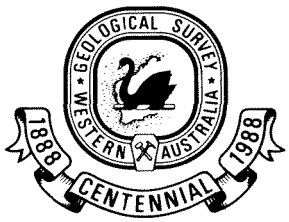
GEOLOGICAL SURVEY OF WESTERN AUSTRALIA

REPORT 28

GEOLOGY AND GOLD MINES OF THE BULLFINCH–PARKER RANGE REGION, SOUTHERN CROSS PROVINCE, WESTERN AUSTRALIA

BY
W. KEATS

DEPARTMENT OF MINES
WESTERN AUSTRALIA



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W. KEATS

Perth, 1991

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GEOLOGY AND GOLD MINES OF THE BULLFINCH–PARKER RANGE REGION, SOUTHERN CROSS PROVINCE, WESTERN AUSTRALIA

Abstract

The supracrustal sequence of the Bullfinch–Parker Range region comprises upper greenschist- to upper amphibolite-facies mafic, ultramafic, and sedimentary rocks. Granitoid and gneiss surround the greenstones and the region is characterized by abundant deformed diapiric granitoid domes. Regional structure is dominated by east-northeast to west-southwest compressional deformation and major shear coupling associated with the diapirism. Gold mineralization is controlled by both structure and stratigraphy. Mafic–ultramafic volcanic rocks are the most important lithological hosts; concordant shear zones are the most significant structures, especially those shears concentric to granitoid dome margins. There is some indication that a number of major deposits have formed at one particular stratigraphic level, at the main mafic–sedimentary sequence contact.

Keywords: gold deposits; gold mines; regional geology; mining geology; Southern Cross Province; Yilgarn Craton.

Introduction

The Bullfinch–Parker Range greenstones form a system of sinuous belts and small inliers within granitoid and gneiss between 119° 00'E, 30° 15'S and 120° 00'E, 32° 00'S, and as part of the Southern Cross Province in the southern central Yilgarn Craton (Fig. 1). The form of the greenstone belts is dominated by major north- to northwest-trending structural axes and ovoid granitoid intrusions (Fig. 3; Plate 3).

One of the earliest important gold discoveries in Western Australia occurred in the Southern Cross district. Gold was first discovered in the area during 1887 at Ansteys Find, in the Eenuin area, by prospectors who had made their way east from the coastal and early farming regions. This was quickly followed by the Colreavy party's discovery of gold mineralization at Golden Valley. The first major mechanized gold-mining operation got underway at Frasers (Southern Cross) in 1889 and was to prove the mainstay of the district through the turn of the century. However, the spectacular discoveries of Coolgardie in 1892 and Kalgoorlie–Boulder in 1893 to 1896 drew prospectors away from the Southern Cross district, and later the region was generally tended to be passed over in favour of the glamorous finds of the Eastern Goldfields.

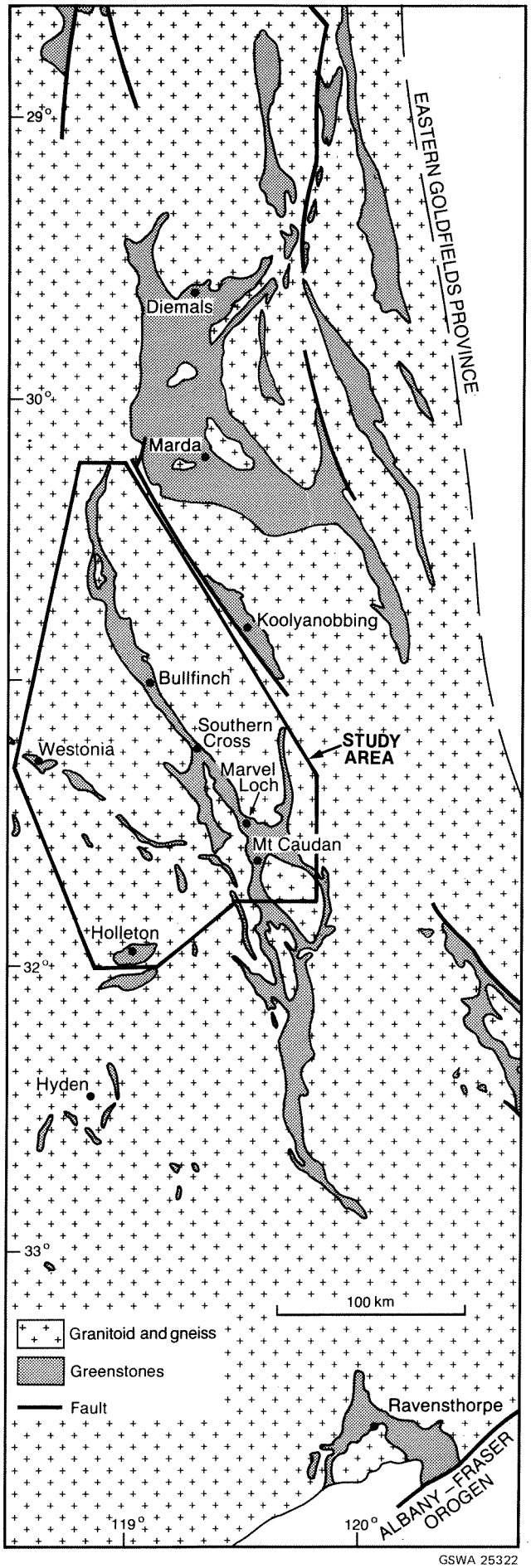
The geology and mineralization of the Bullfinch–Parker Range greenstones have been described in a number of publications by the Geological Survey of Western Australia (GSWA) and the Mines Department of Western Australia, which include many descriptions of mine workings that are now totally inaccessible. These descriptions form a major component of the documentation in this report. Bibliographies are given in the later publications; the more important historical sources are, in chronological order: Gibson, 1904; Montgomery, 1908; Saint-Smith and Farquharson, 1913; Blatchford, 1915; Blatchford and Honman, 1917; Maitland, 1919; Ellis, 1939; Matheson and Hobson, 1940; Hobson and Matheson, 1940; and Matheson, 1947.

The area has also been covered by 1:250 000 scale geological maps: JACKSON* (SH50-12); SOUTHERN CROSS (SH50-16); and HYDEN (SI50-4). Field mapping on these sheets was carried out between 1973 and 1979 and is used as a base for this study's regional interpretation.

Project work for the present study was carried out in 1986 and 1987, and provides an update of information on the controls of gold mineralization in the region. Where historical mining centres have been inaccessible, this study provides a reinterpretation of much of the previous documentation in the context of updated regional geological knowledge. Field mapping was concentrated around the best known and best mineralized portions of the area with considerable reinterpretation of the regional geology using air photography and airborne magnetic data.

Two 1:100 000 scale maps are presented, depicting extended Archaean outcrop and interpretations of the subsurface Archaean geology (Plates 1 and 2). A third interpretive map covers the entire study area at 1:250 000 scale (Plate 3).

* Sheet names are printed in full capitals to distinguish them from similar place names.



Supracrustal sequence

The general stratigraphy of the Southern Cross Province as outlined by Griffin (1990) is shown in Figure 2. Broadly, the greenstones consist of an upper sequence and a lower sequence, separated by a major unconformity. The lower sequence contains a quartzite unit at the base, which is overlain by dominantly mafic and ultramafic volcanics. Clastic sedimentary rocks, accompanied by laterally restricted felsic volcanics, occur near and at the top of this lower sequence. The upper sequence occurs only in the centre of the province and consists of clastic sedimentary rocks (Diemals Formation) and felsic volcanic rocks (Marda Complex) which unconformably overlie the mafic-dominated lower sequence (Griffin, 1990).

The Bullfinch–Parker Range greenstones are atypical of the Yilgarn Craton in that they have generally undergone amphibolite-facies metamorphism as compared to the more usual greenschist facies of the greenstones in most of the Murchison and Eastern Goldfields Provinces. The higher grades of metamorphism have commonly caused total loss of original textures and therefore identification of the protolith can be difficult. The intense deformation and the generally poor outcrop of the greenstones means that detailed stratigraphic reconstruction is rarely possible. In a broad sense, however, the stratigraphy of the region appears simple. In the better preserved portions of the greenstones (north of Bullfinch and between Southern Cross and Parker Range), previous workers have been confident regarding its continuity; though extreme attenuation and necking of the greenstone belts in places, and internal isoclinal folding within the belts, can give a false impression of true stratigraphic thickness.

Broadly, the supracrustal sequence of the Bullfinch–Parker Range region comprises a single cycle with mafic and ultramafic rocks towards the base, overlain conformably by sedimentary rocks — the "lower greenstone sequence" of the Southern Cross Province (Fig. 2).

A thin, discontinuous unit mapped at the eastern margin of the greenstone belt has been interpreted as a basal quartzite unit (Gee, 1982). Similar rocks are well known in the northern portion of the Southern Cross Province, where cross bedding and consistent way-up evidence confirms their stratigraphic position; however, in the south, their stratigraphic level is uncertain due to suspected structural complexities.

The correlation of these metasedimentary rocks with similar lithologies in the southern half of the Southern Cross Province is problematical. Lithological correlatives occur in the Forrestania area, structurally below ultramafic rocks, and on the western and southern margins of the Ghooli Dome (between Bullfinch and Nevoria) where

Figure 1. Granite–greenstone terrane of the southern Southern Cross Province, showing the study area.

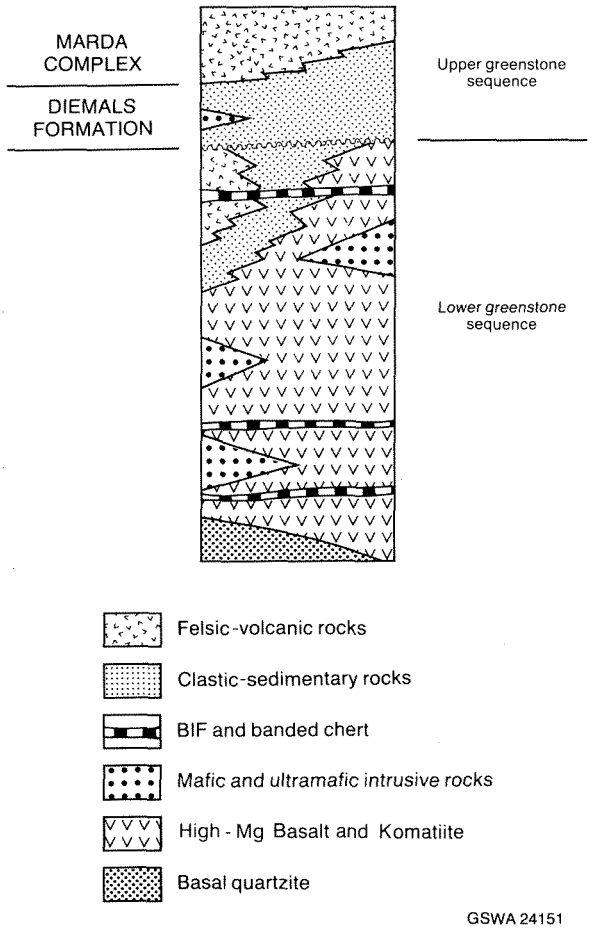


Figure 2. **Generalized stratigraphic column for the greenstone rocks of the Southern Cross Province (from Griffin, 1990).**

they are interbedded or interfolded with mafic amphibolite, or are found at sheared contacts with granitoid gneiss. In contacts with the gneissic Ghooli Dome, the quartz–muscovite schist is strongly deformed and the internal structure of the greenstones is not well enough known to place the schist positively at a stratigraphic base. Some of the schist interpreted as having a sedimentary protolith is undoubtedly so, but may occupy a higher stratigraphic level; other schist appears to grade along strike into banded iron-formation, chert and mafic schist, and should be interpreted as sheared, altered, or granitized contact rock. This is especially the case at the Derwent Jack, Corinthian, and Hopes Hill gold deposits. Matheson (1947) made a similar interpretation of the schist units.

Notwithstanding the above, interpretations of the Ravensthorpe greenstone stratigraphy, in the extreme south of the Southern Cross Province, place a thick intermediate volcanic–metasedimentary sequence below the main mafic–ultramafic sequence (Sofoulis and Connolly, 1958; Thom et al., 1977).

The mafic–ultramafic succession attains a maximum structural thickness of 7500 m, but can vary greatly in thickness. The stratigraphic thickness in the less deformed Marda region to the north of the study area (Fig. 1) has been estimated at 14 000 to 15 000 m, but this succession may bear little relation to that in the Bullfinch–Parker Range region.

Between Southern Cross and Parker Range, the mafic–ultramafic succession ranges from 1500 to about 5000 m in structural thickness. However, the thickest portions of the belt are internally folded and strike-faulted, and its preserved stratigraphic thickness is therefore unlikely to exceed 3000 m. In this area, both mafic and ultramafic extrusive and intrusive rocks occur. The volcanic rocks, originally basaltic lava, komatiitic basalt and komatiite, are now fine-grained amphibolite and variably textured tremolite–chlorite rocks.

A prominent, semi-continuous zone consisting of jaspilite or banded iron-formation (BIF) occurs within the volcanic succession close to the structural base (as now preserved), usually within fine-grained amphibolite; however, it occurs among predominantly more ultramafic rocks near Southern Cross itself. The zone commonly contains three or four individual BIF units, 1 to 30 m thick, which apparently split and rejoin along strike. It is considered likely that this feature could be a result of isoclinal folding and shear repetition of a single horizon, or, more rarely, as a result of dolerite intrusion. The BIF is generally siliceous rather than iron-rich. Magnetite rarely exceeds 5% but may have been metamorphically converted with quartz to grunerite.

The basalt–BIF sequence also contains finely banded or layered amphibolite of arguable origin. On SOUTHERN CROSS and JACKSON, this layering has been attributed to an original tuffaceous or sedimentary component, i.e. the rocks are described as para-amphibolite. There is, however, no evidence of preserved clastic or pyroclastic textures and it was argued by Wilson (1953) that the layering, which consists of alternating quartz–feldspar-, amphibole-, biotite-, and clinopyroxene-rich laminae, is of metasomatic or metamorphic origin. Fine-scale (of mm-scale) layering in these rocks is widespread, across belts of outcrop up to 1 km wide, but it is often very variable both in scale and in intensity along strike. The layering is increasingly common near many of the larger gold-mining centres. Gee (1982) stated that these "unusual features" are only revealed in old mine workings. Similar petrological layering, though on a much coarser scale, occurs in these mines and many of the mine host rocks are banded calc-silicate gneiss. Clinopyroxene, amphibole and biotite layering is parallel to, and controlled by, quartz veining, which itself is mineralized. Both scales of layering, therefore, could arguably be a result of medium- to high-grade (up to upper amphibolite-facies) metamorphism of previously altered, carbonated basalt. The coarse gneissic layering common at these mining centres could be the result of a metamorphic overprint on alteration associated with gold mineralization, i.e. the mineralization and alteration may have taken place at lower metamorphic grade. The finer laminae could be the result of a pre-peak metamorphic regional carbonation.

At most localities, bedding and foliation of the amphibolite are parallel; however, at Nevoria, the layer-

ing is parallel to a second-generation foliation, not to original bedding. In a regional sense, the layered amphibolites are best developed on the margins of the Parker and Ghooli Domes, which are genetically significant with regard to gold mineralization. The source of regional carbonation may have been these granitoid bodies, or carbonate-bearing fluids may have been channelled by structures associated with their emplacement or deformation. In either case, it appears that the distribution of the "para-amphibolite" is more structurally than stratigraphically controlled.

There are two major gabbroid sills intrusive into the mafic–ultramafic volcanic sequence. The sills are differentiated bodies with basal peridotite or pyroxenite, and upper portions consisting of gabbro, quartz gabbro, and thin zones of granophyre. The ultramafic portions are particularly poorly exposed and often silicified and lateritized, but aeromagnetic data indicate that they extend over large distances. The upper portions have generally been metamorphosed at a lower peak grade than the associated volcanic rocks with the result that original igneous textures are locally preserved. This probably occurred due to the sills being more massive and competent bodies, and therefore they were shielded from the intense ductile deformation which affected the volcanic rocks. The sills have been affected by upper-greenschist-facies metamorphism and now consist of porphyroblastic actinolitic hornblende in an actinolite–chlorite–clinozoisite–albite–quartz matrix.

The mafic–ultramafic succession north of Bullfinch is quite similar to that between Southern Cross and Parker Range. Here, the belt attains a structural thickness of up to 6500 m, but folding and faulting preclude any accurate estimation of true thickness at this stage. Two lithological domains occur in this region, and are separated by a major strike-slip and down-faulted block system in which possible upper sedimentary rocks were deposited. The eastern domain of the belt is characterized by tholeiitic amphibolite, metamorphosed komatiite, and BIF. The interpreted base of this domain consists of coarse-grained tremolite–chlorite ultramafic rock and possible cumulate, which are overlain in turn by tholeiitic amphibolite, a thin zone of BIF and komatiite, and further tholeiitic amphibolite. The BIF zone, as on SOUTHERN CROSS, consists of a number of individual thin (up to 10 m) horizons which are believed to be folded and/or sheared repetitions of a single horizon. The eastern margin of the belt has been partly assimilated by granitoid intrusion, and commonly consists of a strongly foliated, often biotite-rich, mafic schist of uncertain parentage. The western domain contains more komatiite (with occasionally preserved spinifex texture), very little tholeiite, and only minor BIF. The domain is intruded by gabbroid sills which contain only minor ultramafic sections. The stratigraphic relationship between the two domains is not clear. It is tentatively interpreted that the western domain may underlie the eastern but this interpretation is based on relatively poor aeromagnetic data in an area totally devoid of outcrop just to the south of Bullfinch. The separation of the two domains, however, is important, as virtually all the major gold deposits known occur in the eastern (?upper) domain.

The upper succession of sedimentary rocks is certainly continuous from just south of Southern Cross through Parker Range southwards towards Forrestania, and consists of similar lithologies throughout the area. Again, estimated stratigraphic thicknesses are uncertain — at anything over 2000 m. The rocks are predominantly pelitic, and consist of schist, phyllite and shale, with minor quartzite and psammite, and rare metaconglomerate. They are commonly graphitic and quartzo-feldspathic, and contain variable amounts of garnet, with andalusite, sillimanite and muscovite. Muscovite may be retrogressive after andalusite, and sericite and chlorite both occur as prograde and retrograde minerals. Metaconglomerates are matrix supported. The best examples are northwest of Colreavy (though, here, their stratigraphic position is arguable) where flattened, rounded chert and fine-grained sandstone clasts (up to 200 mm long) occur in fine-grained quartz–muscovite schist. On SOUTHERN CROSS, a very prominent and continuous massive sulphide marker horizon is present at or near the base of the sequence, with further cherty and partly sulphidic horizons at higher levels.

Of possible equivalent stratigraphic position to the upper pelite sequence is a unit of amphibolitic paragneiss and quartz amphibolite, interlayered with black shale and graphitic schist and pelite, which occurs northwest of Bodallin in the Westonia greenstone belt. On SOUTHERN CROSS, these rocks are considered to have been derived from a felsic volcanic parent (including significant agglomerate). If this is the case, they represent the only preserved felsic volcanic rocks (other than extremely rare feldspar-porphyry dyke rocks) in the region, the nearest known felsic volcanic centre being at Marda, 140 km to the northeast. Alternatively, the gneiss and amphibolite may represent immature arenaceous sediments metamorphosed at upper amphibolite facies.

Granitoid and gneiss

Granitoid and gneiss surround the greenstones, and form some minor intrusions into the greenstone belts themselves. However, they were not investigated in any detail during this project. Previous 1:250 000 scale mapping has subdivided the granitoids, with some transition, into major categories, pre- to syn-tectonic (banded gneiss, granitoid gneiss), and post-tectonic (biotite monzogranite and syenogranite, granodiorite, and tonalite), largely on the basis of textures reflecting deformation and recrystallization.

The early intrusions are generally external to the greenstones; they are deformed to typically ovoid shapes aligned with the greenstone belts, and are most common in elongate zones adjacent to these belts (Fig. 3; Plate 3). Foliated biotite granite is also generally restricted to zones

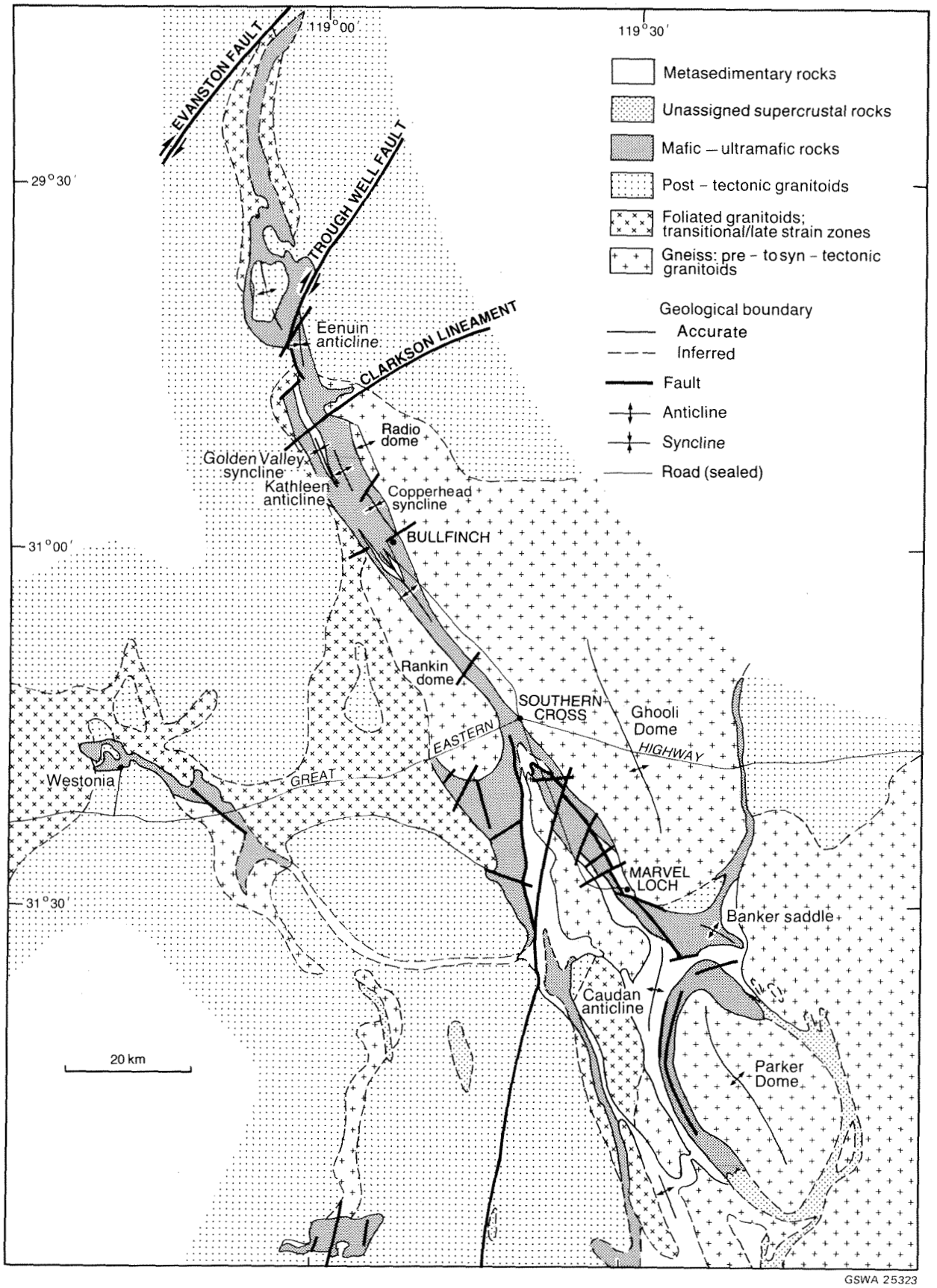


Figure 3. Regional geology of the Bullfinch–Parker Range region.

immediately adjacent to the greenstones. These rocks grade outwards into typical unfoliated "post-tectonic" biotite granite, i.e. the foliated nature of the granite is controlled by high-strain zones associated with the outer margins of the greenstone belt. Contacts between granitoids and greenstone are not well exposed, but the increase in strain towards contacts indicates that shearing has taken place. In places, the contacts are also intruded by younger granitoids, e.g. north of Nevoria.

The gneissic Ghooli and Parker Domes, at least, are thought to have been emplaced largely in the solid state by diapirism. The Ghooli Dome, as defined by Gee (1982), is a complex body containing a variety of banded gneiss intruded by younger granitoid plutons. The Parker Dome is distinctly sygmoidal in shape, which is believed to have been caused by its clockwise rotation during or after emplacement. The greenstones around the Parker and Ghooli Domes dip concentrically away from them (greenstones at the eastern margin of the Ghooli Dome are much steeper than these at the western margin); the Rankin gneiss dome, however, may be an inclined sheet with an easterly dipping western margin and a near-vertical eastern margin. Some large areas of gneiss, especially north and east of Bullfinch, contain abundant rafts of partly assimilated greenstone material.

Post-tectonic granitoid intrusions occur both outside and within the greenstones. Large intrusions into the greenstones are not common, and are virtually restricted to small groups of plutons between Newfield and Eenuin near the northern tip of the main Bullfinch belt, and near the eastern termination of the Westonia belt. At the former locality, contacts with greenstone are sharp, but the granitoids include both somewhat deformed bodies with fabrics parallel to those in the surrounding greenstones and undeformed bodies which clearly cut across the greenstone fabrics and layering. Small bodies of pegmatite are common throughout the greenstones, but have been largely left unmapped.

Metamorphism

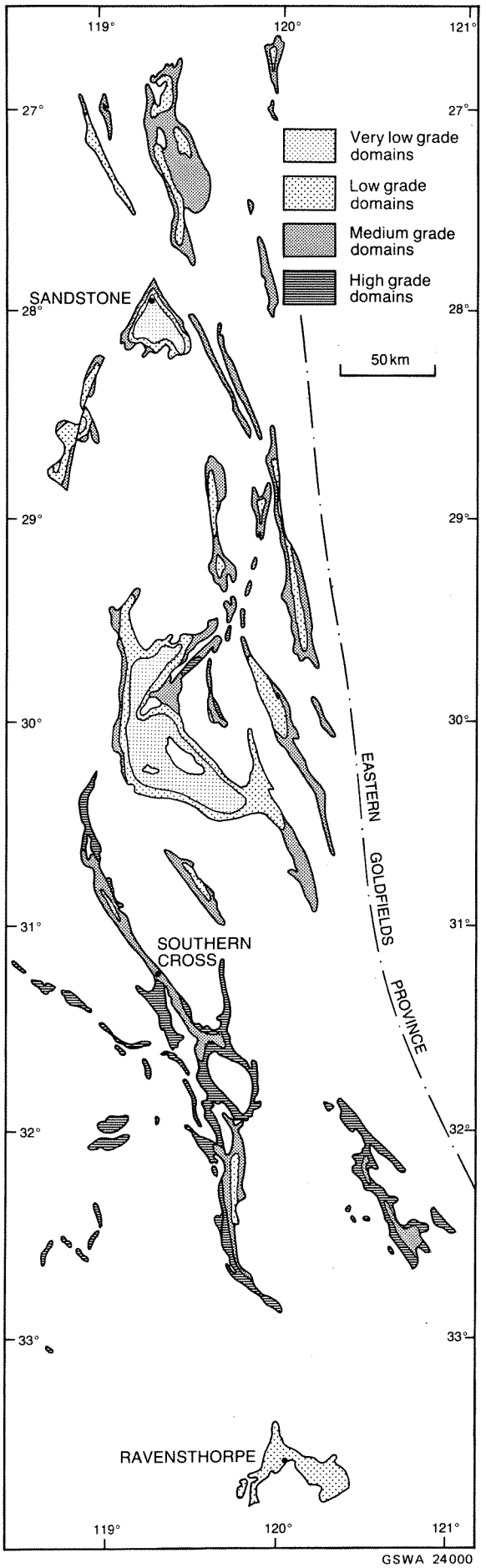
Metamorphic patterns in the region have been discussed in some detail by Ahmat (1986). Metamorphic grades range from upper greenschist to upper amphibolite transitional to granulite facies (Fig. 4). Generally, the grades are highest close to gneissic granitoid–greenstone contacts, and within the narrowest of the greenstone belts and greenstone inliers. Greenschist grades are generally found only in thick, competent and massive gabbroid intrusions which seem to have been shielded from high-strain penetrative deformation. The high-grade metamorphism in the greenstones at the granitoid contacts is attributed to the depth of exposure of the rock sequences rather than to contact metamorphic effects, but there is also a general increase in grade towards the southwest of the region. Upper greenschist metamorphism of gabbroids has formed assemblages of biotite–tremolite-actinolite–clinozoisite–albite. Amphibolite grades are characterized by coloured hornblende and plagioclase (andesine–labradorite)–hornblende in mafic rocks (and diopsidic clinopyroxene in carbonated mafic rocks); by andalusite (–sillimanite)–cordierite–muscovite–quartz–garnet in pelites; by metamorphic olivine and cordierite–anthophyllite in ultramafic rocks; and by grunerite in BIF. Metamorphic hypersthene in some greenstone inliers and narrow belts indicates true granulite facies (Chin and others, 1984; Gee, 1982).

Throughout much of the area, there is some evidence of a later retrograde greenschist-facies event (recorded by retrograde tremolite-actinolite, sericite, and chlorite in mafic rocks and pelites) which followed the formation of predominantly amphibolite-grade rocks during the main tectono-thermal event (Chin and others, 1984; Chin and Smith, 1983; Gee, 1982).

Structure

Progressive east-northeast to west-southwest compressional deformation and major shear coupling, directed by forces associated with granitoid emplacement, have been responsible for the present form of the Bullfinch–Parker Range greenstones. The main greenstone belts are highly elongate, with aspect ratios ranging from 10 to 50, and have a preferred north-northwesterly strike (Fig. 3; Plate 3). Divergences from this trend and local arcuate shapes are controlled by specific domal granitoids or groups of granitoid bodies. The domal configuration of granitoids is not always clear away from the greenstones, but is quite obvious in close proximity to them. The granitoids are distinctly ovoid in shape, and, with their long axes parallel to the regional trends in the greenstones, have aspect ratios of between 2 and 4 (less commonly up to 6) which indicates progressive compression throughout the deformation event. The Parker Dome has been rotated in a clockwise fashion, i.e. dextrally; the Rankin gneiss dome and Ghooli Dome are asymmetrically inclined to east and west respectively.

Trends of folds (generally isoclinal), and axial-planar foliation, within the greenstones are parallel or subparallel to the regional outlines of the belts. Crenulation of foliation is apparent, especially in pelitic sedimentary rocks (Chin and others, 1984), which represents a later stage of deformation. The main folding episode is believed to be contemporaneous with amphibolite-facies metamorphism; the later deformation is accompanied by retrograde, upper greenschist-facies metamorphism. However, both folding episodes are coaxial throughout most of the region and are believed to belong to the one progressive event. Superimposed folding is seen in the hinge zones of earlier folds, and is especially apparent in BIF horizons where



these were first "folded around" the noses of granitoid domes, e.g. at Nevoria and Maries Find.

Early strike-parallel fault traces are also apparently refolded, e.g. in the Kennyville area. Strike-slip faulting is believed to have complicated apparent stratigraphic successions, resulting in repetitions of rock types and probable chronostratigraphic horizons. Again, BIFs are prominent in this respect, forming loci where shearing has preferentially taken place. Within zones of BIF, individual horizons appear to split and rejoin along strike, a feature which would seem extremely unlikely to be primary. Folding and/or shear repetition is a more plausible explanation, and these multiple BIF horizons can be seen folded on themselves in a number of places, e.g. at Bullfinch, Colreavy, and Nevoria.

Irregular plunge reversals of early fabrics in BIF have been explained by Gee (1982) as variations about a mean vertical orientation (the plunges are usually steep to subvertical) rather than the result of cross or interference folding (Matheson, 1947, and earlier GSWA Bulletins). Similarly, the Banker saddle between the Ghooli and Parker Domes is interpreted as an interdomal saddle rather than as a result of east–west axial cross-folding.

Strike-parallel faulting is also seen as a progressive event, largely related to a concentration of linear shearing during compression and doming, which may even date from depositional times. Faults west of Colreavy are possible graben-boundary growth faults; they outline a unit of sedimentary rocks which include pelite, minor psammite, and conglomerate containing apparently locally derived (slumped sediment) clasts (Chin and Smith, 1983). Gneissic granitoid–greenstone contacts are commonly sheared and other strike-slip faults and shear zones within the greenstones are compatible with upward and lateral movement of granitoid domes. Late faults, oriented generally between north-northeast and northeast, cut across unfoliated granitoid and displace deformed greenstone belts with up to 2 km of apparent wrench movement. East-northeast trending swarms of Proterozoic dykes (which include the extensions of Binneringie and Jimberlana Dykes) were intruded during post-cratonic deformation.

The most prominent features in the Southern Cross–Parker Range area are the ovoid granitoid domes which are partly or, less commonly, wholly flanked by greenstones, depending on the tectonic level to which the domes have risen. Gneissic foliations dip radially outward and become steeper towards the dome margins; dips in the adjacent greenstones tend to continue steepening away from the domes. Stretching and mineral-grain lineations in the adjacent greenstones all plunge steeply down the dip of the foliation which is concordant with the granitoid fabrics (Gee, 1982). North–south dextral shearing across the greenstone belt has caused clockwise rotation of the Parker Dome which in turn has resulted in a series

Figure 4. Metamorphic map of the Southern Cross Province (from Ahmat, 1986).

of three or four subparallel, concentric sinistral shear zones within its northwest-flanking greenstones. The BIF horizon, 0.5 to 1 km from the gneiss contact, has provided a locus for one such shear zone which extends for some 20 km around the western side of the dome. Similarly, the dextral shear system through Marvel Loch flanks the southwestern portion of the Ghooli Dome. This could be explained in terms of the squeezing out of the greenstones between the Ghooli and Parker Domes, but then nothing is known of the relative timing of emplacement of the domes or other factors which may have been crucial in setting up this shearing.

Superimposed fabrics occur within the Banker saddle. At Nevoria, BIF with axial-planar foliation after bedding-parallel isoclinal folding (striking approximately 290° near the hinge of the Ghooli Dome "anticline") is refolded by north-northwest trending box-folds plunging at moderate to steep angles southwards, i.e. away from the Ghooli Dome and concordant with stretching lineations. The detailed structure and distribution of lithologies in the Banker saddle is poorly known, but there is little doubt that the area has been complexly deformed. Rotation of the Parker Dome to the south may have resulted in complex faulted relationships between the northern and southern greenstone sequences. The apparent thickness of the northern mafic–ultramafic sequence is strongly suggestive of structural thickening.

A major north to northwest trending sinistral strike-slip fault is traced between the Greenmount and the Edwards Find areas. Movement on this fault is interpreted from the folding pattern south of Greenmount, and was possibly set up by the emplacement of the Rankin gneiss dome (Plate 3). Between this fault and the Southern Cross–Marvel Loch arm of greenstones, Gee (1982) interpreted a broad synform. The core of the synform is not exposed but may consist of sedimentary rocks or granitoid. The pelitic sequence between the Moonargidding Rock and Edwards Find areas is complexely refolded and disrupted by late cross-wrench faulting and by granitoid emplacement southeast of Edwards Find.

The mafic–ultramafic rock sequences striking southeast from Mount Rankin, and south from Greenmount, and both apparently younging to the east, have been married along a major suture zone. Medium-scale crumple folding, as interpreted from air photography, has affected metamorphosed basalt immediately to the west of the suture and indicates a possible sinistral displacement.

The northern section of the region, between Southern Cross and Newfield, consists of a single greenstone belt which shows ample evidence of complex coaxial refolding, and is predominantly antiformal in character. Fold axial traces mapped in the Bullfinch–Golden Valley–Eenuin area convey a good impression of the degree of deformation present, at least in the eastern tholeiite–BIF sequence. As mentioned earlier, this sequence possibly lies stratigraphically above a western mafic–ultramafic volcanic and intrusive dominated sequence, and the two sequences are partly juxtaposed by a major strike-slip fault or system of faults which can be traced over nearly 40 km. The sense of displacement along this zone, however, is ambiguous and may have changed at various periods. The fault trace is arcuate, and disrupted or possibly over-ridden by granitoid intrusions along its central portion west of Eenuin.

Gneissic granitoid doming (e.g. Radio dome) is prominent between Eenuin and Bullfinch near the eastern margin of the greenstones, but not to the west (Fig. 4; Plate 3). The domes have relatively high aspect ratio and include areas of assimilated greenstone.

Gold mineralization

Officially reported total gold production for the study area, up to 31 December 1988 was:

alluvial gold:	91.49 kg
dollied gold:	462.86 kg
ore treated:	18 189 100 t
gold from ore:	100 326.63 kg; average recovered grade 5.52 g/t
total gold:	100 880.98 kg

The reporting area includes most of the Yilgarn Mineral Field (excluding the Evanston, Koolyanobbing, and Mount Jackson centres). However, not all the production is accountable to specific mining leases or even specific mining centres. Mines Department records of production commenced in 1897; however, gold was being mined on a moderately large scale at Southern Cross and Parker Range as early as 1889.

For 1988, production from the area amounted to approximately 8744 kg of gold from 4.9 Mt of ore (1.8 g/t) which represents 8.2% of the State's total gold production, a very significant contribution considering the size of the area, and one which is set to keep pace with the State's expanding gold-mining industry.

The main mines that were producing during the term of this survey, or came on stream shortly afterwards, were Westonia (the old Edna May), Great Victoria at Burbidge, Marvel Loch, Nevoria, Edwards Find, Copperhead at Bullfinch, Frasers at Southern Cross, and Hopes Hill–Corinthian and Transvaal north of Southern Cross. These are all based on redevelopments of old mines.

Table 2 shows production data (rounded figures) for some eighty mines or groups of mines which have been merged to reflect geological deposits. Twelve of these subdivisions have to date produced over 1000 kg of gold each, and twenty-five have produced over 100 kg but under 1000 kg. Deposit size based on production and resource figures are indicated on Plate 3.

There is a clear concentration of known gold mineralization in the north-central portion of the region, especially between Radio–Bullfinch and the Banker saddle area. With the exception of Burbidge, the major deposits through this zone are in a continuous belt of greenstones, on its eastern side within 1 km (and generally much closer) to the greenstone–gneissic granitoid contact. Remarkably, the most important deposits are quite regularly spaced with a first-order periodicity of between 7.5 and 10 km (with one major gap) as follows: Maries Find (400 kg); 9.5 km to Radio group (2600 kg); 8.0 km to Copperhead (21 000 kg); 18.5 km to Corinthian (1810 kg); 9.3 km to Hopes Hill (1030 kg), with Pilot area (920 kg) approximately mid-way; 7.5 km to Southern Cross (9900 kg); 8.2 km to Leviathan (500 kg); 5.7 km to Evelyn Molly (100 kg); 8.3 km to May Queen (500 kg) (which is located more to the west); 9.0 km to Marvel Loch (4600 kg) (Leviathan to Marvel Loch is 21.5 km); 10.0 km to Nevoria (4600 kg), with Donovans Find (960 kg) approximately mid-way.

This periodicity of gold deposits raises the question of fundamental mineralization control by either regularly spaced structure, e.g. cross-folding normal to the greenstone belt (e.g. Matheson, 1947), or regularly spaced cells of source material, e.g. if the gold was derived by local metamorphic dehydration of the greenstones.

Throughout the study area, it is apparent that a combination of stratigraphic and structural controls has acted to concentrate gold into epigenetic ore deposits. A matrix of production apportioned by both host rock and structural setting (Table 1) indicates that both factors are equally important. In regard to host-rock control, the mafic–ultramafic volcanic sequence is dominant with about 60% of production, followed by BIF. The figures for gneiss are strongly biased by just one major deposit at Westonia. For structural control, concordant shear zones dominate; the saddle-reef group is also strongly influenced by production from gneiss at Westonia; Palmers Find (Yellowdine Nos 2, 4, 6) is the only other major deposit included in this category, but this is based solely on old mine descriptions (Matheson and Hobson, 1940).

Stratigraphic control may reflect the distribution of suitable source rocks, or of lithologies suitable for gold precipitation. In turn, the suitability of host rocks as precipitators of gold may reflect their chemical composition or their response to deformation, and these factors themselves are often inextricably linked.

The concentration of mineralization in the eastern tholeiite–BIF dominated sequence between Newfield and Bullfinch (and possibly extending south to Southern Cross), as compared to sparse mineralization in the ultramafic–gabbroid dominated western sequence through the same area, is considered likely to be a primary stratigraphic control. These preferred host rocks presumably have the high iron-activity (high Fe:Fe+Mg ratio) necessary to precipitate gold by sulphidation reactions. Alternatively, the eastward-preferred distribution of mineralization may reflect the contrasting nature of granitoid on either side of the greenstone belt.

TABLE 1. GOLD PRODUCTION OF THE BULLFINCH–PARKER RANGE REGION CLASSIFIED BY HOST ROCK AND STRUCTURAL CONTROL

	Mafic–ultramafic sequence (%)	*BIF* (%)	*Gneiss* (%)	*Pelitic sequence* (%)	*Total* (%)
Concordant Shear zone	47.8	1.3	0.3	3.6	**53.0**
Saddle-reef or fold-related	8.1	-	15.5	-	**23.6**
Fold nose	-	15.0	-	3.9	**18.9**
Discordant fault	4.5	-	0.05	-	**4.6**
Total	**60.4**	**16.3**	**15.8**	**7.5**	

BIF exerts both lithochemical and structural control on mineralization in the region. There are a number of important deposits, e.g. Copperhead, Haddon subgroup at Southern Cross, Nevoria, Evelyn Molly, and some Parker Range centre groups, in which BIF forms the host rock and where replacement of magnetite and grunerite by pyrrhotite has accompanied gold precipitation. There are also numerous deposits where the association with BIF is primarily structural. Layer-parallel shearing tends to be concentrated along BIF–amphibolite (or ultramafic) contacts and the mineralization is concentrated in subsidiary shears, (Riedel shears, etc) in the ductilely deformed lithologies adjacent to the BIF, e.g. Eenuin group, Golden Valley, Days Find, Corinthian, Pilot, ?Hopes Hill, ?Mount Rankin, and many groups at the Parker Range centre. When compressional deformation occurs normal to layering, e.g. at fold hinges (Copperhead and Nevoria are outstanding examples), the result is extensional brittle fracture of relatively competent BIF within ductile wall rock. At Nevoria, this is combined with vertical extension associated with the uplift of the Ghooli Dome, and has provided a most suitable environment for gold deposition.

A third type of stratigraphic control within the region is the intimate association of mineralization with a massive sulphide horizon which occurs in pelite at, or very close to, the contact with the mafic–ultramafic sequence. The Burbidge group and Mountain Queen mine, and possibly the Transvaal group and Devs Reward mine, are on this horizon. The stratigraphic control exerted by this unit is possibly lithochemical (though it is difficult to envisage gold precipitation by a sulphidation mechanism within a massive sulphide horizon), or possibly physical damming of fluids at an impervious level. The actual localization of mineralization, however, is primarily structural. The sulphide horizon can be traced on the ground and by aeromagnetics over at least 30 km of strike length in the Marvel Loch–Burbidge–Mount Caudan area, but the gold deposits in it are restricted to zones of structural complication, e.g. secondary folds within a major anticlinal hinge zone at Burbidge, and at a possible intersection of shear zones at Mountain Queen.

Most larger gold deposits in the Yilgarn Craton are located close to major regional lineaments which probably represent deep-seated crustal fractures. On a more local scale, ore deposits are commonly found on second- or third-order structures, i.e. faults and shears, and fractures associated with folding. The major regional lineaments in the mapped area are mostly parallel to the greenstone belts, commonly on greenstone–granitoid contacts. Probably these contact zones have provided the main conduits for hydrothermal mineralizing fluids. Shearing and compression is associated with the long-term forcible emplacement (doming) of the granitoids; it is therefore important that any future study address such aspects as the relative timing of this emplacement with respect to mineralization, and also the possible contribution of magmatic fluid to the mineralizing system.

Table 1 has shown the dominant structural control in this region to be one of concordant shearing, in which layer- and/or foliation-parallel faults are intruded by quartz, either in discrete veins or as siliceous impregnations of lode material. Within the shear zones, depositional sites are controlled by subsidiary structures, (e.g. Riedel shears, tensional fractures, etc), resulting in the formation of mineralized "shoots" and anastomosing host systems. Discordant faults are, by comparison, poorly mineralized. There are major cross-cutting regional lineaments, but, with the possible exception of a northeast-trending zone through Bullfinch, none is associated with mineralization. Generally, the cross-cutting structures are unlikely to have been sufficiently deep-seated to provide conduits for hydrothermal mineralization; however, if they intersect feeding-structures, mineralization can occur.

Uplift of the Radio dome probably provided concentric fractures through which hydrothermal fluids were channelled, with pressure-release depositional sites at the Radio group and Maries Find being provided by open discordant faults. At the Radio group, lithochemical control has also played a role, i.e. the mineralized faults cut both gneiss and mafic volcanic rocks but the mineralization is largely confined to the mafic host rocks. This could be due to contrasting competency in the different rock types or to chemical precipitation factors.

Mining groups

The descriptions of mining groups in this report are not intended to be exhaustive. Apart from redevelopments, the vast majority of mines in the region have remained inaccessible for many years, and therefore the best and, possibly the only documentation or descriptions are to be found in the early publications of the Geological Survey of W.A. These references are noted underneath each centre and should be read in conjunction with the following summary notes and observations. A summary of mine data is also provided in Table 3. Production data is listed in Table 2.

Westonia centre

General references: Blatchford and Honman, 1917; Matheson, 1947.

The Westonia mining centre is located 60 km west of Southern Cross, towards the northwestern extremity of the Westonia greenstone belt. The greenstone belt runs southeast and east from Westonia to join the Edwards greenstone belt about 5 km west of Edwards Find. The main mining groups of the Westonia centre are the Westonia group which consists of the Westonia mine (formerly the Edna May mine) and minor associated mines (e.g. Golden Point), and the West Westonia and Recovery groups; some small groups are also located at Colossus and Comstock, and small mines are situated east of Bodallin, between 12 and 19 km southeast of Westonia.

Westonia group

Primary gold mineralization at Westonia (Edna May) is hosted exclusively by biotite gneiss of variable composition ranging from tonalite to monzogranite. The gneiss body is linear in form, possibly stratabound towards the east, but possibly diachronous towards the west. The hanging-wall (northern) sequence is ultramafic and the footwall is dominantly amphibolitic with some tremolite–chlorite interlayers. On SOUTHERN CROSS, it is interpreted to be derived, along with other greenstone-interlayered biotite-gneiss bodies (Colossus–Comstock, Felsteads Find, Marvel Loch), from felsic volcanic material. At Westonia, however, xenolithic textures indicate an intrusive origin at least for that body. The Edna May gneiss is medium-grained, polygonal granoblastic textured, strongly foliated and lineated, and layered with biotite–clinopyroxene–pyrrhotite- and hornblende–feldspar–quartz–biotite-rich zones. It forms a sill-like body, about 100 m in true thickness, at 290° to 300°/60°N.

Historically, mineralization was worked from four orebodies and also from eluvial material. Three of the orebodies are antiformal saddle reefs consisting of quartz–feldspar and quartz; the fourth is a northwest-trending cross-coursing lode formation. The saddle reefs and the lode pitch at 45° to 50° NW. The saddle reefs are more highly mineralized at their fold hinges and the richest mineralization is at the nose of the westernmost (Edna May) reef, but mineralization continues for a short distance along the limbs on the contact between the gneiss and the footwall (southern contact) amphibolite. The limb zones are variably sheared. The whole system is highly mineralized; associated minerals include pyrite, pyrrhotite, wolframite (historical production of tungsten concentrates have been recorded), galena, wulfenite, crocoite, scheelite, molybdenite, chalcopyrite, sphalerite, and arsenopyrite. Wall-rock alteration is evident both in the gneiss and, regionally, in the footwall amphibolite in the form of diopside–pyrrhotite–biotite layering. The reefs are of the order of 30 m in thickness (true thickness at the fold noses is difficult to determine) and are mineral-

ized up to 30 m along their limbs. The historical workings extend to 240 m below the surface.

In addition to the primary mineralization, both eluvial (historical production has been noted) and lateritic ores are present. The eluvial deposits are 1.3 to 2.5 m thick, and consist of subangular to subrounded quartz pebbles and boulders cemented by a ferruginous (lateritized) kaolinitic clay. Sorting is very poor and the conglomerate is matrix supported. It is in effect virtually *in situ* residual lode material but does spread out a little to the north of the primary mineralization. The laterite zone, which is up to 5 m thick, is mineralized in the top 1 to 2 m where it is directly over primary mineralization, but not where it overlies the eluvial deposits.

The Westonia group was a very significant producer (Table 2) and until early 1990, mining supported a 500 000 t per annum plant. Demonstrated resources (laterite, eluvium, and gneiss) at March 1989 were 2.90 Mt at 1.3 gt.

Recovery group

The Recovery group of mines is located about 1 km west-northwest of the Westonia mine. Mineralization is hosted by a coarse-grained hornblende gneiss at its contact with amphibolite, in a more or less concordant quartz reef (the regional structure of this area is not well known). The orebody at the Recovery mine pitches at 50° NW and the mineralization is mainly confined to the nose of a minor anticlinal fold on the gneiss–amphibolite contact. Pyrite and pyrrhotite are associated with the mineralization. The quartz reef is up to 2.5 m in width, and extends for a total distance of 40 m (though not mineralized for the entire length); the workings extend to a vertical depth of 30 m.

West Westonia group

The West Westonia mining group, located at the western end of the Westonia greenstone belt, consists of a group of generally small mines within an area of about 3 km by 2 km. The regional geology of the area is poorly known, but is a mafic–ultramafic sequence possibly folded about an east to northeast axis. Small bodies of gneiss occur within the greenstones and the area has been intruded by late biotite granite. The mines are hosted by both gneiss and mafic schist; the most productive deposit, Royal Flush, is within hornblende schist. Orebodies are quartz veins, generally concordant with local foliation (?shear zones).

Pyrite and pyrrhotite are the only documented associated minerals, and wall-rock alteration consists of clinopyroxene segregation and biotite-rich selvedges to quartz veins. At Royal Flush, the quartz veins are up to 1.5 m thick (ranging up from stringer width) and have been worked over a distance of 70 m along strike (depth not known). Elsewhere, the quartz veins are generally between 0.15 to 0.3 m thick, stopes are up to 45 m long, and depths worked up to 35 m (vertical depth).

Colossus and Comstock groups

Emma May Main Lode is the only mine in the Colossus group with any officially recorded production. However, minor production and quite widespread prospecting activity is apparent throughout the area. The Colossus group of mines are hosted by biotite–hornblende schist derived from fine-grained amphibolite. Ore bodies are quartz, concordant with regional foliation at 305° to 315°/65° to 75° NE. A major fault is interpreted 100 to 200 m west of the workings, at which an ultramafic–paragneiss sequence, possibly equivalent to the Edna May sequence, terminates against the mine-series orthoamphibolite. Shearing parallel to this fault may have controlled the mineralization. Wall-rock alteration consists of biotite and calc-silicate layering; no associated minerals have been documented. At the Comstock group, workings are based on quartz veinlets in graphite schist, phyllite, and possible tuffaceous or arenaceous amphibolite and paragneiss; no official production has been recorded.

Eenuin centre

General references: Blatchford and Honman, 1917; Matheson, 1947.

The Eenuin reporting centre includes a number of widespread groups of mines located towards the northern end of the main Bullfinch greenstone belt; the groups are spread out over a distance of 40 km, from Carterton (Newfield) in the north to Eenuin itself in the south. Carterton has recorded the greatest production for the area.

Carterton group

The main producer in the Carterton district has been the Newfield mine. The workings are hosted by a sequence of fine-grained amphibolite with generally minor amounts of tremolite–chlorite rocks derived from komatiite and BIF. At Newfield, mineralization is within lenticular quartz reefs within a sheared and brecciated fault zone which is oblique to the regional foliation. The fault and quartz strike at 005° with a 60 to 70° SE dip with the quartz lenses pitching 50° N. Regional foliation is vertical and strikes 335°. The vein quartz has been described (Matheson, 1947) as laminated, with amphibolite seams parallel to the lamination, which indicate a crack-seal type of fabric. Some unusual breccias also occur on both the footwall and the hanging wall of the shear, and, although sulphidic, they are not of ore-grade. Breccia from the mine dumps contains quartz, carbonate, and lithic and chloritic fragments in an amphibolitic matrix.

Associated minerals at Newfield include pyrite and chalcopyrite, and diverse copper carbonate minerals, with sphalerite, molybdenite and possible arsenopyrite. Wall-rock alteration consists of some restricted bleaching and chloritic alteration selvedges to veins, though carbonate is abundant in veins and breccias. Four main ore shoots have been worked, and consist of quartz lenses averaging 0.9 m in width, over a total of 90 m length

along strike. Mining was carried out to vertical depth of 30 m where workings bottomed on a flat-lying, olivine dolerite dyke of probable Proterozoic age.

Elliots Find group

Elliots Find, 7 km south of Carterton comprises a small group of mines within coarse-grained tremolite–chlorite rock and actinolite schist. Orebodies at the Elliots Find are pyritic quartz veins and some amphibolitic lode material. They are up to 1.5 m wide (0.6 m on average) in shoots of 6 to 25 m in length, which have been mined to vertical depth of about 10 m. The orebodies are possibly saddle-type structures associated with local minor fold hinges in the country rock. The regional foliation varies between 010° and 280° with dips of 65° N and E, i.e. 65° northeast-pitching folds on the northeast limb of a major anticline. This folding was most likely associated with post-tectonic granitoid intrusion within the greenstone belt.

Eenuin group

The Eenuin group is spread along nearly 10 km of greenstone belt and consists of numerous, but small, individual mines. Ansteys Find, towards the northwest of the group, is reputed to have been the site of the first gold discovery in the Southern Cross area, and was the cause of a considerable gold rush to the region. There are a number of lines of workings within the group: a main central line associated with an anticlinorial hinge zone in BIF and ultramafic rocks, and flanking lines of shearing and probable subsidiary anticlinal hinges in generally fine-grained amphibolite. Orebodies in the central zone are BIF lodes with quartz veins and stringers (the quartz probably carries most of the gold mineralization); quartz veins and ultramafic lode material are often present at sheared BIF contacts. The amphibolite-hosted ore bodies are lenticular quartz in strike-concordant shear zones or of saddle-reef form.

Associated minerals in the group include pyrite, pyrrhotite, chalcopyrite, sphalerite, and scheelite. Wall-rock alteration consists of generally localized clinopyroxene–biotite–amphibole layering in amphibolite adjacent to veins. The workings are generally shallow, down to 30 m vertical depth; typical ore shoot dimensions are 0.2 m in thickness (to, rarely, 1.5 m) on 10 to 40 m stope lengths.

The central line accounts for 44.6 kg of official production (Table 2). There is also a significant "sundry" production recorded for the Eenuin centre of 68.1 kg gold from 3300 t of ore, and it is probable that most of this was derived from the Eenuin mining group itself rather than from more distant groups such as Carterton or Elliots Find.

Golden Valley centre

General references: Blatchford and Honman, 1917; Matheson, 1947.

Three main mining groups, Golden Valley, Maries Find (Redwing) and Radio, constitute the Golden Valley mining centre. The Golden Valley group is located centrally within the Bullfinch greenstone belt, between Eenuin and Days Find; Maries Find and the Radio group are on the eastern margin of the belt.

Maries Find group

Maries Find (Redwing) is located 7 to 8 km north-northeast of Colreavy at the eastern margin of the greenstone belt near the northwestern end of the Radio dome, a small ovoid gneissic body. Rock types represented in the group are biotite schist with some minor amounts of BIF. The mafic sequence is believed to be anticlinal, and to have been anticlinally refolded by the Radio dome structure. The orebodies are shoots within a quartz reef, and minor brecciated quartz in banded iron-formation lode material. The quartz reef occupies a fault or shear zone, and strikes 035° to 050° with a dip of 55° to 60° SE; individual ore shoots pitch vertically. Biotite-schist country rock in the immediate vicinity has a strike of 215° to 230° but dips 40° to 45° NW, i.e. normal to the fault plane. Away from the fault, foliation is north-northwesterly, axial to the Radio dome which plunges 65° to 70° NW. The foliation in the fault zone, therefore, has probably been exaggerated by late fault movements associated with the gold mineralization, but is parallel to bedding and, therefore, also probably represents an early phase of deformation.

Accompanying minerals include pyrite, chalcopyrite and galena; wall-rock alteration includes bleaching, and coarsening of biotite selvedges with randomly oriented porphyroblasts up to 5 to 10 mm. The quartz vein averages 1 to 1.2 m in thickness, though it ranges from 0.05 to 1.8 m; the main reef has been worked intermittently over about 800 m of strike length with individual shoots of the order of 25 to 35 m long, and workings extend to vertical depths of 44 m.

Production from lodes in BIF (the southeastern line of workings produced 31 kg gold from 2400 t ore) has been subordinate to quartz-reef production; BIF mineralization was controlled by the intersection of the southeasterly dipping quartz reef–fault plane with the northwesterly dipping BIF strata.

Golden Valley group

The Golden Valley group consists of a widespread scatter of small mines, at least twenty within a 6 km by 4 km area at Colreavy. Most of the mineralization is hosted within concordant, lenticular quartz reefs in fine-grained amphibolite, and subordinate mineralization occurs in BIF with quartz stringers, reefs and lodes in tremolite–chlorite rock. The regional structure is dominated by a series of folds, the southern continuation of the Eenuin anticline, the Kathleen anticline, and an intervening minor syncline which might be itself folded by the Kathleen anticline (Fig. 3). A major strike fault abuts the western limb of the Kathleen anticline and forms the eastern margin of a down-thrown block of metasedimentary rocks. Most of the mineralization is east of this fault, but

there are a few scattered deposits in mafic and ultramafic rocks to the west of the metasedimentary rocks. The greatest concentration of mineralization is along the axis of the Kathleen anticline within 2 to 2.5 km of its southerly hinge; other deposits appear to be localized by minor folding on the limbs of the major folds and by shearing associated with the BIF horizons which are themselves probably fold repetitions.

Associated minerals include pyrite, and minor amounts of chalcopyrite and arsenopyrite in the quartz veins, with pyrrhotite, arsenopyrite and probable stibnite in the iron-formation lode deposits. Wall-rock alteration is limited to the development of some biotitic layering. The BIF lodes are pipe-like, while the quartz veins are lenticular, up to 0.3 m in width. The ore shoots are irregularly distributed and the workings are generally restricted to the oxidized zone above 20 m vertical depth.

Sundry claims at the Golden Valley mining centre recorded an additional 155 kg of gold but this may include production outside Golden Valley district.

Radio group

The Radio mining group is located immediately to the southwest of the Radio gneiss dome in a complexly granitized zone of biotite-gneiss and mafic-schist enclaves. Biotite-rich amphibolitic schist wraps around the western margin of the gneiss dome from Maries Find in the north to Rowans Find in the south and may represent an extensive metasomatic alteration halo to the gneiss. Host rocks to mineralization at the Radio group are the biotite-rich schist, and some minor biotite gneiss; most of the mineralization is located within the schist but at or very close to the contact with the gneiss. The schist occurs both within the body of the greenstone belt and as enclaves in the gneiss. The orebodies are quartz veins, often lenticular, which occupy a set of fault zones (three main zones) oblique to the regional foliation (325° to 345°/vertical), except at the northeast end of the Radio line (Bullwark/Hanks Find), there faulting and regional foliation are parallel. The fault set strikes 030° to 035° and dips at 45° to 60° SE. The pitch of the ore is vertical to steep south-southwest, which indicates probably predominantly vertical movement on the faults associated with the doming of the gneiss.

Associated minerals include pyrite, pyrrhotite, molybdenite, and chalcopyrite; wall-rock alteration includes intense silicification with local vein sheets, stockworks, and irregular impregnations. The southwestern end of the central (Radio–Manxman) fault line has been the main production area, though the reefs and geology of the other lines (Queenslander and Radio Deeps) are all similar. Quartz veins range from stringer width to 1.8 m (1 to 1.5 m on average) and have been worked over strike lengths between 15 to 150 m; the Radio–Manxman line of workings is over 2 km long. The deepest workings extend to vertical depths of 60 m.

Bullfinch centre

General references: Blatchford and Honman, 1917; Matheson, 1947.

Days Find group

Days Find consists of a quite widespread group of mines between 6 and 8 km northwest of Copperhead. Production from the group, however, has been dominated by one mine, Mistletoe. The mineralization at Mistletoe is hosted by actinolite and tremolite–chlorite schist in a strongly sheared zone adjacent to a thin BIF horizon. Ore shoots occur within a quartz reef which is lenticular in form, both vertically and horizontally. The reef, which is strongly laminated in places and may partly replace the BIF, is concordant with regional foliation and bedding at 320° to 330°/65° SW to 65°NE. Locally, foliation is extremely contorted. Stopes pitch 70° SE but pronounced ribbing lineations on the quartz lamination pitch 10° NW. Associated minerals include pyrite, chalcopyrite, and arsenopyrite. The quartz reef is up to 5.5 m wide, though mineralization is confined to a maximum width of 1.5 m, strike length of the reef is 55 m; the workings extend to 65 m vertical depth.

Rowans Find group

Rowans Find is located on the eastern margin of the greenstone belt, 6 km north-northwest of Copperhead. Magpie was the main producing mine in the group and is hosted by biotite schist, but some small workings were located on BIF 100 to 200 m further to the west. Orebodies are lenticular quartz with minor quartz-veined BIF lode material in the western shafts; all are concordant with the regional foliation at 310° to 330°/60 to 80° SW.

Bullfinch group

The Bullfinch mining group is dominated by the Copperhead mine which is still being worked and has, to date, proved the most productive mine in the Southern Cross Province (21 117 kg of gold; Table 2). Within the immediate vicinity of Copperhead, however, there is a paucity of mineralization and the rest of the centre includes a number of generally minor deposits scattered around an 8 to 12 km radius, within both greenstone and gneiss.

Copperhead subgroup

The Copperhead deposit is located in greenstones, between 200 and 500 m west of a major contact with granitoid gneiss. Truncation of lithologies at the contact, which is not exposed, indicates either major shearing or assimilation of the mafic–ultramafic rock sequence. The mine series consists of sheared fine- to medium-grained tremolite–chlorite rocks, chlorite schist, BIF and possible metasedimentary rocks, though the latter may be weathered and bleached chlorite schist.

Production (Table 2) has been from two lode series, known as the northern and southern series, on both of

which open-cuts have been developed in addition to underground workings. The mineralization is located within minor fold structures associated with the hinge zone of a major overturned syncline (the Copperhead syncline). This fold is overturned at 70° to the southwest and plunges 45° NW. There is also a zone of northeast-striking wrench faulting across the greenstone belt through the hinge zone of the syncline, though this event may have postdated mineralization.

Both lode series apparently occur on the overturned southwestern limb of the Copperhead syncline. The northern series is described as a dolomite lode, being composed of dolomite (below about 39 m vertical depth), calcite, and quartz with actinolite schist. Wall rock in the opencut is chlorite schist. Mineralization is closely associated with the quartz in irregular stringers and pods, often normal to the lode, and occurs on the stratigraphic footwall (structural hanging wall) of the northern of two major jaspilite or BIF horizons. The southern lode series contains both "jaspilite lode" and "yellow lode"; the former being mineralized BIF with quartz veins and stringers, and the yellow lode material being quartz-impregnated schistose amphibolite. The yellow colouration of the amphibolite becomes green as the water table, and the limit of oxidation, is reached. The country rock at the southern series is dominantly ultramafic.

Overall, then, the mineralization is largely stratabound within a dominantly ultramafic sequence (with some chlorite and actinolite schist) between two BIF horizons, but it is clearly controlled by the extremely complicated local structure developed at the Copperhead syncline hinge zone. The BIFs extending away from Copperhead have been intensively prospected, but with little success. Little Hill, 1 km west-northwest on the northern extension of the southern series produced a mere 1.9 kg of gold from 46 t of ore.

Associated mineralization is dominantly pyrrhotitic but also includes pyrite, galena, and possibly chalcopyrite and scheelite in the "dolomite lode". Pyrrhotite is both layered within laminated quartz and BIF, and in trangressive veinlets. Wall-rock alteration is not well documented, but includes intense carbonation, at least in the northern series. The BIF lodes are commonly highly contaminated with chromium presumably derived from the surrounding ultramafic rocks. Northern series lode dimensions are up to 20 m in width and 150 m in strike length, with the workings extending to 480 m vertical depth; the southern series is very irregular with widths of up to 30 m but averaging about 5 m, and 240 m of overall strike length — the southern series has been worked to about 180 m.

Demonstrated resources at June 1989 were 1.92 Mt at 3.65 g/t and are supporting a 350 000 t per annum plant.

Chance and Derwent Jack

About 4.5 and 6 km south southeast of Copperhead are two small mining areas, Chance and Derwent Jack respectively. Mineralization at Chance is present in quartz veins in sulphidic black shale and phyllite; the veins are concordant with the regional foliation and bedding at 325°/75°W (the regional structure is 335°/55°W). Derwent Jack is located on the greenstone–gneiss contact (?sheared), as are a number of major mines further to the south. The mineralization there is hosted by mafic schist and fine-grained tremolite–chlorite rocks, and possible altered and quartz-impregnated minor BIF at the (eastern) footwall. Immediately east of the mineralized zone is quartz–muscovite schist which appears to grade rapidly into gneiss.

Irene (Lady Agnes) subgroup

The Irene (Lady Agnes) subgroup of mines is located 4 km west-northwest of Copperhead. Host rocks are coarse-grained tremolite–chlorite–talc rocks, which may originally have been komatiite or may be part of a differentiated sill represented by gabbro and metapyroxenite lying near by to the east. The workings appear to have been along a quartz vein with amphibolitic partings and contamination zones striking at 300° (discordant to the regional foliation at 335°/vertical). Minor actinolite selvedges occur around the quartz.

Reynolds, Rutherfords and Withers Finds, and Mornington groups

The Reynolds, Rutherfords and Withers Find mining groups are located within gneiss or partly assimilated rafts of greenstone within gneiss between 7 and 10 km east of the main Bullfinch greenstone belt. The gneiss is biotitic; at Withers Find, it is also hornblendic which indicates it is clearly derived from substantially mafic rocks. At Reynolds Find, the orebody is a finely laminated quartz reef which may be a totally silicified remnant of BIF. The Mornington group, 3 km east of the greenstone belt, is also based on BIF remnant but there has been no officially recorded production from this group.

The orebodies at Withers Find are lenticular pyritic quartz veins associated with a set of three or four subparallel zones of shearing at 290°/50° to 70°N. The veins have been selectively mined for high-grade shoots — there are at least 35 separate shafts along an 800 m strike length between Volcano and New Italy mines. The quartz is up to 1.5 m in width, about 0.3 m on average, and ore shoots historically have been 5 to 10 m long. Workings are generally shallow, but up to 40 m deep in places.

At Reynolds Find, a single pyritic quartz reef at 080° to 100°/45° to 60°S was mined to 35 m vertical depth. Ore shoots were 1 to 1.5 m wide and 15 to 65 m in strike length.

Discrete, pyritic quartz reefs occur at Rutherfords Find. There are two reef sets, one at 265°/80°S and the second at 315°/50° to 80°SW. Some lamination is present in the quartz. The main working are sporadic over a total strike length of 150 m, on quartz veins 0.2 to 0.5 m thick. An open-cut at Handsfordhaven mine is between 8 and 10 m deep.

Corinthian centre

General references: Blatchford and Honman, 1917; Matheson, 1947.

The Corinthian centre, between Bullfinch and Southern Cross, comprises two mining groups, Corinthian and Babylonian; Corinthian group being by far the more productive (1810 kg of gold; Table 2).

Corinthian group

The Corinthian mining group is located at the greenstone–gneiss contact on the eastern side of the Bullfinch greenstone belt. Contact rocks consist of quartz–muscovite schist which appears to grade eastwards into gneiss and along strike into mafic schist. These rocks have been variously interpreted as granitized greenstone, or as part of a metasedimentary basement to the mafic sequence of the greenstone belt. In places, it is clear that BIF within the mafic rocks passes along strike into the quartz–muscovite schist, either retaining its iron-formation character or as identically laminated quartz reef. A granitized (and probably sheared) contact origin for these rocks therefore appears the more plausible in this area. Host rocks to the Corinthian mineralization are biotite schist; the rocks become increasingly biotite-rich (up to 20%) as the mineralized zone is approached, with biotite replacing amphibole. The main orebody is a quartz reef with minor, partially assimilated, grunerite–magnetite–quartz BIF lode. The quartz is developed on the (western) hanging wall of the BIF horizon which is generally the limit of granitization from the east. The ore is thus concordant with the regional foliation and bedding at 325°/75° SW to vertical.

Associated minerals include pyrrhotite, pyrite, chalcopyrite, and molybdenite. Wall-rock alteration is shown by the strong biotitization with increases in whole-rock silica, lime, potash and soda, and decrease in magnesia. The main ore zone is 7.5 m in width by 250 m in strike length and has been worked to vertical depth of 60 m.

Demonstrated resources at August 1989 were 3.50 Mt at 2.6 g/t to help feed the 2.0 Mt per annum Hopes Hill plant.

Babylonian group

The Babylonian group consists of a number of small mines 2.5 km southwest of Corinthian, near the western margin of the greenstone belt but within the contact gneiss. Host rocks are biotite gneiss and the main orebody was a discordant quartz reef striking 045° with a 30° NW dip. The regional foliation is 310°/vertical to steep NE. Sulphide minerals include pyrite and covellite. The quartz mined was narrow, 0.05 to 0.2 m in width, and 85 m in strike length; the workings extended to 26 m vertical depth.

Hopes Hill centre

General references: Gibson, 1904; Saint-Smith and Farquharson, 1913; Matheson, 1947.

Hopes Hill mining centre, located between Corinthian and Southern Cross, includes two major deposits, Hopes Hill and Pilot, at or very close to the eastern margin of the greenstone belt, and a number of smaller workings within the greenstone belt itself. The greenstones at this location are very narrow, between 1.5 and 2 km wide, resulting from necking between the Ghooli Dome and Rankin gneiss dome, and the lithological sequence is subsequently attenuated.

Hopes Hill group

Pilot

The Pilot gold mineralization is located within 70 m of the greenstone–gneiss contact, about 3.5 km northwest of Hopes Hill. It is hosted by chlorite–amphibole–biotite schist with some minor mineralization also occurring within BIF. The orebodies are lode material, both amphibolitic and BIF types, including quartz veins and stringers, and form a pipe-like shoot (plunging 55° SSE) bounded by the trough of a minor syncline which is outlined by a BIF horizon. The plunge of the ore is concordant with the plunge of the BIF; regional foliation is 340°/70° NE to 70° SW. An alternative explanation for the mineralization controls may be a series of strike-parallel shear zones within the synclinal keel.

Pyrrhotite, pyrite and magnetite are associated with the mineralization, and wall-rock alteration includes silicification, carbonation and the formation of biotite, chlorite, and tourmaline. Average lode width is 10 m, with mineable widths up to 25 m; the orebody continues on strike for an average of 120 m, and workings extend to 120 m below surface.

Exploration (1988) has located demonstrated lateritic and primary resources of 65 000 t at 0.9 g/t and 125 000 t at 3.6 g/t respectively. The lateritic ore is amenable to heap-leach extraction.

Colleen Bawn and Parisian

Colleen Bawn and Parisian are located 0.5 to 1 km west and northwest of Pilot. Mineralization is hosted by tremolite–chlorite rocks (after komatiite) and amphibolite (after basalt), in a series of concordant quartz veins which are lenticular both vertically and horizontally. Ore shoots at Colleen Bawn pitch to the southeast and lense out with local changes in dip and strike, which suggest folding; the regional foliation is 320° to 330°/vertical. There is no documentation of orebodies or controls at Parisian but the quartz in both areas is associated with intense local shearing (strike-slip) and formation of chlorite schist. The shearing is generally within a few metres of a discontinuously outcropping banded chert or iron-formation. Workings extend to 27 m vertical depth at Colleen Bawn.

Hopes Hill

The Hopes Hill mineralization is located at the gneiss–greenstone contact. It is hosted by schistose chloritic amphibolite, talc schists (generally minor), and some possibly altered/replaced BIF. The ore body consists of lode material of alternating quartz and seams of mafic and ultramafic schists, and some kaolinite. The lode is concordant with regional foliation at 325°/75° SW, and is associated with a massive quartz reef which is largely barren of mineralization. The pitch of the mineralization is not documented, but is probably vertical. As at Corinthian, the gneiss contact is marked by the development of a quartz–muscovite schist which is believed to have been formed by granitization of mafic rocks and BIF immediately adjacent to the gneiss.

Associated minerals include pyrite and arsenopyrite but it appears that most of the ore mined was from the oxidized horizon. Wall-rock alteration is not well documented. Intense shearing has resulted in the formation of talc schists, and the mafic schists near the gneiss (and the mineralization) are biotite rich (see also Maries Find, Radio, Rowans Find, Corinthian). Kaolinite in the Hopes Hill lode derived from sericite implies potassic metasomatism. The lode averages 5 m in width and has been stoped for 540 m along strike and down to a vertical depth of 50 m.

Demonstrated resources at August 1989 were 2.1 Mt at 2.08 g/t to help support a 2.0 Mt per annum plant.

Lady Kathe

Minor workings also occur within 1 km or so to the southwest of Hopes Hill. The main group in this area is the Lady Kathe group. The workings are hosted by pelitic schist and phyllite, and some metamorphosed komatiite; the orebodies were probably concordant, lenticular quartz veins and pods.

Southern Cross centre

General references: Gibson, 1904; Saint-Smith and Farquharson, 1913; Matheson and Hobson, 1940.

Included in the Southern Cross centre are the Southern Cross group, and the mines of the New Zealand Gully group, 1.5 km southwest of Southern Cross. The Southern Cross group is subdivided into the Frasers subgroup of deposits and the Haddon subgroup, which includes two major lines of mineralization 0.8 and 0.5 km southwest of the Frasers "line". The Frasers subgroup has dominated production from the Southern Cross centre and was the first major discovery in the region (1888). The mines at Southern Cross are located in zones of intense shearing parallel to the contact with the Ghooli Dome and in a region of considerable necking or constriction of the greenstone belt between the Ghooli and Rankin Domes.

Southern Cross group

Frasers subgroup

The Frasers subgroup or line of workings is located in greenstone 300 to 400 m from the contact with the Ghooli Dome. The gneiss adjacent to Southern Cross contains appreciable amounts of partly assimilated or rafted greenstones, and may be located at the junction between the Ghooli Dome proper and a separate granitoid body to the northwest of the dome. If the gneiss contact itself is sheared, it is not known to be mineralized. The Frasers shear, the sense of which is not known, occurs at the contact between ultramafics (probably after komatiite) and amphibolite. The host rocks are commonly banded; the banding has been attributed an originally pyroclastic character but may be entirely metamorphic in origin, and overprints an extensive alteration halo.

There are three major lodes: Frasers (Main) lode, Sholls lode, and Greenstone lode. Frasers and Sholls are lenticular, brecciated and laminated masses of quartz within amphibolitic and ultramafic schists, and show crack-seal and hydraulic fracturing fabrics. The Greenstone lode is an extremely finely laminated, uniform calc-silicate-bearing amphibolite with generally minor quartz stringers. The lodes are all parallel in strike and dip to the regional foliation which is 325° to 330°/50° to 60°W. However, the regional plunge is generally gently to the north whereas the mineralization plunges at up to 45° to the south. Associated mineralization is mainly pyrrhotite, but also includes pyrite, chalcopyrite, galena, and scheelite. Oxidation extends to a vertical depth of 55 m. Wall-rock alteration about carbonate–sulphide–diopside–quartz cores consists of the development of biotite and hornblende selvedges.

Frasers lode or reef can be traced for up to 2.2 km and is almost continuously mineralized for 850 m; ore blocks averaged 90 to 120 m in length. It is 6 m in width on average ranging from 3 to 15 m, and has been worked to a vertical depth of 120 m. Sholls lode is similar in dimensions to Frasers, though its production has evidently been less than Frasers. The Greenstone lode was mined in blocks of 150 to 170 m and 1 to 2 m widths. It is located towards the southern end of the group and was worked to 200 m vertical depth.

The Greenstone lode is carbonated, biotitic, sulphidic, and diopsidic; there is some internal folding of the fine layering but generally the layering is planar. It has the appearance of a tuff or sedimentary rock, with sulphides forming laminations parallel to the layering. This lode is very similar in many respects to the Marvel Loch eastern lode.

Demonstrated open-cut and underground resources at November 1989 were 465 000 t at 3.09 g/t and 213 000 t at 10.04 g/t respectively. Ore from these deposits is currently (1989) being treated at the Hopes Hill 2.0 Mt per annum plant.

Haddon subgroup

Three main groups of BIF horizons are interlayered with banded amphibolite west of Frasers. It is likely that each group is a single stratigraphic horizon that has been repeated by both folding and, later, shearing associated with the uplift of the granitoid gneiss to the east. The shears are mineralized and concentrated along the BIF. Thus the most easterly horizon (the Reservoir line) of BIF is not sheared and therefore is not mineralized; the central horizon (the Haddon line) is strongly mineralized; and the westerly horizon (the Messina line) being furthest from Frasers, the locus of mineralization at Southern Cross, is only weakly mineralized. The orebodies at the Haddon group are BIF lodes with quartz veins and stringers. The regional foliation is 305° to 325°/50° to 70° SW and plunges are 15° to 20° NW. The ore is generally concordant to the regional foliation as it is concentrated around the hinges of minor folds, in particular the overturned eastern limbs of folds which are adjacent to west-dipping normal faults. Ore shoots plunge 20° to 40° NW with the minor folds.

Pyrite is the only documented associated mineral; wall-rock alteration consists of the ubiquitous calc-silicate layering of the amphibolite. The main lodes average 4 m in thickness, and up to 12 m. Ore-shoot parameters are very variable, between 20 and 90 m in length and the workings extend to generally less than 30 m vertical depth, at or close to the watertable.

Most of the production (Table 2) was from Three Boys (Haddon) and Golden Pig. Demonstrated resources at Three Boys–Golden Pig in June 1989 were 220 000 t at 6.0 g/t and this ore is being treated at the 350 000 t per annum Copperhead plant.

New Zealand Gully group

New Zealand Gully group (Queen Ann–Tarcoola–Maori Lass) has been a relatively minor production area (Table 2). Host rocks to the group are fine-grained tremolite–chlorite rocks, after komatiite, with minor pelitic metasedimentary horizons. The deposits are within a broad zone of shearing which may continue southwards towards the Transvaal subgroup (Greenmount centre). Ore bodies are lenticular quartz veins and lode material which include quartz stringers in sheared amphibolite and ultramafic rocks. They are generally concordant with the regional foliation at 330°/70° NE to 70° SW. Sulphides occurring below the water table are probably mainly pyrrhotite. Wall-rock alteration is not documented, but the countryrock is generally talcose and chloritic, and locally contains abundant opaline silica. Orebody widths range from 1.2 to 1.8 m; ore shoots have been developed over lengths of up to 30 m, and the workings extend to 27 m vertical depth, to the water table.

Demonstrated resources at Maori Lass in September 1988 were 390 000 t at 2.92 g/t. Combined demonstrated resources for the New Zealand Gully group and the Transvaal subgroup (closeby to the south) at June 1989 were 2.19 Mt at 2.73 g/t which includes 1.8 Mt at 2.7 g/t that is feeding the 1.7 Mt per annum Transvaal plant.

Greenmount centre

General references: Gibson, 1904; Saint-Smith and Farquharson, 1913; Matheson and Hobson, 1940.

The Greenmount mining centre is located between 5 and 7 km south of Southern Cross. There are two main groups of mines at the centre, the Transvaal subgroup (Transvaal and Sunbeam mines) to the northeast, and the United Australia (or Greenmount) mine to the southwest.

Greenmount group

Transvaal subgroup

The Transvaal (or Jupiter) subgroup of mines is within pelitic and graphitic schists and wackes with amphibolite-facies mineral assemblages including andalusite, chiastolite, and garnet. Two lines of workings occur, the Transvaal reef system (west) and the Sunbeam reef (east). The Sunbeam reef is developed largely along the contact between metasedimentary rocks to the east and tremolite–chlorite rocks, derived from either komatiite or peridotitic intrusive rocks, to the west; and may cross over the contact into the ultramafic rocks. The orebodies on both lines of mineralization are lenticular quartz reefs; the Sunbeam reef-line becomes a brecciated graphitic schist lode towards the south. The lines of mineralization are concordant with the regional foliation which varies from 340° to 010°/85°W to 85°E.

Arsenopyrite is particularly abundant at Transvaal; the mine was a past producer of arsenic, historical output being estimated at about 100 t. Pyrrhotite is the most abundant iron sulphide; pyrite is present but in minor amounts. The quartz reefs are surrounded by haloes of graphite in the metasedimentary rocks and carbonatization in the ultramafics.

The emplacement of the reefs was probably controlled by shear zones subsidiary to the major strike-slip fault (?sinistral) near Greenmount, which passes between 500 and 700 m to the west of the mines. The reefs are between 0.6 and 6 m in width; ore shoots were mined over strike lengths of about 60 m, to a depth of up to 22 m below surface (groundwater level was at 17 to 18 m below surface).

The Transvaal subgroup and adjacent New Zealand Gully group are currently being mined. Their combined demonstrated resources at the start of the present mining cycle were 1.8 Mt at 2.7 g/t to feed the 1.7 Mt per annum Transvaal plant.

Devs Reward, 4.5 km south of the Transvaal group, is a small mine with similar characteristics to the group. The mine is in graphitic and micaceous shale and pelite along or very close to the Greenmount fault.

United Australia

The United Australia or Greenmount mine is located adjacent to (immediately west of) the Greenmount strike-slip fault. Host rocks are medium- to coarse-grained amphibolite derived from gabbro; some minor mineralization may extend into metasedimentary rocks located on east side of the Greenmount fault. The mine was a major producer in the early part of this century, however documentation on it is scarce (Gibson, 1904, — the only source of information). Little is known therefore about the orebody itself, other than its description as an irregular quartz reef, more or less concordant with the amphibolite foliation at 340°/steep W dip. Sulphides are reported, but not identified; exposed wall-rocks are highly weathered and alteration is not visibly apparent. The mine was worked to 40 m below surface, though not continuously; the quartz reef was driven for 200 m along strike, and was between 1.8 and 9 m wide. The United Australia mine area is now undergoing a major re-evaluation but no reserves statement has been published.

Blackbourne centre

General references: Saint-Smith and Farquharson, 1913; Matheson and Hobson, 1940.

Blackbourne group

The Blackbourne group is located 9 km south-southwest of Southern Cross, approximately 1 km southeast of a contact with gneissic granitoid. The workings are all small, and date from the turn of the century. Host rocks are fine-grained amphibolite derived from basalt and are generally not strongly foliated. Ore bodies are *en echelon* quartz reefs, lenticular in form, and vuggy and iron-stained. They are reported (Matheson and Hobson, 1940) to strike 345°, dip 60°E, and pitch 60°. The regional strike and dip of foliation (at 015° to 040°/45° to 65°E) appears to be discordant to this trend, but the quartz orebodies may occupy local fold hinges.

No associated minerals or wall-rock alteration have been documented, with the groundwater level being some 14 m below the deepest workings. The main shoot was 1.2 m wide and was stoped over 28 m in length, up to 42 m below surface. The Blackbourne group has been investigated recently, but no resource figures have been published.

Mount Rankin centre

General references: Saint-Smith and Farquharson, 1913; Matheson and Hobson, 1940.

The Mount Rankin centre includes mines at Mount Rankin itself, which is 13 km southwest of Southern Cross, and the Bells Find group, 17 km south-southwest of Southern Cross.

Mount Rankin group

Mineralization at Mount Rankin is associated with a prominent BIF horizon approximately 0.8 km southwest of a greenstone–gneissic granitoid contact. The granitoid is ovoid in form and probably domal in structure (Rankin dome), similar to the Ghooli and Parker Domes. Concentric shearing in the greenstones on the flanks of the granitoid has concentrated at the BIF horizon, and is believed to be a primary mineralization control. Host rocks at Mount Rankin are the BIF itself, and possibly fine-grained amphibolite (basalt-derived) with which the BIF is interlayered. Two major iron-formation horizons are present but it is not clear whether these represent one structurally repeated horizon or separate stratigraphic levels. The ore is BIF lode material with quartz stringers; the stringers have been described as seams inferring parallelism with the country rock; regional foliation is 305° to 325°/70° NE, i.e. towards the granitoid contact. The mineralization which is associated with the footwall of the western horizon (2 to 3 m thick) is concordant to regional foliation and possibly concentrated in minor fold hinges; the orebodies pitch 50° SE while regional lineations pitch 60° in the same direction.

No associated minerals have been documented. Wall-rock alteration in the amphibolite is shown by biotite–clinopyroxene layering adjacent to quartz veins which may also be mineralized.

Historically, lode material between 0.6 and 0.9 m wide has been mined in isolated ore shoots down to 69 m below surface, though groundwater level was not reached. The ridge at Mount Rankin is up to 40 m above the general land level and some mine workings are accessed by adit. Re-evaluation of the mineralization has recently been undertaken with a view to proving up low-grade ore over 6 to 8 m widths, and it is therefore likely that these widths include both BIF and the footwall amphibolite. The Mount Rankin ridge is capped by laterite, and historical workings do not appear to have involved any of this material which could also represent a low-grade, heap-leaching resource. Published demonstrated resources at July 1988 were 145 000 t at 2.8 g/t.

Bells Find group

The main producer at the Bells Find group has been the Marjorie Glen Reward mine. Host rocks are fine- to medium-grained amphibolite, derived from basalt, within a basalt–komatiite (and possibly mafic–ultramafic intrusive) sequence, which is located east of a north-northwest trending suture zone between the Mount Rankin greenstones and the greenstone belt extending south from Greenmount. One small mine with no recorded production is located west of the suture, in a brecciated zone within the BIF which extends southeast from Mount Rankin. At Bells Find and Marjorie Glen Reward, the orebodies are described as consisting of poddy or lenticular quartz. The quartz on the mine dumps is quite amphibolitic with crack-seal fabrics.

At Marjorie Glen Reward, the ore zone is discordant to regional foliation (330°/50° NE, plunge 45° SE), occu-

pying a vertical fault zone which strikes at 055°; the pitch of the ore is 75° NE. A series of parallel fault zones (possibly sinistral) has been mapped south of the mines. The Bells Find orebody, however, is concordant to the regional foliation, with quartz lenses plunging down the regional southeasterly lineations. Bells Find is close to the major suture zone, whereas Marjorie Glen Reward is 1 km to the east of the suture.

The mineralization at Marjorie Glen Reward is copper-rich, with abundant secondary copper carbonates in addition to pyrite and chalcopyrite. Wall-rock alteration includes carbonation and saussuritization. The quartz veining is 0.75 m thick on average; at Marjorie Glen Reward, the quartz has been driven on for about 40 m up to a contact with coarse-grained tremolite–chlorite rocks (with spinifex textures), at which point the quartz either rapidly thins or splits. The workings extend to 45 m vertical depth, just above groundwater level.

The cross-fault set mapped to the south of the Bells Find group could present an interesting exploration target, especially where these faults cut across the competent lithologies in the sequence as at Majorie Glen Reward.

Kennyville centre

General references: Saint-Smith and Farquharson, 1913; Matheson and Hobson 1940.

The Kennyville mining centre encompasses a group of mines between 4 and 16 km southeast of Southern Cross, within the main belt of greenstones (Bullfinch belt) extending between Southern Cross and Marvel Loch. The rocks in this region consist of a sequence of basalt and komatiite with banded iron-formation and a sequence of basalt intruded by major layered or differentiated mafic–ultramafic sills. The relationship between the two rock sequences is not clear as a major zone of strike-slip faulting separating the two sequences. Most of the gold mineralization at Kennyville, however, is within the sequence in which banded iron-formation is interlayered with mafic extrusive rocks.

Kennyville group

Leviathan–Cornishman subgroup

In the area around Leviathan and Cornishman, the host rock is a fine- to medium-grained tremolite–chlorite rock, originally komatiite or komatiitic basalt. The orebodies consist of lenticular quartz, some breccia, and some tremolite–chlorite lode material with quartz stringers or leaders. Regional foliation is 315°/45° SW to locally vertical and the orebodies are roughly concordant with this structure. The Leviathan main reef strikes 290° to 300°, dips vertically, and pitches 40° to 45° NW; at its northern end, however, the reef has a variable strike and dips 35° to 40° W. This shape of the orebody is possibly related to local folding in the basalts. The Cornishman reef has a simpler structure; it strikes 335°, is vertical, and pitches south at a fairly steep angle.

Pyrrhotite is the only accompanying sulphide mineral that has been recorded. Wall-rock alteration is also not well documented; at Leviathan, coarse amphibole–clinopyroxene selvedges to veins have been noted, but biotite layering and reaction fronts are not present. At Cornishman, amphibolite grades into foliated clinopyroxene-bearing calc-silicate rocks adjacent to veins.

The mines were worked over 0.6 to 0.75 m widths, and possibly up to 1.8 m widths; stope lengths ranged from 40 to 95 m; Great Leviathan, the main producer, was mined to 90 m below surface and Cornishman to 42 m vertical depth. The Cornishman area is now undergoing a major re-evaluation but no reserves statement has been published yet (1990).

Quandong–Achilles–Pendrea subgroup

The Quandong–Achilles–Pendrea subgroup consists of a series of workings hosted by BIF, quartzite, and banded ferruginous chert in a basalt–komatiite sequence and minor deposits in tremolite–chlorite and banded calc-silicate rocks. The sedimentary horizons appear almost continuous with those at Southern Cross, but the basalt country rock becomes increasingly tremolitic towards the south. Since the BIF should represent a chronostratigraphic horizon, this change in basalt characteristic along strike is somewhat puzzling, and is probably due to an oversimplification of the mapping through this region. The orebodies at this group are probably mostly lode material (mainly BIF) with quartz impregnations and stringers. Regionally, bedding and foliation are parallel, and range from 310° to 315°/50° to 55°SW in the south of the area, to 305° to 325°/vertical to 75°SW towards the north. The structure of individual ore shoots is not documented but mineralization is probably largely stratabound and therefore concordant with the regional structure.

No associated minerals have been documented, neither has wall-rock alteration, though clinopyroxene layering is found in amphibolitic host rocks toward the north. Ore zones are up to 3 m wide, and are patchily developed along strike; and workings extend to 23 m below surface.

Production (Table 2) has come chiefly from Achilles and Quandong.

Golden Arrow

The Golden Arrow or the Catherine mine is apparently within a sheared contact between two portions of a differentiated mafic–ultramafic sill. Medium- to coarse-grained amphibolite occurs to the east, with peridotite to the west. The orebodies consist of small lenticular quartz reefs, possibly associated with a siliceous mylonitic horizon, and possible lode material. The eastern metamorphosed gabbro is generally massive and only weakly sheared; the ultramafics to the west however, have undergone ductile deformation. Regional foliation is at 335°/70°E; the ore is slightly discordant at 315° to 325°/65°E. Associated minerals and wallrock alteration have not been documented at

this deposit and there is very little to be seen now on the surface. The quartz was mined up to 1.2 m wide, from stopes up to 8.5 m long, and the workings extend to 33 m below surface.

Glendower group

The Glendower group contains two main lines of gold mineralization with two different styles of mineralization, Glendower and Evelyn Molly–Victoria. Isolated small deposits (e.g. Battler) occur to the southwest of Glendower.

Glendower subgroup

At the "old Glendower" workings to the south, mineralization occurs in quartz veins hosted by metamorphosed gabbro and peridotite. Regionally, the structure is dominated by intense shearing and major strike-slip faulting near the nose of a northerly plunging anticline. These workings, however, were small and patchy, and yielded only 6.7 kg of gold from 360 t of ore (18.6 g/t).

Evelyn Molly–Victoria

The second line of mineralization forms the Evelyn Molly–Victoria subgroup, and is similar to the Achilles line in the Kennyville group, in being hosted by BIF, ferruginous quartzites and grey schists. The ore bodies are lode material consisting of silica-impregnated host rock; they are stratabound and therefore concordant in that sense (regional structure is 320°/50° to 60° W), although the quartz impregnations, veinlets, and stringers can be quite irregular. Wall-rock alteration is not documented; the only sulphide noted has been pyrrhotite. Ore-shoot lengths are not known, but widths are 3 to 4 m; the workings extend to 33 m below surface.

Exploration to July 1988 located demonstrated resources (alluvium, laterite, and primary) of 580 000 t at 2.13 g/t, which are possibly amenable to heap-leach extraction.

Battler

The Battler ("Agamemnon group") mine is hosted by coarse-grained, tremolite–chlorite rocks to the west, in contact with fine-grained massive amphibolite, and possible gabbro, to the east. Regional strike is 320° to 330° with moderate to steep easterly dip; the deposit possibly occurs on an overturned southwest limb of a north-plunging anticline. The main ore zone is discordant to the regional structure; it strikes 290°, with 45° to 60° NE dips, and pitchs 45° NW (minor concordant ore zones are at 315° to 330°/60° NE). The ore zone is possibly a cross- tensional fracture within a sinistral shear zone parallel to the regional foliation, or may be occupying a portion of a drag fold. No associated minerals have been noted, but there is some minor carbonate bleaching of the wall rocks. The orebodies range from 0.6 up to 4.5 m in width; stope lengths vary between 15 and 60 m and the workings extend down to 63 m vertical depth.

Marvel Loch centre

General references: Gibson, 1904; Blatchford, 1915; Matheson and Hobson, 1940; Hobson and Matheson, 1940.

Included in the Marvel Loch mining centre are thirteen main groups of mines, of varied style and setting, spread throughout a tract of country 30 km long and up to 7 km in width. A concentration of the largest of these deposits, including the mines presently operating (1989) at Marvel Loch, Undaunted, Nevoria and Great Victoria, is found within a synformal saddle (the Banker saddle) of mafic and sedimentary rocks located between two gneissic granitoid domes — the Ghooli Dome to the north and the Parker Dome to the south — and around the southwest flank of the Ghooli Dome. The grouping of these mines as a centre follows their grouping for statistical purposes and has no geological significance.

Lennebergs Find group

Lennebergs Find, 9 km north-northwest of Marvel Loch, is hosted by metasedimentary bands (?silicified BIF) within a sequence of fine-grained tremolite–chlorite rocks. Outcrop in the region is very poor, hence the use of "amphibolite, unassigned" on the map sheet. Regionally the host rocks are a package of metamorphosed basalt, high-magnesian basalt, and komatiite. The ore is a lode in the metasedimentary rocks with pods and veinlets of quartz, and is broadly concordant with the regional foliation at 330°/45° to 80° W.

Neither associated mineralization nor wall-rock alteration have been documented. The low-grade lode material is up to 6 m wide; siliceous cherty bands are about 0.1 m wide. The strike length of mineralization is not known but workings have been developed to a vertical depth of 30 m.

Official production to date is small — 7 kg of gold from 3800 t of ore, i.e. 1.8 g/t recovered, but other production may have been grouped under "sundry claims" in the statistics. Demonstrated resources at 27 November 1989 were 353 000 t at 2.10 g/t to possibly feed the 2.0 Mt per annum Hopes Hill plant.

May Queen group

The May Queen, Christmas Gift, and Ganymede mines are located about 6 km northwest of Marvel Loch, in the belt of greenstones extending towards Southern Cross. Of the three mines in the group, May Queen was the major producer. Host rocks at the group vary from fine-grained amphibolite (with some tremolite–chlorite interflows) at May Queen, to peridotite at Christmas Gift, and medium-grained metamorphosed gabbro at Ganymede. Orebodies also are varied in type; lenticular quartz reefs at May Queen, and lode material with quartz stringers at Christmas Gift. The Ganymede orebody is not clearly described; it may be a quartz stockwork or a distinct reef. The orebodies are apparently concordant with regional

foliation at 330° to 340°/vertical to 75° SW. Pitch has not been determined.

Pyrite and arsenopyrite occur, possibly also pyrrhotite. Wall-rock alteration effects are most noticeable at May Queen and to a lesser extent at Ganymede with the development of clinopyroxene banding and biotite fronts. Carbonation and silicification are apparent at Christmas Gift, and retrograde sericite and saussurite occur at Ganymede and May Queen. Orebodies range in width from 0.6 to 1.2 m and stope lengths from 10 to 40 m. May Queen was worked to 66 m vertical depth, and Christmas Gift, to 44 m vertical depth.

Total production for the group (mainly May Queen) shows a very high average recovered grade of 44.8 g/t. Early production (?late 1800s) at May Queen was reputed to exceed 100 g/t; it was also apparently rich in silver, though this factor is not recorded in official production statistics.

Xantippe group

The Xantippe group is located 4 to 5 km northwest of Marvel Loch. Production from the group is small; however, a significant amount of production may be unaccounted for or grouped under sundry claims for the Marvel Loch mining centre. Mary Lena is the main deposit of the group, and occurs at the contact between metaperidotite and metasedimentary rocks. Cadonia is a small mine in metagabbro, and the Xantippe and Treasury mines occur in metasedimentary rocks. The orebodies have not been documented; they were probably minor quartz veins. Regional foliation is 330° to 345°/vertical to 75° W; quartz bodies at Treasury, at least, are concordant. Associated minerals, alteration, and extent of mineralization have not been documented.

Marvel Loch group

The Marvel Loch group of mines consists of a narrow zone of mineralization about 1.8 km long, from Undaunted in the north, through Exhibition–Firelight, to the Marvel Loch mine in the south, and has had a multitude of historical mine names. Three major deposits within this zone have been worked recently, the Undaunted and Exhibition open-cuts, which have been combined into the Marvel Loch super pit, and the Marvel Loch underground mine. The mineralization in the area is controlled by a major, probably dextral, strike-slip shear zone which is a continuation of the shear that runs through the Donovans Find group.

At Marvel Loch, host rocks are a komatiitic basalt assemblage with interflow sedimentary rocks, bordered to the east by a differentiated ultramafic–mafic sill. The ore bodies are roughly parallel lines of lodes, partly anastomosing in character. The central and west lodes are quartz lenses, pods, and stringers in varying proportion with country rock, all highly sheared. To the east of the mine, series are laminated, sulphidic, biotitic cherty rocks, which may originally have been interflow sedimentary rocks, with quartz in seams parallel to the banding. The limits of mineralization within the eastern lode are often ill-defined.

Regional foliation is 330°/80° SW to 80° NE; the mine series is on the west limb of a regional anticline plunging 65° S but is sheared out on its eastern side, where 15 to 20° NW lineations occur in the east wall of the east lode. The "sediments" may have been caught up in the shear zone as is postulated for Mountain King and Francis Furness at the Donovans Find group, or may be mylonite associated with the faulting. The ore bodies are concordant, broadly, with the regional foliation, while ore shoots plunge 60° to 80° SE; shearing inevitably increases towards the lodes.

Associated minerals are numerous, including pyrite, pyrrhotite, galena, chalcopyrite, arsenopyrite, and scheelite. Wall-rock alteration shows zoning about the lodes, from quartz to quartz–diopside to biotite–diopside to biotite–carbonate to chlorite–biotite to tremolite–chlorite rocks and biotite amphibolite. The mine series effectively constitutes a 50 to 75 m wide alteration zone. It has been worked to 180 m vertical depth with plans at present to develop down to 225 m vertical depth. The western lodes range from 1 to 4 m in width, whereas the laminated eastern lode varies from 5 to 6 m and up to 9 m in width; stope sections are variable.

The Exhibition and Undaunted deposits line up closely with the Marvel Loch eastern lode; they are separated from the Marvel Loch mine by a pegmatite intrusion. Mine series consists of metamorphosed komatiitic basalt with possible interflow metasedimentary rock. Ore bodies have been documented as lodes with variable amounts of quartz. It is possible that these ore bodies at the north end of the structure plunge steeply north. Wall-rock alteration is similar to that at Marvel Loch but it is not known whether it is as intense. Associated minerals that have been noted are fewer and include pyrite, arsenopyrite, chalcopyrite, and tourmaline. Lode widths are not documented; historical development drives are of the order of 6 to 30 m and workings extended to 80 m below surface.

Prior to 1984, production from the Marvel Loch–Undaunted line amounted to 1960 kg of gold (273 000 t of ore; average grade 7.2 g/t) of which approximately 674 kg of gold was won from mines between Exhibition and Undaunted. With the recent developments, production to December 1988 for the group as a whole (predominantly extra production from Marvel Loch and Marvel Loch North open-cuts) has totalled 7980 kg of gold from 2.22 Mt of ore, a recovered average grade of 3.6 g/t. The Marvel Loch, Exhibition and Undaunted open-cuts have been combined to make a "super pit", and this along with the Marvel Loch and Edwards Find underground operations will support the 1.2 Mt per annum Marvel Loch plant. Demonstrated reserves for the Marvel Loch group at June 1989 were 8.1 Mt at 3.5 g/t.

Scorpio subgroup

Scorpio and Eveless Eden, together with Airey and Alexander (not shown on Plate 2), make up a group of

mines within 100 to 200 m east of the main Marvel Loch group. Host rocks are metamorphosed peridotite of a differentiated sill, ultramafic–basalt contacts associated with jaspilite which may have been interflow sedimentary rock, and fine-grained amphibolite derived from basalt. Orebodies are documented variously as lodes, veins, and quartz breccias; they are concordant with the 330°/vertical to steep westerly regional foliation, and pitch southeast as in the case of the Marvel Loch mines. Pyrite has been documented, but there is no indication of wall-rock alteration. The deposits are small isolated ore shoots which have been worked down to a vertical depth of 60 m.

Jaccoletti group

The Jaccoletti mining group comprises a number of deposits about 1.5 km west southwest of Marvel Loch. The main cluster of deposits, making up the Jaccoletti subgroup occur north of a northwest-trending sinistral wrench fault; Mountain Queen, a major historical producer, lies near the fault on the southwest side.

Jaccoletti subgroup

The main mines of the Jaccoletti subgroup are Comet, Eclipse, Geelong, Gentle Annie, and Jaccoletti itself. Host rocks are fine-grained amphibolite, which is commonly layered; pelitic metasedimentary rock; and some gneissic-textured metasedimentary rock which occurs close to a folded mafic–sedimentary sequence contact. The orebodies at the group are lenticular quartz reefs, often emplaced at lithological contacts, and are generally concordant with the regional foliation at 305° to 325°/vertical to 70° NE and SW.

Associated minerals are pyrrhotite and arsenopyrite. Some gneissic texture may be associated with hydrothermal alteration, along with biotite and probable clinopyroxene development. Reef widths were generally less than 1 m, but could have up to 4 m; stope lengths recorded range from 25 to 50 m and the workings extend to 80 m vertical depth.

Mountain Queen

Mountain Queen is located about 0.6 km southeast of the Jaccoletti mine, and 1.3 km southwest of Marvel Loch. The workings, however, have been largely inaccessible since early this century and the descriptions to hand are those by Blatchford (1915). Eluvial laterite ore was also mined from this deposit and is again under investigation. The mine is situated at the same stratigraphic horizon as the Burbidge group, immediately south of a cross-cutting sinistral wrench fault, and in an area of local folding, but its style of mineralization is quite distinct from neighbouring deposits. The host rocks consist of a sequence of metasedimentary rocks — garnetiferous mica schist, quartzite, graphite and sericite schist, and phyllite, which lie stratigraphically just above amphibolite. The orebody is lode material comprising black, graphite–mica phyllite with seams of quartz–pyrrhotite. Regional foliation is 310° to 320°/vertical to 70° W; the ore is concordant, and possibly occupies a doubly plunging syncline. Pyrrhotite and graphite, which may be primary, are the only documented associated minerals; wall-rock alteration effects are not known. The lode was up 7.5 m thick, "cone-shaped" in long section ranging from 100 m long at 30 m depth, to 30 m at 90 m depth.

Demonstrated resources at April 1989 were 213 000 t at 2.6 g/t to possibly feed the 260 000 t per annum Nevoria plant.

Prince–Four Threes

About 1.5 km southeast of the Jaccoletti mine is a small cluster of deposits known as Prince–Four Threes. These are in a similar stratigraphic and structural position, as well as being of similar style to the Jaccoletti group, but the two areas are offset slightly by a sinistral wrench fault.

Donovans Find group

The Donovans Find group of mines is located between 4 and 6 km southeast of Marvel Loch. Mines included in the group are in three structural zones: the Democrat–Mussolini to the west; Mountain King, Donovans Find, Salvation, Francis Furness and Bohemia along a central line; and Pro Patria to the east. The main deposits are along the central line, in particular the Francis Furness mine. Host rocks are fine-grained amphibolite, except for the case of Pro Patria which is within a metamorphosed gabbro; and minor metasedimentary rocks, as in the case of Mountain King and, possibly, Francis Furness. The central structural line is controlled by a major strike-slip shear zone, probably dextral in character, along which slivers of pelitic metasedimentary rocks have been caught up by folding and faulting. Ore bodies are mainly lenticular quartz reefs with some banded amphibolitic lode material. Regional foliation strikes at 310° to 320° with variable dips between 55° SW to 70° NE; the orebodies are generally concordant and pitch mainly to the southeast.

Associated minerals include arsenopyrite, pyrite, and pyrrhotite. Wall-rock alteration is evidenced by bleaching overprint on clinopyroxene–biotite gneiss layering with retrograde saussuritization and prehnite veining. Reef widths varied between 0.3 and 3 m (0.6 to 1.2 m average); mining was carried out to depths of between 20 and 75 m below surface; and stoping lengths were between 10 and 75 m. Some production from Francis Furness is probably included in the statistics for the Marvel Loch mine.

Nevoria group

Nevoria is a major, currently working mine located about 10 km east-southeast of Marvel Loch. At present, three open-cuts are operating and it is likely that underground redevelopment maybe undertaken in the future. The Nevoria orebodies consist of mineralized BIF lodes with quartz veins and stringers; the BIF is interlayered with a mafic–ultramafic sequence containing banded amphibolite and fine- to coarse-grained tremolite–chlorite rocks which may originally have both extrusive and intrusive origins. Up to three or four separate horizons of BIF have been mapped within the mine series, but it seems

likely that it is one single horizon which has been repeated by folding along an east–west axis.

Regionally, the mineralization is located near the nose of a south-plunging anticline — the southern end of the gneissic granitoid Ghooli Dome. There is an early bedding-parallel foliation at about 290°/60° S with 330° cross folding and axial planar foliation associated with the regional anticline. The BIF is box- folded about these later axes, and plunge south towards the centre of the Banker saddle structure. The orebodies pitch 55° to 60° SE along these secondary fold axes, i.e. they are concordant to regional foliation, and are best developed in the crests and troughs of the box folds. The quartz veining intimately associated with the gold mineralization is, however, flat to shallowly southerly dipping, which is indicative of a vertical extensional regime during mineralization.

Associated minerals are pyrrhotite, pyrite, arsenopyrite, and chalcopyrite. Where fresh, the BIF is a grunerite–magnetite–quartz rock; where the BIF is mineralized, grunerite is replaced by actinolite and pyrrhotite. The mafic wall rocks, although not appreciably mineralized, show extensive diopside, grossularite, calcite, and hornblende segregation banding.

At present, five major ore zones are being worked, distributed over 1.35 km of strike length. The ore bodies range from 2 to 20 m in thickness and previous workings have extended to a depth of 210 m. Demonstrated open-cut and underground resources at August 1989 were 2.898 Mt at 4.7 g/t and 705 000 t at 5.8 g/t respectively, supporting a 300 000 t per annum operation. The historical production for the group includes 102 kg gold from 9500 t of ore (10.8 g/t) from the Kurrajong (Quondong) mine which is some 2 km east of the main Nevoria mineralization.

Banker group

Golden Cube–Jester subgroup

The Golden Cube–Jester subgroup of mines are found 10 to 12 km southeast of Marvel Loch and 2 to 4 km west of Banker, within the Banker saddle. Most rocks are metamorphosed komatiite and high-magnesian basalt, with minor metagabbro and metasedimentary rock. The ore bodies are irregular, lenticular quartz reefs, such as at Golden Cube, and quartz and jaspilitic lode material, as in the Jester area; Golden Cube was the main producer.

At Golden Cube, the regional foliation strikes 320° to 330°, with uncertain dip but the sequence is probably part of a west-facing eastern limb of a syncline. The quartz orebody is discordant to the regional structure, striking at 085° to 070° and dipping 60° S or steeper. Foliation immediately adjacent to the reef, however, is reportedly concordant (Hobson and Matheson, 1940) but may be controlled by local faulting. No associated minerals have been documented. Amphibolitic wall rock shows layering, probably due to clinopyroxene and biotite reaction fronts. The mine reef was 0.9 to 1.5 m thick and was worked for a total length of about 85 m to a vertical depth of 40 m.

Banker

The Banker mine is located near the centre of the Banker saddle, approximately 14 km east-southeast of Marvel Loch. Host rocks to the mineralization are mainly medium-grained tremolite–chlorite rocks, derived from a komatiitic basalt sequence, with acicular feldspathic amphibolite (basalt-derived) close by to the northeast. The orebodies are lenticular quartz reefs; no further details are documented. Regional foliation is 310°/70° NE; the reefs, however, strike at 340° and are vertical to dipping 75° E. Therefore, the quartz may be discordant to regional structure, or may be concordant with local flexuring. Small-scale folding is common in mine waste material.

No associated minerals have been documented, even though the workings extended far below the level of the groundwater. Wall-rock alteration is shown by actinolite and anthophyllite selvedges to quartz veins and some minor parallel biotite reaction fronts. The quartz reefs were mined over 2.4 to 3 m average widths; stopes up to 4.2 m wide were mined over lengths of up to 38 m and the workings extended to a vertical depth of 84 m.

Burbidge group

The Burbidge group of mines is found 13 km southeast of Marvel Loch and includes the Great Victoria, Bronco Links, Prince George (Prince Regent), and Grand National lodes. The gold deposits are stratabound within a massive sulphide horizon, which occurs at or very close to the stratigraphic base of a major pelitic metasedimentary sequence. The sulphide horizon can be traced over at least 25 km of strike length, and most of which appears barren of gold. The gold deposits in the sulphide horizon are restricted to zones of structural complexity. The Burbidge group is located around a north-plunging anticlinal fold closure (the Caudan anticline; Fig. 3). Great Victoria is located within the complexly faulted and folded northeastern portion of the fold nose; Grand National is on the eastern limb of the Caudan anticline, about 1.5 km south of Great Victoria; and Bronco and Prince George are on the northern end of the west limb. The area is also strongly lateritized and an appreciable amount of production from the group has been derived from lateritic and eluvial ore.

The massive sulphide horizon maintains its stratigraphic position on both limbs of the Caudan anticline. The footwall rocks are fine-grained amphibolite; within 15 m of the mineralized massive sulphide, these rocks are calc-silicate, composed of tremolite, grossularite, carbonate, magnetite, diopside and quartz, typical of many of the region's gold deposits. The ore horizon is 20 to 30 m thick, and composed of 80% sulphide (pyrrhotite:pyrite ratio 9:1) in a matrix of amphibole–serpentine–carbonate and 5 to 10% quartz. Overlying the sulphide horizon is a quartzite, historically known as "running sand", of arguable origin. The quartzite consists of 50% fine subangular quartz grains, poorly cemented, with dolomite, sericite, pyrrhotite and minor fuchsite, and is overlain in turn by a graphitic schist unit, also containing pyrrhotite, approximately 15 m in thickness. Andalusite- and cordierite-bearing mica schists occur up the sequence.

Regional structure and ore structure are concordant; the Great Victoria mineralization is controlled by subsidiary folding within the Caudan anticline closure, with axial planes striking 005° to 010° and vertical to steeply westerly dipping. The plunge of the fold is 75° to 80° to the north. The surface outcrop of mineralized lode was some 300 m long at Great Victoria, and workings extended to 97 m below surface; lode widths ranged between 15 and 30 m.

In recent years, the Burbidge (Prince George/Prince Regent, Bronco, Grand National, and Great Victoria) deposits have been redeveloped by open-cut mining, and underground mining. Published demonstrated resources at the closing down of the 600 000 t per annum operation in December 1989 were 1.77 Mt at 2.53 g/t.

Harris Find group

Harris Find is located 21 km east-southeast of Marvel Loch, near the eastern extremity of the Banker saddle area. Orebodies are lenticular quartz veins and stringers and some amphibolitic siliceous lode material formed at, or near, a sedimentary–mafic contact. The regional structure is complex and is probably a subsidiary anticlinal fold nose within the synformal Banker saddle. The ore is probably largely concordant with local flexuring within the regional structure, and is reported (Hobson and Matheson, 1940) to occupy a line of weakness near the centre of a grey schist bed interlayered with mafic rocks. This linear feature could be a shear zone or an infold, but probably the former. The orebodies attitudes vary from 315°/80° SW to 030°/70° NW; pitch is unknown.

Associated minerals are pyrrhotite and chalcopyrite; arsenopyrite occurs without gold in pelitic metasedimentary rocks to the northeast of the mining area. The mafic rocks show very pronounced clinopyroxene–biotite segregation and gneissic layering, and are carbonated. They are similar in many respects to the mine country rocks described at Edwards Find; in both areas the country rocks were given the same rock code by Gee (1982) on SOUTHERN CROSS The mineralized zone is 0.6 to 0.9 m in width; stope lengths range from 7 to 20 m and the workings were developed to a vertical depth of 36 m, a few metres above the groundwater level.

Mount Palmer centre

General reference: Matheson and Hobson, 1940.

Palmers Find

Palmers Find was one of the later discoveries (1934) in the region. It is located 20 km east-northeast of Marvel Loch, in the Yellowdine greenstone belt which flanks the eastern side of the gneissic granitoid Ghooli Dome. It is a quite isolated deposit but is also one of the major past producers of the region; the main mines located at Palmers Find are Yellowdine Nos 2, 4 and 6. Host rocks are hornblende, actinolite, and tremolite schists with polygonal granoblastic textures indicating metamorphism at upper amphibolite, bordering on granulite, facies. The orebodies are massive quartz reefs which include zones of assimilated country rock. The regional foliation is 010° to 015°/ steep E and W dip; the direction of way-up, based on pillow basalt structures in the vicinity, is to the east away from the Ghooli Dome. The quartz reefs occupy fold hinges and the limbs of minor folds, both synclinal and anticlinal, and are concordant with the regional structure of the country rock. The main reef (Whinfield) forms both a closed basinal structure (doubly inward plunging syncline) and a further limb of a minor fold.

Arsenopyrite, pyrite, pyrrhotite, and chalcopyrite are associated minerals; alteration of wall rocks associated with quartz veining consists of zones of biotite concentration and layering that comprise biotite schist, clinopyroxene-bearing calc-silicate, and carbonate. The limbs of the quartz reef averaged 3 to 6 m; dimensions at fold noses and in the keel of the main reef are not clearly documented. Mineralization extended over 40 to 150 m strike lengths and the workings extended to a 60 m depth.

Palmers Find was a major producer (Table 2) from a relatively limited reef system, and now presents a target for either the discovery of new reefs or re-evaluation of low-grade mineralization associated with the mined-out zones.

Elsewhere in the Yellowdine belt, mineralization has so far proved very minor and production is minimal. Just east of Yellowdine, minor workings ("Yellowdine North") are found associated with BIF at or near a basalt–komatiite contact; similar situations pertain at Heaneys Find, Meiers Find, and Vickers Find.

Edwards Find centre

General reference: Hobson and Matheson, 1940.

Edwards Find group

Edwards Find is a relatively isolated gold deposit about 15 km southwest of Marvel Loch. It is located near the northern end of a narrow greenstone belt which runs south-southeast from Edwards, between Skeleton Rock and the western flank of the Parker Dome granitoid gneiss. The southern portion of this belt is narrow (less than 1 km wide) and has been metamorphosed to upper amphibolite and granulite facies. At Edwards Find, however, the greenstones form a 5 km wide belt, probably antiformal, with a mafic amphibolite core flanked to east and west by pelitic metasedimentary rocks. Major strike and oblique faults occur about 2 km west of the mineralized area.

Edwards Find is one of the new generation of redeveloped gold mines in the region. A small open-cut was excavated towards the end of 1986, and a decline driven from the base of the opencut to access underground ore which is trucked some 15 km to the Marvel Loch plant. Host rocks to the mineralization are amphibolite and some tremolite–chlorite rocks derived from a sequence of basalt

and komatiite. Ore bodies, historically, were quartz reefs; recent open-cut development has mined broad oxidized bodies of quartz and goethite.

Regionally, foliation trends 330° with vertical to 60° SW dips; the regional pitch is about 50° to 65° NW, probably representing an anticlinal fold closure to the northwest. The quartz bodies are generally concordant to the regional foliation, and on mine scale they are seen to be anastomosing. They may occupy a subsidiary strike-slip shear zone on or near a basalt–komatiite contact, though the movement direction on the shear is unknown. This type of structural detail will hopefully become clearer as the underground development proceeds.

Associated minerals are numerous and moderately abundant; they include pyrrhotite, pyrite, arsenopyrite, scheelite, galena, and chalcopyrite. Wall-rock alteration is strong and extensive, and includes carbonation and the development of coarse-grained clinopyroxene (diopside) and biotite gneissic layering. The mine series was mapped by Gee (1982) (SOUTHERN CROSS) as calc-silicate rock thought to have been derived from siliceous dolomite or dolomitic marl. However, the rock grades along strike away from the mineralized environment to hornblende–plagoclase amphibolite and amphibole–chlorite–carbonate ultramafic rocks; the present gneissic petrography is a result of metamorphism of an intensely metasomatized mafic and ultramafic rock sequence. The mine "gneiss" consists of layers of fine-grained hornblende–plagioclase–biotite amphibolite, and fine-grained carbonate–biotite (in which the sulphides are common), medium-grained carbonate–clinopyroxene, and medium-grained quartz–clinopyroxene rocks. Layering is juxtaposed more or less symmetrically about the central quartz (-diopside) zones.

The "Edwards Reward" mine was originally worked down to 80 m below surface; the main ore bodies were mined over 130 m strike length, with stope dimensions varying upwards from 20 m in length. Quartz widths were in the range 0.6 to 1.2 m. Recent mining of the oxidized zone, to 40 m depth, was carried out over widths up to 17m.

Demonstrated underground reserves at June 1989 were 700 000 t at 7.5 g/t. Open-cut mining at Edwards Find stopped late 1988.

Parker Range centre

General references: Montgomery, 1908; Gibson, 1904; Blatchford, 1915; Hobson and Matheson, 1940; Noldart, 1958a, b.

The mining groups included under the Parker Range centre are all located round the northeast and western flanks of the gneissic granitoid Parker Dome and are all within 2 km of the greenstone–gneissic granitoid contact. From the sinusoidal shape of the dome, it is apparent that the Parker Dome has undergone considerable clockwise rotation in addition to doming and this movement has set up a series of parallel, sinistral shear zones in the mafic rocks and BIF around its flanks. The Parker Range gold deposits are all associated with these shear zones. Similar structural conditions may be expected to occur on the southern and southeastern flanks of the dome; these areas have not been readily accessible and therefore represent a potential exploration target. Many of the amphibolites in the greenstone sequence have been previously mapped (Gee, 1982; SOUTHERN CROSS) as para-amphibolite derived from mafic tuff and sedimentary rocks, on account of their prominent mineralogical layering. These rocks are rich in clinopyroxene and biotite, and are most noticeably layered in the vicinity of shear zones and mineral deposits. It is believed, therefore, that the layering is more likely to be metamorphic in character and derived from previously hydrothermally altered (carbonated) normal basalt.

Toomey Hills group

The Toomey Hills group is located on the northeast flank of the Parker Dome. The mines in the group are quite small, but it is believed the area represents an important exploration target. Host rocks at the group are fine-grained micaceous amphibolite, possibly including some minor metagabbro intrusions; the mines are located immediately northeast of a contact with tremolite–chlorite rocks derived probably from komatiitic basalt. The mine series is located in a strongly foliated shear zone with a foliation of 290° to 310°/60° to 80° NE. The orebodies are quartz veins and schistose lode material with quartz stringers, which are generally concordant with the regional structure of the country rock but possibly slightly shallower dipping (300°/40° to 50° NE) — alternatively they may be occupying locally shallower portions of the shear zone.

No associated minerals have been documented (possibly due to the shallow nature of the workings). The wall rock contains 5 to 10% chlorite. Lode widths are up to 1.8 m, reef quartz is up to 0.45 m wide; development has been carried out over 150 m of strike length but the best ore zone was only 24 m long. The workings appear to extend to 25 m vertical depth.

Centenary group

The Centenary group of mines is located towards the northern end of the northwest flank of the Parker Dome; the mines being prominently aligned along a zone of multiple BIF horizons (individual BIFs may be structural repetitions of the one stratigraphic horizon). Most of the host rock, however, is layered amphibolite and the ore bodies are lenticular quartz reefs. The regional foliation, which is parallel to bedding, is 015° to 020°/40° to 60° NW. The reputedly richest veins, which were mined before production statistics were kept, are discordant, and strike northwesterly; they possibly represent tensional fractures within a sinistral shear system. Other veins, more plentiful but less rich, are concordant with the regional structure.

Pyrite is the only documented associated mineral; wall-rock alteration is shown by metamorphic clinopyroxene–biotite gneissic layering, but the relationship of the layering to bedding and foliation at this group is not clear. The rich cross reefs mined were up to 3 m thick;

and 90 m along strike the concordant quartz ranges from stringer width to 0.75 m and occur in parallel lenses between 15 and 35 m long. Workings at the group extend to 30 m depth (it is not clear whether this is a vertical or underlay depth).

McIntosh group

Mines of this group are located west and southwest of Parker Range townsite in two major shear zones 1 km and 0.4 km west of the BIF horizon. The western line includes Searchlight, Ripper (Piemonte), McIntosh, and Garibaldi (3 km south of McIntosh); the main mine on the eastern line is L.S.D (originally £.s.d). The McIntosh mine is reputed to have been a major producer prior to 1897 and therefore much of its production has not been officially recorded.

Host rocks to the mineralization are layered, schistose amphibolite, possibly including some fine- to medium-grained tremolite–chlorite rock at Garibaldi. Orebodies are quartz veins, often lenticular, and lode formations of amphibolite schist with quartz veins and stringers. They are both concordant and discordant to the regional structure; regional foliation varies from 360° (in the south) to 025° (in the north) with dips of 40° to 80° W (steepening westwards) and variable pitch. Foliation and amphibolite layering increase noticeably towards the mineralized shear zones. At McIntosh, the richest ore was reputedly derived from an irregular cross-coursing quartz reef, which trends at 030° to 035° within country rock regionally foliated at 010°.

Pyrrhotite, chalcopyrite, arsenopyrite, possibly pyrite, and scheelite are associated with the gold mineralization, and wall-rock alteration includes amphibole–clinopyroxene–biotite gneissic layering and carbonation. Stopes at McIntosh are up to 5.5 m wide though quartz veins are generally of the order of 0.6 to 0.9 m, and were developed in an irregular zig-zag array between 6 and 30 m long within an overall shear zone 6 to 15 m wide. Most work at this mine was above a vertical depth of 26 m. Garibaldi was worked to 42 m vertical depth over average widths between 0.15 and 1.2 m.

Up to 2000 t of production from Garibaldi was included with that from the Spring Hill mine, and it is possible that early (?late 1800s to early 1900s) unrecorded production from McIntosh (officially only 22.115 kg from 991 t of ore was reported) could have been up to 20 000 t at grades of between 30 to 40 g/t — this could represent an additional 700 kg of gold (approximately) which would make McIntosh far and away the main mine of the Parker Range centre.

Spring Hill group

Like those mines at Centenary and Olga, this group of mines is centred on a line of shearing closely associated with the BIF horizon that runs down the western flank of the Parker Dome. The descriptions pertain to mines along a 5 km strike length south of Parker Range townsite, between Centipede (Buffalo North) in the north, to Spring Hill in the middle, to White Horseshoe in the south. Mopoke is a small deposit, with no officially recorded production, located some 600 m east of Spring Hill. The main line of workings has mined both discrete quartz veins and lode material with quartz. The nature of the lode material is not always clear; it certainly includes BIF (often only part of a BIF horizon) but may also include finely laminated, altered amphibolite. Mopoke is hosted by massive quartz veins in fine-grained, generally massive, amphibolite. Regional foliation varies from 350° to 025°/35° to 45° W, and is generally parallel to bedding. Veins and lodes are apparently all concordant to the regional foliation. At the White Horseshoe, the ore pitches 55° S but elsewhere pitch has not been determined.

Associated minerals are pyrrhotite, pyrite, and chalcopyrite; wall-rock alteration includes carbonation and the ubiquitous clinopyroxene–biotite–hornblende gneissic layering. Workings have extended to a vertical depth of 48 m, though most do not exceed 30 m; lodes are up to 3 m wide with quartz veins varying from stringer width to 1.2 m. Spring Hill has been mined along a 140 m strike length, but other deposits are characterized by very irregular mineralization.

Official production (Table 2) includes some ore from Garibaldi to the southwest of the group, but probably nevertheless represents a reasonably accurate figure.

Olga group

The Olga mining group is a single line of gold deposits closely associated with the BIF horizon, about 10 km south of Parker Range townsite. As for the main line of mineralization at the Dulcie group, the ore is commonly hosted by layered amphibolite interleaved with multiple BIF horizons, along which shearing has preferentially taken place. The orebodies are quartz veins, lenses and pods concordant with the regional foliation, which varies from 330° to 010°/35° to 65° W and pitches steeply to the southeast. There is a tendency for the veining to reduce in width in a step-wise fashion with local flattening of dip.

Pyrite is documented and scheelite may also be present. Quartz, carbonate, and sulphide are associated with clinopyroxene–biotite–amphibole gneissic layering. Workings have been generally restricted to above the level of the water table which varies from 35 to 60 m (vertical depth); stope lengths are up to 30 m and the quartz ranges from stringer width to 0.9 m.

Dulcie group

The Dulcie group, some 9 km north of Cheritons Find, was one of the more important mining groups of the Parker Range centre. There are three main lines of mineralization within the group, the central one being the most productive and associated with shearing along the BIF horizon. Host rocks to the mineralization, however, are schistose, usually banded, amphibolite within which the BIF is interlayered. Orebodies are quartz veins but some sheared wall-rock was also mined as lode material with the quartz. Regional foliation and bedding are parallel at

335°/30° to 60° W, and the orebodies are concordant to slightly discordant (up to 10° to 15° off line — possibly Riedel fracture zones). Pitch is variable, both to north and south and described as steep to moderate.

Associated minerals include pyrite and chalcopyrite. Wall-rock alteration includes biotite–clinopyroxene gneissic layering and feldspar–hornblende layering in the amphibolite, and this is associated with carbonate and quartz veining. Retrograde chlorite, sericite, and saussurite alteration also occurs. Quartz veins are up to 1.5 m thick, but average between 0.3 and 0.6 m; mineralized wall rock extends up to 0.9 m from vein quartz. Stopes were developed on the order of 25 m and the workings extend to the water table at 50 m (vertical depth).

Most production (Table 2) has come from Constance Una and Dulcie Jean. The area is quite lateritic and recent exploration has located demonstrated lateritic resources of 558 000 t at 1.44 g/t. Mining of 258 000 t at 1.38 g/t was completed mid-1989 and heap-leach operations yielded on excess of 300 kg of gold.

Cheritons Find group

Cheritons Find is a small group of workings on the southwestern flank of the Parker Dome; these workings are hosted by finely banded amphibolite. Orebodies consist of small lenticular quartz veins and some minor amphibolitic lode material, which are concordant with regional foliation at 315° to 320°/40° to 50° SW. No sulphides have been documented but the quartz is iron-stained, so they no doubt do occur at depth. Wall-rock alteration includes carbonation and the ubiquitous calc-silicate layering of the region. The quartz veins are small, pod-like bodies, generally 0.15 to 0.3 m thick, but can reach up to 1.2 m. Workings extend to about 20 m vertical depth.

Holleton centre

General reference: Hobson and Matheson, 1940.

The Holleton mining centre comprises a small group of mines within the Holleton greenstone inlier which is situated about 70 km southwest of Marvel Loch. The inlier is oriented approximately east–west, and consists of fine-grained amphibolites in the north with a major layered medium- to coarse-grained amphibolitic sill in the south.

Holleton group

The mines are within the fine-grained, northern portion, and worked quartz veins, which were noteably amphibolitic, and some lode material. The regional structure of the inlier is not well known, and ore structures are apparently very variable, both concordant and discordant. North End Extended, the main producer, worked an orebody striking at 340°, dipping vertically, and pitching steeply south; the nearby Glenelg Queen was developed on a quartz reef at 030° and dipping 45° E. The Holleton and Calzoni Pit workings are associated with a shallowly northeast-plunging folded shear zone containing hornblende–biotite schist and adjacent to a coarse-grained pyroxenitic portion of the southern layered intrusive.

Associated mineralization at the group is dominantly pyrrhotite, with pyrite, arsenopyrite and scheelite; cassiterite-bearing pegmatites have also been worked in the area. Wall-rock alteration is evidenced by quartz–carbonate–biotite–pyrrhotite–clinopyroxene layering similar to that commonly found in the main greenstone belts. At the main deposits, the quartz averaged between 1.2 and 1.5 m in thickness; stopes up to 110 m long were developed and the North End Extended mine workings are down to 57 m below surface.

Recent exploration has located demonstrated reserves (laterite, primary, and surface ores) of 219 000 t at 1.7 g/t.

Symes Find

About 13 km north-northeast of Holleton is the Brittania mine or Symes Find. This deposit appears to be within an isolated raft of amphibolite in gneissic granite. Mineralization is associated with thin quartz veins and parallel zones of shearing; veins have been noted to strike at 090°/60° N dip and 040°/vertical but there is no outcrop in the area which might elucidate regional structure.

Felsteads Find

At Felsteads Find, 38 km north northeast of Holleton, is another example of isolated mineralization within a greenstone inlier. Production has been very minor; officially 0.2 kg gold from 80 t of ore (2.4 g/t). The workings are in quartz veins in mafic schists and within a folded quartzite, all part of a 0.8 km wide belt of metamorphosed sedimentary rocks (possible felsic tuffs), BIF and mafic rocks.

TABLE 2. GOLD STATISTICS OF THE BULLFINCH–PARKER RANGE REGION (TO 31 DECEMBER 1988)

Centre	*Mining group/subgroup (a)*	*Ore treated (b) (t)*	*Gold produced (b) (kg)*	*Average grade (b) (g/t)*	*Comments*
BLACKBOURNE	Blackbourne group	1 700	13.2	7.6	
BULLFINCH	Bullfinch group				
	Copperhead	4 083 000	21 117	5.2	Au:Ag 4:1; IN PRODUCTION
	Irene subgroup	890	16.8	18.9	
	Chance - Derwent Jack	110	1.6	15.3	
	Days Find group	5 500	126	22.6	Mainly Mistletoe
	Withers Find group	1 700	57.7	34.2	
	Reynolds Find group	1 800	21.1	12.0	
	Rutherfords Find group	900	6.9	7.6	
	Rowans Find group	100	3.8	36.8	
	Others	8 600	136	15.9	Mornington group, no official production
CORINTHIAN	Corinthian group	300 000	1 810	5.9	Au:Ag 4.5:1
	Babylonian group	1 200	36.8	29.5	
	Others	1 100	20.0	17.9	
EDWARDS FIND	Edwards Find group	282 000	1 967	7.0	Mainly Edwards Reward; mining recommenced 1986; Au::Ag 80:1; IN PRODUCTION
	Others	80	0.4	4.8	Other sundry production for this area may have been recorded under Marvel Loch centre
EENUIN	Carterton group	8 700	266	30.5	Mainly Newfield Central
	Eenuin group				
	Birthday s/group	900	22.9	25.4	
	Star of Eenuin s/group	600	21.7	36.2	
	Eenuin Star - Morning Glory s/group	590	16.2	27.5	
	Elliots Find group	400	8.8	22.0	
	Others	3 300	68.1	20.8	
GOLDEN VALLEY	Radio group				
	Radio - Manxman	68 000	2 260	33.5	Au:Ag 33:1
	Radio Deeps	9 600	314	32.7	
	Queenslander - Inspiration	1 800	43.9	24.3	
	Maries Find group	21 000	390	18.3	Mainly Great Bingin
	Golden Valley group				
	Kathleen s/group	1 500	58.0	38.8	
	Violet - Great Willow s/group	1 200	25.6	20.6	
	Lily of the Valley s/group	4 000	15.0	3.8	Includes 2580 t at 1.4 g/t
	Colreavy miscellaneous	1 100	9.3	8.7	
	Others	6 900	155	22.4	
GREENMOUNT	Greenmount group				
	United Australia s/group	66 000	496	7.5	
	Transvaal (Jupiter) s/group				
	Transvaal line	310 000	1 262	4.1	Au:Ag 13:1; arsenic producer; IN PRODUCTION
	Sunbream line	12 000	116	9.9	
	Historical misc.: includes Transvaal and Sunbeam lines	274 000	786	2.9	
	Devs Reward	2 300	7.0	3.1	Au:Ag 1.3:1
	Others	4 700	41.8	8.8	

HOLLETON	Holleton group				
	North End Extended - Glenelg Queen	39 000	364	9.4	North End Extended production approximately double that of Glenelg Queen
	Holleton	1 300	20.9	16.4	
	Calzoni Pit	5 000	17.7	3.5	
	Holleton miscellaneous	640	8.9	13.9	
	Symes Find group	6 910	76.8	14.8	Brittania
	Felsteads Find group	80	0.2	2.4	Felsteads Reward
	Others	3 500	28.7	8.2	
HOPES HILL	Hopes Hill group				
	Hopes Hill s/group	1 727 000	2 901	1.8	IN PRODUCTION
	Lady Kathe s/group	670	7.0	10.5	
	Pilot	180 000	829	4.5	Au:Ag 5.4:1
	Colleen Bawn - Parisian	1 700	91.3	55.0	
	Others	5 000	46.3	9.2	
KENNYVILLE	Kennyville group				
	Leviathan - Cornishman	35 000	492	14.1	Mainly Leviathan (Great Leviathan)
	Golden Arrow	2 900	16.1	5.5	
	Quandong - Pendrea s/group	4 400	16.0	3.6	Mainly Achilles and Pendrea
	Glendower group				
	Battler	14 000	139	9.6	
	Evelyn Molly - Victoria	17 000	103	6.2	
	Glendower (old) s/group	360	6.7	18.6	
	Others	9 200	74.4	8.1	
MARVEL LOCH	Marvel Loch group				
	Marvel Loch - Exhibition - Undaunted line	2 220 000	7 980	3.6	Includes some production from Francis Furness (Donovans Find group)
	prior to 1984 (c)	*273 000*	1 960	*7.2*	Au:Ag 2:1 to 4:1; 1985-88 1.87 Mt at 2.88 g/t; IN PRODUCTION
	Scorpio s/group	4 000	65.6	16.6	
	Nevoria group	1 957 000	6 530	3.3	Au:Ag 5:1 to 30:1
	prior to 1985 (c)	*441 000*	*2 710*	*6.1*	1985-88; 1.44 Mt at 2.65 g/t; IN PRODUCTION
	Burbidge group	2 057 000	5 320	2.6	1985-88; 1.54 Mt at 2.22 g/t; IN PRODUCTION
	prior to 1984 (c)	*452 000*	*1 776*	*3.9*	Mainly Great Victoria
	Donovans Find group	*66 000*	*963*	*14.6*	Au:Ag 30:1; plus 24 kg alluvial/dollied; mainly Francis Furness
	Jaccoletti group				
	Mountain Queen	*110 000*	*942*	*8.6*	Au:Ag 80:1
	Jaccoletti s/group	*57 000*	*621*	*10.9*	Au:Ag 4.5:1
	Prince s/group	*1 300*	*51.6*	*40.2*	
	May Queen group	*12 000*	*532*	*44.8*	Plus 41 kg alluvial/dollied: mainly May Queen

(a) Relative order by gold production by group only
(b) Production figures rounded
(c) Historical production included in total figure for the group

TABLE 2. GOLD STATISTICS OF THE BULLFINCH-PARKER RANGE REGION (TO 31 DECEMBER 1988) — *continued*

Centre	*Mining group/subgroup (a)*	*Ore treated (b) (t)*	*Gold produced (b) (kg)*	*Average grade (b) (g/t)*	*Comments*
MARVEL LOCH *(continued)*	Banker group				
	Banker	18 000	344	18.6	
	Pathfinder	480	3.2	6.6	
	Golden Cube - Jester s/group	5 300	81.4	15.4	Mainly Golden Cube
	Xantippe group	4 000	30.4	7.5	
	Harris Find group	3 100	17.6	5.6	
	Lenneberg Find group	3 800	7.0	1.8	Au:Ag 3.5:1
	Others	40 000	436	10.9	
MOUNT PALMER	Mount Palmer group				
	Palmers Find s/group	310 000	4 950	15.7	Yellowdine Nos 2, 4 and 6
	"Yellowdine North"	50	0.5	8.8	
	Others	460	12.1	26.1	
MOUNT RANKIN	Bells Find group	4 400	146	33.2	Plus 16 kg alluvial/dollied; mainly Marjorie Glen Reward
	Mount Rankin group	6 700	32.4	4.9	
	Others	850	31.1	36.7	
PARKER RANGE	Spring Hill group	41 000	446	11.0	Includes up to 2000 t from Garibaldi; Au:Ag 70:1; mainly Spring Hill and White Horsehoe
	Dulcie group	376 000	718	1.9	Au:Ag 75:1; mainly Constance Una; IN PRODUCTION
	Toomey Hills group	3 400	99.0	29.2	Mainly Blue Hill
	Olga group	2 900	89.4	31.2	
	Centenary group	5 700	88.1	15.3	
	McIntosh group	5 300	58.8	11.0	Probably mainly McIntosh; up to 2000 t from Garibaldi
	McIntosh Mine (c)	991	22.2	22.3	
	estimated additional	*<20 000*	*600 to 800*	*30 to 40*	*Unofficial production 1893-97*
	Cheritons Find group	40	0.3	7.6	
	Others	16 000	186	11.7	
SOUTHERN CROSS	Southern Cross group				
	Frasers s/group	875 000	9 620	11.0	Au:Ag 4.7:1; plus 200 kg alluvial/dollied; IN PRODUCTION
	Haddon s/group	59 000	384	6.5	Mainly Haddon, Three Boys, Golden Pig
	New Zealand Gully group	6 300	32.2	5.1	Mainly Queen Ann
	Others	11 000	94.1	8.9	
WESTONIA	Westonia group	2 485 000	15 530	6.3	Au:Ag 12:1; 1986-88 1.93 Mt at 2.33 g/t; IN PRODUCTION
	prior to 1986 (c)	*565 000*	*11 000*	*19.5*	
	Golden Point	860	25.8	*30.0*	
	West Westonia group	30 000	646	*21.6*	Mainly Royal Flush
	Recovery group	9 500	118	*12.4*	
	Colossus group	40	0.6	*15.4*	
	Others	4 400	87.8	*20.0*	Comstock group, no official production

(a) Relative order by gold production by group only
(b) Production figures rounded
(c) Historical production included in total figure for the group

TABLE 3. SUMMARY OF GEOLOGICAL AND MINING INFORMATION ON GOLD DEPOSITS IN THE BULLFINCH-PARKER RANGE REGION

Centre	*Group/Deposit*	*Host rock*	*Orebody*	*Structure: host rock; orebody*	*Associated minerals; Alteration*	*Area mined (a)*
WESTONIA	WEST WESTONIA GROUP	Mafic schist, various gneiss	Quartz, generally concordant	Variable, about E - W strike; n.d.	Pyrite, pyrrhotite; Biotite, clinopyroxene gneissic layering	Generally, 0.15 - 0.3 m x <45 m; <35 m VD Royal Flush, <1.5 m x >70 m; ?m VD
	RECOVERY GROUP	Coarse-grained hornblende gneiss	Quartz, concordant	300°/?dip; Pitch 50° NW, in nose of minor anticline	Pyrite, pyrrhotite; n.d.	<2.5 m x ?m; 30 m VD
	WESTONIA (EDNA MAY) GROUP	Biotite gneiss; tonalite to monzogranite in composition	Three major quartz - feldspar and quartz saddle reefs, one layered quartz - biotite schist lode (Middle Reef)	290° to 300°/30° to 75° NE; "Reefs" pitch 45° to 50° NW	Pyrite, marcasite, pyrrhotite, wolframite, galena, crocoite, scheelite, molybdenite, chalcopyrite, sphalerite, arsenopyrite; *Clinopyroxene - pyrrhotite* - biotite segregation in mafics	Laterite zone, 1 - 2 m thick Eluvial zone, <2.5 m thick "Reefs", 30 m x 30 m; 240 m VD
	COLOSSUS GROUP	Biotite - hornblende schist	Quartz, concordant	305° to 315°/65° to 75° NE; As above	n.d.; Biotite, calc-silicate	n.d.
	COMSTOCK GROUP	Graphitic schist, phyllite, felsic to intermediate tuff	Quartz veinlets, concordant at least with strike	Broadly folded structure, probably minor folding; n.d.	n.d.	n.d.
EENUIN	CARTERTON GROUP Newfield	Basalt, minor komatiite	Quartz, lenticular, discordant	335°/vert; Fault 005°/65° E, breccia, quartz pitches 50° N	Pyrite, pyrrhotite, chalcopyrite, malachite, sphalerite, molybdenite, ?arsenopyrite; Carbonate, chlorite, bleaching	0.9 m x 90 m; 30m VD
	Mayfield East	n.d.	n.d.	n.d.	Pyrite, sphalerite, galena, chalcopyrite; Calc-silicate	n.d.
	ELLIOTS FIND GROUP	Coarse-grained tremolite - chlorite rock	Quartz, ?saddle reefs	010° to 280°/65° E to N; Drag folds pitch 65° NE	Pyrite; n.d.	<1.5 m x 6 - 25 m; 10 m VD
	EENUIN GROUP	BIF and BIF - komatiite contacts; basalt, ?agglomerate	Quartz, lenticular, concordant and saddle reefs; also BIF lodes and quartz veins, stringers	330° to 350°/vert to steep E - W, anticlinal hinge and subsidiary folds; Minor fold axial zones	Pyrite, pyrrhotite, chalcopyrite, sphalerite, scheelite; Biotite, calc-silicate layering	0.2 - 1.5 m x 10 - 40 m; 30 m VD
GOLDEN VALLEY	MARIES FIND GROUP	Biotite schist, some BIF	Quartz, lenticular, *en echelon* shoots; some BIF lode + brecciated quartz	Possible anticlinally refolded fold structure; Quartz in fault 035°/60° SE, shoots pitch vertically	Pyrite, chalcopyrite, galena; Biotite, bleaching	0.05 - 1.8 m x 800 m intermittent; 44 m VD
	GOLDEN VALLEY GROUP	Mainly basalt, some BIF, minor komatiite	Quartz, lenticular, concordant, some BIF lode + quartz stringers	Regional anticline, 340° (synformal nose); Main deposit in axial zone of major fold, other deposits with minor folds and shears on limbs	Quartz + pyrite, ?pyrrhotite, chalcopyrite, ?arsenopyrite/ Lode + pyrite, pyrrhotite, marcasite, arsenopyrite, stibnite; Biotite, carbonate	Quartz <0.3 m x irregular; 20 m VD Lode, small pipes x 20

TABLE 3. SUMMARY OF GEOLOGICAL AND MINING INFORMATION ON GOLD DEPOSITS IN THE BULLFINCH-PARKER RANGE REGION — *continued*

Centre	*Group/Deposit*	*Host rock*	*Orebody*	*Structure: host rock; orebody*	*Associated minerals; Alteration*	*Area minded (a)*
GOLDEN VALLEY (*continued*)	RADIO GROUP	Biotite schist, schist - gneiss contacts, some gneiss; within granitized zone of biotite gneiss and mafic schist enclaves	Quartz, mainly discordant	Doming of gneiss to northeast; Quartz in fault zones, 035°/45° to 60° SE, pitch vert to steep SSW	Pyrite, pyrrhotite, molybdenite, chalcopyrite; Silicification	0.4 - 1.8 m x 15 - 150 m; 60 m VD
BULLFINCH	DAYS FIND GROUP	Mafic - ultramafic schist	Quartz, lenticular, concordant	325°/65° SW to 65° NE, local strong shearing; As above	Pyrite, chalcopyrite, arsenopyrite; ?Carbonate	0.9 - 1.5 m x 55 m; 65 m VD
	ROWANS FIND GROUP	Biotite schist, minor BIF	Quartz, minor siliceous BIF lode, concordant	310° to 330°/60° to 80° SW; As above	n.d.	n.d.
	REYNOLDS FIND GROUP	Biotite gneiss; 10 km from greenstone belt	Quartz vein, concordant, laminated	080° to 100°/45° to 60° S; As above	Pyrite; n.d.	1 - 1.5 m x 15 - 65 m; 35 m VD
	WITHERS FIND GROUP	Hornblende and biotite gneiss; 7 to 9 km from main greenstone belt	Quartz, concordant	290°/50° to 70° N; set of parallel shears; As above	Pyrite; n.d.	0.3 - 1.5 m x 5 - 10 m; 7 - 40 m VD (35 shafts over 800 m strike)
	RUTHERFORDS FIND GROUP	Biotite gneiss; 8 km from main greenstone belt	Quartz, concordant and discordant	E - W/steep S; 265°/80°, 315°/50° - 80° SW	Pyrite; n.d.	0.2 - 0.5 m x ? m; 10 m VD
	BULLFINCH GROUP Irene (Lady Agnes)	Coarse-grained tremolite - chlorite rock	Quartz, discordant	335°/vert; 300°	n.d.; Minor actinolite selvedge	n.d.
	Copperhead	Komatiite - chlorite schist - BIF sequence	Lodes and quartz veins/ stringers	Overturned synclinal keel, 330°/70° SW, plunge 45° NW; in nose of major fold, in drag fold axial zones and shears	Pyrrhotite, pyrite, marcasite, galena, ?chalcopyrite, ?scheelite; Carbonate, dolomite, silicification	North, <20 m x 150 m; 480 m VD South, 5 - 30 m x 240 m; 180 m VD
	CHANCE	Black shale, phyllite; sulphidic	Quartz, concordant	325°/70° SW: As above	n.d.	n.d.
	DERWENT JACK	Komatiite, ?minor BIF; at gneiss - greenstone contact	Lode and quartz stringers, concordant	335°/55° SW; As above	n.d.	n.d.
CORINTHIAN	CORINTHIAN GROUP	Mafic schist; at gneiss - greenstone contact	Quartz, minor BIF lode, concordant	325°/75° SW to vert; As above	Pyrrhotite, pyrite, marcasite, chalcopyrite, molybdenite; Biotite, silicification	7.5 m x 250 m; 60 m VD
	BABYLONIAN GROUP	Biotite gneiss	Quartz, discordant	310°/vert to steep NE; 045°/30° NW	Pyrite, covellite; n.d.	0.05 - 0.2 m x 85 m; 26 m VD
HOPES HILL	HOPES HILL GROUP Colleen Bawn - Parisian	Komatiite, basalt	Quartz, concordant	320°/to 330° vert; As above, or pitches SE (Colleen Bawn), shearing intense to weak	n.d.; chlorite	27 m VD

	Pilot	Mafic schist, minor BIF	Lode, mainly amphibolitic; minor BIF, plus quartz veins/ stringers	340°/70° NE to 70° SW; Keel of minor syncline, plunge 55° SE	Pyrrhotite, pyrite, marcasite, magnetite, tourmaline, carbonate; Silicification, carbonate, biotite, chlorite, tourmaline, bleaching	10 - 25 m x 120 m; 120 m VD
	Hopes Hill	Mafic schist, komatiite, ?BIF; at gneiss - greenstone contact	Lode material of quartz and schist, concordant	325°/75° SW: As above	Pyrite, arsenopyrite; Kaolinite, sericite	5 m x 540 m; 50 m VD
	Lady Kathe	Mainly pelite; minor komatiite, ?others	Quartz	330°/vert to 80° SW; As above	n.d.	n.d.
SOUTHERN CROSS	SOUTHERN CROSS GROUP					
	Haddon subgroup	BIF in mafic sequence	BIF lodes with quartz veins/ stringers, concordant	305° to 325°/50° to 70° SW; As above, plunge 20° to 40° NW with minor fold hinge zones	Pyrite; n.d.	4 - 12 m x 20 to 90 m; 30 m VD
	Frasers subgroup	Banded amphibolite, ultramafic rock	Quartz, brecciated, laminated and amphibolitic, and laminated lode; concordant, anastomosing	325°/50° to 60° SW: As above, ore plunges 45° SE, major shear zone	Pyrrhotite, pyrite, chalcopyrite, galena, scheelite; Biotite - hornblende, carbonate, clinopyroxene, quartz	3 - 15 m x 850 m; 200 m VD
	NEW ZEALAND GULLY GROUP	Komatiite, pelite	Quartz veins and ultramafic lode with quartz stringers, concordant	330°/70° NE to 70° SW; As above	Pyrrhotite; Silicification, talc - chlorite	1.2 - 1.8 m x <30 m; <27 m VD
GREEN-MOUNT	GREENMOUNT GROUP					
	Transvaal - Sunbeam; Devs Reward	Pelitic and graphitic schist, wacke near or at sedimentary - ultramafic rock contact	Quartz, concordant	340° to 010°/85° W to 85° E; As above	Arsenopyrite abundant, pyrrhotite, ?pyrite; Quartz cores surrounded by graphitic schist, carbonate	0.6 - 6 m x 60 m; 22 m VD
	United Australia	Medium- to coarse-grained amphibolite (after gabbro), pelites	Quart, irregular	340°/vert to 80° SW, adjacent fault; n.d.	Sulphide; ?Carbonation of sediments	1.8 - 9m x >200 m; 30 - 40 m VD
BLACK-BOURNE	BLACKBOURNE GROUP	Basalt	Quartz, folded	n.d.; 345°/60° NE, plunge 60° SE	n.d.	1.2 m x <28 m; 42 m VD
MOUNT RANKIN	MOUNT RANKIN GROUP	Amphibolite and/or BIF	BIF lode with quartz stringers, ?quartz veins, concordant	305° to 325°/70° NE; As above, pitch 50° SE	n.d.; Biotite - clinopyroxene layering in amphibolites	0.6 - 0.9 m (?6 to 8 m low grade) x isolated shoots; 69 m VD
	BELLS FIND GROUP	Fine- to medium-grained amphibolite; minor BIF	Quartz, amphibolitic; main orebody discordant	330°/50° NE, plunge 45° SE; 055°/vert, pitch 75° NE, cross fault	Chalcopyrite, pyrite, copper carbonate; Saussurite, carbonate	0.75 m x 40 m; 45 m VD
KENNYVILLE	KENNYVILLE GROUP					Small, patch; <23 m VD
	Quandong - Achilles - Pendrea	BIF, quartzite, banded amphibolite	Quartz and BIF lode with quartz	305° to 340°/50° to 80° SW; n.d.	n.d. Clinopyroxene	

(a) VD - vertical depth

NOTE: n.d. - no data

TABLE 3. SUMMARY OF GEOLOGICAL AND MINING INFORMATION ON GOLD DEPOSITS IN THE BULLFINCH-PARKER RANGE REGION — *continued*

Centre	*Group/Deposit*	*Host rock*	*Orebody*	*Structure: host rock; orebody*	*Associated minerals; Alteration*	*Area mined(a)*
KENNYVILLE *(continued)*	Leviathan - Cornishman	Komatiite and basalt	Quartz, some amphibolitic lode, concordant to local folding	300° to 385°/45° SW; Leviathan, 300°/vert, pitch 45° NW; Cornishman, 335°/vert, pitch steep SE	Pyrrhotite; Amphibole - clinopyroxene vein selvedge	0.75 m x <95 m; <90 m VD
	Golden Arrow (Catherine)	Gabbro	Quartz, sightly discordant	335°/70° NE; 320°/60° NE		<1.2m x <8.5 m; 33 m VD
	GLENDOWER GROUP Battler	Komatiite - basalt	Quartz, ?concordant	315° to 330°/dip?; within minor fold or cross tension fracture, 290°/45° to 60° N, pitch 45° NW	n.d.; Minor bleaching	0.6 - 4.5 m x 60 m; 63 m VD
	Evelyn Molly - Victoria	BIF, grey schist, quartzite	Probably quartz-rich lode material, concordant	320°/50° to 60° SW; As above	Pyrrhotite	3 - 4 m x ?m; 33 m VD
	"Old" Glendower	Gabbro, ultramafic rock	Quartz	n.d.; Near sheared fold hinge, 320°/60° SW	n.d.	n.d.
MARVEL LOCH	LENNEBERG FIND GROUP	Sedimentary rock, ?silicified BIF	Lode with quartz stringers, concordant	330°/45° to 80° SW; As above	n.d.	<6 m x ? m; 30 m VD
	MAY QUEEN GROUP (May Queen - Christmas Gift - Ganymede)	Basalt-peridotite-gabbro (respectively)	Quartz - lode - ?quartz vein/stockwork (respectively), concordant	330° to 340°/vert to 75° SW; As above	Pyrite, arsenopyrite, pyrrhotite; Silicification, clinopyroxene - biotite layering, carbonate, saussurite	0.6 - 1.2 m x 10 - 40 m; <66 m VD
	XANTIPPE GROUP	Sedimentary and ultramafic rocks, gabbro	Probably minor quartz veins, concordant at Treasury	330° to 345°/vert to 75° SW; As above	n.d.	n.d.
	MARVEL LOCH GROUP	Komatiite - basalt - sedimentary sequence	West: quartz veins and calc-silicate lode; Ease: laminated sedimentary lode, concordant	Major strike-slip fault zone (?dextral), 330°/80° NE to 80° SW; As above, pitch 60° to 80° SE	Pyrite, pyrrhotite, galena, chalcopyrite, arsenopyrite, scheelite; Quartz - diopside - biotite - carbonate alteration (<75 m)	West: 1 - 4 m, East: <9 m x 1.8 km; 180 m VD
	Scorpio subgroup	Peridotite and basalt contact	Quartz veins, breccias and lodes, concordant	330°/vert to steep W, pitch SE; As above	Pyrite, ilmenite; n.d.	Small localized shoots; <60 m VD
	JACCOLETTI GROUP Jaccoletti subgroup	Banded amphibolite interlayered with pelite	Quartz veins, generally concordant	305° to 325°/70° NE to 70° SW; As above	Pyrrhotite, arsenopyrite; Calc-silicate gneissic layering, bleaching	1 - 4 m x 25 - 50 m; <80 m VD
	Mountain Queen	Micaceous, graphitic schist, phyllite, quartzite; close to major mafic - sedimentary sequence contact	Lode, graphite - mica phyllite with quartz - pyrrhotite seams, concordant; also laterite production	Intense local deformation, ?doubly plunging syncline, 310° to 320°/vert to 70° SW; As above	Pyrrhotite, ?primary graphite; n.d.	<7.5 m x 100 m; 90 m VD

(a) VD - vertical depth
NOTE: n.d. - no data

MARVEL LOCH *(continued)*	Prince subgroup	Amphibolite, interlayered with pelite	Quartz veins, generally concordant (?)	n.d.	n.d.	n.d.
	DONOVANS FIND GROUP	Amphibolite, minor sedimentary rocks	Quartz, minor lode material; generally concordant	315°/55° SW to 70° NE, major strike-slip fault zone; As above, ore pitches generally SE	Arsenopyrite, pyrite, pyrrhotite; Chlorite, saussurite (retrograde), clinopyroxene - biotite gneissic layering	0.3 - 3 m x 10 - 75m; 20 to 75 m VD
	NEVORIA GROUP	BIF within banded amphibolite and tremolite - chlorite rocks	BIF lodes with quartz veins stringers; lodes concordant, veins discordant	Bedding parallel foliation 290°/60° S with 330° axial cross folding; Lodes as above, with secondary fold axes, pitch 55° to 60° SE, quartz veining is flat to shallowly southerly dipping	Pyrrhotite, pyrite, arsenopyrite, chalcopyrite; Amphibole and calc-silicate layering, carbonate, silification	2 - 20 m, 5 main ore zones over 1.35 km; 210 m VD
	BANKER GROUP					
	Golden Cube - Jester subgroup	Komatiite - basalt sequence, minor gabbro	Golden Cube, quartz, discordant; Jester, includes lode material, concordant	320° to 330°/dip?; Golden Cube, 070° to 085°/ 60° S; Jester, n.d.	n.d.; Biotite - clinopyroxene layering	0.9 - 1.5 m x ? m; <40 m VD
	Banker	Komatiitic basalt sequence	Quartz, ?concordant locally	310°/70° NE; 340°/vert to 75° NE	n.d.; Amphibole selvedge, biotite layering	2.4 - 3 m x <38 m; 84 m VD
	BURBIDGE GROUP	Massive sulphide within pelite, stratabound; at or close to major mafic - sedimentary sequence contact	Lode: pyrrhotite, pyrite, tremolite, serpentine, quartz, carbonate, magnetite; also laterite	Major anticlinal hinge; In minor fold around hinge of anticline, axis 005°/steep W, plunge 75° to 80° N	Pyrrhotite, pyrite; Carbonate, calc-silicates	15 - 30 m x <300 m; <97 m VD
	HARRIS FIND GROUP	Mafic - sedimentary sequence contact	Quartz veins, stringers, some lode, probably concordant locally	Complex, faulted fold hinge; 310°/80° SW to 030°/70° NW	Pyrrhotite, chalcopyrite, ?arsenopyrite; Clinopyroxene - biotite, gneissic layering, carbonate	0.6 - 0.9 m x 7 to 20 m; 36 m VD
MOUNT PALMER	MOUNT PALMER GROUP					
	Palmers Find subgroup	Hornblende, actinolite-tremolite schist; upper amphibolite grade	Quartz, amphibolitic	010° to 015°/vert; Veins in fold hinges and limbs, main orebody in partly closed basinal structure	Arsenopyrite, pyrite, pyrrhotite, chalcopyrite; Biotite - clinopyroxene - carbonate layering	3 - 6 m (limbs) x 40 - 150 m; 60 m VD
EDWARDS FIND	EDWARDS FIND GROUP	Basalt - komatiite sequence; ?contact	Quartz veins, anastomosing, generally concordant	330°/vert to 60° SW; n.d.	Pyrrhotite, pyrite, arsenopyrite, scheelite, galena, chalcopyrite; Carbonate, clinopyroxene - biotite gneissic layering	0.6 - 1.2 m x 20 - 130 m; 80 m VD Oxidized zone <17 m wide, quartz, geothite
PARKER RANGE	TOOMEY HILLS GROUP	Micaceous amphibolitic schist	Quartz veins and schistose lode with quartz stringers, strike concordant	290° to 310°/60° to 80° NE; 300°/40° to 50° NE, in shear zone	n.d.; Chlorite, intense shearing	<1.8 m x 25 m; ?25 m VD

TABLE 3. SUMMARY OF GEOLOGICAL AND MINING INFORMATION ON GOLD DEPOSITS IN THE BULLFINCH-PARKER RANGE REGION — *continued*

Centre	*Group/Deposit*	*Host rock*	*Orebody*	*Structure: host rock; orebody*	*Associated minerals; Alteration*	*Area mined(a)*
PARKER RANGE *(continued)*	CENTENARY GROUP	Layered/banded amphibolite	Quartz veins, concordant	0.15° to 020°/40° to 60° NW, probable dextral shear system associated with BIF; Cross vein NW - SE, others concordant	Pyrite; Biotite - clinopyroxene gneissic layering	3 m x 90 m (cross vein), 0.75 m x 15 - 35 m (concordant); <30 m ?VD (down dip depth)
	McINTOSH GROUP	Schistose, banded amphibolite	Quartz veins and quartz-rich amphibolitic lodes, discordant and concordant	Within probable dextral shear zone with tension fractures, 360° to 025°/40° to 80° W, pitch variable; As above, 035° tension cross vein, pitch?	Pyrrhotite, chalcopyrite, arsenopyrite, ?pyrite, scheelite; Clinopyroxene - biotite - arsenopyrite gneissic layering, carbonate	<5.5 m x <30 m; <46 m VD
	SPRING HILL GROUP	Sheared amphibolite - BIF sequence	Quartz veins and quartz-rich lode (?amphibolitic/BIF?), concordant	350° to 025°/35° to 45° W; As above	Pyrrhotite, pyrite, chalcopyrite; Clinopyroxene - biotite, hornblende gneissic layering, carbonate	<3 m x <50 m; <48 m VD
	OLGA GROUP	Amphibolite (commonly layered) - BIF sequence	Quartz veins, concordant	330° to 010°/35° to 65° W, pitch steep SE; As above	Pyrite, ?scheelite; Clinopyroxene - biotite gneissic layering with quartz - carbonate - sulphide association	<0.9 m x <30 m; <67 m VD
	DULCIE GROUP	Schistose banded amphibolite plus BIF in sequence	Quartz veins, amphibolitic lode, generally concordant within 15°	335°/30° to 60° NW, pitch N and S; As above	Pyrite, chalcopyrite; Biotite - clinopyroxene and feldspar - hornblende layering, carbonate, retrograde chlorite and saussurite	0.5 - 1.5 m x <25 m; <50 m VD
	CHERITONS FIND GROUP	Fine-grained banded amphibolite	Quartz veins, ?lode material concordant	315° to 320°/40° to 50° SW; As above	Sulphide; Carbonate, clinopyroxene - amphibole layering	0.15 - 1.2 m x ? m; 20 m VD
HOLLETON	HOLLETON GROUP	Fine-grained amphibolite	Quartz, some amphibolitic quartz lode, ?concordant	n.d.; 340°/vert, pitch steep S	Pyrrhotite, pyrite, arsenopyrite, scheelite; Carbonate, biotite - clinopyroxene layering	1.2 m x <110 m; <57 m VD
	SYMES FIND	Amphibolite	Quartz veins within shear zone	n.d.; Veins 090°/60° N, 040°/vert	n.d.	n.d.
	FELSTEADS FIND	Mafic schists, psammite	Quartz veins	n.d.	n.d.	n.d.

(a) VD - vertical depth

NOTE: n.d. - no data

TABLE 4. GEOGRAPHICAL LISTING OF MINING GROUPS, SUBGROUPS, AND MINES

Centre	*Group*	*Subgroup*	*Mine*
WESTONIA	West Westonia		Battler Hill End Westons Reward Pertha M Royal Flush Les Trois
	Recovery		Central No. 1 Contemptible Recovery Greenfinch
	Westonia		Westonia (Edna May) Golden Point (Edna May)
	Colossus		Emma May Main Lode Colossus Central
	Comstock		Comstock
EENUIN	Carterton		Sweet William Newfield Central Newfield East Mayfield East
	Elliotts Find		Trump
	Eenuin		Patricia Lee Trough Well
		Birthday	Lucky Jim Birthday Extended
			Ansteys Find
		Eenuin Star - Morning Glory	Eenuin Star Crown & Anchor Eenuin Daisy Helio This Is It Morning Glory
		Star of Eenuin	Great Gossan Marionette Star of Eenuin Trig Hill
GOLDEN VALLEY	Maries Find		Maries Find (Redwing) Great Bingin
	Golden Valley	Coleavy (miscellaneous)	Golden Valley Welcome Elbi Sunset
		Kathleen	Lake View Kathleen Golden Crown
		Violet - Great Willow	Two Seas Violet Great Willow
		Lily of the Valley	Baby Queen Valley Queen Extended Lily of the Valley (Valley Queen) Southern Queen
	Radio	Queenslander - Inspiration	Queenslander (Rosalie) Inspiration
		Radio - Manxman	Bullwark (Hanks Find) Golden Hole Manxman Radio
		Radio Deeps	Radio Deeps

TABLE 4. GEOGRAPHICAL LISTING OF MINING GROUPS, SUBGROUPS, AND MINES — *continued*

Centre	*Group*	*Subgroup*	*Mine*
BULLFINCH	Days Find		Mistletoe
	Rowans Find		Magpie (New Radio)
	Mornington		Mornington
	Reynolds Find		Reynolds Finds
	Withers Find		Beechwood Peter Pan Millenium Gordon New Italy Volcano
	Rutherfords Find		Golden Frog Handsfordhaven
	Bullfinch		Bullfinch Great Northern Golden Area Illawarra
		Irene	Irene (Lady Agnes)
		Copperhead	Rising Sun Copperhead
		Chance - Derwent Jack	Chance Derwent Jack
CORINTHIAN	Corinthian		Corinthian North Corinthian Deliverance
	Babylonian		Babylonian
HOPES HILL	Hopes Hill	Colleen Bawn - Parisian	Parisian Colleen Bawn
		Pilot	Pilot
		Hopes Hill	Hopes Hill Renegade
		Lady Kathe	Lady Kathe
SOUTHERN CROSS	Southern Cross	Haddon	Golden Pig Nil Desperandum Three Boys (Haddon) Flojene Messina Lord Cardigan
		Frasers	Central Frasers Frasers South Frasers South Extended
	New Zealand Gully		Queen Ann Tarcoola North Tarcoola Maori Lass
GREENMOUNT	Greenmount		Lord Roberts
		Transvaal	Sunbeam Transvaal (Jupiter) Royal George
		United Australia	United Australia (Greenmount)
			Imperial
		Devs Reward	Devs Reward
BLACKBOURNE	Blackbourne		Blackbourne
MOUNT RANKIN	Mount Rankin		Mount Rankin
	Bells Find		Marjorie Glen Reward
EDWARDS FIND	Edwards Find		Edwards Reward Sunshine

TABLE 4. GEOGRAPHICAL LISTING OF MINING GROUPS, SUBGROUPS, AND MINES — *continued*

Centre	*Group*	*Subgroup*	*Mine*
KENNYVILLE	Kennyville	Quandong - Pendrea	Pendrea Mitten New Find Dorothy Leslie Achilles Quandong Gold Wing
		Leviathan - Cornishman	Great Leviathan Cornishman
		Golden Arrow	Golden Arrow (Catherine)
	Glendower	Battler	Battler
		Evelyn Molly - Victoria	Evelyn Molly Victoria
		Glendower	Glendower ("Old Glendower") Searchlight
MARVEL LOCH	Lennenburg Find		Lenneburg Find
	May Queen		May Queen Christmas Gift Ganymede
	Xantippe		Cadonia Mary Lena Xantippe Treasury
	Marvel Loch		Undaunted Firelight Exhibition Marvel Loch
		Scorpio	Scorpio Eveless Eden
	Jaccoletti	Jaccoletti	Eclipse Comet Geelong Gentle Annie Jaccoletti
		Mountain Queen	Mountain Queen
		Prince	Prince Four Threes
	Donovans Find		Mountain King Donovans Find Mussolini Democrat Salvation Pro Patria Francis Furness Bohemia
	Nevoria		Just in Time Nevoria Parbo Kurrajong (Quandong)
	Banker	Golden Cube - Jester	Golden Cube Sandfly Jester Maydo
		Banker	Banker
		Pathfinder	Pathfinder
	Burbidge		Bronco Links (Bronco) Prince George (Prince Regent) Great Victoria Grand National
	Harris Find		New Hope Mundy Hill

TABLE 4. GEOGRAPHICAL LISTING OF MINING GROUPS, SUBGROUPS, AND MINES — *continued*

Centre	*Group*	*Subgroup*	*Mine*
MOUNT PALMER	Mount Palmer		"Yellowdine North" Heaneys Find
		Palmers Find	Yellowdine Nos 2, 4, 6
			Meiers Find Vickers Find
PARKER RANGE	Toomey Hills		Groper Victory (Blue Hill) Golden Rod
	Centenary		Big Ben Centenary (Australia) Raven
	McIntosh		Searchlight L.S.D. (£.s.d.) Piemonte (Ripper) McIntosh Thirteenth Kookaburra Garibaldi
	Spring Hill		Centipede (Buffalo North) Buffalo South Mopoke Spring Hill White Horseshoe
	Olga		Star of the Range Black Cat King of the Range Monita White Lady Twisty (Olga) Miners Dream
	Dulcie		Dollar Fortuna Pomeranian Scots Grey Dulcie Jean Constance Una Snowdrop Janetta
	Cheritons Find		Cheritons Find
HOLLETON	Holleton		Glenelg Queen North End Extended Great Beacon Empress Holleton Calzoni Pit Great Pegmatite Reward Delphi Golden Dawn
	Felsteads Find		Felsteads Reward
	Symes Find		Brittania

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BULLFINCH-PARKER RANGE GOLD MINING AREA

PLATE 1

CARTERTON — BULLFINCH — HOPES HILL AND WESTONIA INSET

SCALE 1:100 000

2000 0 2 4 6 8 10
Metres Kilometres

TRANSVERSE MERCATOR PROJECTION
Grid lines indicate 10 000metre interval of the Australian Map Grid Zone 50

SYMBOLS

Geological boundary
- accurate
- approximate
- subsurface, interpreted

Fault
- accurate
- approximate
- inferred

Fold axis with plunge
- anticline, syncline
- overturned anticline, overturned syncline
- anticlinorium, synclinorium
- minor anticline, minor syncline
- parasitic fold

Bedding
- inclined, overturned
- vertical, locally sub-vertical
- inclined in both directions
- bedding or foliation trace with dip

Way up
- based on sedimentary structures
- based on pillow structures

Cleavage
- inclined, vertical
- coincident with bedding

Metamorphic foliation
- inclined, vertical

Lineation

Highway
Formed road
Track
Railway
Abandoned railway
Vermin proof fence
Townsite — Southern Cross
Locality — Bodallin
Horizontal control; major

Watercourse, ephemeral
Lake
Pipeline — Pipeline
Drain — Drain
Named tank or dam — Currajong Tank
Well
Soak

Mining group
Mine — MARVEL LOCH
Prospect — Pilot

LOCALITY DIAGRAM

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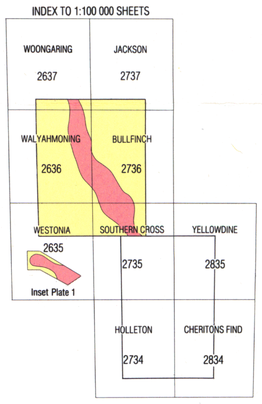

REFERENCE

CAINOZOIC
- Czl — Laterite (Extended outcrop)
- gs — Gossan

PROTEROZOIC
- Ed — Dyke — diorite, dolerite,gabbro
- q — Quartz vein

Subsurface interpretation — Ag

POST-TECTONIC
- Agp — Pegmatite
- Agb — Biotite granite, allotriomorphic to hypidiomorphic, even-grained, locally seriate
- Agv — Granite, variably textured, medium to coarse-grained, commonly seriate
- Age — Biotite leucogranite, fine to medium even-grained. locally seriate
- Agt — Granodiorite and tonalite, medium to coarse, even-grained
- Agr — Granitoid, unassigned; includes much Agb

TRANSITIONAL — Agg — Biotite granite, foliated, medium to coarse-grained

PRE-; SYN-TECTONIC
- Anl — Gneiss: granite, granodiorite or tonalite
- Amx — Gneiss with abundant rafts of partly assimilated greenstone material
- Anb — Biotite gneiss, monzogranite to tonalite
- Afp — Dacitic feldspar porphyry

ARCHAEAN
- Al — Metasedimentary rocks, unassigned
- Als — Psammite,meta-arkose, quartzite
- Alg — Metaconglomerate; chert, quartz and quartzite clasts, matrix-supported in quartz-muscovite schist
- Alp — Pelite, schist, phyllite; chiefly containing quartz, feldspar, muscovite, andalusite, graphite and garnet
- Alq — Quartz-sericite schist, quartzite
- Ala — Amphibolitic paragneiss, quartz-amphibolite
- Aiw — Banded iron-formation; quartz-grunerite-magnetite rock
- Aic — Banded chert
- Aa — Amphibolite, unassigned
- Aab — Amphibolite, fine-grained with minor tremolite-chlorite rock; metabasalt
- Aas — Amphibolite schist, biotite-rich; extrusive origin
- Aak — Tremolite-chlorite rock,fine to coarse-grained,acicular and spinifex texture; metamorphosed komatiite and komatiitic basalt
- Aad — Amphibolite; medium to coarse-grained, metamorphosed gabbro, dolerite
- Aax — Hornblende/actinolite rock, coarse-grained, metamorphosed pyroxenite, melagabbro
- Aah — Hornblende-plagioclase-clinopyroxene rock; upper amphibolite and granulite facies; granoblastic textured, precise origin uncertain
- Au1 — Ultramafic rocks of dominantly extrusive origin
- Au2 — Ultramafic rocks of dominantly intrusive origin
- Aup — Tremolite-chlorite rock, zones of relict cumulate texture; coarse-grained, metamorphosed peridotite and pyroxenite
- Aue — Talc-chlorite (± carbonate) schist

Geology by W. Keats 1987 incorporating surface geological information, together with published and unpublished mining and exploration company information.
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WESTONIA INSET

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BULLFINCH-PARKER RANGE GOLD MINING AREA

PLATE 2

SOUTHERN CROSS — MARVEL LOCH — PARKER RANGE AND HOLLETON INSET

SCALE 1:100 000

2000 0 2 4 6 8 10
Metres — Kilometres

TRANSVERSE MERCATOR PROJECTION

Grid lines indicate 10 000 metre interval of the Australian Map Grid Zone 50

SEE PLATE 1 FOR REFERENCE

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Inset Plate 2

HOLLETON INSET

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ARCHAEAN GEOLOGY AND GOLD DEPOSITS OF THE BULLFINCH — PARKER RANGE AREA

YILGARN MINERAL FIELD

Geology by W. Keats 1987 incorporating surface geological information, together with published and unpublished mining and exploration company information.
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LOCALITY DIAGRAM

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SCALE 1:250 000

5000 0 5 10 15 20 25

Metres — TRANSVERSE MERCATOR PROJECTION — Kilometres

Ticks on the sheet edge represent 10 000 metre intervals on the superimposed A.M.G. Zone 50

REFERENCE

- Al — Metasedimentary rocks
- Ax — Unassigned supercrustal rocks
- Amv — Mafic—ultramafic volcanic rocks
- Ami — Mafic—ultramafic intrusive rocks
- Ai — Banded iron-formation, chert
- Ag — Post-tectonic granitoids
- Agg — Foliated granitoids, transitional/late strain zones
- An — Gneiss: pre- to syn-tectonic granitoids

N.B. Distribution and character of gneiss and granitoids based largely on existing 1:250 000 map sheets.

SYMBOLS

- Geological boundary, accurate
- Geological boundary, approximate
- Greenstone - granitoid boundary
- Greenstone - granitoid boundary, inferred
- Fault
- Fault, showing sense of movement
- Antiform, overturned
- Synform, overturned
- Generalized way-up

Gold mines and mining groups — production plus contained resources

- < 10 kg
- 10—100 kg
- 100—1000 kg
- 1—10 t
- > 10 t

- Highway, road
- Railway
- Lake