Gold in Tasmania

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ABSTRACT

Lode gold deposits are widespread in western and northern Tasmania, and principally occur in the pre-Carboniferous rocks of the Dundas Trough and Lachlan Fold Belt. The northeastern area is particularly important, with numerous gold-quartz veins in the turbidite bearing Mathinna Beds, of Ordovician to Devonian age, in the Lachlan Fold Belt. Some of these deposits are spatially and genetically related to granitoid intrusions, while others have probably been derived from metamorphic fluids. Gold is also a very important by-product of most of the volcanic-hosted massive and disseminated base metal deposits in western Tasmania, which are the only significant gold producers in Tasmania at present. Other interesting styles of gold mineralisation in Tasmania include the stratabound gold in the Arthur Mobile Belt and that related to Cretaceous alkaline intrusives in the Cygnet area. Alluvial gold is also widespread in Tasmania, with about 360 deposits recorded, some relatively large and rich.

INTRODUCTION

This paper is predominantly a brief literature review of gold deposits in Tasmania, firstly describing the geology of the major goldfields in the State, and then the deposits producing gold as a by-product. The different styles of mineralisation will be summarised and discussed, with suggestions for future exploration.

Gold-bearing deposits are relatively common in Tasmania (fig. 1), with over 1260 recorded on the MIRLOCH database of Tasmanian mineral deposits, approximately half of these occurring as quartz veins in the Mathinna Beds of northeastern Tasmania. Alluvial gold and various other mineralisation styles are also present. The gold production for the state is shown in Table 1, but records for smaller, early workings are poor, as a large proportion of the gold was taken directly to the mint in Victoria by the miners. Where not otherwise acknowledged, the production data were collated from various departmental records. Production from gold mines has been sporadic from 1852 to the present, with most production between about 1870 and 1920. Production records and data in McOnie (1983), Bottrill (1991), and Large *et al.* (1990) indicate a total gold production in Tasmania of about 199 t, comprising about 143 t from base metal deposits, 43 t from vein-style deposits and 13 t from alluvial deposits. At present nearly all gold production comes from the base metal mines in western Tasmania.

Acknowledgement

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PRINCIPAL GOLDFIELDS

Northeastern Goldfields

General geology

The Mathinna Beds are turbidite sequences of Ordovician–Early Devonian age, generally classified with the Lachlan Fold Belt and closely related to sequences in Victoria and New South Wales (Powell *et al.*, in press; Powell and Baillie, in press). Powell and Baillie (in press) note two stages of deformation in the Mathinna Beds: upright to overturned folding in the Early Devonian, and recumbent folds and thrusting in the Middle Devonian. Structural and stratigraphic studies are hampered by commonly poor outcrop and the lack of marker beds and drilling. The rocks are intruded and locally contact metamorphosed by granitic to dioritic rocks of the Scottsdale and Blue Tier batholiths, of probable upper Devonian to lower Carboniferous age. The folding and syntectonic metamorphism (to lower greenschist facies) in the Mathinna Beds are considered to predate the intrusion of granitoids (McClenaghan *et al.*, 1982). Gold mineralisation is associated with the aureoles in the Lisle–Golconda district and other areas (see below), but little or no indication of hornfelsing is present in many goldfields.

The sediments consist of sandstone (litharenite and sublitharenite), quartzite, siltstone and pelites (phyllite, shale or slate), with local hornfelsing close to granitoid bodies (McClenaghan *et al.*, 1982; Powell *et al.*, in press). The mineralogy of sequences away from granitoids is simple, usually just quartz and muscovite, with lesser chlorite, albite, graphite and heavy minerals. Poikiloblastic siderite blebs are present in some mineralised areas.

Gold veins commonly occur in one major belt and several minor belts, usually with a NNW, or less commonly, a NE trend (fig.3), throughout the northeast of Tasmania, including the Beaconsfield district (parallel to the Tamar Fracture zone). These gold-mineralised zones may be related to thrust faulting, as proposed for similar situations in Victoria and New South Wales (R. A. Glen, unpublished data). Powell and Baillie (in press) consider that, despite differences in structural detail, these sequences closely resemble those of the Melbourne Trough, so the gold mineralisation in both areas could be expected to be related.

Mangana–Mathinna–Alberton–Warrentinna–Forester–Lyndhurst

The first payable gold discovery in Tasmania was in alluvial material in Tower Rivulet, near Mangana, in 1852. The "gold

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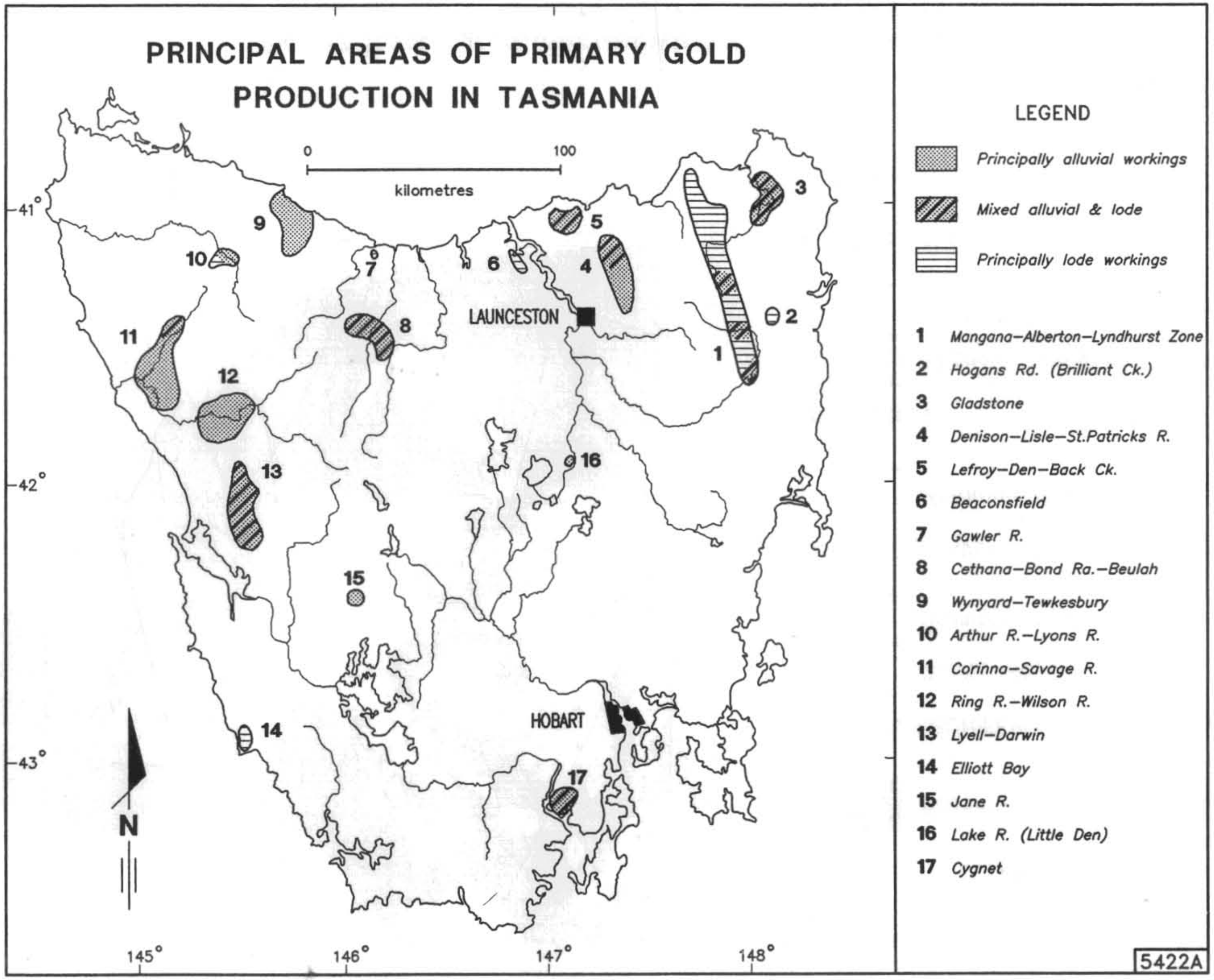

Figure 1

The distribution of major goldfields in Tasmania

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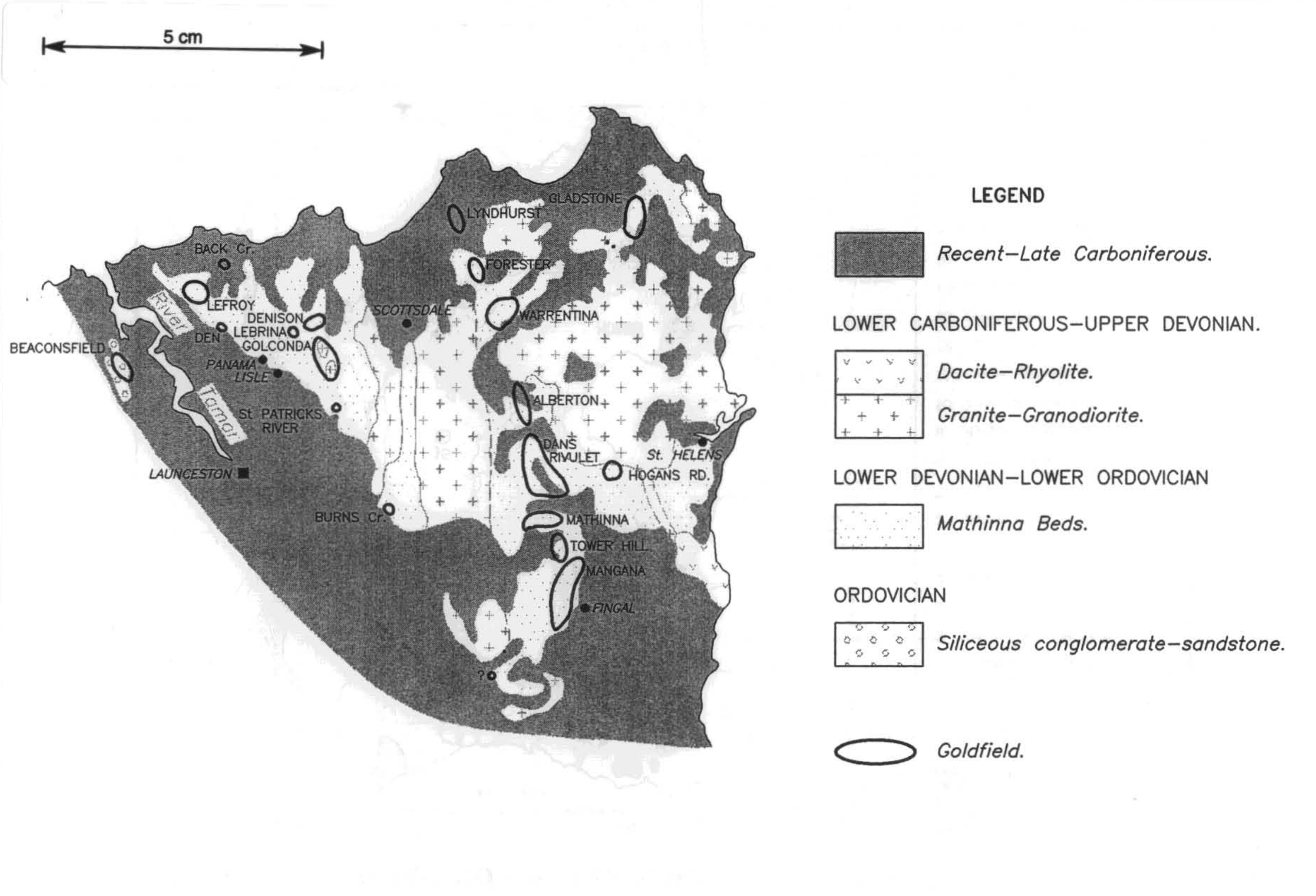

Figure 2. The geology and major goldfields of northeastern Tasmania

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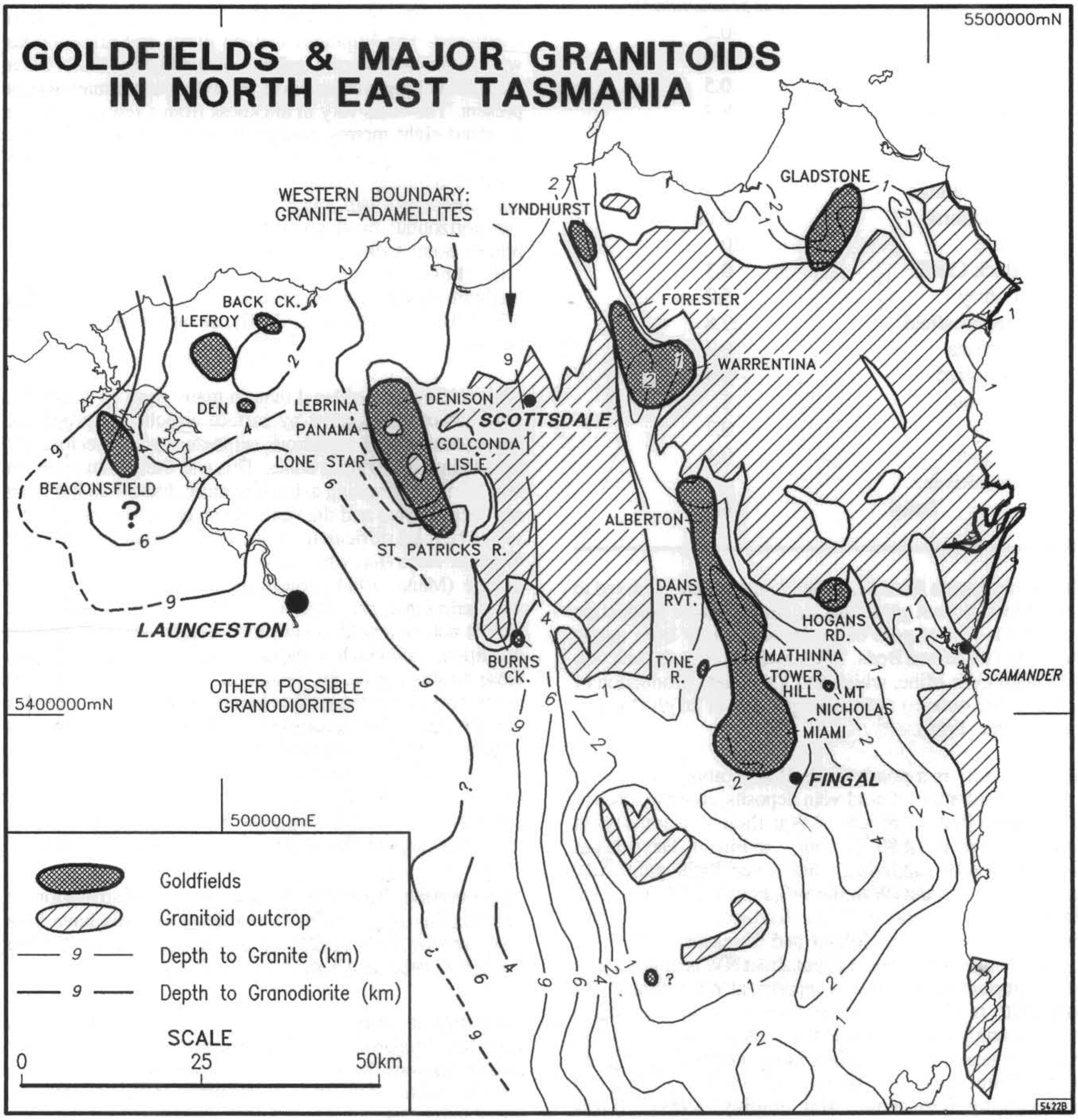

Figure 3

The distribution of the major goldfields in northeastern Tasmania, showing relationships to granitoids, after Leaman and Richardson (1992).

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Table 1

Estimated gold production for various goldfields in Tasmania (from Department of Mines records and various reports). Gold as a by-product is excluded.

Goldfield	*Gold production (t)*
Gladstone	0.2
Scamander	0.01
Mangana	0.5
Mathinna	8.8
Dans Rivulet	0.1
Alberton	0.7
Warrentinna	0.1
Lyndhurst	0.02
Lisle	10
Back Creek	0.3
Lefroy	5.2
Beaconsfield	27.8
Cethana	0.2
Wynyard	0.3
Corinna	1
Lyell	0.7
Cygnet	0.1
Jane River	0.01
Total	**56.0**

belt" running north from here (fig. 2) subsequently proved to be one of the richest goldfields in Tasmania, the production of about 11–12 t of gold being predominantly from quartz veins in the Mathinna Beds. The largest mine in the belt was the Golden Gate Mine, which had a recorded production of 7.9 t (253,865 ounces) at an average grade of 26 g/t (Noldart and Threader, 1965).

The "gold belt" is a poorly-defined zone about 2 km wide with a concentration of gold vein deposits, running through the Mathinna Beds from around Waterhouse, near the north coast, south for about 80 km almost to Fingal. The belt has been historically subdivided into seven main goldfields, namely the Lyndhurst (Waterhouse), Forester, Warrentinna, Alberton (Mt Victoria), Dans Rivulet, Mathinna and Mangana fields (fig. 2; Noldart and Threader, 1965). The strike is about NNW in general, but about NW near Mangana, and an intersecting NE trend is apparent at Warrentinna. The "gold belt" is characterised by close folding, axial plane shears, strongly cleaved slates and abundant quartz veining (of several generations). The belt, along with the bedding and major structures, are disrupted by post-granitoid mega-kinking (Goscombe and Findlay, 1989). It was probably a continuous structure, but is intruded in places by granitoid intrusions, is buried in others by later sedimentary deposits, from the Permian to Recent in age, and is intruded or partly obscured by Jurassic dolerite dykes and sills. M. Roach (this volume, p.201) considers the sediments to be 2.6 km thick below the "gold belt", and no indication of hornfelsing is present in most of the belt.

VEIN STYLE AND RELATED DEPOSITS

The belt is locally highly mineralised, with at least 300 significant known gold deposits within or in close proximity to the area (fig. 2; the MIRLOCH database of mineral deposits). Gold occurs in quartz-rich veins and breccias, samples of which can be very gold-rich (up to 1354 g/t: Twelvetrees, 1907), but are typically erratic in size and grade. Typically the grade of the deposits averaged about 1 oz/ton (31 g/t) but the Great Fingal Mine, for example, averaged nearly 200 g/t.

The quartz in the veins is usually white and glassy, but where auriferous is commonly dense and milky to blue-grey in colour, with minor sulphides, or iron oxides where weathered. The sulphides include pyrite and arsenopyrite, with lesser chalcopyrite, galena and sphalerite. Minor mica, chlorite and carbonates (ankerite and siderite) may also be present. The veins vary in thickness from a few centimetres to about eight metres, and up to about two kilometres in length (Finucane, 1935). They are commonly bedding-parallel, striking NNE, or conjugate to this (fig. 4), and commonly dip steeply. Some veins, however, are sub-horizontal; most are extensional, in fold limbs and hinges. Some lodes are breccia zones (eg. Golden Entrance), and these breccias are cemented by cherty to medium-grained quartz. Such re-faulted veins are highly mineralised (Twelvetrees, 1907), as at Beaconsfield (see below).

Blake (1939*b*) considered that, in many parts of Tasmania, gold has been upgraded by surface enrichment processes, during leaching of auriferous sulphides and reprecipitation of gold into ferruginous zones. This was the reason given for few workings reaching a depth of more than 30 m, but it has not been proven, and the veins are so erratic in grade that it would be quite difficult to prove. The situation is different in Western Australia, where gold is enriched in gossans and laterite (Mann, 1984), following much longer periods of weathering than prevailed in Tasmania. Zeegers and Leduc (1991) note that gold mobilisation usually requires extreme conditions, and much of the dissolved gold is reprecipitated close to the source. In Tasmania, sulphides are common relatively close to the surface in most goldfields. In the New Golden Gate Mine, the original workings were abandoned at shallow depth, as with most of the early mines in the area, but were later re-opened and reached a final depth of about 600 m, still with average grades of 26 g/t (Noldart and Threader, 1965). This suggests a high potential for gold reserves at depth below other mines and "barren" veins.

The possible structural controls on the distribution of gold-bearing quartz veins in northeast asmania have been discussed by Hills (1923), Blake (1933), Hughes (1952), Threader (1967) and Taheri and Findlay (1992).

According to Hills (1923), the gold mineralisation in the Alberton–Ringarooma area is controlled by a fold related to a NNW-dipping thrust fault. He considered that all the lodes were concentrated on the crest and limbs of this anticline and are of two types:

Type 1: The lodes that concentrated near the crest of the anticline and were formed due to tensional fissuring. They are generally limited, both in length and depth, but may contain 'good gold values'.

Type 2: The lodes which have been formed by faulting due to a regional 'compressive force'. These are of greater significance, as they may be continuous at greater depth.

Blake (1933) discussed the possible lithological effect on the distribution of the ore bodies and could not find any structural features which might control the distribution of the lodes.

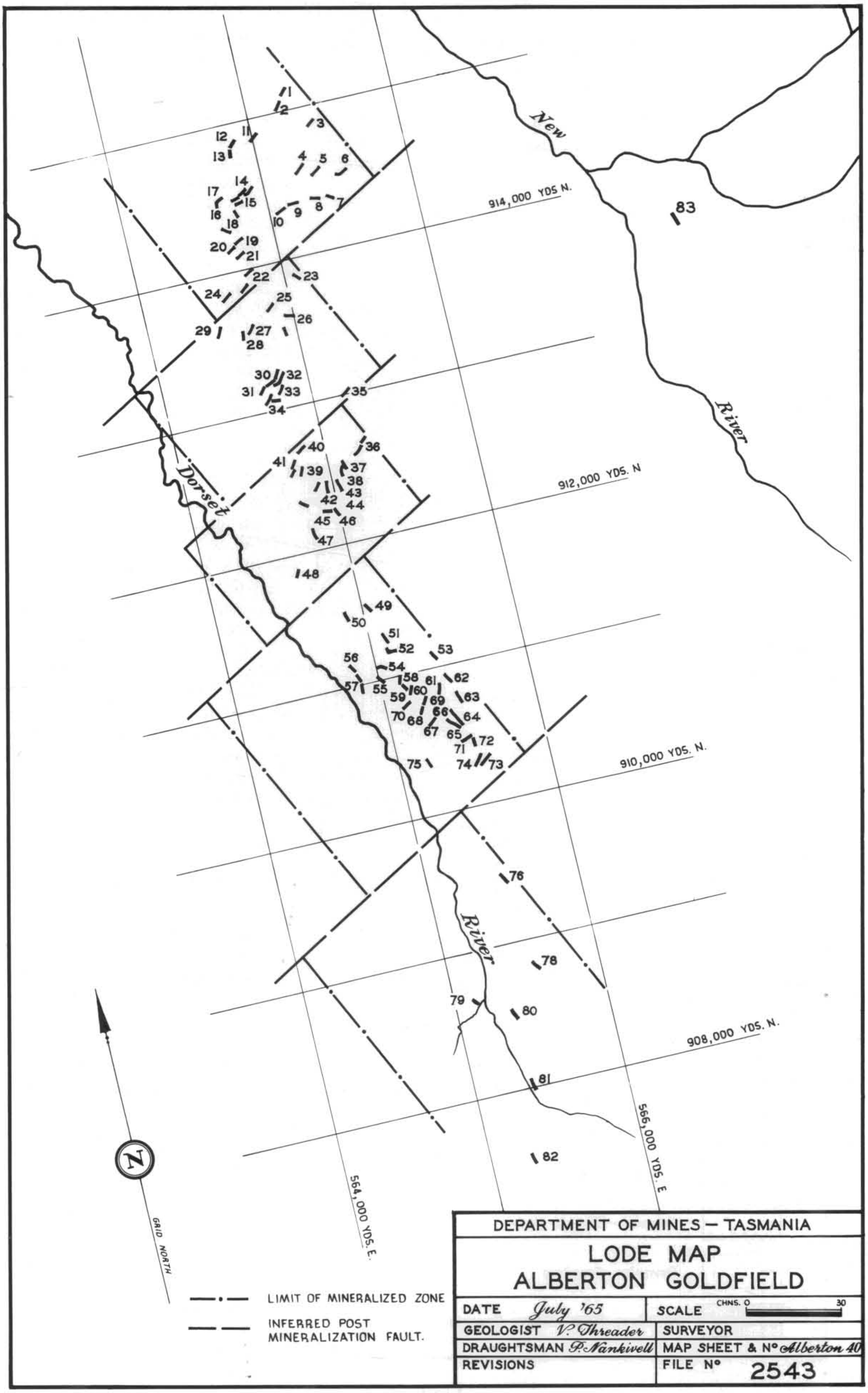

Figure 4

The distribution and strike of veins in the Alberton goldfield, after Threader (1967).

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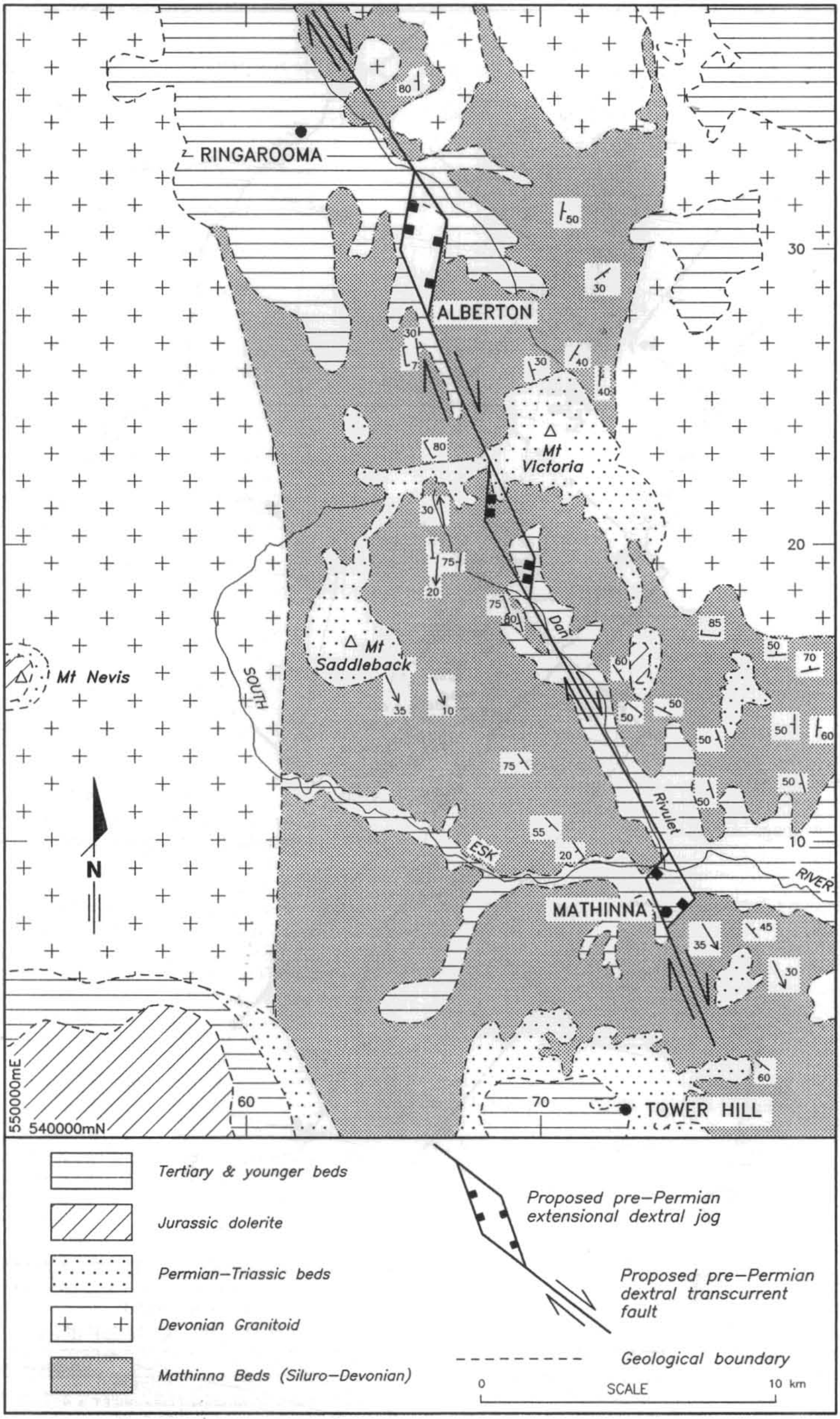

Figure 5

Geology of the Mathinna–Alberton area (after Taheri and Findlay, 1992).

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Hughes (1952) interpreted the lodes in the Alberton–Ringarooma Goldfield to form the western limb of an anticline striking NNW, which has subsequently been subjected to cross folding. The greatest density of the quartz veins occurs where the cross folding is most intense. The ultimate source of gold-bearing solutions was interpreted, both by Hills (1923) and Hughes (1952), to be underlying granitoids.

Threader (1967) concluded that the gold mineralisation is related to shear zones rather than folding and emplacement of granitoid bodies. He noticed that the regional trend of the goldfields in Northeast Tasmania is 330°, whereas the trend in individual goldfields is about 320°. This was interpreted to be due to the effect of a series of N-S dextral post-mineralisation shearing movements within the area.

Based on limited studies, Taheri and Findlay (1992) suggested that the gold-bearing quartz veins occur in post-fold faults, and that the ore-forming solution was probably derived from a metamorphic-derived fluid. It was interpreted that that the mineralisation is controlled by a system of NNW-trending dextral strike-slip displacement zones, jogging right progressively northward, and their related Riedel shear systems (fig. 5). In this model, tensional jogs form the sites of the main goldfields in the area.

Preliminary fluid inclusion and oxygen isotope studies undertaken in the Mathinna and Alberton goldfields suggest that the gold-bearing quartz veins were derived from metamorphically-derived fluids. The fluid inclusions are, in general, rich in CO_2, appear to contain CH_4 in some samples, and are of very low salinities. The vapour-liquid and H_2O-CO_2 ratios vary widely, and their behaviour upon heating was considered to be the result of fluid immiscibility phenomenon. The homogenisation temperature ranged from 261° to 359°C, with more than 60% of the population falling in a narrow range of 297° to 329°C.

Calculated oxygen isotope compositions of water associated with the quartz veins range from 7.0 to 9.5‰, assuming an average formation temperature of 310°C (fluid inclusion data). Considering the compositions of the fluid, consistent homogenisation temperatures and oxygen isotope values, a metamorphic-derived fluid was considered to be more likely than a magmatic-derived fluid. However, it is recognised that more detailed work is needed to substantiate this model.

This model is in contrast with Davidson (1988), who conducted some limited carbon and oxygen isotope analyses and fluid inclusion studies which he took to indicate a magmatic origin for ore fluids in the Gladstone, Burns Creek, and Scamander areas. His data can, however, be reinterpeted to indicate metamorphically-derived fluids.

ALLUVIAL GOLD

Most of the gullies draining these goldfields were worked for alluvial gold (Bottrill, 1991), but the deeper valleys have not been well explored. Some alluvial gold production continues today, principally at Majors Gully, Mangana. Twelvetrees (1907) reported the occurrence of gold nuggets in the area, variously reported as up to 7 or 11 ounces in weight, but most gold particles are relatively fine, as is general in most of Tasmania.

Twelvetrees (1907) and Finucane (1932) also reported some occurrences of alluvial gold in the overlying Permian conglomerate, and suggested that these palaeoplacers made an important contribution to the recent alluvial gold deposits.

Hogans Road (Brilliant Creek)

This small goldfield lies in the outer part of the zoned Scamander mineral field (Groves, 1972). Most of the quartz veins are hosted in hornfelsed Mathinna Beds, in the contact metamorphic aureole of some Devonian granitoids, while some veins are actually hosted by granitoids. Davidson (1988) conducted some isotope analyses and fluid inclusion studies; these are discussed above.

Gladstone–Derby

The gold-bearing quartz veins in this district occur in Mathinna Beds, many in a contact aureole to various granitoids. The lodes were rich in free gold at the surface, but the deeper lodes had gold locked in sulphides and proved unpayable. The lodes at Gladstone contained minor tin and rarely platinum, with abundant wolframite in some lodes (Twelvetrees, 1916; Threader *in* Baillie, 1986). Gee and Groves (1971) considered that this block of Mathinna Beds, with its enclosed veins, was rafted from the west by granitoid intrusions. Davidson (1988) conducted some limited carbon and oxygen isotope analyses and fliud inclusion studies, which indicate a magmatic origin for the ore fluids.

Lisle–Golconda–Denison area

These goldfields were discovered in 1877 and were dominated by the Lisle alluvial field, with a probable production of nearly 10 tonnes. A small production of gold continues at present from Lisle.

The workings are spatially closely related to granitoid intrusions in Mathinna Beds (Roach, 1991; fig. 3). Hornblende-biotite-magnetite bearing granodiorites are present, but more alkali-feldspar rich phases also occur. The metamorphic aureoles are commonly sharply defined, varying from 800 m to about 5 km in width, depending upon the dip of the contact (McClenaghan *et al.*, 1982). Within these aureoles the sediments are commonly spotty and/or hornfelsed, and may contain biotite, epidote-clinozoisite, tourmaline, andalusite and cordierite, as well as recrystallised quartz, muscovite and chlorite. Small quartz and greisen veins and granitic dykes occur in the aureole.

LISLE

Workings at Lisle included alluvium and eluvium in a basin-shaped depression, possibly representing an old lake bed of Tertiary age (Reid, 1926; Marshall, 1969). There were numerous, patchy, gold-rich horizons in the possible lacustrine sediments, and in carbonaceous horizons underlying talus, which produced relatively pure, free, angular (crystalline?) gold (Noldart *in* Marshall, 1969). This type of gold suggested a secondary origin (i.e. *in situ* reprecipitation of dissolved gold from groundwater (Reid, 1926; Bottrill, 1986). Some gold grains are highly porous and/or colloform, while some have silver-rich cores and silver-depleted rims (Bottrill, 1991; Roach, 1991), confirming that some gold is detrital and some reprecipitated.

Auriferous quartz was relatively rare, both in alluvium and bedrock, and Twelvetrees (1909) found evidence for gold originating in the contact metamorphosed sandstone of the Mathinna Beds surrounding the basin, near the contact with

Devonian granitoid intrusives. Inclusions of mica, rutile and magnetite in the gold grains suggest that the gold was more likely to have been disseminated in the hornfels or granitoids than in quartz veins, while rare gold-limonite composite grains in placers suggest gold-bearing pyrite may have been originally present (Bottrill, 1986). Some gold was, however, found in small quartz veins in the granitic intrusive underlying the alluvial materials (Thureau, 1882*b*; Montgomery, 1894*b*). Recent drilling by the Department of Mines revealed very minor quartz-carbonate-pyrite alteration zones in the magnetite-pyrite bearing granodiorite, with trace gold (to 0.05 g/t).

OTHERS

Other poorly-recorded deposits worked nearby include the Lone Star, Tobacco, Cradle, Panama, Golconda and Den Creek, and the Lebrina and Denison goldfields (Noldart *in* Marshall, 1969). Most of these deposits were alluvial or eluvial.

The Denison Goldfield consisted of a number of auriferous quartz veins in Mathinna Beds, similar to Lefroy in style, and probably overlying granodiorite (Roach, 1991).

The Panama field miners worked veins in both granitoids and hornfels. Reconnaissance geochemical surveys have indicated minor gold in hornfels (up to 3 g/t) and some very gold-rich quartz-sulphide veins (up to 210 g/t).

Stockwork-hosted gold mineralisation (to about 1 g/t) in arenite at Bessells's Reward, near Cradle Creek, has been reported (Roach, 1991). Minor gold veins occur in the St Patricks River–Myrtlebank area, south of Lisle, and one of these deposits contained ruby silver and gold in a porphyry dyke, suggestive of epithermal mineralisation (Reid, 1926). There is a supposed lamprophyre occurrence in the Den Ranges, perhaps related to nearby gold occurrences (Noldart *in* Marshall, 1969).

Back Creek–Lefroy

Gold was known to occur in the Lefroy area in the 1840s, but the reefs were not worked until about 1869, still one of the earliest workings in Tasmania. There were about fifty lode mines working on thirty separate reefs to produce over five tonnes of gold (Noldart and Threader *in* Gee and Legge, 1979). Most of these lodes were rich at the surface (about 30 g/t) but the deeper ores were patchy and low in grade (about 3 g/t; Noldart and Threader *in* Gee and Legge, 1979). The deepest mine reached 380 metres. The quartz veins contained stibnite and cervantite, as well as the more typical pyrite, chalcopyrite and arsenopyrite. The Back Creek lodes were similar, and a possible lamprophyre is present nearby (Noldart *in* Marshall, 1969).

Four Tertiary leads, all partly basalt covered, were worked in the Back Creek area, with production of about 300 kg of gold estimated by Broadhurst (1935). Similar Tertiary Leads were worked at Lefroy between 1853 and 1900 for an estimated 155 kg of gold (Noldart and Threader *in* Gee and Legge, 1979). These included the Pinafore, Golden Point and Native Youth leads, all worked up to where they pass beneath basalt. Quaternary (Recent) alluvial gold is also present (Noldart and Threader *in* Gee and Legge, 1979). A small amount of gold is still being produced in the Back Creek area.

Beaconsfield

Gold was also known in this area in the 1840s, but the reefs were not worked until about 1877, and many of the numerous workings were eventually incorporated into the Tasmania mine, the most productive gold mine in Tasmania to date. This mine produced 26.6 t of gold from about 1.1 Mt of ore, up until 1914, and Beaconsfield Gold Mines Ltd have been endeavouring to reopen the mine to develop an estimated resource of about 0.7 Mt at 24 g/t for 16.8 t gold (Hicks and Sheppy, 1990).

The principal reef in the area, the Tasmania reef, is developed in conglomerate and arenite of the upper Cabbage Tree Formation, of probable early Ordovician age. These sediments have been thrust against the Precambrian Badger Head Block and the Cambrian Andersons Creek Ultramafic Complex to the west. Recent studies by Powell and Baillie (in press) have indicated that the The Cabbage Tree Formation is a probable time equivalent of the Mathinna Beds, separated by the Tamar Fracture Zone. The other reefs present in the area are also confined to the same formation.

The Tasmania reef occupies a minor fault and averages two metres in thickness, about 400 m in length, and more than 800 m in depth (this and following data from Hicks and Sheppy, 1990). The ends of the reef, where they approached the overlying limestone of the Gordon Group and some underlying pebble conglomerate, are highly branched and ragged. The reef is zoned, with an ankerite-rich core, a quartz-rich outer zone, and a gold-sulphide enriched contact zone between these two zones. Wallrocks are locally altered with carbonates and pyrite, and partly assimilated. Sulphides include pyrite, arsenopyrite, chalcopyrite and minor sphalerite, galena and tetrahedrite. Most of the gold occurs as fine inclusions (<5 μm) in pyrite. Later fracturing and brecciation of the reef has resulted in recrystallisation, forming secondary, coarse-grained quartz, calcite, pyrite, chalcopyrite and gold (to several millimetres), as high-grade shoots parallel to bedding.

There was also a recorded production of 1.1 t of alluvial gold at this goldfield up to 1907 (mostly pre-1890). The major producer was a deep Tertiary lead to the east of Cabbage Tree Hill, with minor production from a deep lead near Salisbury Hill to the south. The gold was enriched in probable eluvial detritus on the western wall of the northern lead, and in carbonaceous false bottoms; the true bottom was probably never reached (Noldart and Threader *in* Gee and Legge, 1979).

Northwestern to Southern Tasmanian gold deposits

Bond Range–Cethana–Beulah

This rather complex mineral field contains a great variety of mineralisation, mostly related to the Devonian Dolcoath granite. Deposits of gold, tin, tungsten, bismuth, copper, silver, fluorite, topaz, rare earths, beryllium, magnetite, garnet, lead and zinc are known, and host rocks include Cambrian Mt Read Volcanics, Ordovician Moina Sandstone and Gordon Limestone, and the granites themselves (Collins *in* Jennings, 1979). The Bell Mount alluvial goldfield was the largest gold producer in this area, with production estimated as 124 kg (Reid, 1919). This was produced from high level Tertiary gravel, and a number of smaller deposits in the district worked other Tertiary to Recent alluvial deposits (Bottrill, 1991).

The second largest gold producer was the Round Mountain group of workings, described under the section on by-product gold, along with a number of other deposits in the area. A number of quartz and greisen-style veins, mostly in Moina Sandstone, were also worked primarily for gold, particularly in the Lake Cethana area (Jennings, 1979; 1963). Some of these veins contain tin, tungsten, bismuth and other granite-related minerals, and mostly occur in faults. Other deposits contain disseminated gold in skarn, sandstone, feldspar veins and Cambrian porphyries (Thureau, 1882*a*; Jennings, 1979; 1963).

Wynyard

There were numerous workings in this area in the 1890s, including Big Creek, Blackfish Creek (Moores Plains), Calder Creek, Camp Creek, Cam River, Deacons Creek, Inglis River, St Marys River and Seabrook Creek (Montgomery, 1896). The only gold production recorded from the area is 12 kg from the Doctors Rocks–Seabrook Creek beach sands in 1940–44, but it was estimated as 310 kg for the wider area (Reid, 1927). Most of this was recovered from Quaternary gravel reworked from extensive Tertiary sub-basalt gravel (Montgomery, 1896), but some gold may have originated in Permian fluvioglacial sediments (Morrison *et al.*, 1988) or quartz veins present locally in pre-Carboniferous basement rocks (Montgomery, 1896). Extensive low-grade offshore placer gold deposits exist (Morrison *et al.*, 1988).

Arthur River–Lyons River

The river terraces along the Arthur River are gold-bearing, particularly near the confluences with the Lyons, Keith and Hellyer Rivers, and with Campbells and Grays Creeks (Montgomery, 1896). Some higher level, possibly Tertiary deposits at Folly Hill were worked from 1910–1943 (Jack, 1964). No records of production are known for the area. The source of the gold is unknown, but Cu-Au bearing quartz veins are known in the Precambrian schist, quartzite and dolomite nearby (McNeil, 1961; Jack, 1964). The Tertiary sub-basaltic gravel and the Permian fluvioglacial deposits are also possible sources, as for the Wynyard area.

Corinna–Savage River

Gold has been recovered from a wide area about Corinna since 1877, to at least 1941. The principal workings were alluvial and include the Paradise River, Rocky River, Savage River, Whyte River and many tributaries (Bottrill, 1991). The Rocky River produced the two largest nuggets in the state (7.6 and 4.4 kg) (Montgomery, 1894*a*). Tin and platinum-group metals ("osmiridium") were minor by-products (Twelvetrees, 1900; Scott, 1926).

Montgomery (1894*c*) noted that much of the alluvial gold was concentrated in sandy carbonaceous 'bottoms', presumably palaeosols. The alluvial sediments included deep leads in high-level Tertiary deposits (Browns Plains Gravels), partly reworked into the more recent deposits (Blake, 1939*a*). There is a great variation in fineness and roundness of the gold, indicating multiple sources (H. D. Nolan, pers. comm.).

The source of much of the alluvial gold was the mineral-rich Precambrian Bowry Formation, the host for the Savage River magnetite deposits and other ores (Shannon *et al.*, 1985; Turner *et al.*, this volume). Some auriferous reefs in the Golden Ridge (Long Plains) and Specimen Reef fields also contributed gold (Finucane and Blake, 1933*a*), and Smith (1897) noted the presence of copper and gold in quartz veins in a porphyry at Lucy Spur.

Montgomery (1894*c*) noted the abundance of chalcedony in many of the gold placers around Corinna, and this suggests a possible replacement origin in some of the Precambrian limestones, which are locally silicified. Khin Zaw (1990) investigated the geochemistry and fluid inclusions in these rocks, and suggested that homogenisation temperatures were up to 298°C, with CO_2-rich, low to moderate salinity, probably methane-bearing fluids. These fluids were probably magmatically derived rather than metamorphic, and would have been capable of carrying gold. The fluids could be consistent with a Carlin-style gold deposit (i.e. disseminated gold in limestone). His study of placer gold composition and morphology indicates that the grains have not travelled far, but until gold is found *in situ*, the source remains enigmatic.

The Savage River and Rocky River magnetite deposits were first prospected for gold, and grades of up to 55 g/t were recorded at Savage River (Twelvetrees, 1903). No production was recorded. Twelvetrees (1900) noted that the Long Plains gold was stratabound, as disseminations and small veins in various weathered schists, and was typically skeletal in form, suggesting recrystallisation *in situ*. The purity of the gold supports this (Thureau, 1881). The Rocky River deposit is poorly understood, with gold being stratabound in magnetite-rich rocks with nickel, cobalt, copper and silver-bearing sulphides (Twelvetrees, 1900).

Wilson River–Murchison Dam–Tyndall Range

HENTY

The Henty deposit is the most recent discovery in the Mt Read Volcanics. It is approaching development, with extensive drilling and a decline in place (Roberts and Fleming, 1990). The development proposal (1990) gives an indicated resource of 45 000 t at 13 g/t, and an inferred resource of 259 000 t at 59 g/t (including a zone of 186 000 t at 78 g/t), making this the richest gold resource in Tasmania (Table 2). Most of the following data is extracted from McNeill and Corbett (1992).

The deposit lies immediately adjacent the Henty Fault Zone (fig. 6), a major NNE-trending structure separating the Central Volcanics Sequence in the west from the overturned Tyndall Group to the east. This shear zone dips about 65°W, may be hundreds of metres wide, and has undergone at least five phases of movement from the Early Palaeozoic to the Tertiary (Berry, 1989). The deposit lies on the footwall of, and is partly truncated by, the fault (fig. 7), in probable Tyndall Group volcaniclasic rocks which have been highly altered to cherty quartz-sericite-pyrite. Massive lenses of pyrite ± base metals and minor gold, for which the area was first prospected, occur sporadically, as do very gold-rich quartz shoots. The zone of mineralisation is relatively continuous, but grades are erratic. Pemberton and Corbett (this volume) suggests that the mineralisation lies at a chrono-stratigraphically equivalent level to the major VHMS deposits in Tasmania, such as the somewhat similar mineralised sequences at Comstock and Mt Lyell.

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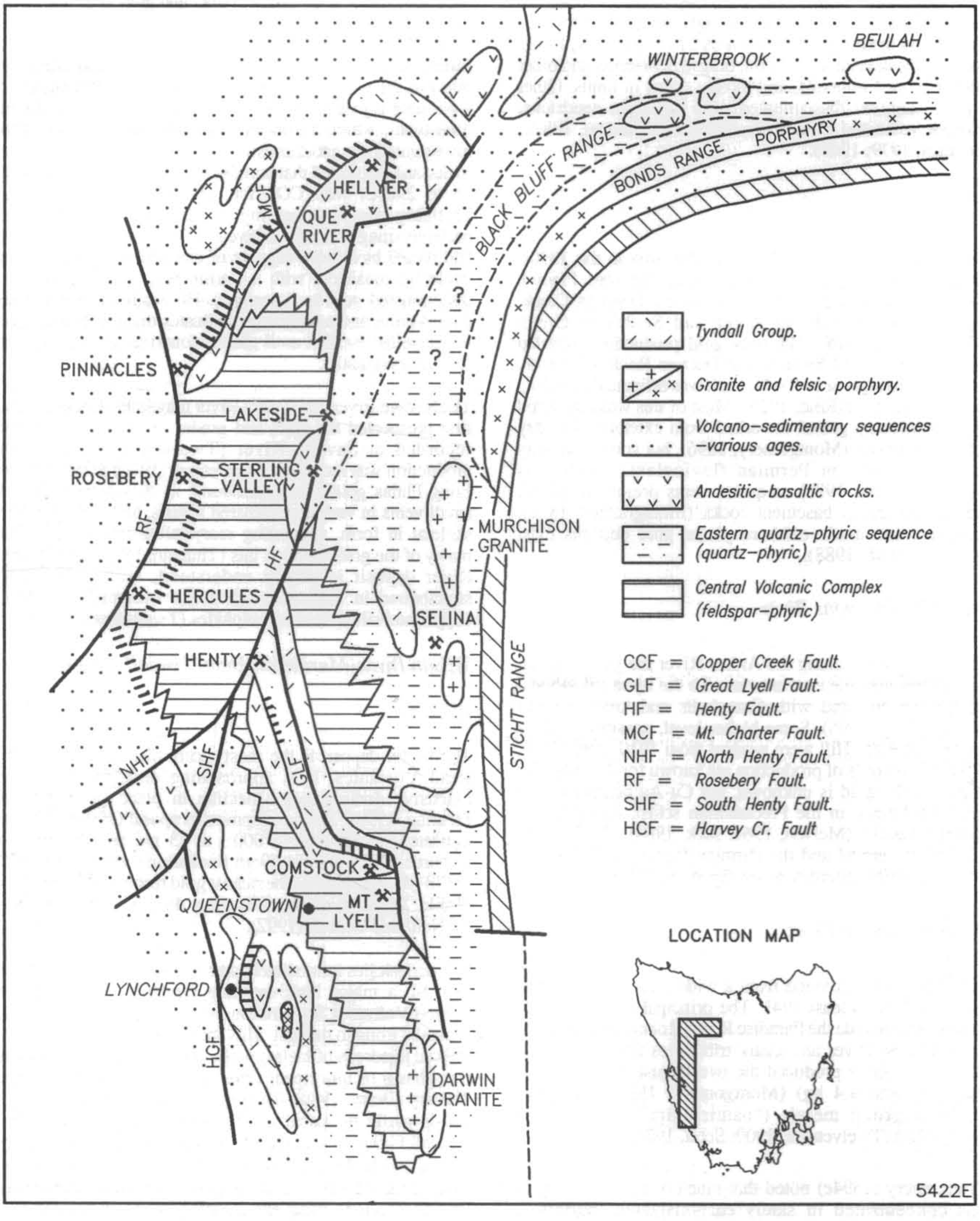

Figure 6

Location of western Tasmanian volcanic-hosted massive sulphide and related deposits

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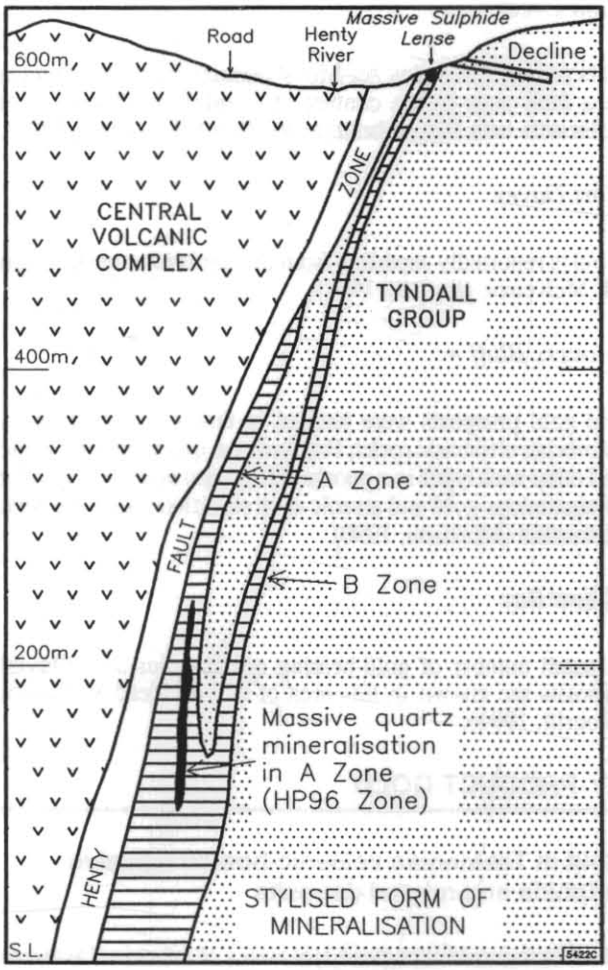

Figure 7
Generalised cross-section of the Henty prospect

Very little published information is available in regard to the style of the mineralisation (i.e. Cambrian VMS vs Devonian vein type), however the gravity modelling of Leaman and Richardson (1989) suggests that the granite is located at a depth of about 8 km, and the lead isotope results are of Cambrian signatures (Gulson and Porritt, 1987). This indicates that Cambrian ore-forming solutions may have had the major role in the formation of this deposit, and that several styles of mineralisation may exist along the fault. The genesis of the deposit has been studied by J. Taheri and G. R. Green (Department of Mines), but the results are presently confidential.

LAKESIDE AND STERLING VALLEY TIN–GOLD DEPOSITS

The polymetallic Lakeside and Sterling Valley Tin deposits are characterised by the metallogenetically rare Sn-Au association, and lie alongside the Henty Fault in western Tasmania (fig. 6). The Lakeside deposit lies on the eastern side of the fault and is hosted by the Farrell Slates (Tyndall Group), whereas the Sterling Valley deposit is hosted by the Mt Black Volcanics (part of the Central Volcanic Sequence) on the western side of the fault. The mineralisation is of vein style, and is associated with the crest of the subsurface granite ridge extending from the Granite Tor to the Pine Hill granites and possibly as far west as the Heemskirk granite (Taheri and Green, 1990; Leaman and Richardson, 1989).

The Lakeside deposit is considered to be sub-economic, with a resource of 0.75 Mt at 2.1 g/t Au.

The Sterling Valley Prospect contains less gold, but is characterised by higher As and pyrrhotite. Based on metal zoning, mineralogical data, and Berry's (1989) reconstruction of the deformation history of the Henty Fault zone, Taheri and Green (1990) suggested that the two deposits were initially juxtaposed, with the Sterling Valley deposit being the deeper section of the mineralisation. The deposits were later displaced relative to one another by faulting. Based on this model, potential for further discoveries should exist on both sides of the Henty Fault (Taheri and Green, 1990).

ALLUVIAL GOLD

Widespread workings for alluvial gold were present in the Pleistocene fluvioglacial deposits along the Pieman River last century. A deep lead in the nearby Ring River was also worked extensively, and other minor alluvial gold occurrences produced osmiridium and tin, while gold was a by-product of osmiridium mining in some placers (Bottrill, 1991). No production records are known, although the Ring River field supported 300–400 men in 1891 (Blisset, 1962).

Some of the alluvial gold in this area was derived from the ultrabasic rocks, particularly where gold was subordinate to osmiridium, but most was derived from the gold-enriched base metal deposits in the area. These include the Mt Read, Hercules, Rosebery and Pinnacles deposits (see below). Reid (1918) noted the gold in Strong Creek to be very fine grained, reflecting the nature of the source gold in the nearby Pinnacles deposits.

Lyell–Darwin

This district produced more than 162 kg of gold, excluding that from the Mt Lyell and other copper mines, which were first worked as gold mines. Many of the mines appear to be spatially related to fault zones, particularly at contacts between the Mount Read Volcanics and Denison Group conglomerate (Fitzgerald and Pease, 1985). One of these faults is the Harvey Creek Fault, and where it intersects Gordon Limestone near Lynchford (fig. 6) some zones of anomalous gold, arsenic and antimony are considered prospective for Carlin-style gold deposits (Tasmanian Chamber of Mines, 1992). Other styles of gold mineralisation in the area include quartz stockwork and pyritic schist in the Mount Read Volcanics (Fitzgerald and Pease, 1985).

The district contains numerous areas of workings for alluvial gold, from south of Mt Darwin to north of Queenstown (Bottrill, 1991). There was 837 kg of alluvial gold production recorded from the West Coast between 1866 and 1890, probably predominantly from the Queenstown area but including the Pieman and other areas. The alluvium worked was probably all Quaternary, and included Pleistocene fluvioglacial deposits. Henderson (1938) thought that some gold was reworked from high-level Tertiary gravel in the Darwin plateau, but bedrock sources for many deposits are still uncertain (Fitzgerald and Pease, 1985). A large but low-grade gold resource is present in the King River Delta, reworked from the Mount Lyell mine tailings (Berkman, 1987).

5 cm

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Jane River (Warnes Lookout)

Gold was discovered in this area in about 1894, and Bacon (1989) estimated between 60 and 250 kg for the total gold production. Gold is enriched where Cainozoic gravel has been reworked (Jennings, 1974), particularly where coarse gravel overlies bedrock (Bacon, 1989). The gold is rather angular to crystalline and porous (as at Lisle), rarely attached to quartz, and is commonly mercury-rich (up to 14 wt.%: Bottrill, 1989). It is associated with rutile, zircon, chromite, pyrite and, more rarely with cinnabar, xenotime, monazite and gersdorffite (Finucane and Blake, 1933*b*; Bottrill, 1989). The source is uncertain, but suggestions include local quartz veins (Finucane and Blake, 1933*b*), limonitic beds (Blake, 1936), and Precambrian to Palaeozoic bedrock (Turner, 1990). Jennings (1974) and Bottrill (1989) consider that most of the gold was formed *in situ*, but the mercury content suggests epigenetic mineralisation and the deposit is still quite enigmatic.

Cygnet

Gold was discovered at Cygnet in 1877, and the district produced about 100 kg of gold by 1902, mostly from Quaternary placers (Twelvetrees, 1908*b*). The gold was derived from mineralised breccia, veins and contact zones of Cretaceous alkaline intrusive rocks in the Permian sediments, (Twelvetrees, 1908*b*; Leaman and Naqvi, 1967). The intrusives range in composition from monzonite to syenite and lamprophyre, and intrude calcareous and carbonaceous mudstone, tillite and limestone of the Parmeener Supergroup. There is a pronounced domal structure associated with the intrusives, which crop out sporadically over an area of about 20 × 30 kilometres. Some recent gold exploration has focussed on the potential for "Carlin style" and porphyry-hosted gold deposits (Jones, 1988). Limited drilling and geochemistry failed to delineate a viable gold resource, but indicated that gold and base metals are enriched in shear zones. The best intersection was 17 m at 1 g/t, but grades of up to 22 g/t occur (Jones, 1988). Lamprophyric intrusive rocks also occur in several other parts of western and northern Tasmania, and some may have a spatial association with gold, but the associations have not been investigated (see sections on Back Creek and Lisle).

Miscellaneous

Furneaux Islands

Gold-bearing veins are found in Mathinna Beds on Cape Barren and Flinders Islands, similar to those on mainland Tasmania (Blake, 1947). There are also isolated occurrences of lode and alluvial gold on King Island.

Little Den (Lake River)

There is an isolated occurrence of alluvial gold in this area, derived from quartz veins in an inlier of Cambrian volcanic rocks (Nye and Blake, 1933; Threader, 1963).

Ten Mile Creek

This prospect shows the presence of gold in hematitic stockwork in Bonds Range Porphyry (Pemberton *et al.*, 1991).

Anio Creek

This prospect contains Au-Mo-V anomalous pyritic breccia in a fault zone at the contact of Cambrian volcanics and sediments with Precambrian rocks (Pemberton *et al.*, 1991).

Port Davey

Gold is reportedly shedding from Precambrian sandstone on Mt McKenzie (Bottrill, 1991).

Glovers Bluff

Old gold prospects were located in this area, which hosts Cambrian ultrabasic rocks, Precambrian quartzite, limestone and other rock types in a poorly understood area. A large area of anomalous gold and arsenic over silicified rocks has been delineated (Morrison, 1990).

Elliott Bay

A small number of gold-bearing quartz veins and alluvial deposits are known in this area of Mount Read Volcanics (Bottrill, 1991).

BY-PRODUCT GOLD

Gold in Tasmanian volcanic-hosted massive sulphide and related deposits

The Cambrian Mount Read Volcanics of western Tasmania host a number of world-class volcanic-hosted massive sulphide (VHMS) deposits (fig. 6). Although mined primarily for their base metals, the deposits contain high levels of by-product gold (Table 2). The Rosebery, Mt Lyell and Hellyer deposits each contain in excess of 40 t of gold, which is a respectable resource even for a gold-only deposit. The Rosebery deposit contained the largest pre-mining gold resource of any Tasmanian mineral deposit, including the Tasmania Mine at Beaconsfield.

The distribution and occurrence of gold in these deposits is quite variable, and has been the subject of considerable research over the past ten years. This section summarises the results of this research with respect to the distribution, mineralogy and metallurgical characteristics of gold for each deposit. Theoretical discussions about transport and depositional mechanisms for gold in VHMS systems are not discussed; the reader is referred to Huston and Large (1987, 1989), Large *et al.* (1989), and Hannington and Scott (1989) for such discussions.

Rosebery

The Rosebery deposit is the largest VHMS deposit in western Tasmania, with a pre-mining resource of nearly 20 million tonnes (Table 2). The deposit occurs in interbedded siltstone and tuffaceous sandstone ("host rock") between an underlying mass-flow unit of sericite-pyrite altered, feldspar-bearing pumice-rich volcaniclastic breccia and an overlying polymict mass-flow unit of quartz and feldspar-bearing, crystal-lithic rich volcaniclastic sandstone and breccia (McPhie and Allen, 1992). Black slate occurs in a discontinuous lens at the contact between the host rocks and the overlying volcaniclastic unit.

Table 2

Pre-mining gold resources of western Tasmanian volcanic-hosted massive sulphide and related mineral deposits (data from Lees *et al.*, 1990; Farquhar, 1983; Hills, 1990; McArthur and Dronseika, 1990; McNeil and Corbett, 1992). Metallurgical recovery data is for mid-1991 courtesy of the relevant companies. The Tasmania Mine is added for comparison (Hicks and Sheppy, 1990).

Deposit	Tonnage (m.t.)	Gold grade (g/t)	Contained gold (tonnes)	Metallurgical recovery (%)
Rosebery	19.4	2.9	56	85
Pyrrhotite-pyrite body	0.075	9.0	0.68	
Mt Lyell				
Massive pyrite-chalcopyrite	5.6	2.0	11	
Disseminated pyrite chalcopyrite	109.71	0.36	39	73
Chalcopyrite-bornite mineralisation	6.16	0.46	2.8	
Hellyer	16.9	2.5	42	14-21
Que River	3.3	3.3	11	
Henty	0.26	59.0	15.9	
Hercules	2.57	2.7	6.9	
South Hercules	0.70	2.7	1.9	
Tasmania Mine	1.8	24.1	43.4	

The ore occurs in a number of blanket-like lenses. Barite-rich lenses are commonly separated by several metres of host rock from the underlying barite-poor massive sulphide lenses. Small, massive pyrite-chalcopyrite pods occur at the base of the massive sulphide lenses, which are mostly composed of massive sphalerite-galena-pyrite (fig. 8; Brathwaite, 1972; Green *et al.*, 1981). The deposit has been moderately deformed and recrystallised.

The original Rosebery deposit contained over 56 tonnes of gold (Table 2). The distribution of gold at Rosebery was initially studied by Brathwaite (1969) and Green (1983), as part of larger studies on the genesis of the Rosebery orebody. The detailed distribution and mineralogy of gold at Rosebery has been studied by Huston and Large (1987, 1988) and more recently by Huston *et al.* (1992).

Gold is enriched in the upper part of massive sphalerite-galena-pyrite zones and in overlying baritic zones. Within these zones grades in excess of 3 g/t are common (fig. 8). High gold grades have a positive correlation with high zinc grades, but gold grades are generally low in the copper-rich bases of the massive sulphide lenses. As such, Rosebery is the type example of the zinc-gold association noted in many VHMS deposits (Huston and Large, 1989; Large *et al.*, 1989).

Electrum (gold-silver alloy of any composition for this contribution) is the dominant host of gold at Rosebery. Cyanidation tests of the mill feed indicate that 85% of gold occurs as electrum (Huston *et al.*, 1992). In massive sphalerite-galena-pyrite ores electrum occurs mostly as 0.5–60 μm (median size = 4.5 μm) grains in cracks within or along grain boundaries in pyrite. Minor associations of electrum in this ore type include galena, sphalerite, chalcopyrite and tetrahedrite. Electrum does not have a strong association with pyrite in the overlying baritic zones; rather it occurs with galena, tetrahedrite, sphalerite and chalcopyrite. Huston *et al.* (1992) ascribed these differences in occurrence to differing mechanisms of precipitation in the two zones, and inferred that the pre-deformation occurrence of gold in the massive sphalerite-galena-pyrite zone at Rosebery was in the pyrite lattice.

Mass balance calculations by Huston *et al.* (1992) indicate that Rosebery pyrite contains at most an average 0.2 ppm Au, a conclusion supported by pixeprobe analysis. Most gold not occurring as electrum at Rosebery occurs in auriferous arsenopyrite. Electron microprobe analyses indicate that arsenopyrite contains up 3000 ppm Au.

As recrystallisation of the Rosebery ores has expelled gold from the pyrite lattice to form electrum, and arsenopyrite is not a major repository of gold, metallurgical recoveries of gold are high in comparison to the nearby Hellyer deposit, which has not been as extensively recrystallised and has a high arsenopyrite content (Table 2).

The southern end of Rosebery has been partially replaced by zones of massive magnetite and massive pyrrhotite-pyrite associated with the emplacement of Devonian granitoids (Solomon *et al.*, 1987). Fluids exsolved from the granite dissolved lead and zinc from pre-existing Cambrian massive sulphide, but the pre-existing gold was reconcentrated to form a high-grade zone within the pyrrhotite-pyrite assemblage (Khin Zaw, 1991). A resource of 0.68 t of gold has been defined for the pyrite-pyrrhotite zone (Farquhar, 1983; Table 2).

Khin Zaw (1991) observed that electrum within the pyrrhotite-pyrite zone has the following occurrences:

(1) as inclusions in pyrite,

(2) along microfractures in pyrite,

(3) as inclusions in pyrrhotite,

(4) in chalcopyrite veins that cut chalcopyrite, and

(5) in association with chalcopyrite.

This electrum tends to be coarser grained than electrum elsewhere at Rosebery, with a total range of 0.5 to 160 μm and a median grain size of 20 μm (Khin Zaw, 1991).

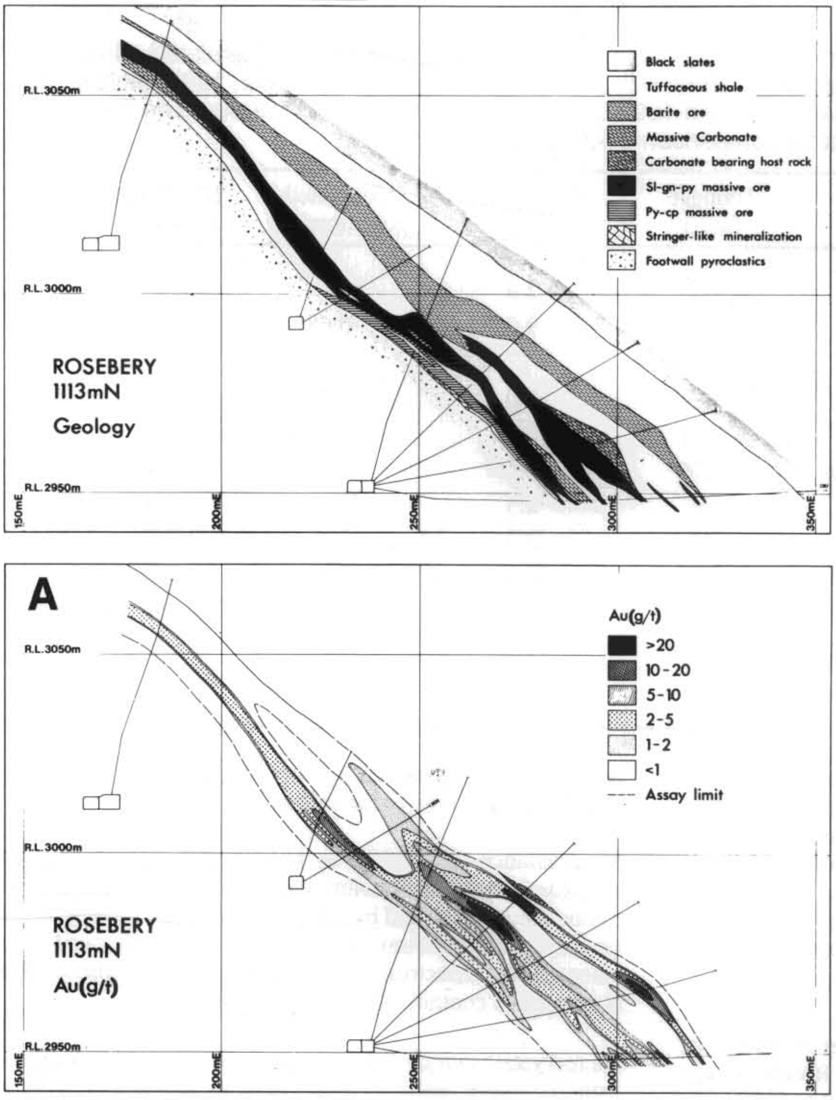

Figure 8

Cross-section from the north end of the Rosebery ore deposit showing the geology (upper) and gold distribution (lower) (after Huston and Large, 1988).

Mt Lyell

The Mt Lyell mineral field consists of twenty separate mineralised bodies in a 2×5 km area. Three styles of mineralisation are present: massive pyrite-chalcopyrite mineralisation; disseminated pyrite-chalcopyrite mineralisation; and chalcopyrite-bornite mineralisation (Walshe and Solomon, 1981; Hills, 1990). In total the ore field contained nearly 52 t of gold (Table 2). Although alluvial and gossan gold was recovered from the field during the early period of mining activity (Large *et al.*, 1990), this contribution only summarises the primary occurrence and distribution of gold.

The distribution and mineralogy of gold in the Mt Lyell field has been recently studied by Large *et al.* (1990), Bottrill and Duncan (1991), and Huston *et al.* (1992). The highest concentrations of gold occurred in massive pyrite-chalcopyrite lenses, with an average of 2.0 g/t. The disseminated pyrite-chalcopyrite and the chalcopyrite-bornite styles of mineralisation contain substantially lower grades of 0.35 and 0.46 g/t respectively (Table 2). Large *et al.* (1990) found that gold has a strong association with copper in both massive and disseminated pyrite-chalcopyrite mineralisation, whereas in chalcopyrite-bornite mineralisation gold grades are independent of copper values. The association of copper and gold in pyrite-chalcopyrite dominated mineralisation at Mt Lyell exemplifies a second major association of gold with copper in VHMS deposits (Huston and Large, 1989; Large *et al.*, 1989).

The dominant host of gold at Mt Lyell is electrum (78% of the mill feed based on cyanidation tests) with the following occurrences:

(1) grains included in pyrite;

(2) grains associated with chalcopyrite in fractured and brecciated pyrite grains;

(3) grains associated with galena, sphalerite, pyrite and/or chalcopyrite; and

(4) coarser grains associated with remobilised quartz veins (Edwards, 1939; Green, 1971; Large *et al.*, 1990; Bottrill and Duncan, 1991; Huston *et al.*, 1992).

Electrum grains in the remobilised quartz veins tend to be silver-rich, whereas electrum from all other occurrences tends to be silver-poor.

Although electrum is the dominant host of gold, telluride minerals and pyrite also host gold at Mt Lyell. Arsenopyrite is unlikely to be a significant host, as it is extremely uncommon in the ores. Bottrill and Duncan (1991) recorded the presence of petzite and calaverite is copper concentrates from Mt Lyell. The maximum possible average level of gold in Mt Lyell pyrite is 0.62 ppm, which would account for 12% of the gold in the mill feed (Huston *et al.*, 1992).

Hellyer

The Hellyer deposit consists of an elongate, bulbous massive sulphide lens at the contact between underlying massive andesite, and overlying pillow basalt (fig. 9). A thin, discontinuous lens of volcaniclastic rocks drapes the sulphide lens and andesite at this contact (McArthur and Dronseika, 1990). The sulphide lens occurs above a well-defined, sub-vertical stringer in altered andesite (Gemmell and Large, 1992).

Hellyer occurs along the crest of a NNE-plunging open anticline, and the sulphide lens has complex internal folding. The contacts of the orebody indicate the presence of open anticlines with tight to locally isoclinal synclines. The deposit has been bisected by the Jack Fault (fig. 9), which has moved the east block 150 m north and 30 m up (McArthur and Dronseika, 1990). Despite this internal folding, much of the massive sulphide retains primary, undeformed textures;

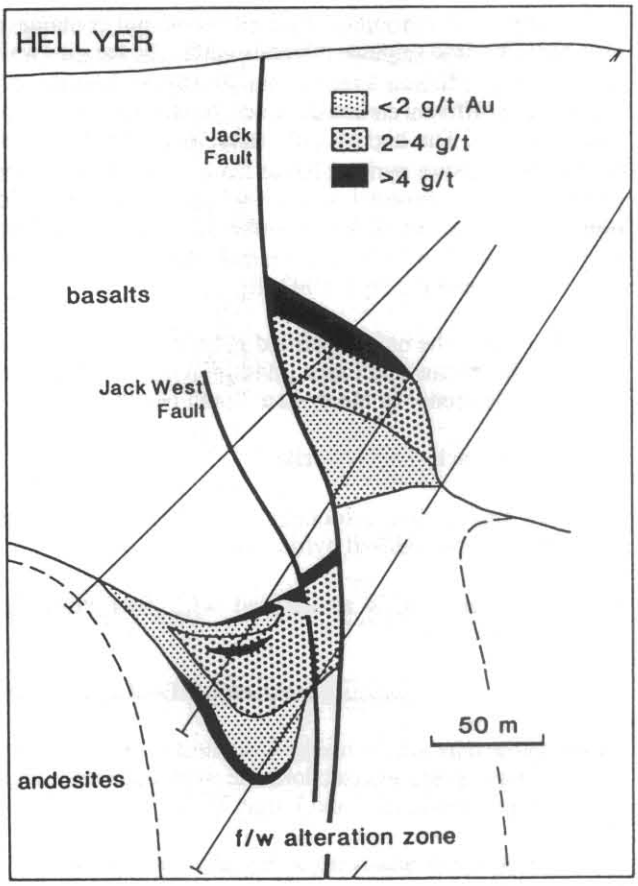

Figure 9

Cross-section of the Hellyer deposit showing gold distribution (after Large *et al.*, 1990)

recrystallisation is most strongly developed in the tight internal folds (G. McArthur, pers. comm., 1992).

The spatial distribution of gold has been described in detail by Large *et al.* (1989, 1990) and by McArthur and Dronseika (1990). Like Rosebery, gold is enriched in the upper portions of the lens, but gold is also enriched along the lower contact of the structural keel in the western half of the lens (fig. 9). In detail, gold values increase from ~1.6 g/t in the core to ~3.0 g/t at the top of the massive sulphide zone. The baritic cap contains ~2.5 g/t gold, and the glassy silica pyrite (GSP) cap contains ~3.2 g/t gold (fig. 10). The baritic and GSP units overlie the massive sulphide lens and are complexly interfingered (Sharpe, 1991). The GSP unit consists of colloform pyrite in a gray chert with finely disseminated pyrite. Small quantities of a similar gold-rich unit also occur at Rosebery (Huston and Large, 1988).

Detailed studies on the mineralogical hosts to gold at Hellyer have been undertaken by Ramsden *et al.* (1990) and Sharpe (1991). Electrum grains are uncommon in Hellyer ores, with only a few grains being observed by McArthur (pers. comm., 1986), Sharpe (1991) and Huston *et al.* (1992). Sharpe (1991), who observed the greatest number of electrum grains, noted that electrum occurs mostly with pyrite, in a similar association to that at Rosebery. Ramsden *et al.* (1990) suggested that electrum might be more common in barite-rich zones, based on the results of cyanidation tests.

Ramsden *et al.* (1990) inferred that 90% of Hellyer gold occurs either in auriferous arsenopyrite or auriferous pyrite. This accounts for the low gold recoveries at Hellyer (Table 2). Electron microprobe analyses by Ramsden *et al.* (1990) and by Sharpe (1991) reported gold values up to 1100 ppm in arsenopyrite and up to 4500 ppm in pyrite. Examination of Sharpe's (1991) results indicates that the highest gold values in pyrite are associated with framboidal and acicular habits, but not euhedral habits. The predominance of gold in arsenopyrite and pyrite in Hellyer ores results from the unusually high concentration of the former (2%; McArthur and Dronseika, 1990) and by the lack of metamorphic recrystallisation of the latter.

Que River

The Que River deposit occurs in the core of a tight W-shaped synclinorium at the contact between underlying quartz-sericite altered andesitic volcaniclastic rocks and overlying massive unaltered dacite (fig. 11). A carbonate-fuchsite altered polymict volcanic breccia stratigraphically overlies the massive sulphide lens (Large *et al.*, 1988). The Que River deposit has the highest overall gold grade of zinc-lead-rich Tasmanian VHMS deposits, which places it among the richest gold-bearing VHMS deposits in the world.

The complex folding present at Que River makes interpretation of the distribution of gold in the ores difficult. The highest gold grades occur along the two synclinal axes in the W-shaped synclinorium, which indicates that the gold was enriched along the top of the original massive sulphide lens in a similar manner to the Rosebery deposit (Large *et al.*, 1988). Large *et al.* (1988) reported an exponential increase of gold grades with zinc grades.

An unusual characteristic of the Que River deposit is the presence of the so-called 'precious metal zone', a zone in the footwall stringer zone enriched in gold (0.1–10 g/t) and silver but with relatively low concentrations of zinc, lead and silver (section 7725 mN, fig. 11; McGoldrick and Large, 1992). The Que River precious metal zone has a cross-sectional area of 50 × 200 m and is associated with a coarse-grained epiclastic unit along the northern edge of the footwall alteration zone (McGoldrick and Large, 1992). Although the precious metal zone was not economic to mine, it represents a new exploration target in the immediate environment in which VHMS deposits form.

The occurrence of gold in the Que River deposits has been discussed by Large *et al.* (1990) and Huston *et al.* (1992). As at Rosebery there is a close association of electrum with pyrite. The finest grained electrum (<10 μm) occurs as intergranular grains in pyrite; grains with an intermediate grain size (>10 μm) occur along the grain boundaries between pyrite and other sulphide minerals; and the coarsest grains (10–400 μm) occur with galena and sphalerite. As at Rosebery, auriferous arsenopyrite and/or possibly auriferous pyrite probably account for a significant portion of the gold. As Que River ore was processed in the Rosebery mill, no estimates can be made for Que River gold recovery.

Hercules and South Hercules

The Hercules deposit consists of numerous small lenses of massive sulphide within a host rock consisting of siltstone and tuffaceous sandstone. The overall sequence is similar to the Rosebery deposit, with an altered underlying mass-flow unit of pumice-rich volcaniclastic breccia and an overlying quartz and feldspar-bearing, crystal-lithic-rich volcaniclastic sandstone and breccia (Lees *et al.*, 1990; McPhie and Allen, 1992). As at Rosebery, a lens of black slate occurs at the top of the host sedimentary package. The South Hercules deposit occurs one kilometre south of the Hercules deposit in a similar stratigraphic package (Khin Zaw and Large, 1992).

The rocks containing the deposits have been folded into north-trending open folds with steep east-dipping axial planes. The ore lenses have been moderately deformed and rotated into the cleavage. Maximum metamorphic grade was lower greenschist (Lees *et al.*, 1990; Khin Zaw and Large, 1992).

Studies of the J(K)-P lens at Hercules have been undertaken by Khin Zaw (1991), who found that the highest gold values mainly occurred in the zinc-rich upper portion of the lens. Khin Zaw (1991) also reported a minor association of gold in copper-rich zones (>4%). Electrum is the only confirmed gold-bearing mineral, and it has two occurrences in the J(K)-P lens:

(1) coarse grains associated with galena and sphalerite in the cores of recrystallised pyrite grains, and

(2) very coarse, visible grains associated with fluorite (Khin Zaw, 1991).

The South Hercules differs from other Tasmanian VHMS deposits in that it contains high grades of gold (2.7 g/t) and silver (147 g/t), but low grades of zinc, lead and copper (total base metal = 5.5%; Khin Zaw and Large, 1992). The deposit contains thin lenses of semi-massive sphalerite-galena ± pyrite which are surrounded by a siliceous unit containing stringery zinc-lead sulphide mineralisation. The hangingwall to these zones contains lenses of massive pyrite ± barite and a number of different carbonate zones (Khin Zaw and Large, 1992; fig. 12). The highest gold (and silver) values occur within the massive pyrite ± barite lenses and in the upper parts of the stringery siliceous unit. Patchy gold mineralisation occurs in the semi-massive sphalerite-galena ± pyrite lenses, but carbonate-bearing units are devoid of gold (Khin Zaw and Large, 1992; fig. 12).

As at Hercules, the only identified gold-bearing mineral is electrum. Khin Zaw and Large (1992) reported four general modes of occurrence of electrum at South Hercules:

(1) 5–40 μm inclusions in pyrite,

(2) 5–70 μm grains associated with galena in cracks between recrystallised pyrite grains,

(3) 3–200 μm grains associated with recrystallised sphalerite, and

(4) 5–20 μm grains associated with remobilised tetrahedrite.

Arsenopyrite may also be a significant host to gold, as many of the highest grade intersections are associated with high arsenic grades (Khin Zaw and Large, 1992).

Other important sources of by-product gold

Round Mountain, near Cethana, is a Pb-Ag-Bi vein system grading about 0.5 g/t Au, and which produced about 90 kg of gold. Many other deposits in the Cethana area were auriferous, including greisen W-Sn-Mo-Bi-Au veins, disseminated Bi-W-Ag-Au skarn, and Cu-Au stockworks. The Mt Ramsay Bi-W bearing skarn carried significant gold. At Mt Horror, near Scottsdale, tungsten-arsenic rich veins in metamorphic aureoles carry high gold values. Small amounts of gold were apparently produced in some tin mines in the Waratah and Rossarden areas. The Scamander mineral field carried gold in several of the base metal veins (Groves, 1972), as did some of the copper mines in the Dial Range. In the Mount Read Volcanics and the Dundas mining field, gold is associated with many of the base metal veins and some tin veins (e.g. Sterling Valley, described above).

The alluvial tin deposits of northeastern Tasmania also produced large amounts of gold (about 0.3 t), and gold was an important by-product in most osmiridium fields in western Tasmania (probably derived, in part, from the ultrabasic rocks; Bottrill, 1991).

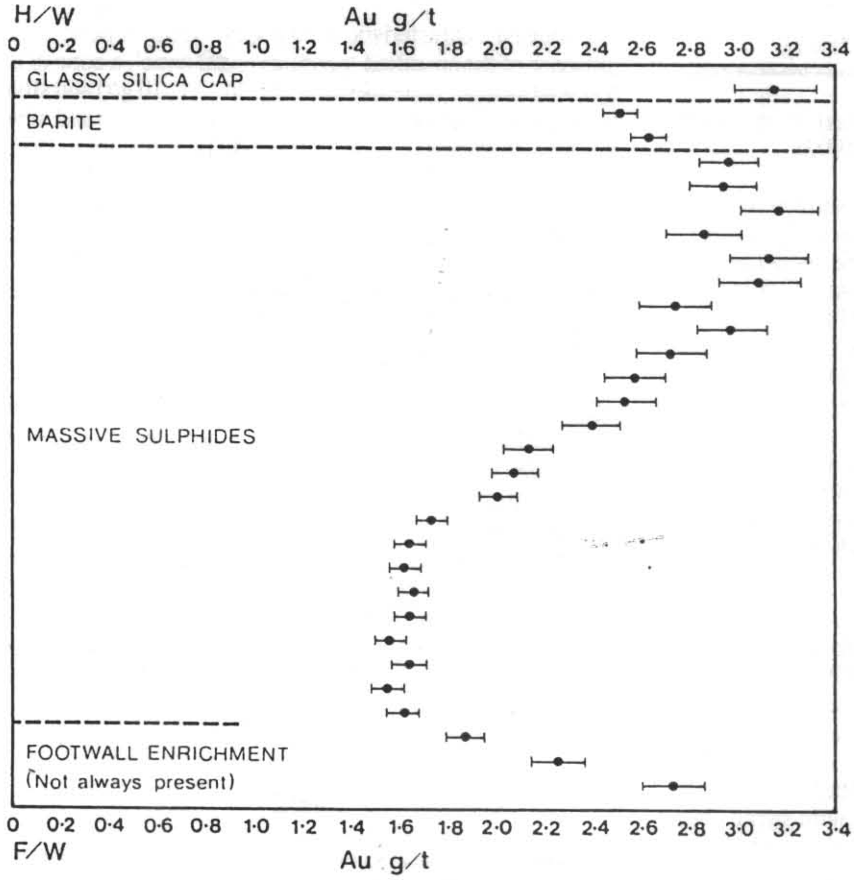

Figure 10

Generalised distribution of gold in the Hellyer deposit (after Large *et al.*, 1990)

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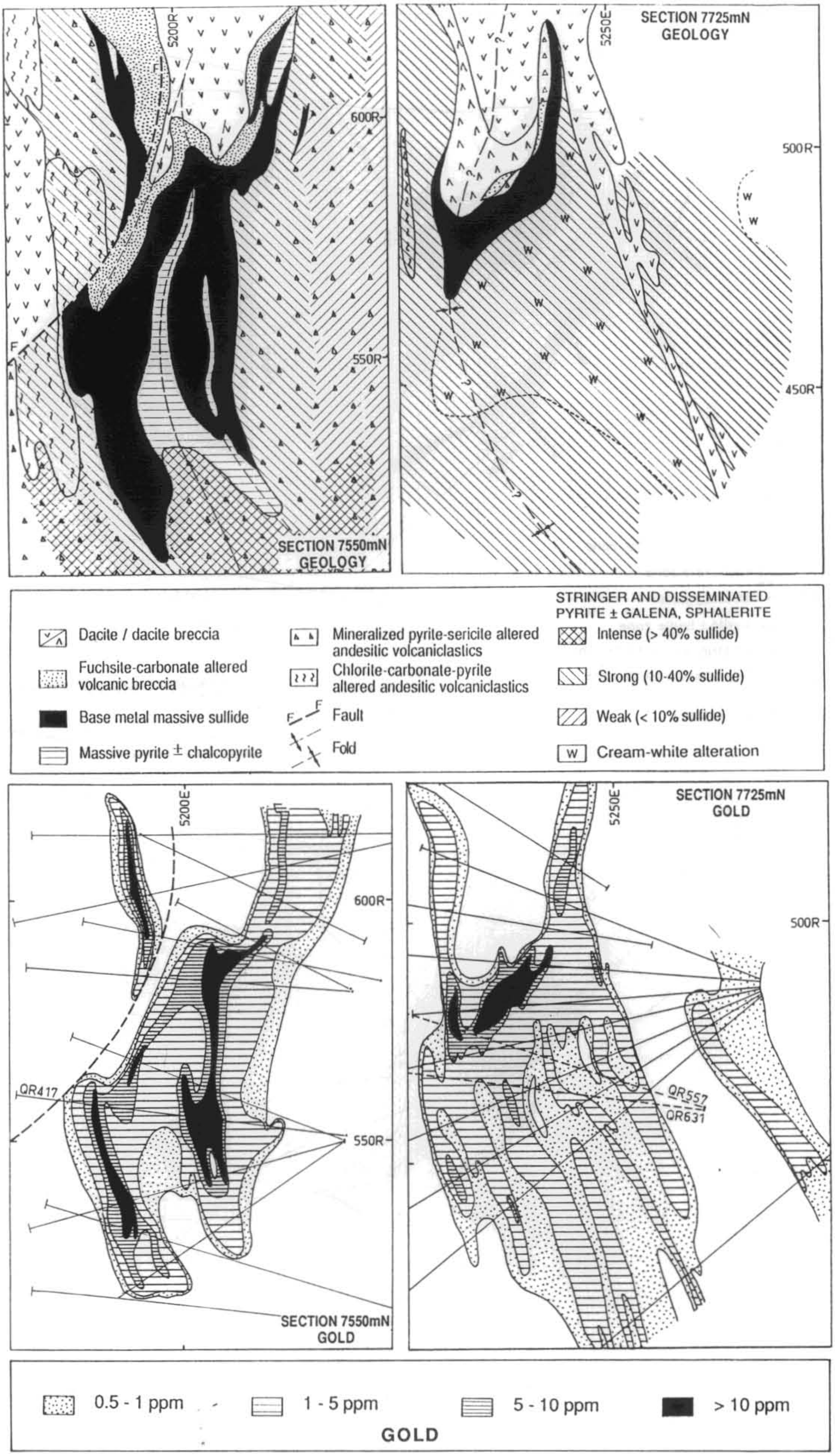

Figure 11

Cross-sections showing the geology (upper) and gold distribution (lower) in the Que River deposit (after McGoldrick and Large, 1992).

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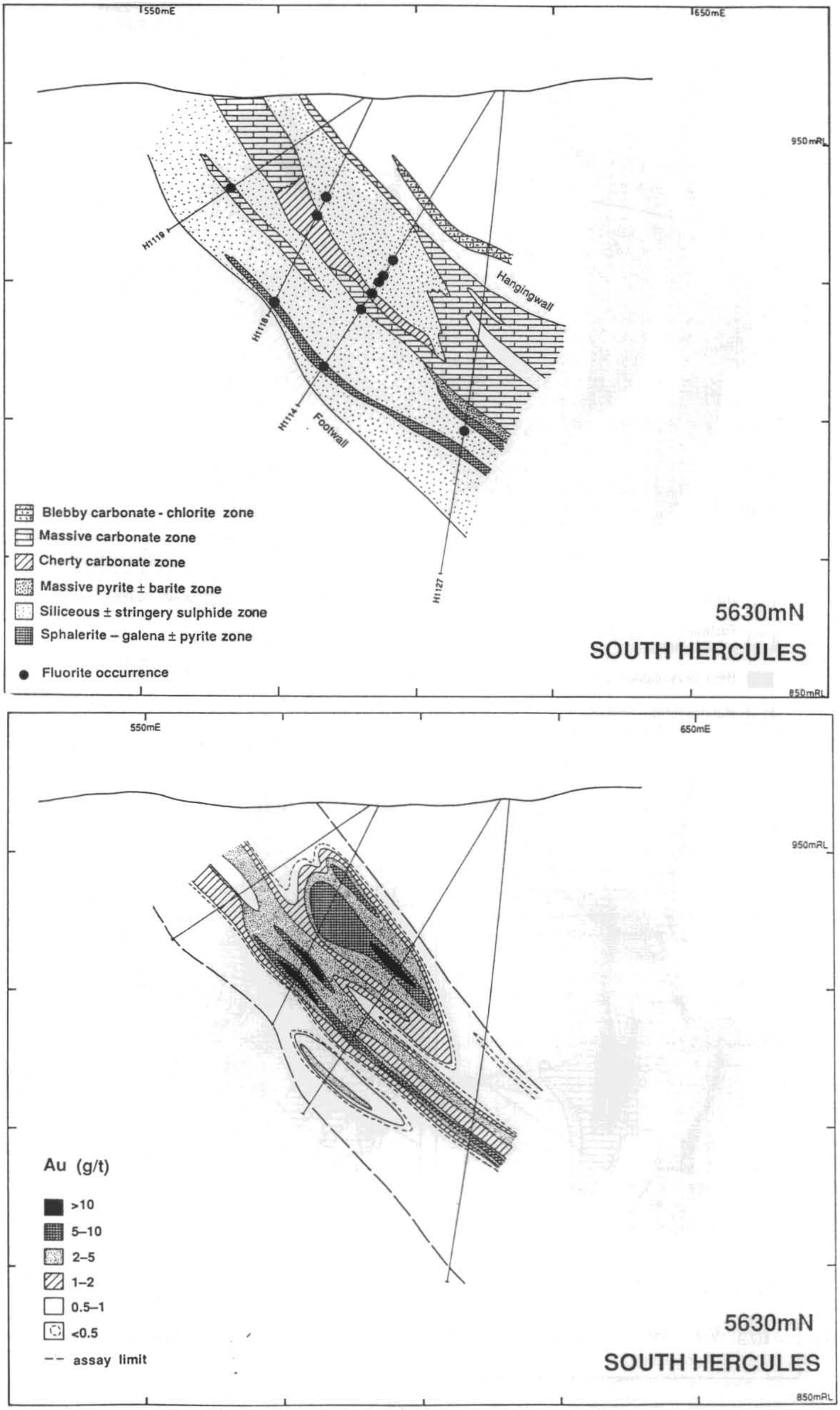

Figure 12. Cross-section showing the geology (upper) and gold distribution (lower) in the South Hercules deposit (after Khin Zaw and Large, 1992)

SUMMARY AND POTENTIAL EXPLORATION TARGETS

The major styles of gold mineralisation, organised by age, are:

1. Precambrian(?), stratabound gold in the Bowry Formation around Savage River and Corinna.

2. Cambrian VHMS and related sulphide deposits in the Mount Read Volcanics (economically the most important style).

3a. Devonian turbidite-hosted mesothermal quartz vein deposits (the most numerous deposit style).

3b. Devonian granite-related quartz and greisen veins in various rock types, usually fault-related and often subordinate to other commodities, including Pb, As, W, Bi and Sn.

3c. Devonian granite-related, disseminated deposits in skarns, with Bi and W.

4. Permo-Triassic placers, as in the Wynyard and Mangana areas.

5. Cygnet-style disseminated gold mineralisation, associated with Cretaceous alkaline intrusives in calcareous, carbonaceous Permo-Carboniferous sequences.

6. Tertiary to Recent placers (the most widely distributed style).

The principal style of gold mineralisation in the northeastern area is turbidite-hosted, mesothermal, quartz-sulphide-gold veins, very similar to those Phanerozoic deposits of central Victoria, Nova Scotia, Alaska, Wales and many other areas (Nesbitt, 1991). Early gold mining focussed on the rich but relatively small veins, while more modern exploration and mining has focussed on open-cuttable resources, such as disseminated, stockwork and multiple vein style deposits. Two medium to large gold mines of this mesothermal vein type have operated as underground workings in Tasmania; the Tasmania Mine at Beaconsfield, and the New Golden Gate Mine at Mathinna. There appears to be great potential for locating similar deposits but, unfortunately, most recent exploration has been rather superficial. Few lode deposits have been drilled, and few systematic geological, geochemical or geophysical surveys have been conducted over the mines, on either a regional or detailed scale. Many of the gold deposits can be related to major lineaments and crustal-scale structures, e.g. the Mangana–Waterhouse Belt, the Tamar Fracture Zone, the Arthur Metamorphic Belt, and the Henty Fault Zone. More work needs to be done to define such controlling structures.

Tasmanian VHMS deposits are gold enriched by world standards. In all deposits except Mt Lyell, Henty and South Hercules, the gold enrichment is associated with zinc and/or barite enrichment towards the top of the respective massive sulphide lenses. In the Mt Lyell deposits the gold has a strong positive correlation with copper, whereas the gold-rich parts of the South Hercules system contain relatively low base metal grades. These deposits include three new styles of VHMS-related gold mineralisation which have been recognised in the last ten years in Tasmania:

(1) Henty-style high-grade Au mineralisation,

(2) Que River-style precious metal zone style mineralisation in alteration zones below massive sulphide lenses, and

(3) South Hercules-style gold-silver mineralisation associated with minor base metal.

Gold-bearing stockworks and sheeted veins occur in sediments and volcanic rocks in some areas, and are highly prospective because of their potential for open-cut operations. There is a low prospectivity for economic disseminated gold in the Mathinna Beds; disseminated gold in turbiditic greywacke has been described in very similar settings, with quartz-gold veins, in the Meguma area, Nova Scotia, but is very low in grade (Crocket, *et al.*, 1986). There is a greater potential for disseminated gold (e.g. in granite aureoles), porphyry gold in high level intrusives, and epithermal deposits.

There is also significant potential for more placer gold deposits, including palaeoplacers in the Permian conglomerates, the probable source for most of the gold in Majors Gully (Twelvetrees, 1907; Finucane, 1932).

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