

A Report Prepared for Gold Fields Exploration Pty Limited

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AN EXAMINATION OF BASE- AND PRECIOUS-METAL  
AND LITHOPHILE-ELEMENT MINERALIZATION IN NEW  
SOUTH WALES AND TASMANIA, AUSTRALIA

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SYNOPSIS

During a 3½ week assignment with Gold Fields Exploration Pty Limited, mineral prospects were examined in New South Wales and Tasmania. The following general observations, conclusions and recommendations were made:

- (i) Gold mineralization at Peak Hill is associated with enargite-bearing advanced argillic alteration of the type characteristic of the upper parts of porphyry copper systems. Further shallow drilling of the auriferous oxidized zone defined to date is recommended.
- (ii) Gold mineralization at Yalwal and Pambula occurs within and around rhyolitic flow-dome complexes. At Yalwal, emphasis should be assigned to the main Yalwal sector, rather than the Grassy Gully sector, and rock chip sampling should be concentrated on oxidized material. Further work at Pambula is recommended only if the completed chip sampling programme reveals areas of interest, given the apparent structural control of much of the mineralization.
- (iii) At the old Cowarra Creek gold mine, chip sampling across the main metamorphogenic quartz lodes and intervening sedimentary wallrocks would be worthwhile to determine if mineralization is present over sufficient widths for open-pit mining.
- (iv) During drilling of old gold districts in search of low-grade bulk-minable mineralization, more emphasis during early exploration stages should be placed on shallow, high-angle drilling of oxidized material hosting the old workings, rather than on drilling of inclined diamond holes beneath zones of previous exploitation. This is considered important at Peak Hill and Seaview and, with the benefit of hindsight, would have been preferable at Wolumla.
- (v) Field inspections in central-western New South Wales revealed copper skarn, distal gold replacement and porphyry-type prospects, the last not reported previously. In addition to follow-up studies of these, and previously recognized, gold and copper-gold targets, a long-term approach to exploration in the region is firmly supported. Geological, geochemical (including auger sampling) and geophysical (including magnetic) techniques should be valid tools in the search for gold-bearing skarn, distal replacement, breccia and porphyry deposits.
- (vi) The Sam's Mountain tin prospect adjoining the Mole batholith of New England is believed to possess certain geological similarities with the nearby Taronga tin deposit. At Sam's Mountain, however, any

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sheeted vein system is concealed, and its most likely subsurface location requires better definition using rock-chip geochemistry, with samples analyzed for tin, copper and arsenic.

- (vii) A number of copper prospects in the Tyndall E.L. south of Mt. Lyell, as well as farther north at Red Hills, are recognized for the first time to be intimately related to endogenous volcanic domes. The mineralization is of volcanogenic massive sulphide type, with stockwork feeders confined to dome rhyolite or flanking talus breccia, and syngenetic mineralization present in adjoining sedimentary basins carrying fine-grained volcanoclastic sediments. The ease of recognition of the rhyolite domes, which normally constitute topographic prominences, provides the basis for an effective exploration method, both within the E.L. and elsewhere in the Mt. Read volcanic belt. A deeper level of mineralization in the E.L. than in areas farther north is not supported, although dome-flanking basins may have been smaller and hence shallower. Therefore, there may be less chance of encountering lead-zinc-silver-rich massive sulphides of Rosebery type.
- (viii) The chances of locating large-tonnage porphyry or breccia-type tin mineralization in the Heemskirk granitic pluton are regarded as minimal. However, small base-metal and silver-rich tin deposits like that at Sweeney's and the nearby Anomaly 1 and Globe prospects commonly occur in swarms and may be "blind", thereby enhancing the chances of further discoveries. The recognition that the highest grade mineralization is present as low-angle lodes above micro-granite sills provides a useful exploration tool at both prospect and district scales.
- (ix) Stockwork wolframite-molybdenite-cassiterite mineralization in the Foley zone beneath the tin-copper limestone replacement ore bodies at Cleveland is recognized as a small lithophile-element porphyry system. Such bodies, which could easily be larger than the Foley zone, are thought likely to crop out in the northwest Tasmanian tin province and represent a valid exploration target, of a type never previously considered. A preliminary programme of field checking is strongly recommended.

#### A. INTRODUCTION

This report summarizes results of a 3½ week assignment for Gold Fields Exploration Pty Limited, undertaken from 10 November - 4 December, 1982. Field work was completed in New South Wales and Tasmania. In New South Wales, attention was focused on the gold potential of the southern coastal and central-western areas, and on the tin potential of an area in New England. In Tasmania, prospects for base- and precious-metals south of Queenstown, and for tin and other lithophile elements in the northwest were appraised.

The coordination of, and collaboration during, the field programme by Gold Fields geologists is gratefully acknowledged. Field work in southern New South Wales was with A. Ross, C. Cannard and M. Hutton, in New England with G. Moore, W. Delaney, N. Stevens-Hoare and D. Richards, and in Tasmania with G. Purvis, P. Roberts, P. Komyshan and F. Fitzgerald (of Getty). Discussions and data review with these geologists, as well as L. Newnham, were carried out in Canberra, Brisbane and Burnie.

B. NEW SOUTH WALES1. PEAK HILL

A brief examination was made of drill core from the first four holes (PHD 5 to 8) completed at Peak Hill. All were inclined westwards to intersect the principal mineralized zone which extends north-south through the largest open-cuts.

The major part of all holes intersected a felsic, now highly altered and deformed volcanic rock. It contains partially, and locally completely, collapsed pumice fragments, as well as a few lithic clasts, and is therefore clearly an ignimbrite. It is underlain by an andesitic fragmental rock, probably an air-fall breccia, and overlain by a fine-grained volcanoclastic siltstone.

The ignimbrite, and to a lesser extent the andesitic fragmentals and siltstones, have undergone pervasive advanced argillic alteration. Pyrophyllite is the main mineral, but chalcedonic quartz and alunite are also both widespread. Patches, streaks and disseminations of fine-grained pyrite are abundant, and coarser-grained enargite is present more locally. The highest gold grades in the two holes assayed to date appear to be in some (but not all) of the high-pyrite zones. Rather surprisingly, enargite-rich material is low in gold.

Deformation post-dated alteration and mineralization, and imposed a steep foliation, particularly penetrative in pyrophyllite-rich rock. Chalcedonic silica deformed in a brittle manner, and tended to form rounded clasts isolated in foliated pyrophyllite. Although local hydrothermal brecciation, showing evidence of hydraulic fracturing, was observed, much of the clastic texture is a product of deformation.

Alteration and mineralization appear to have been concentrated within the permeable, poorly welded parts of the ignimbrite horizon, and to have affected the hanging- and footwall rocks to a markedly lesser degree. This observation is also borne out by the rock-chip gold geochemistry.

The north-south-trending zone currently being investigated at Peak Hill appears to be the prime near-surface target, and is considered to merit further exploration. This should include at least one east-directed diamond drill hole to ensure that the west-directed holes did not pass either above or below the main part of the auriferous body. Given the isoclinal folding and axial-plane cleavage developed at Peak Hill, it is a distinct possibility that the mineralized body will plunge northwards and have undergone elongation to produce a grossly rod-like body.

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At this stage, it is felt that the main exploration effort should be tailored to evaluating the gold content of the near-surface oxidized material close to, and along strike from, the main open-cuts. The inclined holes completed to date do not effectively do this. A drilling method, perhaps using a reverse-circulation rig, has to be selected to drill short (say 50 m) vertical and steeply inclined holes in fences across the zone of interest.

## 2. YALWAL

### a. Introduction

Prior to any systematic geochemical sampling, and with geological traversing carried out only over the Grassy Gully sector, a field inspection was made of the Yalwal gold prospect.

### b. Grassy Gully sector

Much of the area is occupied by an aphanitic rhyolite exhibiting well-developed flow foliation. The rhyolite is totally devitrified and is locally spherulitic. In places the rhyolite was seen to be overlain by an unbedded, unsorted fragmental rock carrying widespread lithic clasts. Although no clear eutaxitic texture was observed, the rock is tentatively identified as an ignimbrite. The rhyolite is commonly hydrothermally brecciated, with chalcedonic silica widespread as a cement. Amygdaloidal basalt flows are present along part of Grassy Gully.

Most of the rhyolite, and all of the basalt, at Grassy Gully are largely unaltered, except for scattered chalcedony-pyrite veinlets. The principal gold mineralization is present in a northeast-trending belt within the rhyolite. Mineralization accompanies grey to black chalcedonic silica, some cementing pods of breccia, and limonite after minor pyrite. The mineralized belt is characterized by a greenish alteration mineral, probably illite. White quartz of metamorphogenic origin is present, commonly as flat veinlets, in the gold-bearing area and beyond, but is apparently barren.

Several old workings are in the basal conglomerate of the overlying Permian sequence and apparently sought alluvial gold. This style of mineralization appears to possess little potential.

### c. Yalwal sector

A brief examination was made of the geology of the main part of the Yalwal district. The broad rock distribution pattern presented by Love (1965) was confirmed. The principal gold-bearing area, at the Homeward Bound mine, is hosted by strongly-foliated, micaceous siltstones and sandstones. In

contrast, the northern part of the main Yalwal district is occupied by localized masses of rhyolite, and by sedimentary rocks, especially conglomerates. Rhyolite exhibits flow foliation and spherulitic texture in places.

Most of these rocks are stockworked by limonite after pyrite. Several percent pyrite is typical. A mica-like mineral, probably pyrophyllite, is widespread. In parts of the area, patches and veinlets of white to grey chalcedony are developed. Although gold workings are commonly linear, no obvious structurally controlled mineralization is evident in most of the open-cuts.

#### d. Conclusions and Recommendations

Gold mineralization at Yalwal is clearly related to the rhyolites, which previously were considered as flows. They are in fact volcanic domes and, in the main Yalwal district, related dykes. Yalwal may therefore be compared with a number of other epithermal precious-metal districts associated with felsic dome fields. In view of the bimodal (basalt-rhyolite) character of magmatism at Yalwal, a particularly close comparison may be made with Delamar, Idaho.

It has yet to be demonstrated at Yalwal, however, that significant amounts of dispersed gold mineralization are present. A detailed programme of rock-chip sampling, to include both outcrops and accessible surface and (oxidized) underground workings, is required. Trenching to augment rock outcrop, followed by continuous chip sampling, is strongly recommended. In view of the far more widespread alteration and pyritization in the main Yalwal district, priority should be given to that sector. In fact, at Grassy Gully the altered area is relatively restricted and little evidence of gold dispersion is evident.

As an accompaniment to the sampling programme at Yalwal, geological mapping should pay special attention to delimiting the rhyolites and measuring the dip and strike of their flow foliation, and to outlining the principal areas of chalcedony and pyrite introduction. It is possible that gold may have been concentrated around rhyolite centers, especially in permeable lithologies such as conglomerates and sandstones.

It should be stressed that the target at Yalwal is shallow (<50 m) oxidized material, and that all sampling, and any subsequent drilling, should be directed to this end.

### 3. PAMBULA

At the time of this visit, a detailed rock-chip geochemical programme combined with reconnaissance geology had been completed at Pambula, but no analytical results had been made available. The visit emphasized the geological setting of the gold mineralization.

All mineralization at Pambula is hosted by rhyolite, which in most places exhibits well-developed flow foliation. More locally a spherulitic texture is discernable. The considerable extent of the rhyolite, the lack of any interbedded units, and the commonly steep flow foliation indicate an origin as one or more volcanic domes, as at Yalwal. Taylor's (1978) concept of both extrusive and intrusive rhyolites may be rationalized in terms of rhyolite domes, although dykes of rhyolites are certainly also present. At the nearby Sugarloaf property, however, air-fall lapilli tuffs are present in addition to flow-banded rhyolite.

Gold exploited at Pambula appears to occur in irregular but broadly structurally controlled zones. Most are marked by fault breccia. The usual presence of clasts of chalcedonic silica in the breccia indicates that post-alteration (and probably post-mineralization) movement took place. Mineralization accompanied introduction of grey chalcedony and minor amounts of pyrite. Pyrophyllite alteration is also present but is apparently more widespread. Foliation and emplacement of pods and gash veins of metamorphogenic quartz post-dated gold mineralization, although in places it is closely associated with the same fault structures.

Further work at Pambula depends on the results of the geochemical work, although plotting of mineralized structures and flow-foliation directions is probably worthwhile in the meantime. If gold values greater than 2 ppm are shown to be present beyond the main structures, more detailed surface sampling should be carried out to determine the extent of dispersed mineralization. Sampling should combine rock chips and soils.

### 4. WOLUMLA

#### a. Comments on drilling

Six east-directed diamond drill holes have been completed at Wolumla, all with extremely discouraging results. Core from these holes was examined, with particular attention paid to the relationship of mineralization to the "quartz-eye" intermediate intrusive - a topic of previous discussion.

The tonalite intrusion was shown to dip flatly beneath the mineralized basalts and sediments, as interpreted previously from surface evidence

(Sillitoe, 1981 a), and not to possess a steep faulted contact. Since it was recognized early that the intrusive possessed no gold potential, drill holes were stopped once it was intersected. As a consequence, holes did not penetrate beneath the main target area, in the vicinity of the principal workings. It is clear, however, that the tonnage of untested material is unlikely to exceed three million tonnes and, given the sampling data, sufficiently high gold values to render that volume of rock interesting cannot be realistically expected. Therefore no further work can be recommended at Wolumla.

Unfortunately, the dispute regarding genesis of the Wolumla mineralization was not unambiguously answered by the drilling. While the evidence is interpreted in terms of volcanic-related mineralization, with the intrusive merely representing basement, by Project personnel, the writer still favours gold introduction by the intrusive, with mineralization taking place above its flat roof. In drill core, xenolith-like pieces of basalt enveloped by intrusive are interpreted to support intrusion later than at least part of the volcanism. The bedded sandstone-conglomerate intersected immediately above the intrusive in one hole is considered as a normal part of the Upper Devonian volcano-sedimentary sequence, rather than as a localized regolith developed over the intrusive, an interpretation that is supported by sandstone xenoliths in the intrusive.

b. Appraisal of gold prospects

The drilling at Wolumla highlights a potential problem in appraisal of the bulk, low-grade possibilities of old lode gold camps. Such abandoned deposits are normally elongate along strike, and are to be tested to determine whether the widths over which low-grade gold ore is present are adequate for open-pit mining. The material to be mined is generally oxidized, and the best material may normally be expected in close proximity to any old open-cuts. In such a situation at Wolumla, Peak Hill and Seaview we have elected to drill inclined diamond holes beneath the old workings, in order to test tonnage potential and to increase geological understanding. This system fails to test the oxidized ore of prime interest.

It is suggested, therefore, that we adopt an exploration strategy which first tests oxidized material close to old workings. If this preliminary work fails to yield encouraging gold values, then deeper diamond drilling need not be considered, and the property may be relinquished after a far smaller expenditure.

Trenching to bedrock, followed by continuous channel (or chip) sampling, should be made use of wherever practicable, in conjunction with systematic

shallow drilling.

The drilling method adopted as an accompaniment to trenching should be suitable for shallow, normally less than 80-m, holes, of a vertical or steeply inclined nature. In some cases, old mine openings and stope fill may have to be drilled, whereas in others marked contrasts in rock hardness are likely to be encountered. It is recommended that persons familiar with the capabilities of the various drilling options be consulted.

#### 5. COWARRA CREEK

A brief inspection was made of B.H.P.'s old Cowarra Creek gold mine, now held by Australian Paper Manufacturers Ltd, who are currently seeking either to sell or joint venture the property.

The mineralization is hosted by an Upper Ordovician flysch sequence, which has been transformed to slates and phyllites during low-grade regional metamorphism. The sequence is isoclinally folded and carries an axial-plane cleavage. More resistant arenaceous horizons are boudinaged. Pods, lenses and gash fractures carrying metamorphogenic quartz occur throughout the sequence, but are concentrated in a series of steep, north-trending crush or shear zones, which parallel the foliation and are up to 5 m wide. Besides irregularly distributed quartz, these zones carry calcite, sulphides and gold. Sulphides are dominated by pyrite, although pyrrhotite, arsenopyrite, galena and sphalerite are also present.

The mineralization is undoubtedly of metamorphogenic origin, and bears similarities with that currently under exploration by the Company at Pine Creek. Wallrocks are essentially the same, and mineralization is aligned parallel to the foliation, but metamorphogenic quartz appears to be less abundant.

At several places along the 2-km strike length of the mineralized zone, two or more wide shear zones are closely spaced and associated with several subsidiary subparallel fractures, for a total width of some 25 m. Although no obvious indications of gold dispersion beyond discrete shears was observed, its presence should be tested for with a view to outlining mineralized widths of 50 m or more potentially amenable to open-pit mining.

With this goal in mind, it is thought to be worthwhile making several rock-chip traverses across the widest parts of the composite shear system at surface, and in the zone of intersection between the main adit and the number two level. If overall gold grades exceeding 2 gm/tonne were encountered, further interest in the Cowarra Creek property would be justified.

6. CENTRAL-WESTERN N.S.W.a. Introduction

The Company has now taken out an E.L. over the Cargo area, and is shortly to joint venture exploration of an E.L. centred on Junction Reefs with Amoco Minerals. Further E.L.'s, including the one covering Carcoar now held by Pancontinental Minerals, are also under consideration.

This 1½ day visit to the Junction Reefs and Carcoar E.L.'s, and adjoining areas, was to examine several selected old mine sites, and to discuss future exploration strategy in the region with A. Ross.

b. Mine sites visited

- (i) *Stoke Hill copper mine*: Pyrite-chalcopyrite in a shear cutting hornblende-rich gabbro and leucocratic diorite. No further interest.
- (ii) *Carcoar cobalt mine*: Foliated andesitic tuffs and a (?) rhyolite porphyry dyke rock examined at southern end of mineralized horizon. Deposit carried Co-Mo-U-As-Ni-Cu, and is of no interest to the Company.
- (iii) *Bald Hill copper mine*: Chalcopyrite, partly oxidized to malachite, azurite and pitch limonite, in fractures, disseminations and quartz veinlets in andesitic volcanics and in a dacite porphyry dyke. No further interest.
- (iv) *King and House gold mines*: These two closely spaced old mines appear to possess similarities with Junction Reefs and are located only 1.5 and 2.5 km to the southeast. Pyrite and arsenopyrite occur in hornfelsed laminated siltstones, and interbedded quartz-actinolite-rich rocks as disseminations and semi-massive aggregates. Adjoining hornblende diorite carries the same sulphides as disseminations near its contacts. Samples collected by Amoco Minerals from dumps assayed 1 to 2 gm/tonne gold.

The area should be geologically mapped and rock-chip samples collected wherever possible.

- (v) *Blayney South (Sugarloaf) copper mine*: This property was not located by modern investigators. It is skarn-type copper mineralization surrounded on three sides by andesitic flows. A hornblende andesite porphyry abutting the old workings could be intrusive. An early garnet-diopside assemblage is retrograded to actinolite-pyrrhotite-chalcopyrite skarn. If a composite sample collected during this visit

carries gold, soil geochemistry, with analysis for Cu and Au, of the poorly exposed area to the east is recommended.

- (vi) *Malloy's arsenic prospect*: Occurs in small hornblende diorite stock. Traces of epidote-arsenopyrite rock found on small dump. No further interest.
- (vii) *Errowanbang gold deposit*: In andesitic flow sequence. No gangue or sulphide minerals observed on degraded dumps. No further interest.
- (viii) *Infirtaris copper deposit*: In andesitic volcanics, mainly flows, on the contact of a small syenite/monzonite stock. Zone of pervasive sericitic alteration at least 750 x 300 m at surface. Stockwork-disseminated pyrite, largely oxidized to jarosite-hematite at surface, amounts to 3-5 vol.% of rock. Minor chalcopyrite accompanies pyrite in weakly sericitized andesite from shaft on roadside, near centre of alteration zone. Nearby loose material (possibly from same shaft) carries pyrite-molybdenite assemblage. Sericitization gives way to propylitization outwards. Stock essentially unaltered. Quartz-tourmaline-pyrite float found in short gully. Mineralization was previously described as a dissemination in dacitic tuffs (Paterson and Bowman, 1977), apparently a misidentification of sericitic alteration.

The Infirtaris property appears to be a small porphyry copper system. Like comparable deposits in the Intermontane Belt of British Columbia, mineralization appears to be external to the stock, which is essentially unaltered. If gold is present in a composite rock sample, the zone will acquire greater importance. No feldspar-stable alteration was recognized, but its most likely position is occupied by river flats.

In view of the presence of shoshonitic (or alkaline) suite porphyry copper deposits elsewhere in the the region (Cargo, Parkes) and the fact that the porphyry affiliation of Infirtaris has not been recognized previously, further work is recommended. This should commence with mapping of geology, alteration and limonite types and abundance, followed by auger geochemistry, with samples analyzed for Cu, Mo and Au. An induced-polarization survey might assist geological and geochemical interpretations should the latter appear promising.

#### c. General conclusions

The central-western New South Wales region holds substantial promise for discovery of Cu, Au and Cu-Au deposits. The dioritic, monzonitic and

syenitic intrusives, many of them small, little-eroded stocks, are of shoshonitic affiliation, which is generally a good sign for gold potential (e.g. Intermontane Belt, Porgera - Ok Tedi belt). Moreover, the Ordovician host rocks are well endowed with calcareous, and therefore reactive horizons to localize wallrock mineralization.

Deposit types of prime interest include porphyry copper-gold (Cargo, Parkes), skarn (Cadia), breccia pipe (Burnt Yards), and distal replacement (part of Junction Reefs). All these mineralization types are represented, and copper and gold prospects and occurrences are widely distributed, both favourable indicators when selecting a search area. Although a substantial amount of work has been carried out in the region, it is most encouraging to still be able to recognize previously unknown mineralization styles in old mine areas, as with the case of the breccia pipe at Burnt Yards (Sillitoe, 1981 b) and the porphyry system at Infirtaris (see above).

d. Recommendations

It is recommended that a long-term view is taken of exploration in the central-western New South Wales region. Although a number of specific targets, such as King and Infirtaris, for immediate work programmes are already defined, the main thrust of the Company's effort in the region should be to locate previously undocumented copper and/or gold mineralization. The agricultural character of the terrane, with widespread soil cover and sparse outcrops, enhances the likelihood of the existence of concealed mineralization.

Although numerous stocks have already been mapped, others doubtless exist, and some may not crop out at all, either because they are still covered by their host rocks or they are concealed beneath soil or alluvium. An analysis of available aeromagnetic data, with follow-up ground magnetic surveys where necessary, should assist with definition of concealed near-surface stocks, and may also pin point skarn-type mineralization carrying magnetite and pyrrhotite.

A geochemical approach would seem to be the most effective search procedure for mineralization. This work should be concentrated over and around outcropping and concealed stocks, with attention focused on areas within about 1.5 km of stock contacts. Work should commence with stream-sediment sampling of drainages within the areas of interest, and should continue with rock-chip and soil surveys. In many areas, auger sampling of C-horizon material will be mandatory to properly sample thick overburden. Geochemical samples should be analyzed for Cu, Mo, Au and As, and perhaps for other elements too in certain areas.

Shallow stocks still capped by host rocks could be of special importance because of the likelihood of skarn and distal replacement types of Au and/or Cu deposits in their roof rocks. At the Coombing Park iron mine, where no stock has been recognized at surface, drilling by Occidental Minerals encountered diorite beneath one of the mineralized areas (Paterson and Bowman, 1977). Furthermore, during their recent drilling campaign at Junction Reefs, Amoco Minerals intersected fingers of diorite in subsurface fault zones thereby suggesting that the gold mineralization was generated not by nearby outcropping diorites but by a concealed subjacent body.

Once coherent geochemical targets have been defined, induced-polarization, electromagnetic or magnetic surveys could help in further delimiting drilling targets.

## 7. SAM'S MOUNTAIN

### a. Introduction

Sam's Mountain is a tin occurrence, on the northern side of the Mole batholith, that is on offer as a joint venture by Kennecott. On the basis of geological and limited geochemical data, their conceptual model of the occurrence infers the presence of concealed tin mineralization. They suggested that tin grades could be higher than those proved by Newmont at the Taronga deposit, on the southern side of the Mole batholith, because of the apparent tightness of the fine-grained clastic host rocks - the inferred lithocap.

This inspection was made in order to assess the validity of Kennecott's model, and to determine whether their concealed target warranted drill testing. In view of the similarity in geological setting of Sam's Mountain and Taronga, both probably situated above subsurface extensions of the Mole batholith, a brief visit was made to Taronga in the company of Newmont personnel.

### b. Geological observations

The lutites and somewhat more arenaceous interbeds at Sam's Mountain have been converted to dense hornfels, locally biotite-bearing, almost certainly by a non-outcropping intrusive. The rocks are closely jointed, with the predominant set striking N20-30°E. The rock types, contact metamorphic effects and well-developed jointing are reminiscent of Taronga.

The closely-spaced joints over an appreciable area at Sam's Mountain carry coatings of pyrite and, at least locally, arsenopyrite, and a few joints carry quartz as well as sulphides. One, and perhaps two, N20-30° E-trending zones at least 100 m wide appear to carry more abundant sulphides, probably

2-3 vol.%, on the basis of more intense surface jarosite staining. Stream sediment tin anomalies and up to 300 ppm Sn in rock chips reported by Kennecott are considered to be good evidence that at least some of these joint fillings also carry cassiterite.

At Taronga the predominant joint set is filled with thicker veinlets, in which quartz, fluorite, topaz, chalcopyrite and cassiterite, in addition to pyrite and arsenopyrite, are readily visible. Coarse-grained cassiterite in this swarm of sheeted veins (and veinlets) constitutes the Taronga orebody - some 46 million tonnes of 0.14% Sn.

Pervasive greisenization is absent at both Sam's Mountain and Taronga, although white mica veinlets and restricted white mica selvages to some quartz veins and veinlets were observed at Taronga, and minor white mica is present at Sam's Mountain. At Sam's Mountain a narrow linear quartz-tourmaline vein, partly brecciated, cuts the mineralized joints, and is reported by Kennecott to contain up to 0.3% Sn. At Taronga, tourmaline is present as an unimportant veinlet mineral.

#### c. Conclusions

At Sam's Mountain, the presence of an underlying intrusive, in all likelihood a northward extension of the Mole adamellite, may be reasonably inferred on the basis of the surface evidence. A single drill hole near the southern (probably shallower) end of the Taronga zone intersected the Mole adamellite, greisenized in its uppermost few metres.

However, the tight lithocap proposed by Kennecott at Sam's Mountain would appear to have possessed a comparable permeability to that at Taronga prior to mineralization. Consequently, additional tightness of the Sam's Mountain lithocap cannot be cited as a reason to expect a higher-grade tin-bearing body in depth.

It is proposed here that the style of mineralization at Sam's Mountain is closely similar to that at Taronga, albeit much more weakly developed and therefore lower in grade. It may be concluded that the outcropping mineralization at Sam's Mountain is a lower-grade, "failed" version of Taronga or, alternatively, that Sam's Mountain is the lower-grade top or bottom of a Taronga-type body. In view of the lack of any veins or wide veinlets as joint fillings, an interpretation of Sam's Mountain as the tin-deficient top of a Taronga-type body is preferred.

Kennecott geologists were impressed with the tin-bearing quartz-tourmaline vein at Sam's Mountain, and considered it as leakage from a concealed zone of tin mineralization. However, this writer considers the vein as a late

fault filling, and to be insignificant when compared with the sulphide-filled joint system.

In conclusion, therefore, Sam's Mountain may represent either the top of a Taronga-type body or a low-grade equivalent of Taronga. If the former interpretation is the correct one, then any higher-grade tin mineralization is likely to be at depths greater than 100 m and therefore not amenable to low-cost mining as at Taronga. This depth estimate is based on the apparent absence of any significant tin mineralization on the steep sides of Sam's Mountain, which provide exposures of mineralized rock over vertical intervals exceeding 100 m.

d. Recommendations

At this stage, drilling at Sam's Mountain cannot be justified. Any future drilling would have to be dependent upon locating areas of significant (say + 0.1%) tin mineralization at surface. Although these seem unlikely, they cannot be excluded because of the extremely limited rock-chip geochemistry undertaken by Kennecott.

It would therefore be worthwhile to carry out a series of rock-chip geochemical traverses, perpendicular to the strike of the predominant joint set. Samples should be analyzed for tin, arsenic and copper. If a significant zone of joints carries high tin values or a marked arsenic or copper anomaly, relative to surrounding areas, consideration might be given to further work at Sam's Mountain.

C. TASMANIA1. MT. READ VOLCANICS, TYNDALL AREAa. Introduction

Four days were spent in the Tyndall E.L. south of Queenstown, which the Company is joint venturing with Getty, and in immediately adjacent areas. A number of base-metal and gold prospects and abandoned mines, as well as unmineralized sections through the Mt. Read Volcanics, were inspected. All visits were intended to assist with understanding of the overall geological setting of volcanogenic base-metal mineralization as an aid to future exploration. In addition, some consideration was given to the possibilities of bulk-minable gold targets in the Mt. Read Volcanics.

b. Localities visited

- (i) *East Darwin:* The abandoned copper mine is located in the Eastern Sequence, the easternmost of the three north-trending volcanic-intrusive sequences recognized in the Mt. Read Volcanic belt. In this area, the sequence is steeply dipping and appears to face eastwards. The ore horizon occurs towards the base of a well bedded volcanoclastic succession, in which tuffaceous siltstones and breccia-conglomerates are prominent. As with most of the tuffaceous rocks in the region, axial-plane cleavage is well developed. Siltstone clasts in breccia-conglomerates overlying the ore horizon suggest a local high-energy environment. The volcanoclastic succession is overlain by a welded ignimbrite carrying abundant quartz crystals in the ash matrix, and scattered lithic clasts. The mineralized horizon is underlain by a massive rhyolite, probably part of an endogenous dome, which is cut by a stockwork of specularite, magnetite, chlorite and limonite after sulphide veinlets. Drilling encountered minor chalcopyrite in this footwall stockwork.

The mineralized horizon is highly siliceous in parts, and carries variable amounts of pyrite, chalcopyrite, specularite, magnetite and chlorite. Sulphides range from massive to disseminated, and crude bedding of sulphides plus gangue was noted in places. The stratiform copper-bearing horizon at East Darwin possesses a strike extent of 800 m, and would still appear to be capable of containing an ore zone of interest.

- (ii) *Huxley*: The Huxley area is a base-metal prospect currently undergoing renewed exploration by the joint venture partners. It is located in the eastern part of the Central sequence, abutting the fault which juxtaposes the latter with the Late Cambrian - Early Ordovician (post-ore) Owen Conglomerate.

Immediately west of the Huxley area is the Whip Spur sequence, mapped as dominantly agglomerates by Corbett (1979). On the Huxley road section, volcanoclastic sediments, including delicately banded and cross-bedded cherty siltstones, an amygdaloidal andesite (or perhaps basalt) flow, and several ignimbrites appear to have been designated as agglomerates by Corbett (1979). The sequence is weakly altered compared with surrounding rocks, and is believed to be at least partly a shallow-water, perhaps lagoonal, sequence. Siltstone clasts at the base of welded ignimbrites support shallow-water conditions, with the fragments being ripped up during passage of the pyroclastic flows. Corbett (1979) considers the Whip Spur sequence as a pendant in a feldspar porphyry intrusive. At least parts of this body appear to be ignimbrite.

Rocks east of the Whip Spur sequence in the northern part of the Huxley area are dominantly fragmental, and include highly welded ignimbrite, and epiclastic and possibly air-fall pyroclastic rocks. Foliation is intense, and chlorite-pyrite alteration is developed in places. Minor sphalerite-galena accompanies disseminated pyrite at one locality. A chlorite-rich tuffaceous siltstone in the northern part of the area carries chalcopyrite. At a single horizon accretionary lapilli were tentatively identified. They must be of air-fall origin and, along with the welded ignimbrites, support only shallow water depths during subaqueous volcanism.

A prominent hill, Nasty Knob, on the northern edge of the Huxley area, is a small rhyolite endogenous dome, alongside which there is a second. The copper-bearing volcanoclastic siltstone passes between the two domes and must have been deposited in a small lagoon. Magnetite - specularite veinlets are present in the Nasty Knob dome.

- (iii) *Jukes Proprietary*: Four adits and several pits explore this copper prospect, which is currently undergoing reappraisal by the joint venture partners. The gossanous, copper-bearing unit occurs in the faulted interval which separates a series of post-mineral ignimbrites

from a pre-mineral endogenous dome of rhyolitic composition.

The ignimbrites are largely poorly welded, although at least one horizon exhibits eutaxitic texture. The units all carry abundant bipyramidal quartz crystals, and clasts of pumice and lithics. The sequence is entirely unaltered. Previous workers classified these rocks as grits.

The rhyolite dome, previously considered as flows, comprises a prominent, steep-sided, bulbous mass. Flow foliation is difficult to discern because of development of a microspherulitic texture during devitrification. Towards the copper-bearing horizon, the dome is chloritized and carries pods and veinlets of quartz-magnetite-specularite-chlorite, which also appear to have contained sulphides, probably chalcopryrite. Barite veinlets are also present.

The copper-bearing horizon is a tuffaceous siltstone carrying abundant chlorite, magnetite, quartz, streaked-out chalcopryrite, and traces of brittlely deformed pyrite and a little siderite and galena. This siltstone is overlain by volcanoclastic siltstones, grits and breccia-conglomerates, the last containing clasts of siltstone and dome rhyolite, and quartz pebbles. Some horizons are rich in quartz grains similar to those in the overlying ignimbrite, but obviously from another source. These units are more weakly mineralized.

The dome is essentially unfoliated, the ignimbrite is weakly foliated, whereas the volcanoclastics are highly cleaved. Faulting may also have affected the volcanoclastics.

The chalcopryrite-bearing siltstone is a syngenetic horizon deposited alongside an endogenous dome. The coarse overlying volcanoclastics also underwent the effects of the hydrothermal system, whereas the ignimbrites post-dated it, and perhaps even terminated it. The feeder zone to the syngenetic horizon is represented by the veins and veinlets in the flank of the dome.

The Jukes Proprietary prospect is considered to be worth further work, although tonnage potential would appear to exist only in a down-dip direction. The next stage of exploration, now that the geological setting is better understood, is to prepare a detailed geological map of the volcanoclastic sequence, including the underground exposures. Particular attention should be paid to structural details. In depth,

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chalcopyrite-bearing stockwork mineralization on the margin of the dome could be of interest. The hydrothermal system was of low-sulphur type, as shown by the lack of pyrite in the mineralized siltstone and the presence of magnetite (not pyrite) in the dome. Chargeability anomalies should therefore be a direct indication of the presence of chalcopyrite.

- (iv) *Prince Darwin:* The copper prospect is hosted by an endogenous dome of rhyolitic composition. Mineralization is present in an elongate zone on the western flank of the dome, and consists of open stockworks, and replacement veins and patches of magnetite, chlorite, pyrite and minor chalcopyrite. Adits and drill holes reportedly intersected only low-grade mineralization (0.5% Cu), and no further work is warranted given that most of the dome is unaltered.

No syngenetic sulphide appears to be present, although known black shale horizons along the western side of the dome in the Clarke valley should perhaps be considered further.

A coarse-grained equigranular granite truncates the dome on its eastern side, and imposes contact metamorphic effects. It is unaltered and unmineralized except for quartz-tourmaline pods. The presence of such a relatively deep-seated (say, 3 km) intrusive at the same level as the near-surface Prince Darwin dome demonstrates that the latter must have been buried by several kilometres of volcanic rocks, into which the granite was emplaced during later stages of volcanism, when it would have acted as a magma chamber. Emplacement during caldera resurgence would be a particularly attractive hypothesis. Erosion down to roughly the present level must have preceded deposition of the Owen Conglomerate.

- (v) *Lake Jukes:* This old copper mine is also located in an endogenous dome of rhyolitic composition. The dome is flow banded in places, and is flanked by crumble breccia, built as a talus apron during dome growth. Mineralization is present within the dome and in the crumble breccia as stockworks, which locally grade into replacements and hydrothermal breccias. The mineralogy is a typical low-sulphur assemblage of magnetite, chalcopyrite, bornite and chalcocite, accompanied by quartz and chlorite. Although the Lake Jukes mineralization is more intense than that in any of the other domes recognized during this visit, it is too erratic to warrant further work.

The dome appears to be flanked on all sides by essentially unmineralized, and perhaps post-mineral, welded ignimbrites. No horizon capable of hosting syngenetic mineralization was observed.

c. Conclusions

Although the writer agrees with current concepts of the Mt. Read Volcanic belt as a series of calderas along a rift (Corbett, 1979), some of the more detailed aspects of the Belt's geology appear to have been misrepresented. In particular, the tripartite longitudinal subdivision of the Belt into Eastern, Western and Central sequences, and much of the volcanological interpretation of rock types are suspect.

A coherent, and apparently generally applicable, model for volcanogenic mineralization in the Tyndall E.L., and perhaps elsewhere in the Belt, has resulted from this work. Mineralization is intimately associated with endogenous domes, and comprises stockwork (and subordinate breccia) feeder zones and, in some localities, adjoining syngenetic mineralization deposited under tranquil conditions in apparently shallow lagoons.

The E.L. is occupied by a substantial volume of dome material, with much of the Mt. Darwin Plateau underlain by rhyolite of dome origin. Clearly the region may be considered as a dome complex, possibly emplaced during resurgence of one or more calderas.

Previous workers have concluded that the E.L. contains mineralization of a deep-seated type, with the large volume of rhyolites in the Central sequence, and the granite pluton, taken to indicate a deep erosion level. Evidence presented above argues strongly against this conclusion, and unambiguously defines surface and near-surface environments of mineralization. If any difference between the E.L. and areas farther north is to be emphasized, it would be one of volcanic setting of mineralization. In the E.L., syngenetic mineralization appears to have taken place under relatively shallow subaqueous conditions in restricted basins abutting domes. This is probably the reason that mineralization is essentially cupriferous. The deeper-water conditions, in more widespread basins, necessary for distal Pb-Zn-enriched stratiform mineralization of the Rosebery type have not been recognized, although their presence cannot be precluded. Shallow subaqueous conditions probably also favour sub-seafloor ore deposition rather than syngenetic massive sulphide accumulation, as appears to have been the case at Mt. Lyell itself. However, knowledge of the volcanic geology at Mt. Lyell is inadequate for a proper comparison to be made with the model proposed above.

The E.L. is dominated by ignimbritic volcanics. It is generally assumed that ignimbrite-dominated terrains are not conducive to massive sulphide formation because of their subaerial (or very shallow subaqueous) origin. However, major deposits like Mt. Lyell were emplaced in ignimbrite terrains. A traverse of part of the Gormanston road section at Mt. Lyell confirms far more ignimbrites in the Mine Sequence than indicated by Cox (1981). It would therefore appear that ephemeral subaqueous conditions, perhaps induced by cauldron subsidence, are adequate for massive sulphide formation. Ignimbrite terrains can therefore be prospective areas for massive sulphides.

Although no significant gold mineralization (lacking base metals) is known from the E.L., the gold-rich nature of massive sulphides in the Mt. Read Volcanics, at Mt. Lyell, Rosebery and Que River, provides support for its presence somewhere. In common with many epithermal gold deposits, dome complexes could provide a suitable setting for bulk-minable targets, which would always be accompanied by significant pyritization, and possibly by chalcedonic silicification and hydrothermal brecciation.

An understanding of the effects of Devonian deformation of the Mt. Read Volcanics is essential for exploration. Its effects were highly selective: Domes acted as resistant buttresses and underwent essentially no deformation. Volcaniclastic sediments were highly compressed, underwent isoclinal folding, and exhibit an axial-plane cleavage. Ignimbrites tend to have responded in an intermediate fashion. Therefore in the mineralized settings described above, the sulphide-bearing basinal sediments tend to have acted as stress guides, and are plastered against the domes. The deformation of volcaniclastics in the E.L. is probably little different from that detailed by Cox (1981) at Mt. Lyell, where shortening of 60 percent and elongation by up to 150 percent was calculated. Therefore sulphide bodies tend to become steeply plunging, cigar-shaped bodies parallel to the lineation.

#### d. Recommendations

It is clear that future work in the Tyndall E.L., and elsewhere in the Mt. Read Volcanic belt, should be based on a better understanding of volcanic geology, and consequently rely less on geophysical and geochemical techniques. Geological work must attempt to understand the total volcanic setting instead of merely giving rocks lithological (and commonly incorrect) names. In this regard, it should be noted that previously domes were unrecognized and usually assumed to be flows, and many ignimbrites, especially unwelded ones, were

termed flows, tuffs or agglomerates.

The results of this work in the E.L. strongly suggest that recognition of endogenous domes is the basic parameter of any exploration programme. This is relatively easy since they commonly constitute topographic prominences. If the domes show evidence of stockwork mineralization, their environs should be traversed in detail in search of fine-grained volcanoclastic units, potential hosts for syngenetic mineralization. If such epiclastic units are extensive, potential for Rosebery-type bodies could exist. The applicability of this model beyond the Tyndall E.L. is confirmed by the presence of an apparently identical situation at the Red Hills prospect north of Mt. Lyell. There, according to G. Purvis and F. Fitzgerald and supported by a helicopter overflight, a copper-bearing rhyolite (now reinterpreted as a dome) is flanked by a highly deformed basinal sequence, within which a single high-grade massive sulphide intersection has been obtained.

This model for volcanogenic mineralization in the Mt. Read Volcanic belt is believed to be equally applicable to Corbett's (1979) Eastern, Western and Central sequences. During exploration of selected targets, special attention should be paid to structural complications in the basinal fill, and a representative selection of samples should always be assayed for gold.

At this time, it would appear that syngenetic mineralization abutting domes is likely to constitute a more attractive target than mineralization in the domes themselves. It should be remembered, however, that Mt. Lyell mineralization appears to occur largely as subsurface, albeit shallow, replacement bodies. This fact, combined with the lack of understanding of its local geological setting, strongly emphasizes the need for a reappraisal of Mt. Lyell geology from a volcanological standpoint. This writer would be prepared to undertake such a study, which would have to be based on a programme of remapping. Not only would the results benefit regional exploration in the Belt, but they would undoubtedly also aid further ore search at Mt. Lyell itself.

A five month compilation of the voluminous exploration results available for the Tyndall E.L. is planned as part of the joint venture. Although this work would be useful from a geochemical, and perhaps also from a geophysical, standpoint, it would be geologically valueless. It has become clear during this work that existing geological descriptions cannot be appraised, or even related to the field situation, without additional fieldwork. It is therefore recommended that a substantial part of the allotted 5-month period be given over to field inspections of all documented prospects in the E.L., combined with search for the dome/basin combination described above.

## 2. HEEMSKIRK TINFIELD

### a. Introduction

A series of old tin mines and new prospects were examined in the southern part of the Heemskirk granitic pluton, with a view to commenting on mineralization styles. All the mineralization inspected has been drilled by the Gold Fields group, and several prospects are the subject of ongoing exploration. One and a half days were spent in the field, and one day examining representative drill core stored at the Renison mine site.

### b. Federal area

Most of the tin mineralization inspected on the Federal plateau is of small-scale type, and appears to have been controlled by a variety of joint sets and their intersections. At Black Face, the intersection of two joint sets has controlled quartz-tourmaline replacement. Original joints are commonly still visible, as quartz-tourmaline veinlets, with intervening adamellite replaced by friable tourmaline aggregates. The Black Face prospect is not a breccia pipe, as proposed by some previous workers. Nearby, however, limonite-cemented hydrothermal breccia is present as a tiny pipe or restricted dyke within the pluton. The limonite is reportedly enriched in base metals but lacks significant tin. The presence of fragments of fine-grained sediment, as well as adamellite, in the breccia suggests collapse played a part in breccia emplacement.

At West Federal, sericitized adamellite was exploited for its tin content, both as flat bodies, perhaps bordering a flat quartz-tourmaline vein, and as a small pipe generated at an intersection of two or more joints.

At Waxman's-and-Westman's and nearby areas, adamellite and later microgranite (or microadamellite) are altered to a green sericite-siderite-pyrite assemblage, similar in many ways to alteration in the Sweeney's area (see below). Tin values are patchy and low, and zinc was encountered locally. Massive to disseminated specularite is the most obvious product of mineralization, and at Waxman's-and-Westman's and in the nearby FED 7 drill hole it is concentrated immediately adjoining microgranite bodies. If the microgranite occurs as flat sill-like bodies, as seems likely, the specularite is present immediately above them, a geometrical arrangement dominant in the Sweeney's area (see below).

None of the prospects examined on the Federal plateau appears to possess significant tin potential, although the presence of a larger tin concentration cannot be ruled out given the vagaries inherent in such granite-hosted tin mineralization. Although evidence from the small breccia body suggests mineralization at no great depth below the pluton's roof, the Federal plateau tin

mineralization appears to have been emplaced too deep for any large volume of tin-bearing rock to have formed. The joint-controlled occurrences could represent feeders to greisen development in a higher-level cupola, or in a sheeted vein system in the roof rocks, both of which would now have been lost to erosion.

c. Sweeney's area

Three base-metal and sulphur-rich tin prospects, Sweeney's, Anomaly 1 and the Globe, were examined in the southernmost part of the Heemskirk pluton. Drilling by the Company has partially defined the three prospects as grossly flat bodies, underlain at Sweeney's by a pipe-like extension. Metallic minerals occur as massive to disseminated aggregates in restricted bodies of green sericite-chlorite-siderite-pyrite alteration. Quartz-tourmaline alteration is also important at the Globe. The halos of surficial argillic alteration around the three prospects are believed to be of supergene origin. Besides cassiterite, tin is also present as stannite. Sphalerite is commonly the dominant sulphide of interest, and is accompanied by chalcopyrite, galena and a series of sulphosalts of which jamesonite, boulangerite and tetrahedrite have been identified by microscopical methods and were recognized during this inspection. High silver values are present in the sulphide assemblages. Fluorite is a common gangue mineral, and forms massive intergrowths with sphalerite.

Within the flat mineralized bodies at all three prospects, the highest grade mineralization also appears to be present in low-angle zones. At the Globe, a sheeted quartz-tourmaline-cassiterite lode dips at a low angle and emphasizes this configuration. It was recognized for the first time during this examination that the best and most massive mineralization at all three localities occurs as flat lodes along the upper contacts of sill-like bodies of microgranite emplaced into the coarse-grained adamellite. This disposition of the mineralization is believed to reflect flat tensional fractures developed above the sills, which during mineralization provided high-permeability channelways.

These flat structures appear to have been fed by a subvertical conduit, the sulphide pipe, at Sweeney's, and by a swarm of quartz-tourmaline greisen veinlets developed within the footwall microgranite at the Globe. The veinlets carry sphalerite and sulphosalts for a short distance below the flat mineralized body.

A better understanding of the distribution of microgranite sills could provide an effective exploration tool, both at the prospect scale and at a semi-

regional scale. It is recommended that all drill core from the three prospects is relogged with emphasis on microgranite distribution and intensity and styles of mineralization. If microgranite sills can be correlated between drill holes and with surface exposures, they should provide an indication of the location of the highest grade mineralization. During further prospecting, zones of microgranite sills could be assigned a higher priority than microgranite-free areas because of the possibility of better structural preparation. These selected areas could then be subjected to the geochemical and geophysical techniques currently being employed.

The intense and pervasive feldspar-destructive alteration of hydrolytic base-leaching type in the Sweeney's, Anomaly 1 and Globe prospects, and their high-sulphide assemblages, support the presence of a significant meteoric water component in the ore-forming fluids. Emplacement at a higher level than much of the tin mineralization on the Federal plateau, and perhaps closer to the original pluton roof, might therefore be suggested.

#### d. Conclusions and recommendations

In accordance with Company priorities, the writer agrees that exploration in the Heemskirk pluton should be focused on the Sweeney's area, where base- and precious-metal contents supplement tin grades. Potential for further discoveries is considered high, since mineralized bodies of the Sweeney's type generally occur in swarms (as already suggested by the three known occurrences) and may be "blind". Shallow "blind" bodies are probably capable of localization using the induced-polarization method.

In conclusion, it should be emphasized that little possibility of encountering large-tonnages of dispersed tin mineralization seem to exist in the Heemskirk pluton. Emplacement appears to have been too deep for widespread development of stockwork or breccia styles of mineralization. In the Sweeney's area, no evidence of hydrothermal brecciation is present, and fluids appear simply to have soaked through permeable zones in the pluton without the fluid pressure exceeding the lithostatic pressure plus tensile strength of the suprajacent rock column.

### 3. CLEVELAND TIN MINE

#### a. Introduction

A half-day visit was made to Aberfoyle's Cleveland tin-copper mine, in the hope of examining the underlying stockwork tungsten-molybdenum mineralization in the Foley zone. This was achieved under the guidance of Aberfoyle geologists.

b. Geological observations

The cassiterite-chalcopyrite orebodies, described by Collins (1981), were briefly inspected. They comprise massive sulphide replacements of carbonate horizons, in many ways similar to those at Renison. Two salient differences from Renison are readily apparent: Firstly, the replaced beds are limestones and not dolomites; and, secondly, the beds are vertical and themselves acted as conduits for the ore fluids, a major fault zone feeder, like the Federal-Bassett structure, being absent.

The tin-bearing lenses at Cleveland are up to 800 m long, and extend to some 400 m below surface. In the footwall siltstones and sandstones, but extending as a finger-shaped vertical body to within 150 m of surface, is a zone of stockwork wolframite-molybdenite mineralization. The zone is centred on a dyke-like body of rhyolite porphyry, which has its top some 250 m beneath the apex of the stockwork, and has been intersected in drilling over a vertical interval of 600 m. It is some 30 m wide in its upper parts and widens slightly downwards, and is known over a length of 200 m. In the upper part of the porphyry and the enclosing sedimentary rocks a kidney-shaped body of stock-worked rock is defined by the 0.3%  $WO_3$  isopleth.

Aberfoyle currently considers the W-Mo resource to be uneconomic, but is continuing with a drilling programme. At present, they estimate 15-20 million tonnes averaging 0.3%  $WO_3$ , 0.03-0.04% Mo and 0.08% Sn. Tin values average about 0.1% in the porphyry.

The rhyolite porphyry carries prominent quartz "eyes" up to 1 cm across, in a highly siliceous topaz-sericite matrix. All the porphyry is highly altered, therefore rendering whole-rock chemistry meaningless.

The stockwork is relatively dense within the main mineralized body, and is dominated by quartz. Quartz veinlets, up to 3 cm wide, carry bladed wolframite (ferberite), molybdenite, cassiterite, chalcopyrite, pyrite, arsenopyrite, fluorite, sericite, siderite and minor tourmaline. Bismuthinite and native bismuth are also reported, and in depth pyrrhotite is also present. Molybdenite commonly occurs on veinlet margins. In the sediments, biotite is present as a selvage to some veinlets. Upwards, beyond the 0.3%  $WO_3$  zone, the stockwork is more open and veinlets tend to be wider, up to 40 cm. Pyrite, wolframite, molybdenite and fluorite were also observed as disseminations in the porphyry. The main mineralized zone carries 3%  $Ca F_2$ , some of it as monomineralic veinlets.

c. Conclusions

The Foley zone is characterized by a lithophile enriched, high-fluorine

rhyolite porphyry, of possible A-type. The W-Mo-Sn stockwork mineralization is draped over the upper parts of the dyke-like stock. Clearly the mineralization may be considered as of porphyry type, with many characteristics in common with Climax-type molybdenum deposits, in which tungsten (as wolframite) and tin may be recoverable by-products. At the present time, Aberfoyle geologists think of the zone as of greisen type, make comparisons with the rhyolite dykes at Mt. Bischoff, and apparently do not recognize the porphyry affiliation. Furthermore, they do not believe the Foley zone to be related to the Sn-Cu orebodies, and consider its location fortuitous and its age to be younger than the Sn-Cu mineralization. In contrast, this writer believes that the Foley zone will prove to be the earliest stage of mineralization at Cleveland, and that the rhyolite porphyry body is the apical portion of a larger stock which provided ore fluids for all mineralization stages at Cleveland.

d. Recommendations

The recognition of the Foley zone at Cleveland as a lithophile-element porphyry system demonstrates that similar mineralization may be expected elsewhere in the northwest Tasmanian tin province. Mineralized bodies of larger size and higher grade than that at the Foley may realistically be expected. If such bodies crop out, or at least are at shallower depths than the Foley, they could be amenable to open-pit mining.

Exploration to date in Tasmania has never considered Climax-type porphyry targets, and much geochemical work has ignored molybdenum and, in many cases, even tungsten. Therefore the Company is strongly urged to include a lithophile-element porphyry search in its Tasmanian exploration programme. If the Company is to maintain any advantage over its rivals, this interpretation of the Foley zone should be assigned a high degree of confidentiality.

The first stage of an exploration effort for outcropping or near-surface bodies of Foley type should commence with a literature search, followed by ground checking. All known occurrences of molybdenum, tungsten and fluorite mineralization, including vein and skarn types, should be given priority. Tin, copper or lead-zinc prospects or occurrences could also be of interest as indicators of the upper or marginal parts of Foley systems. Rhyolite porphyries with high fluorine contents, probably described as quartz or quartz-feldspar porphyries, or felsites in the literature, might also be examined. In this regard, the Pine Hill intrusive centre near to Renison, where molybdenum mineralization is already known, deserves an in-depth reappraisal. In general,

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parts of the tin province lacking granitic plutons or carbonate rocks could prove more prospective because they will not have been explored for replacement, skarn or granite-hosted tin deposits, and should therefore prove to be less well known geologically.

Brisbane, Australia  
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