.0	Andesite breccia or tuff, feldspar-phyric, clasts from few millimetres to 50 mm mainly. Larger basalt-like clast (0.1 m) at 376.4 m.	TS 56829 at 360.7 m TS 56830 at 369.9 m
379.0–384.6	Interbedded thin flows of massive vesicular basalt and units of andesitic-basaltic breccia. Contacts mostly irregular to gradational.	TS 56831 at 379.9 m TS 56832 at 380.7 m
384.6–405.0	Basalt lava, mostly massive with a few patches of breccia, vesicular in part, with vesicles mainly carbonate-filled.	TS 56833 at 395.0 m

DRILL CORE GEOLOGICAL RECORD – HOLE MCH-1 MT CHARTER (continued)

Depth (m)	Description	Sample and depth
405.0–407.0	Andesite breccia with spotchy coloration. End of original hole – Department of Mines.	
407.0–416.5	Andesite breccia, grey-green, massive, clasts evident as darker chlorite-rich patches.	TS 57446 at 412.3 m
416.5–425	Andesite lava, paler grey, feldspar-phyric, some pale cherty material; finely jointed in patches with chlorite films on joints; very broken in parts.	
425–437	Andesite breccia with very faint breccia texture.	TS 57447 at 428.0 m
437–456	Mainly andesite lava with few breccia patches, some pale cherty areas, prominently feldspar-phyric from 448–455 m. Very broken from 440–442 m.	
456–470	Andesite breccia with prominent to faint breccia texture, patches with abundant pale cherty material surrounding darker clasts, particularly 458–460 m.	TS 57448 at 460.0 m
470–491.5	Andesite lava, pale to mid-grey, slightly vesicular in part. Flow-banding at 484 m has angle of 45° to core axis. Fairly massive, uniform, fine-grained, looks a bit like basalt but probably too pale. Becomes paler due to 'quellite' alteration towards lower contact, as in footwall andesite at Hellyer (A.M. Hespe, pers. comm.) Irregular, chilled-looking contact on underlying siltstone has 30° angle with core axis.	TS 57449 at 478.6 m TS 57450 at 489.0 m
491.5–497.2	Siltstone, grey, massive, grading down to fine sandstone. Tuffaceous, with some fine mica also. Fist clear bedding at 494.4 m makes angle 65° to core axis. Good bedding at 495.4 m has angle 55° to core axis, also 58° at 496.6 m. Small pale carbonate flecks in places resemble 'vesicles'. Sharp, scalloped margin on underlying andesite has angle of about 50° to core axis.	TS 57451 at 493.0 m TS 57452 at 496.0 m
497.2–498.7	Andesite lava, dark green-grey, massive, feldspar-phyric. Sharp contact on underlying unit has angle of 45° to core axis.	
498.7–501.1	Basalt (?) lava, pale grey-fawn, very fine-grained, showing quench-breccia texture over about two-thirds of length, with sub-rounded clasts separated by pale carbonate cement. Looks like 'dacite' but thin section shows pilotaxitic microlath texture in plagioclase and chlorite, with basaltic affinities. Rock is bleached, probably hyaloclastic lava breccia. Irregular, inter-penetrating contact with underlying andesite unit.	TS 57453 at 499.8 m
501.1–518.0	Andesite lava and lava breccia. Patches and lenses of fine-grained wispy cherty material may be secondary silicification. Dark grey-green, feldspar-phyric. Sharp contact with underlying sandstone has angle 25° to core axis.	TS 57454 at 514.0 m
518.0–524.2	Interbedded grey tuffaceous sandstone and darker grey siltstone; some thick beds of medium to coarse-grained sandstone, some thinly laminated parts. Good erosional contact at 518.5 m indicates uphole facing. Bedding-core angle 50° at 518.5 m, 65° at 520 m. Good uphole facing at 523.2 m from grading and erosional base.	
524.2–538	Coarse crystal-lithic tuff grading to massive medium-grained crystal-lithic tuff, greenish-grey, with fine chlorite flecks and a few recognisable small clasts. Probably andesitic; feldspar-rich, with chlorite and carbonate alteration. Sharp contact with underlying basalt has angle of 50° to core axis.	TS 57455 at 524.6 m
538–540	Basalt lava, fine-grained, faintly vesicular, massive, dark grey. Bottom 0.1 m is paler-coloured and chilled, has strongly scalloped contact on underlying tuff.	TS 57456 at 539.7 m
540–541.6	Tuff, crystal-lithic, grey-green, andesitic, fairly massive, medium-grained.	
541.6–543.8	Bedded tuffaceous sandstone with some grey silty interbeds. Some beds very pyrite-rich, with 2-5% pyrite showing. Erosional contact indicates uphole facing at 542 m. Bedding-core angles 55° at 542 m, 50° at 543.5 m. Good grading and erosional base at 543.7 m.	
543.8–547	Tuff, thick-bedded, coarse to medium-grained – could be tuffaceous sandstone.	
547–559	Interbedded to laminated tuffaceous sandstone and grey siltstone. Bedding-core angles 40° at 554 m, 50° at 557 m. Probable radiolaria in thin section.	TS 57457 at 551.4 m
559–606.3	Interbedded mid-grey quartzose micaceous sandstone and dark grey siltstone. Well-bedded to laminated with thicker sandstone beds to 3 m or so. Several uphole facings. Unit with abundant small shale clasts from 579.8-581.3 m. Bedding-core angles: 40° at 564 m, 45° at 572 m, 60° at 575.8 m, 50° at 579.8 m, 45° at 594 m, 20° at 601m, 40° at 604 m.	TS 57458 at 562.9 m TS 57459 at 567.6 m
	End of hole. *K. D. Corbett*	

DRILL CORE GEOCHEMICAL DATA – HOLE MCH-1 MT CHARTER

Interval		Metal content											
from (m)	to (m)	Cu	Pb	Zn	Ag	Au	Ni	As	Ba	Cr	Zr	Ti	Comments
0.0	10.4	80	25	115	0.5	<0.008	65	61	760	100	130	3300	Que River Shale
10.4	15.2	35	10	85	<0.5	<0.008	40	72	1400	<5	230	2350	
15.2	20.2	110	55	400	<0.5	<0.008	45	16	1650	9	210	2100	
20.2	30.2	125	30	840	<0.5	<0.008	50	23	1400	<5	190	1950	
30.2	40.2	115	<5	240	<0.5	<0.008	25	11	400	5	190	1900	andesite
40.2	50.2	90	<5	270	<0.5	<0.008	30	8	1450	<5	210	1800	
50.2	57.7	120	85	660	<0.5	<0.008	50	13	1500	65	200	1950	
57.7	65.0	255	160	570	0.5	<0.008	130	13	1400	420	140	2600	
65.0	68.0	160	30	285	0.5	<0.008	150	63	930	460	130	2700	
68.0	81.4	235	15	440	<0.5	<0.008	195	40	980	620	110	2600	
81.4	86.7	160	<5	170	<0.5	<0.008	125	15	980	410	130	2600	basalt
86.7	100.2	215	20	190	<0.5	<0.008	135	13	1200	440	120	2700	
100.2	104.5	195	15	185	<0.5	<0.008	160	59	1100	500	130	3000	
104.5	115.1	250	<5	380	<0.6	<0.008	145	8	1250	360	110	2300	
115.1	116.0	215	185	635	0.5	<0.008	110	73	1900	300	160	3200	siltstone
116.0	120.5	275	120	680	<0.5	<0.008	305	88	880	1050	70	2350	basalt
120.5	135.0	130	5	350	<0.5	<0.008	35	65	1400	30	230	2050	andesite tuff
135.0	145.0	185	<5	260	<0.5	<0.008	45	6	900	<5	230	2150	
145.0	155.0	735	<5	690	<0.5	<0.008	115	5	1500	45	180	1650	
155.0	165.0	1500	<5	1250	<0.5	<0.008	180	10	1600	<5	220	2000	dacite
165.0	178.0	545	<5	600	<0.5	<0.008	95	3	1150	20	220	1950	
178.0	188.0	205	<5	230	<0.5	<0.008	35	2	1250	<5	240	1850	epiclastic
188.0	195.7	280	<5	290	<0.5	<0.008	50	4	1350	25	220	2350	breccia
195.7	205.0	105	<5	270	<0.5	<0.008	40	11	1050	65	150	5800	
205.0	215.0	95	10	460	<0.5	<0.008	40	10	940	70	140	5750	
215.0	225.0	125	10	505	<0.5	<0.008	35	4	1250	55	140	5450	
225.0	235.0	55	15	480	<0.5	<0.008	45	3	1250	50	140	5150	
235.0	245.0	100	105	1250	0.5	<0.008	45	2	820	70	150	5600	
245.0	255.0	205	50	450	<0.5	<0.008	55	4	940	65	150	5650	
255.0	265.0	170	50	360	<0.5	<0.008	55	2	1050	65	150	5400	
265.0	275.0	360	30	665	<0.5	<0.008	80	6	730	50	130	4600	basalt
275.0	285.0	215	20	405	<0.5	0.017	55	5	820	60	120	4450	
285.0	295.0	105	20	320	<0.5	<0.008	45	4	750	70	150	4900	
295.0	305.0	110	60	845	<0.5	<0.008	40	18	1150	75	140	5100	
305.0	315.0	25	15	190	<0.5	<0.008	30	5	620	50	130	4650	
315.0	325.0	25	10	250	<0.5	<0.008	85	2	690	60	130	5200	
325.0	335.0	35	10	235	<0.5	<0.008	30	3	520	50	140	5350	
335.0	345.0	10	10	125	<0.5	<0.008	35	4	750	55	120	4800	
345.0	354.3	10	10	130	<0.5	<0.008	35	6	420	75	130	5450	
354.3	359.7	45	195	2250	0.5	<0.008	260	34	230	430	170	2150	sandstone
359.7	369.7	280	<5	330	<0.5	<0.008	100	5	880	120	210	2500	andesitic
369.7	378.9	9200	5	7750	<0.5	<0.008	1550	4	850	100	200	2350	breccia-tuff
384.6	394.6	85	360	500	0.5	0.058	110	10	930	420	160	2600	basalt
394.6	399.8	265	25	505	<0.5	<0.008	135	11	780	370	140	2450	
407.0	417.0	1050	20	1050	<0.5	0.008	215	11	210	75	180	2500	
417.0	425.0	1900	20	1850	<0.5	0.008	370	3	490	7	180	2150	
425.0	435.0	615	10	650	<0.5	<0.008	135	5	540	15	190	2200	
435.0	447.6	1750	10	1650	<0.5	0.008	325	4	570	6	190	2200	
447.6	454.0	840	10	830	<0.5	0.008	195	6	390	5	190	2350	andesite
454.0	459.7	645	15	680	<0.5	0.008	170	8	700	8	190	2300	
459.7	463.5	1300	20	1400	<0.5	0.008	315	34	1250	40	190	3200	
463.5	470.0	510	15	590	<0.5	<0.008	145	12	860	8	170	3000	
470.0	480.0	355	15	280	0.5	<0.008	80	6	700	30	170	2850	
480.0	491.5	325	15	350	<0.5	<0.008	90	8	1050	15	170	2750	
491.5	494.2	425	15	480	<0.05	<0.008	135	19	900	45	160	2150	siltstone
494.2	497.2	2050	10	2000	<0.5	<0.008	485	8	1100	50	170	2250	
497.2	498.5	1500	15	1600	<0.5	<0.008	355	12	1200	30	170	3450	andesite
498.5	500.8	285	25	320	0.5	<0.008	85	16	410	55	140	4850	basalt
500.8	510.0	245	15	270	<0.5	<0.008	75	9	690	15	150	3700	andesite
510.0	518.1	620	10	650	<0.5	<0.008	170	8	640	25	150	3250	
518.1	528.0	455	15	590	<0.5	<0.008	135	8	360	70	130	3850	
528.0	538.0	330	15	390	<0.5	<0.008	105	4	1450	25	150	5300	tuff and
538.0	548.0	200	10	233	0.5	<0.008	90	9	390	75	130	4300	tuffaceous sandstone
548.0	561.7	360	25	390	1.0	<0.008	140	16	440	170	150	2500	
561.7	570.0	140	40	160	0.5	<0.008	105	29	300	350	190	2350	
570.0	580.0	205	50	220	0.5	<0.008	280	19	100	290	180	2800	Animal Creek
580.0	590.0	390	20	470	<0.5	<0.008	220	11	290	390	170	2500	Greywacke
590.0	606.3	130	15	150	<0.5	<0.008	260	12	340	330	200	2900	
Analytical technique		101	101	101	101	309	101	114	401	401	401	401	
Detection limit		5	5	5	0.5	0.008	5	1	10	5	5	50	

Laboratory: Analabs

Sample type: Fillet grinds done for Aberfoyle

MCH-2A – MT CHARTER

DIAMOND DRILL CORE RECORD	MCH–2A (MT CHARTER)		
PROJECT: Mt Read Volcanics	SURVEY DATA (Aberfoyle)		
OBJECTIVE: To determine the attitude of the Mt Charter Fault and examine Que-Hellyer Volcanics in vicinity of fault	DEPTH (m)	INCLIN-ATION (°)	AZIMUTH (°)
PROPOSED BY: K. D. Corbett	0	-58.6	356.8
LOGGED BY: A. McNeill, K. D. Corbett	50	-60	358.2
LOCATION: South Charter Track 600 m west of Mt Charter	100	-59.1	359.8
MAP SHEET: Mackintosh – 44 (8014N)	150	-57.6	361.6
AMG CO-ORDINATES: 388987.70 mE 5390999.7 mN	200	-56.1	362.9
COLLAR R.L.: 743.0 m TOTAL DEPTH: 376.45 m	250	-54.4	362.5
COLLAR DIP: -58.6° AZIMUTH: 356.8°	300	-53.4	360.7
DATE COMMENCED: 13.10.1986 DATE COMPLETED: 19.12.1986	350	-52.6	361.7
DRILL RIG: Longyear 44	376	-52.0	363.3
DRILL CREW: Mitchell and Schier			
HOLE SIZE: HQ to 30 m NQ to 376 m			

DRILL CORE GEOLOGICAL RECORD – HOLE MCH-2A MT CHARTER

Depth (m)	Description	Sample and depth
0–275.5	Interbedded grey micaceous sandstone and dark grey to black siltstone and shale. Some thick-bedded to massive sandstone zones, some thinly laminated shale-rich zones. Some zones of contorted lamination and slumping. Shale unit at 152.4-155 m shows flame structures suggesting downhole facing. Micro-faulting and brecciation in places. Strongly cleaved in part. Cleavage-core angle 10° at 154 m. Bedding-core angle 35° at 161 m, downhole facing indicated by load casts. Shale clasts in greywake at 164 m. Graded bedding at 179 m indicates dowhole facing, bedding-core angle 22°. Thick quartz-carbonate vein (0.8 m) at 181.5 m. Highly veined and brecciated at 199 m. Bedding-core angle 30° at 191 m, 16° at 204 m, 24° at 225 m. Probable downhole facing at 235 m from load structures. Laminated and contorted zone at 250-252 m, has bedding-core angle less than 10°, cleavage-core angle less than 10°. Bedding-core angle 5° at 267 m. Strong quartz-carbonate veining, with shearing and faulting, at 272-274.4 m. Puggy clay zone from 274.45-274.5 is a fault, associated with quartz veining in shale on either side.	TS 57359 at 203.8 m TS 57360 at 258.8 m
275.5–280.0	Felsic porphyry, pale greenish-grey. Has welded irregular contact against black shale above – probably an intrusive contact, not a fault. Has an inclusion of black shale from 278.9-279.2 m, with very irregular, inter-penetrating contacts which also look intrusive, not faulted. The porphyry is quartz-feldspar-phyric, fairly strongly cleaved, looks sericitic and altered. Contact with lava unit below is marked by a single quartz vein, with minor carbonate, 50 mm wide, making angle of about 45° with core axis.	TS 57361 at 276.5 m
280.0–310.2	Mid-grey to pale grey lava, possibly dacite; flow-banded in few places; quite pale and dacitic-looking from 296-299 m. Few small breccia zones. Sparsely to strongly feldspar-phyric. Splotchy dark and light green-grey coloration in places. Carbonate-quartz-chlorite veining.	
310.2–376.45	Basalt lava, fine-grained, grey-green, sparsely to strongly vesicular. Some breccia zones. Patch of inter-pillow-type cherty dark grey ash from 315.6–316.5, with veinlets and blebs of galena, sphalerite and chalcopyrite. Mainly basalt breccia from 340.8–345 m, where core is very broken. Good example of vesicular pillow margin against inter-pillow chert at 333.35 m.	TS 57362 at 290.3 m TS 57363 at 298.1 m
	End of hole. *K. Corbett, A. McNeill*	TS 57364 at 312.2 m TS 57365 at 322.7 m

MCH-3 – MT CHARTER

DIAMOND DRILL CORE RECORD		MCH–3 (MT CHARTER)		
PROJECT: Mt Read Volcanics		SURVEY DATA		
OBJECTIVE: To determine the attitude and nature of contact between Animal Creek Greywacke and Central Volcanic Sequence		DEPTH (m)	INCLIN-ATION (°)	AZIMUTH (°)
PROPOSED BY: K. D. Corbett		Not surveyed		
LOGGED BY: A. McNeill, K. D. Corbett				
LOCATION: South Charter Track, 750 m WSW of Mt Charter				
MAP SHEET: Mackintosh – 44 (8014N)				
AMG CO-ORDINATES: 388853.0 mE 5390891.3 mN				
COLLAR R.l.: ~715 m	TOTAL DEPTH: 74 m			
COLLAR DIP: -59.6°54′	AZIMUTH: 222.5°			
DATE COMMENCED: 23.3.1987	DATE COMPLETED: 3.4.1987			
DRILL RIG: Longyear 38				
DRILL CREW: Whamond and Barrett				
HOLE SIZE: HQ to end of hole (74.0 m)				

DRILL CORE GEOLOGICAL RECORD – HOLE MCH-3 MT CHARTER

Depth (m)	Description
0.0-2.6	No core
2.6-6.8	Grey siltstone and micaceous fine sandstone, strongly cleaved and sheared, with bedding disrupted by cleavage. Includes some fine-grained vitric ashy siltstone. Cleavage-core angle 45° at 2.7 m.
6.8-10.8	Brown-tan-pink coloured fine siltstone and ashy siltstone. Cleavage-core angle 40° at 7.2 m.
10.8-19.3	Grey to fawn siltstone with tuffaceous feldspar-phyric sandstone layer from 12.5 to 13.1 m, with sole marks indicating uphole facing at 13.1 m. Bedding-core angle 30° at 13.1 m. Very broken zone from 15.5-17.0 m with chips of cleaved shale – seems to have broken on the cleavage planes, not a major fault. Another similar broken zone 18.4-19.0 m with cleavage plates of shale.
19.3-20.8	Pale pink vitric ash and ashy siltstone, strongly cleaved. Cleavage-core angle 25°.
20.8-24.0	Micaceous siliceous sandstone, grey-pink-brown, with brown staining and weathering on joints and cleavage.
24.0-26.0	Lot of core loss, with fragments of vein quartz and sandstone - could be a fault.
26.0-36.0	Interbedded grey-fawn micaceous siliceous sandstone and grey siltstone; bedding and facings very variable, indicating folding. Very broken core in places and some core loss, but no obvious faults. Cleavage-core angle 20° at 34.5 m.
36.0-36.1	Vein quartz, with irregular penetrating contact with lava below. Sandstone above is very broken for 0.4 m.
36.1-69.9	Rhyolitic volcanic (mainly lava ?), pink to pale greenish grey, fine-grained, strongly cleaved, moderately weathered and MnO_2-stained, sericite-rich. Lots of small quartz veins. Mostly feldspar-phyric. Cleavage-core angles 40° at 37 m, 35° at 39.8 m.
69.9-74.0	Dark green-grey, brown-weathering, fine-grained andesite(?). Closely brecciated for first 0.6 m. Probably a dyke.
	End of hole. *A. McNeill, K. D. Corbett*

GEOLOGICAL SURVEY OF TASMANIA–DEPARTMENT OF MINES–HOBART

MT READ VOLCANICS PROJECT 1986

SAMPLE LOCALITY MAP OF THE MT CHARTER–HELLYER AREA

P. KOMYSHAN. B.Sc (Hons.)

1 0.5 0 1 2 km

SCALE 1 : 25000

Field No.	Mines Dept. Cat. No.	Field No.	Mines Dept. Cat. No.	Field No.	Mines Dept. Cat. No.	Field No.	Mines Dept. Cat. No.
P001	C101175	P051	C101008	P104	C101042	P181	C101150
P003	C101176	P052	C101127	P105	C101043	P182	C101151
P004	C101177	P053	C101009	P106	C101044	P185	C101152
P005	C101178	P059	C101010	P108	C101039	P186	C101111
P006	C101179	P060	C101011	P109	C101170	P188	C101153
P007	C101180	P061	C101012	P115	C101101	P189	C101154
P008	C101181	P063	C101013	P116	C101102	P190	C101155
P010	C101182	P064	C101014	P117	C101103	P191	C101112
P011	C101168	P065	C101015	P130	C101130	P192	C101113
P013	C101183	P066	C101016	P133	C101172	P193	C101114
P015	C101184	P067	C101017	P134	C101131	P194	C101115
P016	C101185	P068	C101018	P135	C101104	P195	C101156
P017	C101186	P069	C101019	P136	C101132	P196	C101116
P018	C101187	P070	C101020	P137	C101133	P197	C101157
P020	C101188	P072	C101021	P138	C101134	P198	C101117
P022	C101189	P073	C101022	P139	C101135	P199	C101118
P023	C101190	P074	C101023	P143	C101105	P200	C101121
P024	C101191	P075	C101024	P145	C101136	P201	C101122
P025	C101192	P077	C101025	P146	C101137	P202	C101119
P026	C101193	P081	C101026	P149	C101106	P206	C101158
P027	C101194	P082	C101027	P150	C101107	P208	C101159
P028	C101195	P083	C101028	P155	C101138	P209	C101120
P029	C101196	P084	C101029	P158	C101139	P210	C101123
P031	C101125	P085	C101030	P160	C101108	P211	C101124
P038	C101126	P087	C101031	P161	C101140	P212	C101174
P039	C101197	P088	C101032	P162	C101141	P215	C101160
P040	C101198	P090	C101033	P166	C101109	P216	C101161
P041	C101199	P091	C101034	P168	C101142	P217	C101173
P042	C101200	P093	C101035	P169	C101143	P218	C101162
P044	C101001	P094	C101036	P170	C101144	P219	C101163
P045	C101002	P095	C101045	P173	C101145	P220	C101164
P046	C101003	P096	C101128	P175	C101146	P221	C101165
P047	C101004	P097	C101037	P177	C101110	P222	C101166
P048	C101005	P099	C101038	P178	C101147	P223	C101167
P049	C101006	P102	C101040	P179	C101148		
P050	C101007	P103	C101041	P180	C101149		

Sample numbers from underground mines:

1. Hellyer - P087, P088, P116, P117
2. Que River - P136 to P139

LEGEND

- ● Thin sectioned
- ■ Assayed
- ▲ Thin sectioned and assayed

5 cm

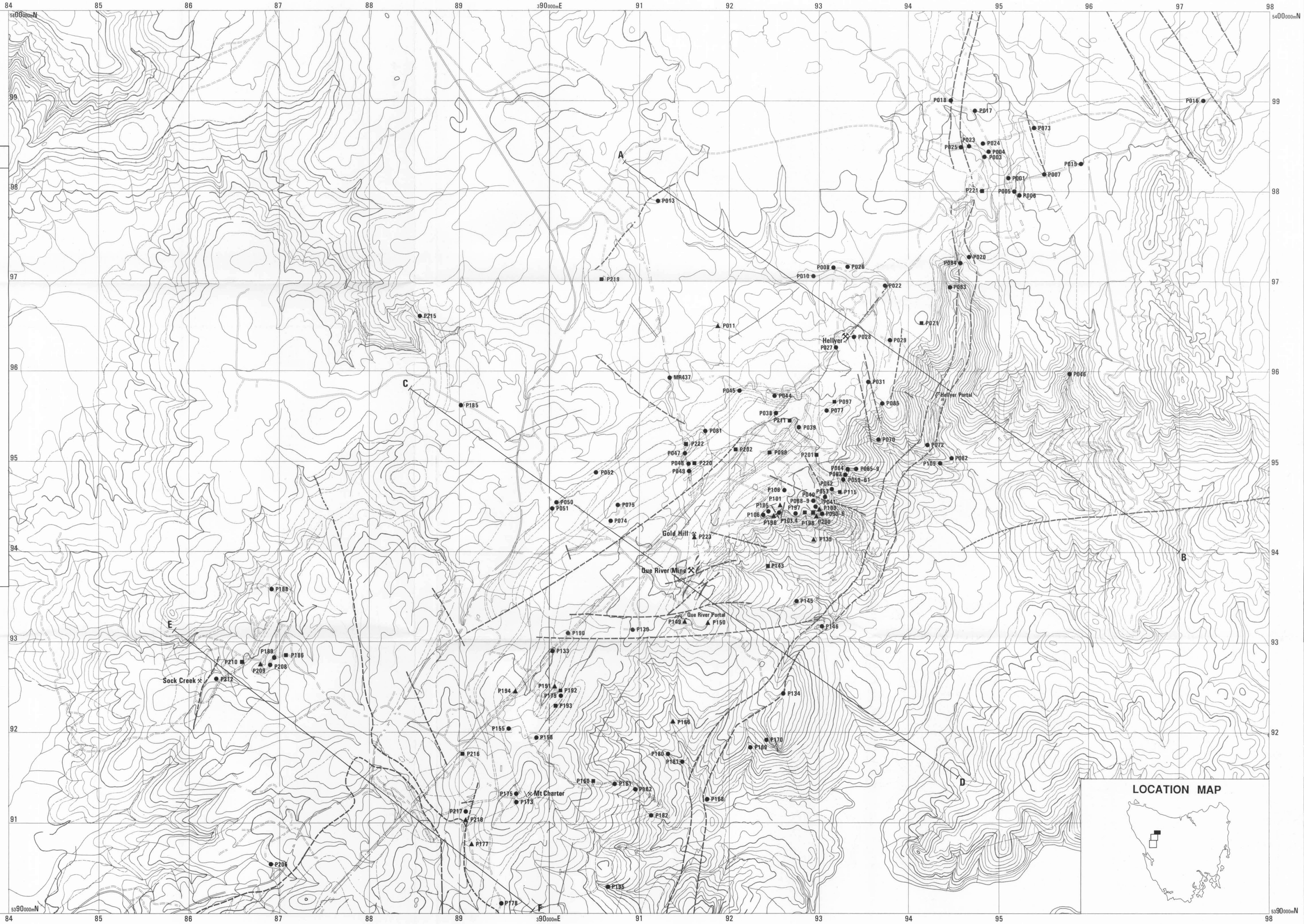

Figure 2.