

# Stratigraphic-facies associations and their relationship to mineralisation in the Mount Read Volcanics

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## ABSTRACT

The highly mineralised Cambrian Mount Read Volcanics form an arcuate belt along the western margin of the Precambrian Tyennan region. Volcanic-hosted massive sulphide (VHMS) deposits at Hellyer, Que River, Rosebery, Hercules, and Mt Lyell occur in a sequence of deformed, regionally metamorphosed (lower greenschist facies), and hydrothermally-altered volcanic rocks.

The Mount Read Volcanics can be broadly subdivided into a lava-rich eastern and central belt with the Eastern quartz-phyric sequence interfingering with the feldspar-phyric Central Volcanic Complex. They both interfinger with the western volcano-sedimentary successions (Yolande River succession, Dundas Group and the Mount Charter Group). The youngest part of this volcanism is time equivalent to a belt-wide period of andesitic-basaltic volcanism and VHMS deposit formation (Hellyer, Que River and some at Mt Lyell). A period of extension and rifting occurred at this time, with a tholeiitic dyke swarm concentrated along the Henty Fault and tholeiitic pillow basalts in the Henty Fault wedge.

Recent volcanological studies have suggested that the final phase of volcanism which produced the widespread mass-flow deposits of the Tyndall Group and Southwell Subgroup resulted in an extensive basal marker sequence. If the widespread extent of this marker sequence is confirmed then the previous position of the Rosebery-Hercules mineralisation, as early during the Central Volcanic Complex formation, will result in a re-interpretation which places those VHMS deposits at time-equivalent or slightly younger than the Que-Hellyer mineralisation.

## INTRODUCTION

A major part of the Mount Read Volcanics Project (MRVP) conducted by the Department of Mines over the past seven years has been the 1:25 000 scale mapping program. During this period, the mineralised part of the belt from Elliott Bay in the southwest to Moina in the northwest has been mapped, with the thirteenth sheet (Mt Jukes-Mt Darwin) due for publication late this year (Corbett *et al.*, in press).

Data derived from the mapping, coupled with ongoing volcanological, geochemical and ore deposit studies, has resulted in an evolving view of the relationships of the various rock units (see Corbett, 1992; McPhie and Allen, 1992; Allen and Cas, 1990; Corbett and Lees, 1987; Crawford *et al.*, 1992; Berry and Crawford, 1988). As noted by Corbett (1992), "... originally complex facies relationships are now very difficult to unravel, and correlations along and across the belt continue to be controversial and in need of constant reassessment". The recent mapping in the Mt Jukes-Mt Darwin area confirms this statement, with a reappraisal of the Central Volcanic Complex-Eastern quartz-phyric sequence-Tyndall Group relationships.

This paper summarises the work from the MRVP mapping, and with the work of others, updates our views on the stratigraphy of the Mount Read Volcanics and its relationship to mineralisation.

## SUMMARY OF THE MAJOR STRATIGRAPHIC-FACIES ASSOCIATIONS OF THE MOUNT READ VOLCANICS

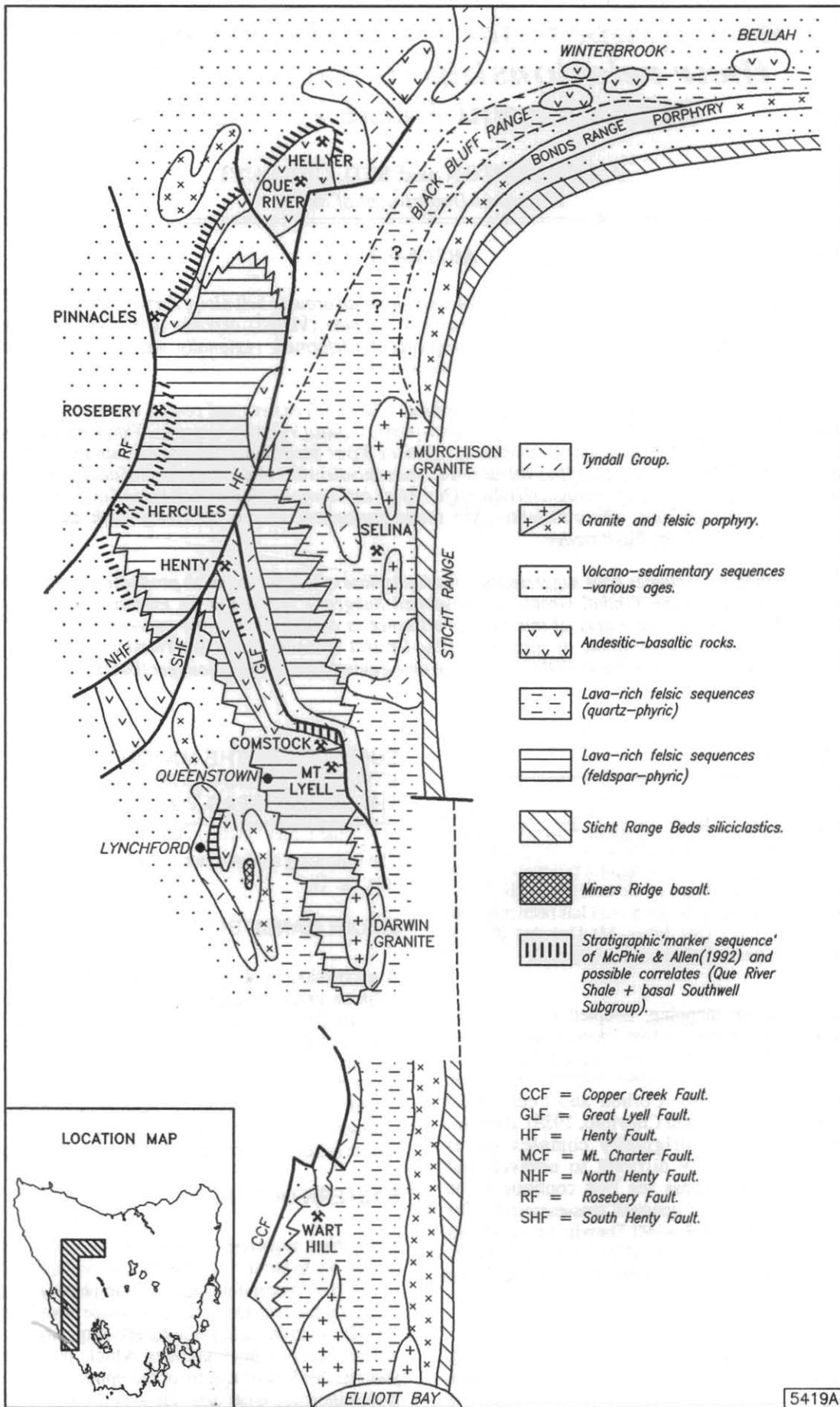
The following is a summary of the major units we recognise (see fig. 1).

### STICHT RANGE BEDS

A succession of siliciclastic sandstone, conglomerate and siltstone predominantly derived from and unconformably overlying Precambrian basement occurs along the eastern margin of the belt. Outcrop is found from Back Peak-Mt Remus in the north, Lake Mackintosh to Lake Dora, and from the D'Aguiar Range to Elliott Bay in the south. An upward gradation into volcanoclastic rocks in most areas suggests it represents the basal unit to the Mount Read Volcanics. Baillie (1989) reports a Middle Cambrian fossil age.

### EASTERN QUARTZ-PHYRIC SEQUENCE

A complex sequence of quartz-phyric volcanoclastic rocks mixed with lavas (usually quartz-feldspar phyric) and porphyries (quartz-feldspar  $\pm$  biotite-phyric) occurs mainly along the eastern side of the belt. There have been problems over the years in understanding this sequence, as it includes volcanoclastic conglomerates which pass directly into younger but identical units of the upper Tyndall Group, but it also includes lavas and clastic rocks which appear to be lateral equivalents of the Central Volcanic Complex which



**Figure 1**  
Stratigraphy of the Mt Read Volcanics between Elliott Bay and Beulah.

5 cm

predates the Tyndall Group. McNeill and Corbett (1992) resolved this problem (partially) in the Murchison area by referring to the bulk of the sequence as the 'Eastern quartz-phyric sequence', and used 'Tyndall Group Correlates' for the volcanoclastic conglomerate units which contained granite clasts. This problem is discussed further in the sections on the Tyndall Group and Mt Jukes–Mt Darwin. The quartz-phyric volcanic rocks east of the Copper Creek Fault at Elliott Bay are considered to be part of this grouping.

### CENTRAL VOLCANIC COMPLEX

The Central Volcanic Complex is dominated by feldspar-phyric porphyritic lavas and domes with minor amounts of clastic rocks. These rocks are distinctive in the field, with a paucity or absence of quartz phenocrysts, a spherulitic nature, and are often pink-coloured because of K feldspar-chlorite-hematite-magnetite alteration.

Recent mapping in the Mt Jukes–Mt Darwin area has shown that the feldspar-phyric rocks interfinger with the quartz-phyric rocks, both to the east and west. Similar relationships are seen at Stirling Valley, Murchison Gorge and Red Hills. From this work it appears that the Central Volcanic Complex feldspar-phyric rocks represent a magma/facies variation rather than an older stratigraphic unit.

### ANDESITIC-BASALTIC VOLCANIC ROCKS

Large lenses of andesite and basalt, dominated by hyaloclastic breccias and pillow lavas in most areas, occur between and partly interfingering with the Central Volcanics Complex–western volcano-sedimentary sequences and younger Southwell Subgroup–Tyndall Group at a number of places, e.g. Que–Hellyer, Pinnacles, Anthony Road, Comstock (Mt Lyell) and Lynchford. They are either plagioclase-pyroxene-phyric or plagioclase-hornblende-phyric, and their relationship to the majority of VHMS deposits in Tasmania is well documented. However, in the Rosebery–Hercules area they are absent, perhaps as a result of faulting, although they could be represented by the nearby, little known Curtin-Davis basalts.

Corbett (1990, 1992) has postulated that this widespread phase of volcanism coincided with a period of tensional tectonics associated with major faults and splay faults (e.g. Henty Fault, Mt Charter Fault, North and South Henty Faults and the Great Lyell Fault). Within the Henty Fault wedge, a large lens of calc-alkaline andesite with affinities to the other andesites crops out. A sequence of tholeiitic pillow basalts and dolerites, which also crop out, are geochemically identical (high  $TiO_2$ , low Nb and low  $P_2O_5/TiO_2$ ) to a suite of mafic dykes ('Henty dyke swarm') which intrude throughout the northern Central Volcanic Complex, but are concentrated along the North Henty and Henty Faults. There are tantalising similarities between these Henty tholeiites and the basalts at Sock Creek, which are along strike from the Que–Hellyer volcanics (Crawford *et al.*, 1992). This suggests that the Sock Creek basalts could be transitional between the tholeiites and the Que–Hellyer shoshonites, and that all are related to the same rifting episode.

The highly sheared and altered Miners Ridge Basalt has a distinctive tholeiitic chemistry, with low  $K_2O$  and depleted LREE patterns plus both low and high  $TiO_2$  values (Crawford *et al.*, 1992). The basalt appears to be interbedded with the Miners Ridge Sandstone (a micaceous quartzwacke). A tentative correlation with the Double Cove basalts south of Macquarie Harbour is made by Crawford *et*

*al.* (1992) who suggest that the basalts are rift tholeiites related to the passive margin basement onto which the Mount Read Volcanics were erupted. Corbett (1992), on the other hand, states that the available evidence could also support an early phase of tholeiitic volcanism associated with the *in situ* evolution of the belt. The Miners Ridge Basalt is fault bounded and probably tectonically emplaced.

### VOLCANO-SEDIMENTARY SEQUENCES

From Elliott Bay to Beulah, marine volcano-sedimentary sequences flank the lava-dominated Central Volcanic Complex and Eastern quartz-phyric sequence (predominantly on the western side). The sequences typically consist of interbedded tuffaceous mass-flow deposits, turbiditic sandstone, shard-rich tuffaceous mudstone, micaceous siltstone and black shale. A local volcanic provenance is common, but interfingering with sediments derived from the Precambrian does occur. Extrusive andesitic and minor felsic volcanic rocks crop out, as do large intrusive porphyry bodies. The sedimentary units have provided a number of trilobite fossils giving dates from the early Middle Cambrian to early Late Cambrian (Corbett, 1992) (see fig. 8).

In the Queenstown area these rocks are known as the Yolande River sequence. At Lynchford a lens of Que–Hellyer type basalt, the Lynch Creek basalts, crops out within but close to the top of the sequence. Large sill-like quartz-feldspar  $\pm$  biotite porphyries are intrusive and partly extrusive into this succession.

The term Dundas Group has been used widely to not only describe the volcano-sedimentary successions but to also include the Mount Read Volcanics in total (Carey and Banks, 1954). Recently Corbett (1992) redefined the rocks in the Que–Hellyer area as the Mt Charter Group, to replace the ill-defined term 'Dundas Group Correlates'. Brown (1986) used the term Huskisson Group to describe the rocks to the north of Renison, and Corbett and Lees (1987) used the term White Spur Formation at Hercules to describe a west-facing unit of volcanoclastic and mixed source sediments apparently overlying the Central Volcanic Complex. The White Spur Formation was included in the Dundas Group but recent work by McPhie and Allan (1992), using facies analysis, has suggested an alternative correlation (see later section on the Hercules–White Spur area). Fossil ages (Jago and Brown, 1989) from the Middle Cambrian are associated with sediments derived from the Mount Read Volcanics, while in the Late Cambrian upper Dundas Group, detritus derived from the volcanics is scarce and an offshore correlation with the Lower Owen Conglomerate is likely. From this discussion it would appear that the term Dundas Group will become less widely applied in the future.

### TYNDALL GROUP

The Tyndall Group is a much battered and abused term since it was first used in 1974 (Corbett *et al.*, 1974). From its humble origin at Comstock Valley and the Tyndall Range, the term was extended to encompass all of the quartz-phyric rocks up the eastern side of the Mount Read belt (Corbett and McNeill, 1986), and even most of those at Elliott Bay (Large *et al.*, 1987). With the recent mapping it is now known that only part of the eastern succession is Tyndall Group, the larger part being older.

The Tyndall Group does, however, remain a valid stratigraphic unit, overlying the andesites at Comstock (also

at Lynchford and Anthony Road), with late Middle Cambrian fossils in a basal limestone at Comstock. The group comprises distinctive banded pink and green crystal-rich sandstones and mass-flow deposits in the lower parts, passing up into mainly volcanoclastic conglomerate.

Primary volcanic rocks are not common, with quartz-phyric lava lenses intercalated within the group at Newton Creek and minor andesites in the equivalent Mt Cripps Subgroup on the Cradle Mountain Link Road. Welded tuffs occur within the upper volcanoclastic unit at Comstock (Corbett *et al.*, 1974), on the Cradle Mountain Link Road (Pemberton *et al.*, 1991), and as clasts in mass-flow deposits near the Tyndall Range (J. McPhie, pers. comm., in Corbett, 1992). The presence of granite and quartz-feldspar  $\pm$  biotite porphyry clasts is common, and suggests the unroofing of the Darwin–Murchison granites and Bonds Range Porphyry during this time (Pemberton *et al.*, 1991; McNeill and Corbett, 1992). It is interesting to note that the Winterbrook volcanics and Black Bluff Range Cambrian windows have volcanoclastic conglomerates with granite and porphyry clasts, welded tuffs and dacites (with geochemistry that does not match the Que–Hellyer Volcanics) (Vicary and Pemberton, in prep.). The nearby fossil locality at Native Track Tier (Baillie and Jago, 1985) gives a late Middle Cambrian age, as does that on the Cradle Mountain Link Road (Pemberton *et al.*, 1991) and also at Paradise near Beulah (J. B. Jago, pers. comm.). Considering these criteria, it is likely that the Black Bluff Range windows and Winterbrook volcanics are Tyndall Group equivalents.

The Tyndall Group appears to be the final erosional phase of the Mount Read Volcanics pile, with mixing of basaltic-andesitic debris with felsic-quartz rich material in a shallow water to subaerial environment prior to deposition of the Owen Conglomerate.

#### GRANITES AND QUARTZ-FELDSPAR $\pm$ BIOTITE PORPHYRY

The period prior to the deposition of the Tyndall Group and its correlates appears to have been one of intense intrusive activity, not only of andesite-basaltic magma but also of granites (Murchison, Darwin and Low Rocky Point) and quartz-feldspar  $\pm$  biotite porphyries (Bonds Range, Elliott Point and others). A majority of these intrusive rocks occur in the Eastern quartz-phyric sequence and could be responsible for the widespread episode of activity recognised

by McPhie and Allen (1992) at the base of the Southwell Subgroup and in the White Spur Formation. It is also possible that they may have provided heat to the VHMS producing hydrothermal cells.

#### DIAGRAMMATIC CROSS-SECTIONS OF THE RELATIONSHIPS BETWEEN THE MAJOR UNITS

These simplified cartoon cross-sections have been drawn to illustrate our presently perceived understanding of the stratigraphic-facies relationships and positions of the various ore bodies and prospects. For a more detailed overview and in-depth discussion the reader is referred to Corbett (1992).

#### MT JUKES–MT DARWIN AREA (see fig. 2)

Recent mapping in the Jukes–Darwin area has shown that the feldspar-phyric Central Volcanic Complex interfingers with the Eastern quartz-phyric sequence, both to the east and west (Corbett *et al.*, in press). Parallel bands of quartz-phyric and feldspar-phyric lavas crop out on the western side at Slate Spur, while on the eastern side there are lenses of feldspar-phyric lava within the more abundant quartz-phyric rocks (at Lake Jukes, Allans Creek and east of Mt Huxley).

The Darwin Granite intrudes this mixed succession of quartz-phyric and feldspar-phyric rocks. A wedge of younger conglomerate containing clasts of the granite lies unconformably on the granite at South Darwin Peak. This was originally interpreted by Corbett (1979) as being part of the 'Eastern Sequence' and thus a Tyndall Group equivalent. Although our recent detailed mapping did not reach this area, work done to the north indicates that the volcanoclastic conglomerates of the Eastern quartz-phyric sequence and those of the Tyndall Group are indistinguishable. Rocks previously referred to as the 'Tyndall Group' (Corbett, 1979) in this area include older rocks which obviously interfinger with the Central Volcanic Complex. In many places it is quite difficult to distinguish between the two groups of similar rocks, so for mapping purposes an 'undifferentiated' category is retained. This difficulty appears to be due, in part, to the younger conglomerates being deposited on an originally irregular surface and, in part, to later folding and faulting. As noted earlier the occurrence of volcanoclastic sediments with granite or porphyry clasts overlain by the Owen Conglomerate is recognised as Tyndall Group. Considering this the relationships of these rock types at

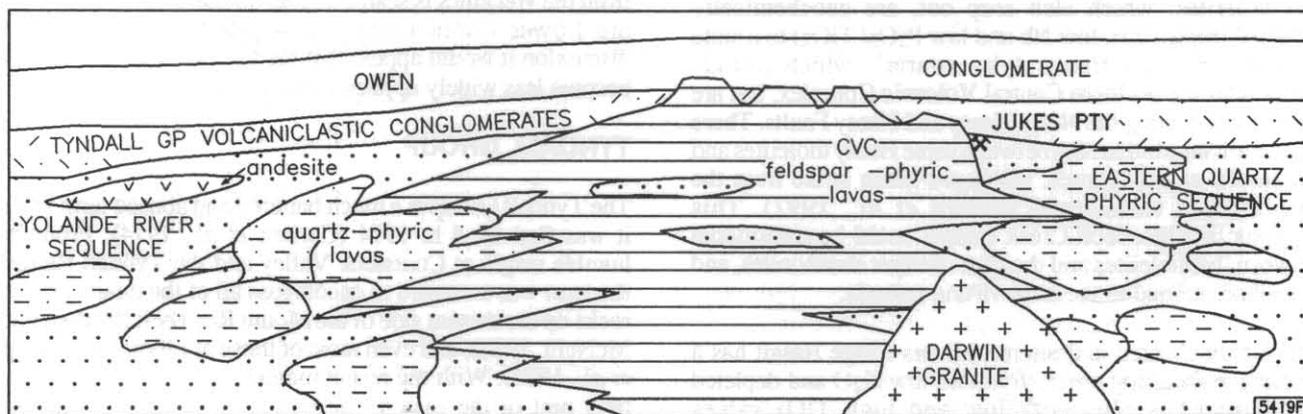


Figure 2

Schematic cross-section of the geology of the Mt Jukes–Mt Darwin area.

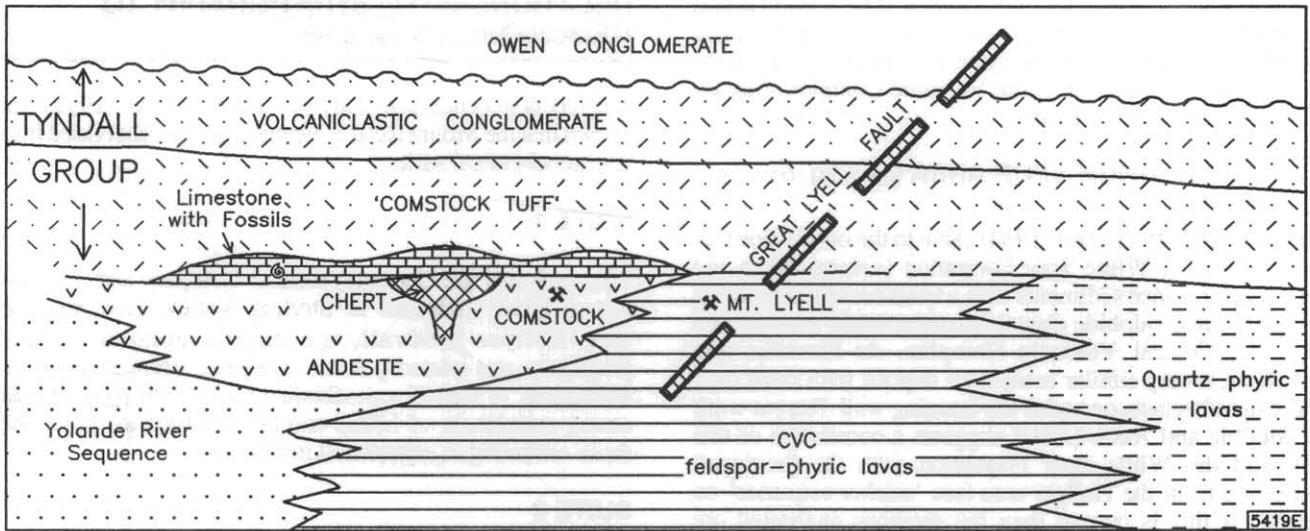


Figure 3

Schematic cross-section of the geology of the Comstock-Mt Lyell area.

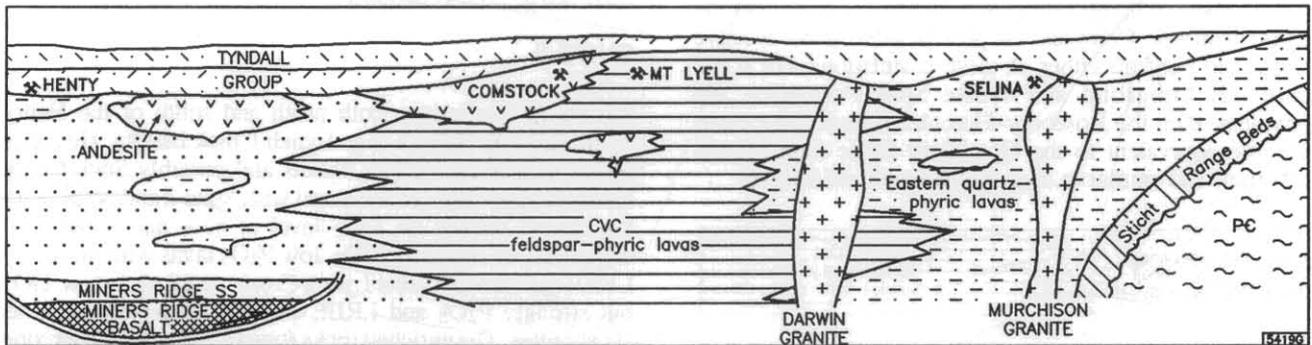


Figure 4

Summary diagram of facies relationships southeast of the the Henty Fault.

South Darwin Peak needs to be re-examined in the light of our present understanding to determine whether the contact with the Eastern quartz-phyric sequence is tectonically affected or depositional.

Mineralisation in this area is related to the contact (probably faulted) of the Eastern quartz-phyric sequence and the Central Volcanic Complex at East Darwin and close to it at Jukes Proprietary, with large alteration zones of K-feldspar, chlorite, magnetite, hematite, sericite and pyrite with minor chalcopyrite and gold.

**COMSTOCK-MT LYELL AREA (see fig. 3)**

The mineralisation at Mt Lyell-North Lyell-Prince Lyell etc. appears to be along strike and related to the nearby Comstock massive sulphide, which is associated with altered andesites of the Lynch Creek and Que-Hellyer type. Interfingering of the andesite with the Central Volcanic Complex and with the overlying fossiliferous limestone of the basal Tyndall Group (late Middle Cambrian) suggests a lateral and vertical facies relationship in a limited time scale. A similar succession is seen at the Anthony Road, with a major andesite accumulation immediately underlying Tyndall Group rocks.

**SUMMARY DIAGRAM OF FACIES RELATIONSHIPS SOUTHEAST OF THE HENTY FAULT (see fig. 4)**

From the diagram the suggested relationships from the oldest to youngest are:

- (1) Faulted in Miners Ridge sequence
- (2) A time equivalent Yolande River sequence-Central Volcanic Complex-Eastern quartz-phyric sequence
- (3) A partly equivalent (to the above) but late andesite phase in the west, and granites and porphyries in the east (mainly). VHMS mineralisation at about this time.
- (4) Tyndall Group

**NORTH OF THE HENTY FAULT**

A large block of feldspar-phyric and pumiceous volcaniclastic rocks (Central Volcanic Complex) is bounded to the east by the Henty Fault (see fig. 1); to the north is the Que-Hellyer volcanics (Mt Charter Group); to the northwest

is the Pinnacles area with Que–Hellyer type volcanics and Central Volcanic Complex rocks; and to the west is Rosebery–Hercules with the enigmatic relationship of the White Spur Formation–Central Volcanic Complex–Dundas Group sedimentary sequence.

### HERCULES–WHITE SPUR AREA (see fig. 5)

Previous work by Corbett (1984) came to the conclusion that the west-facing White Spur Formation (volcaniclastic and mixed-provenance sediments with a basal breccia containing shale rafts and sulphide clasts) unconformably transgressed over the Central Volcanic Complex. At Hercules and Rosebery, a very similar mass-flow deposit with shale rafts and sulphide clasts occupies the hanging wall. Recent work by McPhie and Allen (1992) suggests a correlation of this unit and the White Spur Formation with the Southwell Subgroup from the Hellyer area (see 'marker sequence' on fig. 1). If this is correct then the previous suggested ore position of Rosebery–Hercules within the Central Volcanic Complex, and therefore older than Que–Hellyer, is reversed with a slightly younger age than Que–Hellyer.

Corbett (1992) suggests another possible correlation with the Black Harry Beds (rich in mass-flow deposits) which are basal to the Mt Charter Group and interfinger or overlie the Central Volcanic Complex. At present there is no decisive evidence to confirm either of these correlations, but if the Southwell Subgroup and White Spur Formation are equivalent, then the Rosebery–Hercules mineralising event was time equivalent to the Que River Shale (late Middle Cambrian) and similar to that of Que River and Hellyer.

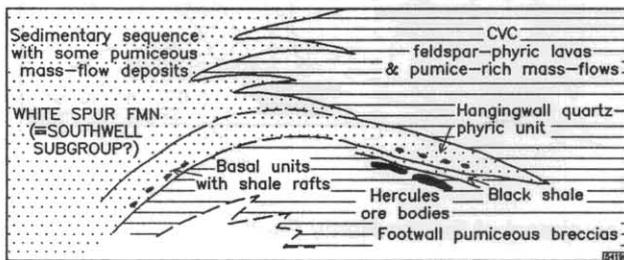


Figure 5

Schematic cross-section of one interpretation of the geology of the Hercules–White Spur area.

### HELLYER–PINNACLES AREA (see fig. 6)

The relationship between the Central Volcanic Complex and the Que–Hellyer volcanics is difficult to decipher because of the faulted contact at Mt Charter. However, correlates of the Que–Hellyer volcanics extend along strike through Sock Creek to Pinnacles, and here the stratigraphic relationships can be more easily inferred. The Hollway andesite lies within feldspar-phyric lavas of Central Volcanic Complex type, overlain by correlates of the Que River Shale and Southwell Subgroup. Feldspar-phyric lavas interfinger up to the level, probably, of the lower part of the Southwell Subgroup.

From this correlation it would appear that the Que–Hellyer volcanics are laterally equivalent to the Central Volcanic Complex, and possibly to have formed as a result of a significant period of rifting which produced basalts and andesites at many places along the Mount Read belt.

### RELATIONSHIP OF STRATIGRAPHY TO GEOCHEMISTRY (see fig. 7)

The recent geochemical study by Crawford *et al.* (1992) has shown that the Mount Read Volcanics can be subdivided into five geochemical suites.

#### SUITE 1

This includes the Central Volcanic Complex and Tyndall Group lavas, andesites at Sterling Valley, Hollway, the Que–Hellyer footwall, the quartz-feldspar  $\pm$  biotite porphyries and related granites. They are 'normal' orogenic medium-K to high-K calc-alkaline rocks with moderate to strong enrichment of LREE and are regarded as typical of those occurring in continental margin arcs.

#### SUITE 2

The hornblende-phyric andesites occurring mainly as intrusives within the upper part of the southern Central Volcanic Complex (e.g. Crown Hill, Anthony Road and Reservoir andesites) have lower  $\text{TiO}_2$  and higher  $\text{P}_2\text{O}_5$  than Suite 1, and are slightly more enriched in LREE. They are regarded as high K andesites.

#### SUITE 3

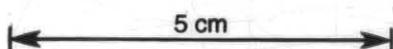
Basalts and andesites, both north and south of the Henty Fault, fall into Suite 3 (e.g. Lynch Creek basalts, Howards Plains intrusives, Hellyer basalts and possibly Sock Creek basalts). They form a continuum with Suite 2 andesites, with the cut-off mainly on  $\text{SiO}_2$  level at 57% and a range of compositions from low  $\text{TiO}_2$ , low  $\text{P}_2\text{O}_5$  lavas with moderate LREE enrichment (some Lynch Creek samples), to low  $\text{TiO}_2$  but strongly  $\text{P}_2\text{O}_5$  and LREE enriched lavas classified as shoshonites. The enriched rocks (two from Lynch Creek, one from Swan Creek and one from Hellyer) have no compositional equivalents in the Andes or in modern arc systems, and are correlated with 'post-collisional' lavas.

#### SUITE 4

The Henty Fault wedge tholeiites and Henty dyke swarm have the geochemical characteristics of rift tholeiites (with slightly low  $\text{TiO}_2$  and definitely low Nb). The low Nb is seen in basalt erupted above subduction zones during early phases of rifting of magmatic arc, back-arc basin opening. Field relationships show this to have been post-Central Volcanic Complex but pre-Tyndall Group time. It is noted by Crawford *et al.* (1992) that it is difficult to relate this to a post-collisional setting of the Mount Read Volcanics.

#### SUITE 5

The Miners Ridge Basalt, with its depleted LREE pattern, is unrelated geochemically to any others in the Mount Read Volcanics. Its closest correlate would be some of the tholeiites of the Crimson Creek Formation (older and to the west of the Mount Read belt). Stolz and Large (1992) have suggested that the relatively gold-enriched Crimson Creek Formation could be the reason why Mount Read Volcanic VHMS deposits are gold enriched, and point to the recent tectonic models of Green (1984), Corbett and Lees (1987), Corbett and Turner (1989), and Berry and Crawford (1988), which all have the Crimson Creek Formation as basement to the Mount Read Volcanics. Recent work by Dower (1991) and Corbett *et al.* (in press) show the Miners Ridge



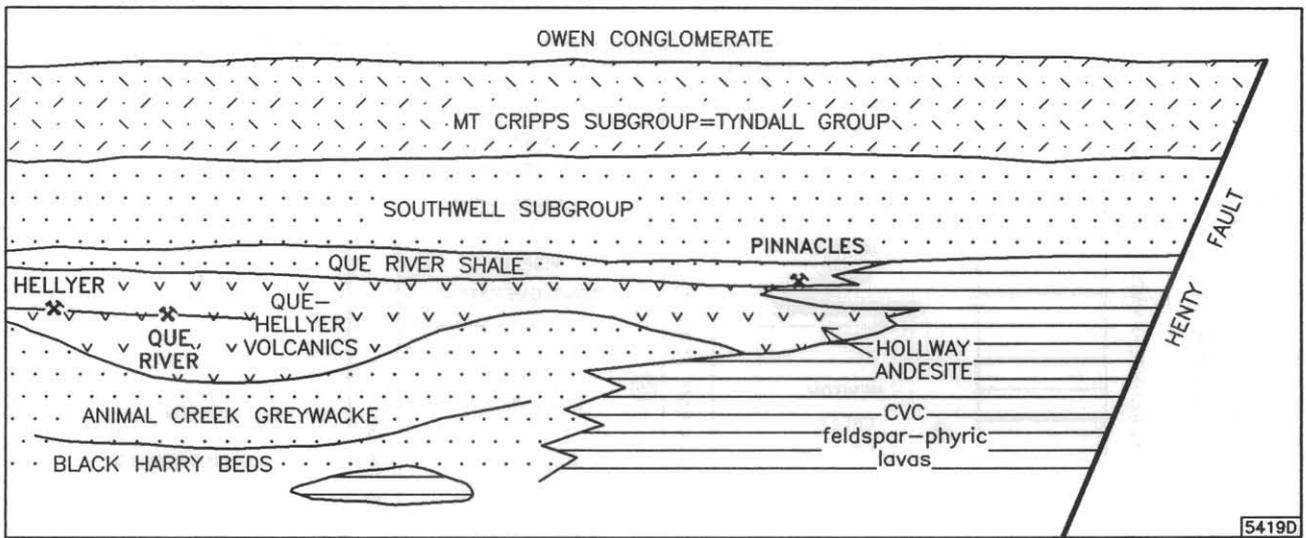


Figure 6

Schematic cross-section of the geology of the Hellyer-Pinnacles area.

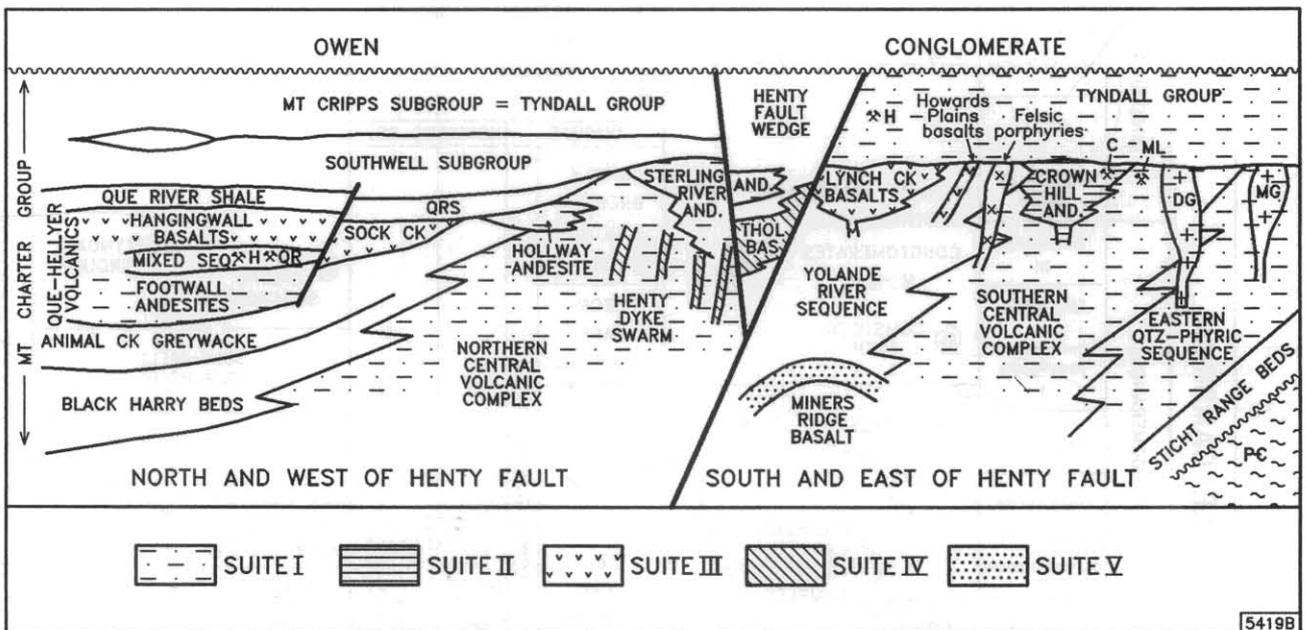


Figure 7

Summary of the stratigraphic relationships of the different geochemical suites (modified after Crawford *et al.*, 1992).

Sandstone and basalt to be fault enclosed, suggesting tectonic emplacement.

**RELATIONSHIP BETWEEN STRATIGRAPHY AND MINERALISATION**

**MAJOR VHMS DEPOSITS (see fig. 1)**

*Hellyer and Que River*

These occur within an andesite-basalt succession at the change between Suite 1 and Suite 3 (shoshonitic) rocks. They probably formed during a rifting episode associated with the

development of the Henty and Mt Charter Faults. The Que River Shale (late Middle Cambrian) and Southwell Subgroup (the 'marker sequence' at its base) immediately overlie the Que-Hellyer volcanics.

*Rosebery-Hercules*

These are found in a felsic sequence with no andesites known in the immediate vicinity. There is a possible connection with the ancestral Rosebery Fault. Recent correlations (McPhie and Allen, 1992) of the hanging wall quartz-phyric unit with the basal Southwell Subgroup suggests an ore position just below the Que River Shale and perhaps of similar age to Que-Hellyer.

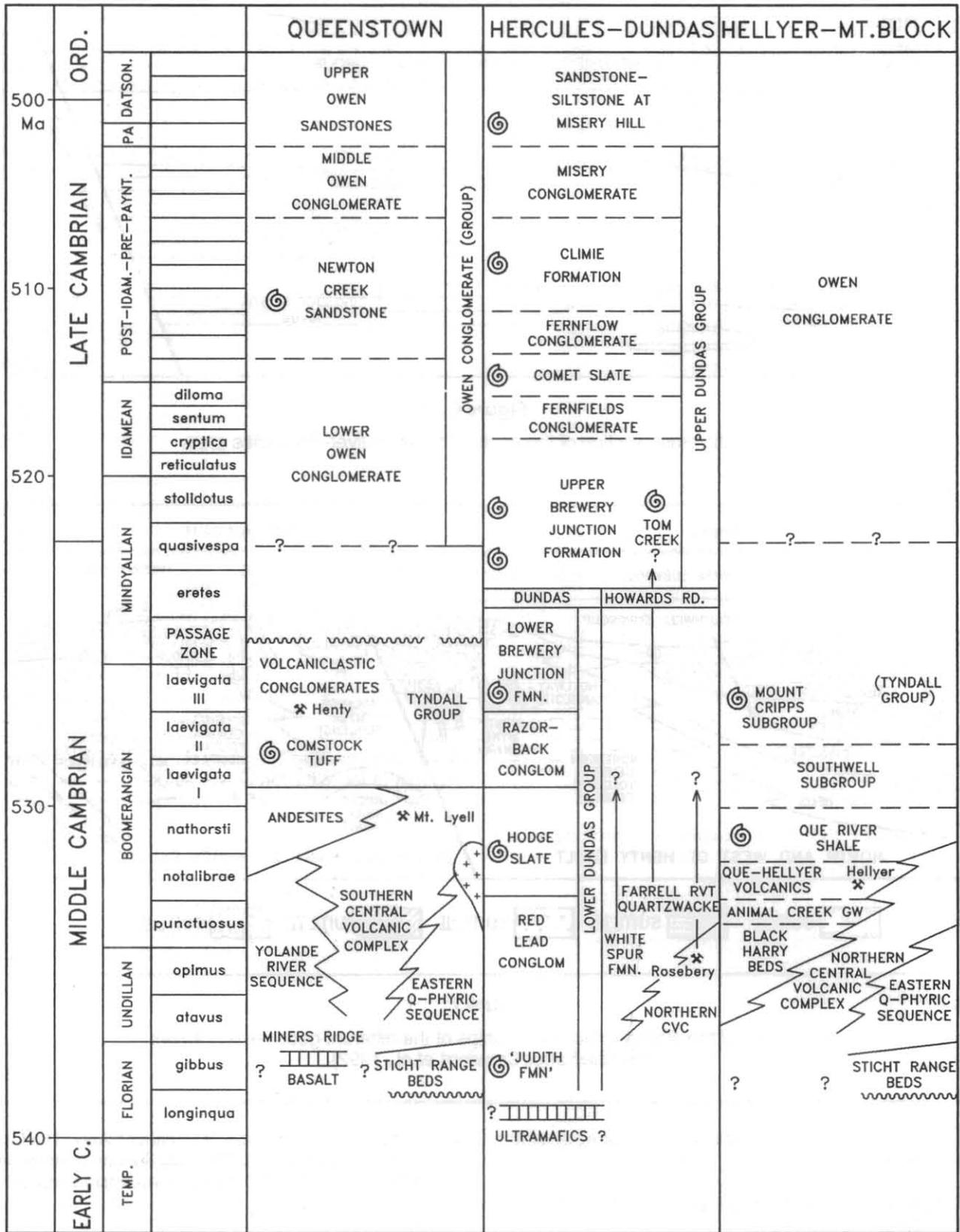


Figure 8

Comparative stratigraphic columns for Queenstown, Hercules-Dundas and Hellyer-Mt Block areas (from Corbett, 1992).

5 cm

### Comstock–Mt Lyell

These occur partly in andesite and partly in felsic volcanic rocks adjacent to andesite. Preliminary data suggest the andesites may be Suite 3 type. The Tyndall Group (possibly includes Southwell Subgroup equivalents) immediately overlies Comstock. There is a strong inferred relationship to the Great Lyell Fault, which appears to have been the locus for large hydrothermal systems (e.g. the chert-sinter exhalites such as the Comstock Chert).

### Conclusion

The evidence for a stratigraphic correlation at the pre-Tyndall Group–Southwell Subgroup position with the 'andesite connection' and 'marker sequence' for the major VHMS deposits is now gaining strength.

### OTHER VHMS-RELATED DEPOSITS (see fig. 1)

#### Henty

The Henty mineralisation occurs at or near the contact between lavas below and volcanoclastic mass-flow rocks above, and has traditionally been assigned to the 'Tyndall Group'. With the recent refinement of the term Tyndall Group, it is possible that the lower lavas are equivalent to felsic lavas and andesites elsewhere, and that the VHMS mineralisation is in a similar position to that of the large VHMS deposits. The immediate footwall position of the deposit to the Henty Fault also suggests a tectonic and perhaps genetic influence from the fault. As the gold is hosted in large zones of intense silicification, McNeill and Corbett (1992) suggests an epigenetic-epithermal origin, and parallels could be drawn with the silicification seen in the Comstock–Mt Lyell area.

#### Pinnacles

There is strong evidence that the Pinnacles mineralisation is at or about the Que River Shale stratigraphic level (Reid, 1991; Coutts, 1990). Once again there is the andesite connection with the Hollway andesite, and a possible influence from the Rosebery Fault or its precursor. Therefore Pinnacles could fit the same general pattern as the large VHMS deposits.

#### Wart Hill

Large massive sulphide clasts ( $\pm 5$  m) occur as rafts in a mass-flow deposit near the western margin of a quartz-phyric-rich lava sequence where interfingering with a volcano-sedimentary sequence takes place. This unit has similarities to the Rosebery hanging wall unit, which has large sulphide clasts at the Bastyan Dam. However the original deposit may have been some distance from the present prospect and in a different stratigraphic position.

### GRANITE-RELATED DEPOSITS

Copper-gold-pyrite-hematite-magnetite deposits, usually associated with chlorite-K feldspar ( $\pm$  tourmaline) alteration, are common along the Jukes–Darwin Range, in the Dora–Selina–Murchison area, at Mt Remus, and to a lesser extent in the Elliott Bay area. There is an obvious geographic association with Cambrian granite bodies and with quartz-feldspar  $\pm$  biotite porphyry bodies. Other lines of

evidence (S isotopes, Zn ratio, presence of tourmaline, etc.) indicate a genetic link to the granites.

### POST-CAMBRIAN MINERALISATION

Two styles are commonly recognised with Devonian granite-related mineralisation (lead, zinc and silver; e.g. Farrell and Lakeside) and gold occurrences associated with fault zones in the Lynchford–King River areas (e.g. Coupon, Harris Reward, Lynch Creek, Sailor Jack and perhaps the source for the alluvials at Flannigans Flats).

### CONCLUSION

The recent mapping of the Mount Read Volcanics Project and other detailed work (e.g. McPhie and Allen, 1992; Crawford *et al.*, 1992) has refined and altered our definitions of some of the established Mount Read Volcanic stratigraphic groupings. It is now apparent that the western volcano-sedimentary sequences, Central Volcanic Complex and Eastern quartz-phyric sequence are facies variations of time equivalent units. The andesitic-basaltic volcanism associated with the mineralising event of Que–Hellyer was widespread, and interfingers with the upper part of the Central Volcanic Complex, and if coupled with the 'marker sequence' of McPhie and Allen (1992) suggests a stratigraphic correlation with the major VHMS deposits at this period.

Mapping at Jukes–Darwin has clearly shown the interfingering relationship between the Central Volcanic Complex and Eastern quartz-phyric sequence, and that the Tyndall Group should be confined to later volcanoclastic sediments with granite and quartz-feldspar porphyry clasts. Minor volcanism (andesitic to rhyolitic) and welded tuffs are present to the north (Comstock, Newton Creek and Link Road), plus granite and porphyry clasts. All of these features are seen in the Winterbrook volcanics, and it is suggested that they are correlates of the Tyndall Group / Mt Cripps Subgroup.

Although the 1:25 000 mapping of the Mount Read Volcanics is not complete the coverage achieved during the Mount Read Volcanics Project has rapidly advanced our understanding of the stratigraphic-facies relationship and stimulated a great deal of study by others, which has been of benefit to all those working on these rocks.

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