**A REPORT FOR ZINIFEX ROSEBERY MINE**

# A COMPILATION AND INTERPRETATION OF THE GEOLOGY OF THE BURNS PEAK AREA

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**SUMMARY**

1. This report describes the geology of the Burns Peak area between the Marionoak River and the syncline east of Burns Peak as determined from a mapping – compilation – drill logging exercise carried out by the author for Zinifex Rosebery Mine during March-July 2005. A similar exercise has been done concurrently on the North Pinnacles area and is reported separately.

2. Considerable use has been made of drill hole information to compensate for the poor outcrop over much of the area. Some 55 holes have been re-logged in summary form to provide a consistent interpretation of lithologies, and much of this information has been shown in plan projection form at 1:5,000 scale.

3. The geology of the area is dominated by rock units lying immediately above the Central Volcanic Complex and beneath the local equivalents of the Que River Shale and Southwell Subgroup, including the Hollway Andesite body, the Boco Road dacite, the Pinnacles Rhyolite, the Browns Tunnel Host Sequence of volcaniclastic sediments with intercalated felsic to andesitic flows, and a complex of interfingering pumice breccias, felsic flows and breccias, and volcaniclastic sediments on the Boco Road around Pinnacles Ridge. This diverse group of semi-contemporaneous volcanic and sedimentary rocks is incorporated into a new unit herein termed the ***Burns Peak Subgroup***, being more or less equivalent to the Que-Hellyer Volcanics.

4. Quartz-feldspar porphyry bodies are an important component of the geology in the area, with multiple sills and flows present in the Southwell Subgroup, Que River Shale, Burns Peak Subgroup, and the upper CVC. Some sulfide mineralisation and silica-sericite alteration is associated with the margins of some of these bodies.

5. Structurally, the area is dominated by the Devonian N-S Rosebery Fault system, which here splits into several sub-parallel splays, with ‘hangingwall’ and ‘footwall’ faults recognized, and a series of NE-trending Devonian structures, the main one being a corridor of strongly deformed rocks, including the Browns Tunnel sediments, bounded on its eastern side by the steeply-dipping Burns Peak Shear Zone. In addition to the large NE-trending syncline cored with Southwell Subgroup rocks immediately east of Burns Peak, there appears to be an anticlinal fold in the western margin of the Hollway Andesite, and a synclinal fold which terminates the lower part of the andesite (with abundant felsic intercalations) just south of the Hollway Rivulet.

6. VHMS-type Pb-Zn mineralisation is present within the Browns Tunnel Host Sequence, marked by banded sulfides, cherty host sediments and many occurrences of detrital sulfide clasts in sediment units (seen in at least 4 drill holes), but there has been considerable tectonic modification, disruption and remobilization of sulfides and alteration minerals during the Devonian deformation.

## INTRODUCTION

### Scope of Project

The author was contracted in March, 2005, to produce a coherent geological interpretation and geological map of the Burns Peak area which fitted with previous Pasminco/Zinifex mapping in the Boco-Hollway and Shale Basin- North Pinnacles areas. This was to include a compilation of previous outcrop mapping, review and relogging of old drill cores as necessary, and new mapping to resolve conflicts in existing interpretations. A second phase of the project was to produce new interpretive cross-sections of the Browns Tunnel – Southern Trenches area to allow for planning of further resource drilling. A review and report, with maps, on the North Pinnacles area, was to be done concurrently.

As the project developed it became clear that a great deal of relogging of drill core would be required, since some 90 or more diamond holes had been drilled in the area since the 1960's, many of which would need to be viewed if a coherent and consistent interpretation was to be reached. Consequently, 55 holes (up to 650m depth) were relogged (34 held at MRT Mornington, 21 at Tullah) in summary form, and summary graphic logs plotted. This information, much of it plotted as drill hole projections on a geological map (fig. 2 ), proved critical in deciphering the complex geology.

In addition, most of the important outcrops and road/track sections were re-mapped, all previous fact and interpretation maps were consulted, and a large number of previous reports on the geology and exploration were examined. In the end, it was agreed that an initial report would cover the general geology of the area (herein), and a follow-up report would deal with the highly complex Browns Tunnel – Southern Trenches zone and the cross-sections thereof. A report on the North Pinnacles area (EL 23/2000) extends the geological interpretation into that area. This report is accompanied by a 1:5,000 scale geological outcrop map, a 1:5,000 scale geological interpretation map showing projections of many of the drill holes in the area, and a 1:10,000 scale geological summary map.

### Previous Work

A complete review of previous exploration in the area will be given in a later report on the Browns Tunnel area. Historical summaries of exploration are contained in Rosenhain and Mathison (1989), Lorrigan (1990), Poltock and Saxon (1994), Weber et al (1997) and McNeill (2001). Exploration has been ongoing in the Pinnacles area since the 1940's, when EZ Co created access to the area and drilled some 13 shallow holes. Rio Tinto followed in the 1950's (EL 4/59) with various surveys, followed by Comstaff in the 1960's and 1970's (EL 5/63), when several phases of gridding and drilling were done. EZ Co was involved in several joint ventures in the area from the late 1970's, including with BHP in 1986, when blanket UTEM coverage was done.

Drilling of the BPD series of deep holes by Pasminco commenced in the late 1980's, as interest expanded from the Browns Tunnel area to the areas north and east of Burns Peak, and continued into the mid-1990's. Interest was re-focussed on the Southern Trenches – Browns Tunnel area and the possible open-pittable resources in the late 1990's, when detailed drilling programs were followed by mining of approximately 15,000 tonnes of zinc-lead ore at Southern Trenches. Resource drilling was also undertaken at Browns Tunnel, but was not followed by mining (Edwards et al, 1998; McNeill, 2001).

Fairly detailed mapping of the area was carried out for the Mt Read Volcanics Project (MRVP) in the mid-1980's (Corbett and McNeill, 1986), and further mapping of the Boco Road – Burns Peak area by Reid (1990) and the Hollway Andesite area by Coutts (1990). Company mapping has covered the Burns Peak area (e.g. Lorrigan, 1990; Kirsner, 1992; Poltock and Saxon, 1994), and there has been recent mapping of the Boco – Hollway area by McNeill (2002).

Mapping for the Mt Read Volcanics Project established much of the framework of the geology, but placed too much of the rock sequence into the CVC. The strong links to Que-Hellyer geology were brought out by the work of Reid (1990), Coutts (1993) and McNeill (2002), who recognized the correlates of the Animal Creek Greywacke, Sock Creek dacite, Que River Shale, Southwell Subgroup and Que-Hellyer andesites/basalts . However, the stratigraphic affinities of the Pinnacles Rhyolite body have remained uncertain (McKibben, 1993), and the stratigraphic and structural relationship of the mineralized host rock sediments of the Browns Tunnel area, particularly to the Que-Hellyer units on the eastern side of Burns Peak, have also been difficult to determine. Regional studies have also clarified the general geological setting (e.g. Corbett, 2002)

The large amount of drilling data now available, particularly in areas of little or no surface outcrop (mainly because of the extensive cover of glacial moraine), greatly facilitates the geological interpretation, and makes it possible to prepare an updated map with some confidence, although significant uncertainties remain. Fact maps or outcrop maps compiled by previous workers, particularly Poltock and Saxon (1994) and Kirsner (1992), have been invaluable, as have early notes made by the author in the 1980's, when many of the bulldozed tracks had reasonable outcrop as opposed to the present regrowth scrub cover.

## REGIONAL SETTING AND MAJOR STRUCRURAL FEATURES

The Burns Peak – Pinnacles Ridge area represents a major strategic 'turning point' in the Mt Read Volcanics belt, where the trend of the main part of the belt, the Central Volcanic Complex (CVC), swings from its northerly trend through Rosebery and Mt Kershaw to a north-easterly trend towards Sock Creek, Mt Charter and the Que-Hellyer area. This major bend may be a primary depositional feature related to the parallel bend in the margin of the Tyennan Precambrian block well to the east, but the feature has clearly influenced and been overprinted by tectonic effects related to the Devonian Tabberabberan Orogeny. Some of the major tectonic features are listed below.

(i) The Rosebery Fault, a major Devonian 40-45° east-dipping thrust fault controlling the western margin of the CVC where it over-rides younger Late

Cambrian Owen Group correlates, divides into several sub-parallel faults at the level of the Southern Trenches. The two major faults, referred to as the 'footwall' and 'hangingwall' Rosebery Faults, are about 600m apart where they cross the Boco Road heading for the Silver Falls area. At least one other major fault is present within the Rosebery Fault complex, and a probable fault along the western margin of the Pinnacles Rhyolite body in this area is likely to be another 'splay' from this system.

(ii) A major NE-trending fault zone, referred to as the Burns Peak Shear Zone, originates in a broad area of sheared CVC rocks adjacent to the Rosebery Fault in the Cone Hill area. It may also be a splay from the latter, but the presence of CVC rocks on the western side into the Burns Peak area suggests west-side-up movement is perhaps more likely, implying that it might represent a conjugate fault to the west-directed thrusts. It is poorly exposed but appears to be sub-vertical or steeply east-dipping, with drag folding on the Hollway Andesite indicating a dextral component to the movement.

(iii) The Burns Peak Shear Zone forms the eastern margin of a 600m-wide NE-trending corridor of sheared rocks between Burns Peak and the Browns Tunnel area, dominated by intermixed CVC pumice breccias and younger sediments of the Browns Tunnel Host Sequence. The sediments and pumice breccias are folded into a complex anticlinal structure (referred to as the 'Pinnacles Anticline' or 'Pinnacles Axis'), indicated by reversal of facing across the area, but the precise location of the fold axis is difficult to determine. The relatively massive Pinnacles Rhyolite unit, of rhyolite flows and breccias mainly younger than the Browns Tunnel sediments, forms a broad competent zone west and north of the corridor of deformed rocks, but its contact with the sediments is poorly exposed at surface and of uncertain character.

(iv) Cleavage and shear planes within the corridor are mostly NE-trending and steeply dipping, but a later cross-cutting set of SE-trending steep faults appears to be important in controlling the distribution and continuity of the sediment zone in the Boco Road area. A detailed structural study of the Browns Tunnel area by Elliott (1990) showed rock distribution to be largely controlled by the abundant small faults, with the larger structures suggesting a steepened west-directed thrust fault situation – again possibly related to the Rosebery Fault movements.

(v) A major NE-trending Devonian synclinal structure lies immediately east of the Burns Peak Shear Zone (BPSZ). The NW extremity of the Hollway Andesite body appears to be folded around this syncline, before being truncated against the BPSZ. The syncline may in part be developed on a narrow depositional basin, as suggested by the apparent thickening of the Que River Shale correlate (and an associated porphyry body) around the core of the fold, and the wedging out of the shale on the western flank south of Boco Road. Sedimentary units of the Southwell Subgroup occupy the core of the fold in this area, with basal conglomerates on Pinnacles Rhyolite on the western flank indicating that the rhyolite complex formed a basement high during at least part of the depositional period.

(v) Other NE-trending Devonian folds appear to be present in the Hollway Rivulet area, with an anticlinal core of CVC rhyolitic rocks indenting the western margin of the Hollway Andesite, and a probable synclinal fold responsible for the fingering out of the andesite just south of the Rivulet.

## STRATIGRAPHY

### Stratigraphic Sequence

The stratigraphy in the Burns Peak area is best considered in terms of youngest to oldest units, and is summarized as follows:

Top (1) *Owen Group correlates of Late Cambrian age west of the Rosebery Fault*: marine sequence of quartzwacke (Stitt Quartzite correlate), polymict sandstones, siltstones, shales and polymict conglomerates. Exposed along Boco Road and in Marionoak River, and seen in several drill holes (e.g. BPD82; CP14). Typically strongly folded and sheared close to the fault zone. Not examined in detail in this study.

(2) *Southwell Subgroup* (= White Spur Formation): volcaniclastic sandstone-siltstone- shale- minor conglomerate marine sequence. Occupies large synclines on either side of the Pinnacles Ridge, and two or more fault slices within the Rosebery Fault zone.

(3 *Que River Shale correlate*: only recognized in the eastern syncline. Black shale with interbedded siltstone and minor sandstone. Typically closely associated with quartz-feldspar porphyry bodies.

(4) *Quartz-feldspar porphyry intrusive-extrusive bodies*: the main one of these is almost strata-bound within the Que River Shale, but a second major body is present on Burns Peak, and a number of smaller bodies in the Browns Tunnel – Southern Trenches area.

(5) *'Burns Peak Subgroup'* : this new unit has been established to encompass the highly variable sequence of felsic lavas, andesites, and volcaniclastic sediments below the Que River Shale and above the Animal Creek Greywacke correlate. It includes the Hollway Andesite, Boco Road dacite, Pinnacles Rhyolite, Browns Tunnel sediments, and a complex of interfingered sandstones, pumice breccias, and felsic lavas and breccias (in part from the Pinnacles Rhyolite) north of Burns Peak. Pumice breccias underlying and interfingering with the Browns Tunnel sediments are tentatively placed in the CVC, although they have obviously been an integral part of the volcanism and sedimentation in the Browns Tunnel 'basin'.

(7) *Animal Creek Greywacke/ Black Harry Beds correlate*: a thin unit of micaceous and volcaniclastic sandstone, siltstone and shale, intercalated with lenses of dacitic and andesitic lava, lying between the Hollway Andesite above and the CVC below. The unit appears to wedge out westwards near the Hollway Rivulet, and has not been seen in the presumed anticlinal area of CVC rocks NW of this.

(8) *Central Volcanic Complex(CVC)*: represented in this area by felsic lavas and breccias and pumice breccias intruded by mafic dykes along and south of the Hollway Link Track (intersected in holes BPD75, 83, 84, 87; EAB4; BOC3, 4), and by the felsic lava – pumice breccia sequence in the Cone Hill area, forming the footwall of the Browns Tunnel sedimentary sequence. The sequence around Cone Hill appears to represent the upper part of the CVC repeated in an anticlinal fold position. A single mafic dyke mapped on the Chester- Pinnacles Track in this area supports the correlation.

**Southwell Subgroup**
Three major lithotypes make up the bulk of this subgroup: (i) interbedded sandstone and siltstone in beds 5cm- 1m thick, commonly graded; (ii) sandstone-dominated units with 20-40% siltstone; (iii) siltstone-shale-dominated units with thin sandstone interbeds. The sandstones are typically volcaniclastic and felsic, with the major components being feldspar crystals, quartz crystals (ranging from sparse to abundant, and up to 8mm across as 'quartz eyes'), felsic lava clasts, pumice clasts, shards, and sedimentary clasts (mostly shale-siltstone and cherty ash). Graded mass-flow sandstone units to 10m thick, with lithic-rich bases and fine-grained tops, are fairly common. Coarse quartz-feldspar crystal-rich sandstones, with a fine-grained matrix and large 'quartz eyes', and a variable percentage of lithic clasts, are present in places. These rocks have arkosic or 'granitic' textures, and may be difficult to distinguish from igneous quartz-feldspar porphyries. Pumice-rich sandstones with abundant pumice clasts up to 10cm across also occur.

***Boco Road east- Leos Creek area***
Four main formations have been mapped in this area, folded around a central NNE-trending syncline axis. The base of the sequence on the western side, against the Pinnacles Rhyolite, is a breccia-conglomerate unit of the order of 40m thick, containing abundant clasts of rhyolite lava up to 30cm across. This is followed by a well-bedded sandstone unit with some interbedded siltstone and conglomerate bands. This unit includes some crystal-rich 'quartz-eye' sandstone and some pumice-rich sandstone, and was fully cored in BPD80, where it overlies the Que River Shale correlate. A unit dominated by thin-bedded grey-green siltstone with lesser sandstone overlies this, and is followed by another sandstone unit containing zones of crystal-rich quartz-eye sandstone – probably the same unit which

***Marionoak River - Rosebery Fault area***
A volcaniclastic sandstone- siltstone- shale sequence exposed along Boco Road east of the Marionoak bridge for some 600m is assigned to the Southwell Subgroup on

lithological grounds. The zone appears to consist of several fault slivers associated with the Rosebery Fault, but is bound to the west by the main 'footwall' fault near the bridge. The sequence has also been intersected in a number of drill holes which have penetrated the upper 'hangingwall' Rosebery Fault, e.g. BPD63, EAF2, CP12. Hole BPD82 actually collared in the sequence near the Boco Road, and drilled through it into the 'footwall' fault.

A distinctive feature of the sequence is the abundance of coarse quartz-feldspar-rich zones which resemble quartz-feldspar porphyry but, in some cases at least, probably represent crystal-rich sandstones. Exposures on the Boco Road around 5384,900N show complex inter-penetrating contacts of this crystal-rich 'porphyry' and siltstone. These resemble irregular intrusive contacts, but the apparent lack of chilling or other effects contact effects suggests they may be sedimentary mass-flow phenomena produced by slumping of crystal-rich masses into fine-grained sediments.

Conversely, large masses of quartz-feldspar porphyry intersected beneath the 'hangingwall' fault in BPD63 and CP14 are massive and quartz-veined, and appear to be igneous intrusive-extrusive bodies. Some of the interbedded sediments are conglomeratic and contain clasts of similar porphyry and abundant large quartz crystals, suggesting in-situ disintegration of the porphyry bodies to form sediment bodies.

**Que River Shale Correlate**

This unit of black to grey shale and siltstone with minor interbedded sandstone is present on the eastern limb of the Boco Road syncline and in the core of the fold east of Burns Peak, but appears to wedge out on the west limb of the structure just south of Boco Road. It is generally poorly exposed except in a few tracks, but is well displayed in drill intersections in BPD76, 80, 89 and EAB1. Its thickness and character are modified somewhat by the presence within it of a large body of quartz-feldspar porphyry, which seems to have found it a favourable host for lateral intrusion. The thickness appears to vary from about 30m on the eastern limb to 50-100m around the core of the syncline. Pyrite is common in the shale as blebs and disseminations, and also appears on joints and veins, making it a classical IP target.

**Quartz-Feldspar Porphyry Bodies**

The porphyries are typically grey-green to pink in colour, with quartz phenocrysts 5-10mm across forming quartz 'eyes'. Flow-banding and autobrecciation textures are seen in places. Peperitic contacts marked by irregular 'dykes' of porphyry surrounded by dense blue-grey mudstone are common, and indicate emplacement of the sill-like bodies into wet sediments. A 'carapace' of normal quartz-poor felsic lava partly surrounds the porphyry in a number of areas.

***Body within Que River Shale***

The largest body lies largely within the Que River Shale east of Burns Peak, and appears to be continuation of a long 'finger' of porphyry subtended along the stratigraphy from a much larger body in the Sock Creek area (McNeill, 2002). Three drill holes have collared within this body, and BPD80 intersects its full thickness, with shale on either side. In BPD76, the porphyry body is composite and complex, with abundant breccias of both autoclastic and sedimentary type, and the contact zone marked by intermixed lava breccia, sedimentary breccia, and a zone of flow-banded feldspar-phyric lava. In EAB1, the main porphyry body is in contact with silicified sandstone with disturbed bedding, and a second smaller porphyry body (or offshoot?) is present 20m below the main one.

***Burns Peak body***

The Burns Peak porphyry body is elongated NE-SW, and has a continuous 'carapace' of felsic lava around its western, southern and eastern sides. Its northern boundary is not exposed, and it is not certain how this lava carapace relates to the poorly exposed mixture of lavas, pumice breccias and sediments to the north. The drill intersection in BPD65 shows the porphyry in two parts, separated by some 20m of mixed breccias, partly of sedimentary origin but rich in siliceous lava clasts. The basal contact is sharp against partially silicified pumice breccia rich in lava clasts. Some sulfide mineralisation near the contact, including a 20cm band of semi-massive pyrite, probably corresponds to the zone of strongly silicified pumiceous sandstone- conglomerate, with blebby sulfides, which marks the contact at surface at Leos Find.

The eastern margin of the Burns Peak body is well exposed on a drill access track, where it appears to grade via silicified lava breccias into non-porphyritic felsic lava of the 'carapace'. The marginal rock is strongly veined, brecciated and silicified, and has large blebs of pyrite through it, suggesting some mineralisation/alteration emanating from the porphyry.

***Other smaller porphyry bodies***

A series of narrow porphyry bodies with generally NNE trend intrude felsic lavas and pumice breccias SW of Burns Peak and in the Southern Trenches area. Drill intersections are available in BPD64, EAB3 and PIN2. The largest body is well exposed along the road to Southern Trenches, where its contact is associated with moderate to intense silica (-sericite) alteration of pumice breccias, producing augen schist textures in part, and with disseminated to blebby sulfide mineralisation. A zone of spectacular net-veining of fine quartz veins, with some sulfide, is present along the porphyry margin in the vicinity of the EAB3 collar. This zone extends at least 400m to the south and at least 150m upslope to the east, within a felsic lava body. EAB3 drilled through this net-veined zone for 200m, with sulfide-rich veins to 2cm across apparent in the first 100m. Assays showed up to 2%Pb and 1-2%Zn in three zones of 1-3m.

Hole BPD64 collared in a small offshoot sill of porphyry east of Southern Trenches, and intersected a series of four thin sills, ranging from 2-10m thick, between 180-212m downhole corresponding to the main porphyry body.

Two small porphyry bodies with a characteristic orange-red weathering colour are exposed on Boco Road about 200m NE of the Browns Tunnel junction, within the continuation of the Browns Tunnel Host Sequence. The bodies appear to grade into crystal-rich sandy breccia deposits with clasts of porphyry and of ashy sediment (up to a m long). The units appear to be large mass-flow deposits, and the presence of the porphyry bodies, seemingly at the base, suggests they may have been triggered by emplacement of the porphyritic flows.

Other porphyry bodies within the Browns Tunnel Host sequence have been intersected in a number of drill holes, including BPD63, 66, 78, 79, EAF12, 13. The bodies range from a few m to tens of m thick, and typically have peperitic contacts against shales and sandstones. BPD drilled largely down-dip to produce a 212m long porphyry intersection.

**Burns Peak Subgroup**

This new subgroup has been established to encompass a series of diverse lithologies within the stratigraphic zone between the Que River Shale above and the Animal Creek Greywacke (and Black Harry Beds) below. In this sense, it is virtually equivalent to the Que-Hellyer Volcanics. Rapid and dramatic facies changes occur within the subgroup, and the sequence to the east of Burns Peak shows significant differences to that west of the peak. Although the base of the subgroup can be defined by the Animal Creek Greywacke (+/- Black Harry Beds) in the Hollway Link Track area, this sediment unit is not present (or not recognized) west of Burns Peak, where the base of the sequence is a partly interfingering contact with underlying pumice breccias. These pumice breccias are tentatively assigned to the CVC, although they are essentially identical with pumice breccias throughout the subgroup. The subgroup is described geographically from east to west.

***Boco Road – Hollway Link Track area***

A thin upper unit of volcaniclastic sandstone here overlies the westwards-thinning Boco Road dacite body, thought to be a correlate of dacites in the Sock Creek area. Lenses of andesitic material have been mapped within the body (McNeill, 2002), highlighting the probable interfingering relationship with the adjacent westwards-thickening Hollway Andesite, which has lenses of felsic lava and breccia in its lower part. The Hollway Andesite is chemically and petrologically similar to the Hellyer Basalt (Coutts, 1993), which lies immediately above the Hellyer and Que River ore bodies.

***Hollway Rivulet – Burns Peak area***

A much thicker upper sandstone- siltstone unit in the synclinal core has an intercalation of pumice breccia – pumiceous sandstone, heralding the appearance in force of pumiceous rocks at this level further north. This overlies a wide area of Hollway Andesite in the form of two arms separated by a poorly-exposed nose of felsic (probable CVC) rocks. The nose is interpreted as an anticlinal fold core, following Coutts (1993), and the southern arm of andesite, with its numerous intercalations of felsic rocks, is interpreted as the synclinally folded lower part of the Hollway Andesite sequence. This synclinal structure helps to explain the apparent wedging out of andesite in CVC rocks just south of the Hollway Rivulet (Corbett and McNeill, 1986).

The abundant intercalations of felsic rocks in the lower part of the andesite is a notable feature, and is associated with large areas of pyritic alteration (e.g. Hollway and Eastern Pyrite Zones). This silica-sericite-pyrite-carbonate alteration (Saxon, 1995) may be 'leaking' through from the underlying CVC rocks, as suggested by BPD83, and the presence of similar alteration at the base of the andesite in BOC3, well to the east, suggests an extensive zone of alteration-mineralisation paralleling the northern CVC contact. A relationship to the striking zone of aeromagnetic anomalies which also follows the CVC boundary in this area seems likely.

The northern arm of the Hollway Andesite becomes somewhat attenuated in the core of the syncline, and is then truncated by the Burns Peak Shear Zone (which would appear to have a dextral component of movement). The andesite does not reappear west of this shear zone – the 'andesitic' units in the Browns Tunnel sequence appear to be chemically and lithologically different- suggesting that the original andesitic volcano may have been confined by some topographic feature to the area east of Burns Peak.

***Western flank of syncline – Burns Peak Shear Zone area***

The intersection in BPD76 shows the Que River-type black shale underlain by an unusual brownish amygdaloidal lava and breccia like the 'andesite' of the Browns Tunnel area, followed by a longish interval of interbedded volcaniclastic sandstone and ashy siltstone (drilled partly down-dip), a unit of pumice breccia and pumiceous sandstone, another unit of amygdaloidal 'andesite', and a thin sandstone-ash unit with sulfide clasts above a broken ashy shale which probably marks the Burns Peak Shear Zone. Pumice breccia and a small amount of siliceous felsic lava were intersected west of the fault. Some surface outcrop on an access track just to the north shows sheared pumiceous breccias near the fault zone lying west of mass-flow sandstones with sediment rafts and shale bands.

It should be noted that a number of other drill intersections at this stratigraphic level have produced sediment units containing clasts of massive sulfide or sulfide-rich material (e.g.BPD77, BPD72, BPD69, BPD66), emphasizing the point that active mineralisation was associated with formation of the subgroup.

There is virtually no outcrop along strike from the track to BPD76 to the Boco Road, where the Burns Peak Shear Zone is flanked to the east by a wedge of sediments, including sheared sandstone- shale and a mass-flow sandstone with lava clasts, followed by a thickish section of felsic lavas. The latter seem to continue east to the conglomerate unit marking the base of the Southwell Subgroup. Similar lavas are present west of the fault, and appear to be subtended from the Pinnacles Rhyolite mass to the north. A linking section is available in BPD77, which intersected a complex mixture of pumice breccias and lava breccias with intercalated sandstones, conglomerates and shales. Sulfide clasts were present in two of the conglomeratic units. The outcrops and drill sections are interpreted to indicate a lateral facies variation from a predominantly sandstone sequence to the south and east, with relatively distal pumiceous sandstones and breccias, to a proximal sequence of lavas, lava breccias and pumice breccias, with lenses of conglomerate-sandstone-shale, near the margin of the Pinnacles Rhyolite complex.

As noted in the North Pinnacles report, the Pinnacles Rhyolite is most likely a correlate of the Que-Hellyer- Sock Creek sequence, rather than the CVC, and appears to represent a seafloor volcano or cryptodome which developed off the northern margin of the CVC in response to similar tensional tectonics to those which triggered the Que-Hellyer and Sock Creek andesitic-dacitic volcanism. The rhyolite complex was probably centred near its present zone of maximum thickness just north of Boco Road, and had early flows which interfingered with sediments of the Browns Tunnel sequence, and later flows which interfingered with sandstones and pumice breccias just prior to Que River Shale time.

***Boco Road section from Pinnacles Ridge to Browns Tunnel junction***

Massive to flow-banded Pinnacles Rhyolite crops out on Boco Road just east of the North Pinnacles junction, and passes east via an unexposed but probably faulted contact into a mixed sequence of pumice breccias, lavas and sediments. The latter sequence is interpreted to interfinger northwards with the Pinnacles Rhyolite. To the south, the sequence is intersected in BPD72, which shows it to be east-facing and to include several shale-siltstone units, including one with sulfide clasts, as well as a complex mix of pumice-lava breccias and flows. The drill hole shows the sequence extending well beneath the surface position of the Pinnacles Rhyolite (which seems to have a westerly dip of about 55°), where it is also intersected in BPD71 coming from the west. It seems likely that the sequence represents, in part at least, the continuation of the Browns Tunnel sediment zone on the eastern flank of a complex anticlinal structure.

Some uncertainty exists as to how this sediment-bearing sequence relates to the large body of quartz-feldspar porphyry, and its associated ‘carapace’ of felsic lava, in the vicinity of Leos Find prospect just to the south, because of the poor outcrop in the area. However, there is probable continuity with the east-facing sediment unit extending along the western flank of this body and exposed in costeans on the west flank of Burns Peak, considered to represent the Browns Tunnel sequence. This sediment package includes volcaniclastic sandstones and ashy siltstones with intercalated pumice breccias and felsic lavas. At Leos Find, a zone of strongly silicified pumiceous pebbly sandstone and conglomerate, with disseminated and blebby sulfides, lies close to the porphyry margin. BPD65 drilled beneath this area, but intersected only a thin sulfide-bearing zone, with a 20cm band of massive pyrite, within silicified pumiceous breccia near the contact.

The sediment sequence is exposed along Boco Road west of Leos Find, and from here to the Browns Tunnel junction appears to be west-facing, on the western limb of the Pinnacles anticline. The contact with the Pinnacles Rhyolite lies below the road and is nowhere exposed along this section, and its nature is problematic. Outcrop of the sediment sequence in the road cuttings is relatively good (although deteriorating because of regrowth), but a number of gaps are present, some of which probably correspond to NW-trending cross-faults. The eastern part of the sequence consists mainly of thin-bedded ashy siltstones and sandstones, with some units of conglomerate with felsic lava clasts to 20cm across and some mass-flow pumiceous and polymict breccias.

Further west, probably across a small fault, is an unusual reddish-weathering sequence of crystal-rich sandstone and breccia with two bodies of quartz-feldspar porphyry. The irregular porphyry bodies appear to form the basal parts of thick mass-flows, which also include breccia zones with clasts of the porphyry in a crystal-rich granitic' matrix, topped with crystal-rich sandstone. This zone of red-weathering rocks seems to be faulted against the next zone of pale coloured ashy shale, sandstone, pumiceous mass-flows (with sediment rafts), and conglomeratic rocks around the junction to Browns Tunnel. The rocks here are strongly sheared, such that much of the bedding has been smeared out along cleavage, and there are numerous steep shear planes. Disseminated sulfides and veins with pyrite, galena and sphalerite are common in this area. A strong set of cross-cutting subvertical planar joints trending ~140°, some of them mineralized and associated with silicification, is present in this area, and is probably related to the cross-faults.

Immediately west of the junction on Boco Road, a gap in exposure has some boulders of red-brown weathering material suggestive of andesite, followed by a zone of thin-bedded grey-fawn siltstones which are folded into NNE-plunging folds. The siltstones pass west, possibly via a faulted contact, into massive red-weathering feldspar-quartz-phyric rhyolite, assigned to the Pinnacles Rhyolite. Two thin units of volcaniclastic sandstone-siltstone occur within the rhyolite sequence, which further west includes a massive spherulitic rhyolite which weathers like sandstone.

***Browns Tunnel – Southern Trenches area***

The zone of dominantly sedimentary rocks between Boco Road and Southern Trenches is mineralized in several places, and has been subject to intense exploration over several decades. This has included some 8 or more separate phases of drilling, involving over 70 drill holes. The geology is highly complex in three dimensions because of the plethora of lithologies and the number of facies changes, coupled with the complex structural overprint of shearing and faulting. Tectonism appears to have been focused on the zone because of its being 'sandwiched' between two relatively competent bodies (CVC rhyolite-pumice breccia to the east and Pinnacles Rhyolite to the west), and because of the presence of abundant weaker sediment units and extensive zones of alteration to sericite-rich rocks. The large amount of structural overprinting was emphasized in the detailed study of the small area between Browns Tunnel and Boco Road by Elliott (1990), where many of the boundaries are sheared or faulted on a scale not easily resolvable. Mapping and understanding are frustrated by very poor surface outcrop.

The geology consists of the steeply west-dipping and west-facing Browns Tunnel Host Sequence (BTHS), forming a sediment-rich zone 50-200m wide, overlain by the Pinnacles Rhyolite (rhyolite flows and breccias with generally thin sediment intercalations) to the west, and underlain by pumice breccias with felsic lavas and porphyry bodies to the east, assigned to the CVC. The BTHS sediment zone tapers to the south, and is quite narrow where it passes through the Southern Trenches, where it is flanked on both sides by pumice breccias.

Further complicating the geology, and forming a structural footwall to the mineralisation-alteration systems, is the Rosebery Fault complex. This major 40-45° E-dipping Devonian thrust complex extends south from this area to Rosebery and beyond, forming the contact of the overthrust CVC and various younger sedimentary sequences to the west. The fault changes character in this area, however, in that it apparently breaks up into several sub-parallel faults in the vicinity of Southern Trenches. The main lower 'footwall' thrust, which is underlain by correlates of the Late Cambrian Owen Group, swings slightly westerly to cross the Boco Road just west of the Marionoak River bridge, and is assumed to continue northwards under moraine cover to the Silver Falls area.

The upper 'hangingwall' thrust has been shown by drilling (BPD63, 82; CP14; EAF2) to pass just east of the collar of BPD82 (which stayed beneath the fault and also intersected the 'footwall' fault), some 400m west of Browns Tunnel and 450m beneath it, following a northerly trend before disappearing under moraine. It is underlain by a volcaniclastic sandstone– siltstone– shale sequence with quartz porphyry-like bodies (some considered to be sandstone, some to be igneous porphyry) correlated with the Southwell Subgroup.

At least one other major east-dipping fault lies between these two, with an excellent exposure on the Boco Road 200m east of the Marionoak bridge. Volcaniclastic sandstones and shales, with a porphyry-like body, beneath this fault are also correlated with the Southwell Subgroup.

Some drill holes, e.g. BPD63, CP14, appear to have intersected both hangingwall and footwall faults, showing them to be about 100-120m apart. The effect of these faults on the overthrust BTHS and associated rocks is complex and difficult to reconstruct from drill holes and surface exposures, and will be considered in a later report. Drag on the faults probably accounts for the east-dipping bedding in the sediments south of Thomas' Tunnel, and for the complications in the base of the Pinnacles Rhyolite evident between EAF2 and BPD81 and 85.

The general stratigraphy may be summarised as follows:

Top: (i) Pinnacles Rhyolite – felsic lavas and breccias, possibly grading to pumice breccias in places;

(ii) Sediment-rich zone at top of BTHS with ashy to pumiceous sandstones and siltstones, which becomes a sulfide-rich zone in altered pumice breccia – augen schist- ashy shale at depth (e.g. BPD78,81; EAF2). This may be equivalent to the chert-rich mineralized zone seen at shallower levels (e.g.in EAF7,14) and at Browns Tunnel, or it may be at a slightly higher level stratigraphically.

(iii) 'Andesite' – dacite flows.

(iv) Lower sediment sequence including mass-flow sandstone/conglomerate/siltstone units, pumiceous mass-flows, quartz-feldspar porphyry bodies.
(v) Basal sequence dominated by pumice breccias, marking the interfingering contact with the CVC.

A unit or zone of green-weathering feldspar-phyric lava/breccia/intrusive crops out around Thomas' Tunnel and has been referred to as 'andesite' (e.g. Gregory, 1987, and later authors). The rock has abundant quartz-filled amygdales in places, and a pale felsic-looking groundmass in places, and is geochemically more of a dacite (Poltock et al, 1993). Thin flows of this 'andesite' have been intersected in a number of holes around and north of Browns Tunnel, where they appear to be 'footwall' to the main zone of mineralisation. At Thomas' Tunnel, however, the main mineralisation is stratigraphically beneath the 'andesite', with another zone above it. The present author's logging has designated many of the intersections of this rock type as felsic lava.

A zone of cherty fine-grained rocks, possibly partly of exhalative origin, is associated with outcropping massive and disseminated sulfide mineralisation at Browns Tunnel. This is the main zone of mineralisation other than that at Southern Trenches, and much effort has been directed towards proving its continuity or otherwise. Recent drilling suggests that the higher grade pods have limited extent within lower grade halos, and an inferred resource of the order of 110,000t of moderate grade ore suitable for open pitting has been estimated (Edwards et al, 1999) The zone plunges northwards, and has been intersected in a number of holes (e.g. EAF3,4,6,7,14; BT1,2,3,4). It appears to finger out northwards into ashy shales.

The poddy mineralisation at Southern Trenches was mainly hosted within the thin sedimentary unit of ashy shales and sandstones, sandwiched within strongly silica-sericite-altered and partly mineralized pumice breccias with augen schist textures. A small open pit operation recovered 15,000t of >25%Pb+Zn during 2000-2001.

## SUMMARY COMMENTS

The geology of the Burns Peak area is dominated by the rock sequences formed in the stratigraphic 'transition' interval between the volcanic-dominated CVC below and the sediment-dominated Que River Shale/Southwell Subgroup above, and influenced by being in a tectonic hinge-zone between the N-S Rosebery Fault system and a series of NE-directed structures. The abundance and variability of volcanic and sedimentary rocks in the interval suggests the area was an unusually active one in Middle Cambrian times, presumably involving tensional basins and changing volcanism at a 'node' point on the CVC margin. The area received both andesitic/basaltic (including shoshonitic) and dacitic/rhyolitic volcanism, from several separate volcanoes, and sedimentation accompanied by at least some VHMS mineralisation, and has much in common with the Que-Hellyer basin. In addition, there is a close association of upper CVC pumice breccias with overlying sediments hosting VHMS mineralisation, echoing the Rosebery Mine stratigraphy.

The zone now occupied by the Burns Peak Shear Zone and the Burns Peak lava-porphyry body seems to separate the Hollway Andesite volcano from a semi-separate (small?) basin to the NW, where volcaniclastic sediments and shales initially interfingered with CVC pumice breccias and later with rhyolite flows from the large Pinnacles Rhyolite volcano or cryptodome complex just to the NW. The nature of the porphyry-lava complex on Burns Peak itself, i.e. whether it represents a small volcano in its own right, a thickened flow from the Pinnacles Rhyolite, or an upfaultd block of CVC 'basement', remains a puzzle, as does the amount and direction of displacement on the Burns Peak Shear Zone.

Quartz-feldspar porphyries in the form of sill-like intrusions and peperitic flows appear at several levels in the stratigraphy: in the upper CVC, in the Browns Tunnel sediments, in the Que River Shale, and in the Southwell Subgroup (particularly in the vicinity of the Rosebery Fault but also as proximal-looking crystal-rich mass-flows in the eastern area). The apparent association of silica +/- sericite alteration and pyrite +/- Pb-Zn sulfides with the margins of porphyry bodies (e.g. at Leos Find, on the east flank of Burns Peak, and around EAB3 on the west flank) strongly suggests that they have been one of the 'trigger mechanisms' or 'heat engines' for mineralisation in the Browns Tunnel area. The 'andesite'-dacite body at Thomas' Tunnel has probably been another. The remarkable abundance of such porphyries in this area, at all levels, suggests they were being actively generated in the area as part of the diverse volcanism.

That some primary VHMS-type mineralisation occurred during Southwell Subgroup time seems well established, considering the nature of some of the massive sulfide outcrops and intersections, the presence of exhalative-like cherty host sediments at Browns Tunnel, and the widespread occurrence of sulfide clasts in sedimentary units within the subgroup. Pumice breccias and ashy shales have been favoured host rocks for associated silica-sericite-rich alteration. It is also apparent, however, that there has been considerable tectonic modification and remobilization of both sulfides and alteration minerals, particularly during Devonian folding, faulting and cleavage formation, and much disruption and local displacement of mineralized horizons. Such focusing of Devonian tectonism on zones of altered (particularly sericite-rich) rocks, to produce various sericitic schists, is a common phenomenon in western Tasmania, and is a feature of Mt Lyell geology. The relative coherence of the Southern Trenches sulfide pods may reflect their location within a protective zone of semi-massive silicification in altered pumice breccias, a situation faintly reminiscent of Henty.

At least one other source of mineralisation-alteration is represented by the zones of pyrite-silica-sericite-carbonate alteration within the Hollway Andesite at its interfingering contact with CVC rhyolitic rocks. Several such zones are exposed at surface in the Hollway Rivulet area, and may be related to similar strong alteration (with some sulfide-bearing veins) intersected in BOC3. The zone of strong aeromagnetic anomalies associated with this northern margin of the CVC, and the occurrence of abundant mafic dykes (showing affinities to some of the Sock Creek mafic rocks?) supports the general impression of an active (and fertile) margin with many similarities to both Que-Hellyer and Rosebery, and considerable potential.

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