SECTION 2 49

FIGURE

SECTION 2

MINERAL RESOURCES — KNOWN OCCURRENCES

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The Yarrol Province was evaluated for 12 deposit types (porphyry type; skarn and replacement; intrusive-related veins: *mesothermal gold-quartz, polymetallic; podiform chromite; epithermal: quartz-adularia, quartz-alunite*; lateritic nickel; non-intrusive-related veins: *low-sulphide gold-quartz veins, mesothermal metamorphic, listwanites*; Cu-Zn subtype massive sulphide; ZnPb(Cu) massive sulphide; volcanogenic manganese; basaltic copper; and gold on low-angle faults.

Knowledge of the geographic distribution and geological characteristics of local deposits is an important part of resource analysis. The presence of a deposit confirms that specific ore forming processes have occurred within the area and can suggest the occurrence of related deposit types. Deposits[1] and occurrences described in the following section were classified using descriptions from USGS Bulletin 1693, University of New England Ore Deposit Models, and Geoscience Australia's mineral potential GIS of Australia (OzpotGIS, in preparation). The process involved reviewing collated mineral occurrence data, literature references and discussion with departmental geological teams to classify over 670 deposit/occurrences by deposit type. Some sites did not have sufficient data to unequivocally assign a deposit type and require further field investigations. In these instances a 'most likely' deposit model was assigned based on the geological team discussions, which considered factors such as spatial relationship to other deposits, and the tectonic setting.

In the following section a summary of the general characteristics of the deposit types considered is presented along with some local characteristics of deposit types/occurrences known in the area. Deposit types have been grouped under the headings: intrusive related or non-intrusive related.

INTRUSIVE RELATED

The following text discusses by 1:100:000 sheet areas known mines and occurrences that are considered to be intrusive related.

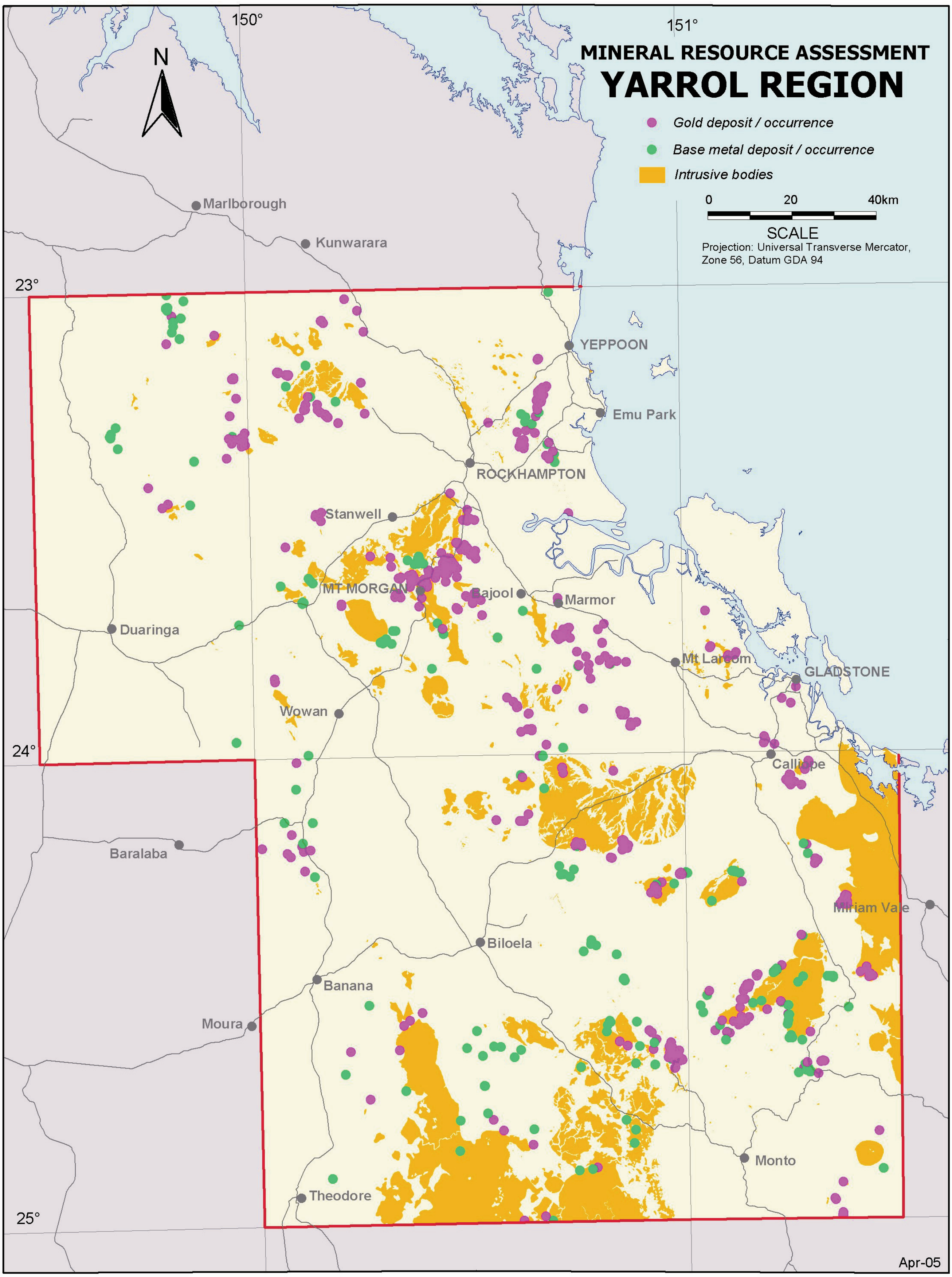
The over 350 intrusive related deposits and/or occurrences in the Yarrol Province include some found in intrusions and others in surrounding rocks and structures. There are over 40 granitoid bodies and 9 gabbroic bodies in the region. Ore deposits associated with the intrusives vary with the chemistry of the plutons and distance from the pluton contact. The deposits shown in Figure 6 contain gold and basemetals, primarily copper.

Porphyry Style Deposits

Porphyry deposits are large tonnage, low-grade deposits associated with high-level porphyritic intrusives ranging in composition from quartz diorite or tonalite to granite, and typically being granodiorite in composition. The deposits formed from large-scale hydrothermal systems, driven by the porphyritic intrusive, which also produced characteristic zoned alteration assemblages. The hydrothermal system may have been responsible for other styles of mineralisation, including breccia pipes, skarns, and epithermal deposits.

1 The distinction between a deposit and an occurrence — a deposit having a concentration of mineral of sufficient size and quantity that it might, under favourable circumstances be considered to have economic potential whereas an occurrence is uneconomic.

Figure 06 - Principal Commodity - Gold and Base Metals



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The current economics of porphyry copper deposits was reviewed by Sillitoe (1998). He concluded that three types of porphyry copper deposits are economically viable:

1. large, high-grade hypogene deposits containing >1000Mt averaging ≥1% Cu,

2. gold-rich deposits, and

3. supergene-enriched deposits with cumulative chalcocite enrichment.

The favoured tectonic setting for large deposits is a compressive arc above a shallowly dipping slab, characterised by crustal thickening, isostatic uplift, restricted volcanism, and large fractionated magma chambers. Uplift related to compression must be short lived to avoid deposit destruction by erosion. Sillitoe (1998) observed that porphyry copper deposits in pre-Cenozoic and particularly pre-Mesozoic fold belts (as in the area considered here) will generally be small and low grade because their preservation implies an extensional rather than a compressional setting. The largest deposits discovered in the New England Orogen are an order of magnitude smaller than the minimum figure given for large deposits, and are also low grade. For example, the Coalstoun deposit west of Maryborough contains 85Mt of 0.287% copper to 300m depth. It also needs to be recognised, however, that many of the deposits in the region have been incompletely explored and may have potential to increase resources.

It has been proposed that gold-rich porphyry copper deposits formed in island arcs rather than at continental margins, and that they are mainly associated with alkaline rather than calc-alkaline magmas. However, Sillitoe (1998) notes that the most important requirement for the formation of gold-rich deposits is a highly oxidised magma. The Permian–Triassic granitoids of the New England Orogen are highly oxidised, containing abundant magnetite (Blevin & Chappell, 1992). Despite this, most porphyry copper deposits within the New England Orogen have low gold contents.

The most favourable conditions for oxidation and enrichment occur where uplift of deposits takes place under semi-arid climatic conditions, and development of mature supergene profiles takes several million years. This does not seem to have been the case in eastern Queensland in the Mesozoic and Cenozoic. For example, the secondary enrichment zone containing chalcocite and covellite at the Coalstoun deposit is only 12m thick (Horton, 1982).

Over 40 mines and/or occurrences in the Yarrol Province have been classified as porphyry style and are discussed on a sheet by sheet basis in the following text.

Monto Sheet

Five porphyry type systems have been identified: Burns Spur, Mount Cannindah, Boggy Creek, Kelly Molybdenum Find, and the Magpie prospect.

The **Ridler Creek Prospect**, over the old **Burns Spur copper mine**, is located in the Cretaceous Burns Spur Nepheline Monzosyenite, which is part of the alkalic suite intruding the Triassic rocks of the Glassford Igneous Complex. Copper mineralisation here appears to be associated with syenite dykes. The sulphide content is variable over short distances, but generally does not exceed 5% by volume. An estimate of tonnage and grade around the Burns Spur mine by Noranda was 9Mt per 100m at 0.2% copper. However, drilling results indicated a grade below 0.2% Cu. The high-grade ore consists of 3000t per vertical metre at 0.1% copper (Blake & others, 1996).

Mount Cannindah and a number of associated occurrences (eg **Blockade, Cannindah East**) are part of a complex porphyry copper system with associated copper-gold-magnetite skarn mineralisation and a copper-gold mineralised breccia body. The latter, located at the old Mount Cannindah mine, is a defined resource of 6.9Mt grading 0.92% Cu and 0.45 g/t Au. Mineralisation is related to the intrusion of a Permian to Triassic biotite granodiorite stock, which caused hydraulic fracturing of the host rock to produce breccias in which voids have been infilled by quartz-carbonate-chlorite-pyrite-chalcopyrite (Creenaune & Harvey, 1996).

Four types of mineralisation have been recognised:

1. pyrite, chalcopyrite and molybdenite associated with intrusive and host rock,

2. breccia infill type with pyrite and chalcopyrite associated with a quartz-calcite gangue,

3. skarn replacement with magnetite, pyrite and minor chalcopyrite in calcareous sediments, and

4. fissure-vein type with pyrite, chalcopyrite and gold. Gold post-dates the porphyry copper mineralisation (refer to skarns and intrusive related vein deposit types).

At **Boggy Creek**, just east of the Triassic Lawyer Granodiorite, a porphyry gold prospect has been identified. The mineralisation is related to small intrusions of altered microdiorite, locally porphyritic, and associated breccia. The deposit has been estimated to contain 3Mt of 0.33g/t Au to 100m depth.

The **Kelly Molybdenum Find** is located in the Permo-Triassic Monal Granodiorite. The **True Blue** and **Silver Plane** porphyry-style copper and copper-molybdenum occurrences, are located in and proximal to the Monal Granodiorite. The Silver Plane occurrence has pyrite and malachite mineralisation in quartz veins, disseminations and quartz-ironstone breccia. Chloritic and epidote alteration of the host rock is evident. The True Blue has at least two phases of quartz veining. The quartz gangue is vuggy, with medium to coarse comb texture and some brecciation with malacite, chalcopyrite, chalcocite, azurite and specular hematite.

In the north-western corner of the Monto sheet and to the east of the **Silver Star**, pyrite, chalcopyrite and molybdenite occur as disseminations and fracture coatings in altered quartz diorite. This mineralisation was classified as a porphyry-style deposit by Horton (1982). The Silver Star is described here under intrusive-related vein style deposits.

Calliope Sheet

The **Riverston** occurrence is associated with a stock of porphyritic biotite granodiorite/diorite composition. The stock contains numerous breccia pipes with quartz-sulphide matrices and east-west trending porphyry dykes. Old gold workings near the southern margin of the stock are centred on an area of intense brecciation, silicification and argillic alteration that forms a small hill and is interpreted as a breccia pipe 300m by 150m. The main breccia fragments are diorite or granodiorite cemented by coarse quartz, some calcite, and sulphides (including chalcopyrite and molybdenite) (Amax Australian Ventures Ltd, 1976). Traces of copper oxides, chalcopyrite, molybdenite and gold occur in the old workings. There is also an area of quartz stockworking in porphyritic rhyolite that is anomalous in copper and molybdenum. Horton (1982) classified the Riverston prospect as a porphyry style deposit. Drilling to date suggests the volume of mineralised rock is limited (Blake & others, 1996).

The **Booreco Creek Prospect** lies in the south-western part of the Diglum Granodiorite and is expressed as a leached capping over altered granodiorite and porphyry. Weak pyritic mineralisation is localised within a clay-quartz-sericite alteration zone.

Plumtree Creek and **McGraths** are both located in the Triassic Ridler Granodiorite to the north of Mount Robert. Here porphyry-style chalcopyrite mineralisation occurs in granodiorite cut by intermediate to felsic dykes. Rock samples from McGraths assayed up to 0.4%Cu, 49g/t Ag, 0.23%Mo and 0.17% Bi. The granodiorite host rocks at Plumtree Creek are only weakly altered with chalcopyrite occurring in fracture veinlets with quartz and pyrite as blebs associated with biotite-magnetite alteration.

At **Munholme Creek**, the Munholme Quartz Diorite has in part been extensively altered to a pyrite-bearing phase, which is structurally controlled.

Ball (1916) reported an occurrence of molybdenite in quartz veins in the northern part of the Littlemore Granodiorite south-west of Nagoorin, close to the contact with the Rockhampton Group.

Biloela Sheet

The **Mannersley Prospect** has been classified in the AMIRA 385 research project as a porphyry style occurrence. It is located within the Mannersley Quartz Microdiorite, a small Permian to Triassic stock north of the Galloway Plains Igneous Complex. Pyrite, chalcopyrite and minor molybdenite occur in quartz ± calcite in fractures. Some pyrite and chalcopyrite also occurs as disseminations (Horton, 1982). Results from drilling were 3–70g/t Au, 0.37% Cu and from 2–520g/t Mo (Blake & others, 1996).

Sampling of the nearby Zig Zag Tonalite suggests that it may also be prospective for porphyry-style mineralisation (Morwood, 2002a).

The **Mount Seaview** area, including **Griffiths Hill** has been considered a porphyry system because of the presence of hydrothermal breccia, quartz-sericitic alteration and stockwork mineralisation with variably disseminated pyrite and minor zones of base metal anomalism (Horton, 1982). Gold mineralisation is considered to be a later overprinting event (refer polymetallic vein deposits).

Bajool Sheet

Limonite Hill, located ~5km south of Bajool and **Riverhead** or **Briggs Prospect**, located in the headwaters of the Calliope River, are both reported in the AMIRA 385 research project as copper porphyry type occurrences.

Limonite Hill comprises a mineralised and altered breccia pipe associated with a small granodiorite-quartz monzonite porphyry complex (Horton, 1982). A limonite-rich surface capping is centred on the pipe.

Riverhead is located within small bodies of porphyritic granodiorite intruding Balaclava Formation. The prospect is located at the intersection of a major north-west trending lineament, disrupted by later north-east trending faults, north of the Galloway Plains Igneous Complex. A quartz vein stockwork and sheeted vein system is developed within the intrusive. Primary mineralisation consists of chalcopyrite, both disseminated and in quartz-feldspar veins, and molybdenite in pyritic quartz-feldspar veins and shears. The primary grade is ~0.2% Cu and 35ppm Mo. Limited and discontinuous supergene enrichment is present in parts of the deposit.

Horton (1982) listed an intrusion near **Mount Bennett** as a porphyry deposit. The Mount Bennett gold mine, located 1km south-south-west of Mount Bennett, is described in AMIRA 385 as a weakly developed copper porphyry system with mineralogy including hessite, chalcopyrite, galena, and tellurides. Mineralisation is minor. The mine is associated with an unnamed gabbro and a magnetic interpretation of the subsurface extent of the Cecilwood Quartz Diorite.

The **Ultimo (Snow White) Prospect** is a quartz pipe located 5km south of Bajool in which rare flakes of molybdenite are found (Watkins, 1989). The **San Jose** and **Little San Jose** occurrences are also silica pipes that have been emplaced in a biotite-albite monzonite intrusion of probable Late Permian–Early Triassic age.

The **Littlemore Scheelite** deposit is associated with a porphyry dyke hosted by the Littlemore Granite. Minerals associated with the scheelite include tourmaline, malachite, magnetite, quartz and calcite.

Mount Morgan Sheet

Copper mineralisation at the **Moonmera** Group of mines occurs in a medium-grained biotite quartz diorite of the Bouldercombe Igneous Complex in the Moonmera Porphyritic Granodiorite, which forms a central zone of weakly mineralised granodiorite porphyry and brecciation. The mineralised zone is partially encircled by dykes of an older granodiorite porphyry, which are interpreted as a possible ring dyke system. The central breccia system consists of an andesitic breccia pipe and collapse breccia, which overlies younger granodiorite porphyry bodies (Horton, 1982). This deposit is considered to be of Permian to Triassic age.

Three stages of mineralisation and alteration have been recognised at Moonmera. The first and most significant is a zoned chalcopyrite-molybdenite-pyrite-sphalerite-galena halo around the central core. This event preceded intrusion of the oldest granodiorite porphyry and was accompanied by a weakly developed zone of pervasive biotite development that overlies a deeper zone of moderate biotite and anhydrite alteration. The second stage of mineralisation occurs as very finely disseminated chalcopyrite and pyrite together with strong biotisation in the matrix of the andesite breccia. A small zone of supergene chalcocite occurs within this breccia (Horton, 1982). The last mineralisation stage is associated with the younger granodiorite porphyry and includes chalcopyrite and pyrite crystals that fill voids in the overlying breccias. Moderate to intense sericitisation occurs in the centre of the porphyry bodies and associated breccias with minor propylitic alteration on the peripheries (Dummett, 1978).

Rockhampton Sheet

The **Wasp** occurrence is associated with an unnamed Permian to Triassic intrusive and unnamed acid to intermediate ignimbrite and breccia. Mineralisation is described as disseminated but is focused about a granodiorite stock. Disseminated pyrite is the predominant sulphide with lesser amounts of arsenopyrite, molybdenite and chalcopyrite recorded in fractures and breccia zones. Potassic alteration is evident throughout the intrusive with argillic, propryllitic and sericitic alteration confined to the intrusive margins.

Ridgelands Sheet

The **Golden Spur** and **Native Cat** mines display characteristics of a hydrothermal system, possibly a high-level porphyry system associated with an unnamed Triassic diorite body that intrudes the local andesite (Burrows, 2004). The gold is coarse-grained and is disseminated with copper sulphides throughout breccia and shear zones in the andesite. Comb quartz and vughhy quartz veins are associated with silicic, chloritic and hematitic alteration.

Rookwood Sheet

Round Mountain, near Rosewood, is a horseshoe shaped outcrop of brecciated Craigilee beds (acid volcanics, volcaniclastics and tuffs) intruded by felsic volcanics and porphyries. This suite of rocks, exhibiting argillic, sericitic, silicic, pyritic, and some hematitic alteration is interpreted as a possible high-level porphyry system (Burrows, 2004).

Intrusive bodies in the Yarrol Province known to be associated with porphyry style mineralisation are: the Cretaceous Burns Spur Nepheline Monzosyenite, Permo-Triassic Monal Granodiorite; Diglum Granodiorite; Triassic Ridler Granodiorite; Munholme Quartz Diorite; Mannersley Quartz Microdiorite; Upper Permian to Middle Triassic Bundaleer Tonalite and Moonmera Porphyritic Granodiorite, Unnamed Permian to Triassic Granodiorites/Diorites/microdiorites/quartz monzonite for example those located east of the Triassic Lawyer Granodiorite and north of the Galloway Plains Igneous Complex; the Triassic Wingfield Granite, Littlemore Granite (associated with the Littlemore scheelite), Zig Zag Tonalite, Mount Seaview Igneous Complex, and the Cecilwood Quartz Diorite.

Skarn Deposits

The following overview of skarn deposits is sourced from Meinert (1993).

Skarns can form during regional or contact metamorphism and from a variety of metasomatic processes involving fluids of magmatic, metamorphic, meteoric and/or marine origin. They are found adjacent to plutons, along faults and major shear zones, in shallow geothermal systems, on the bottom of the sea floor, and at lower crustal depths in deeply buried metamorphic terranes. Almost all large skarn deposits are directly related to igneous rocks. One of the fundamental controls of skarn mineralogy and metal content is the genesis and crystallisation history of the associated pluton. The late-stage hydrothermal evolution of the pluton is mirrored by alteration and mineralisation in the surrounding rocks. The reactivity of sedimentary rocks, particularly carbonate rocks, accounts for the abundance of skarns in most localities where magma is emplaced in the upper crust.

Skarns have been subdivided using several criteria — exoskarn and endoskarn are common terms used to indicate a sedimentary and igneous protolith, respectively; magnesian and calcic skarn are terms that describe the dominant composition of the protolith; reaction skarns are those that form from isochemical metamorphism where metasomatic transfer of components occurs on a small scale. Economic skarn deposits are generally subdivided into seven major types based upon the dominant contained metal (Fe, Au, W, Cu, Zn, Mo and Sn).

The following skarn types are known to occur in the Yarrol assessment area:

Iron Skarns: are typically mined for their magnetite content, but also may contain minor amounts of Cu, Co, Ni and Au. Some deposits contain significant amounts of copper and are transitional to more typical copper skarns. Calcic iron skarns in oceanic island arcs are associated with iron-rich plutons intruded into limestone. In contrast, magnesian-rich iron skarns are associated with diverse plutons in a variety of tectonic settings; the unifying feature is that they all form from dolomitic wall rocks.

Gold Skarns: most high-grade gold skarns are associated with reduced (ilmenite-bearing), diorite to granodiorite plutons and dyke/sill complexes. Gold skarns are also associated with oceanic island arc related magnetite-bearing intrusions. Gold skarn plutons are typically mafic, low silica bodies, which could not have formed by melting of sedimentary crustal material. Most gold is present as electrum and is strongly associated with various bismuth and telluride minerals, including native bismuth, hedleyite, wittichenite and maldonite. Gold skarns are known to be part of larger zoned skarn systems in which the proximal part may be mined for copper or iron-copper. Such zoned skarn systems suggest that other skarn types may have undiscovered precious metal potential if the entire skarn system has not been explored (Soler & others, 1990). Recently, there have been some significant gold skarn deposits discovered around the world. Nevertheless, total historic production of gold from skarn (~1000t of metal) is minute compared to production from other deposit types.

Copper Skarns: are particularly common in orogenic zones related to subduction, both in oceanic and continental settings. Most copper skarns are associated with I-type, magnetite series, calc-alkalic, porphyritic plutons, many of which have cogenetic volcanic rocks, stockwork veining, brittle fracturing and brecciation, intense hydrothermal alteration and are associated with subduction-related magmatic arcs. These are all features indicative of a relatively shallow environment of formation. Most copper skarns form in close proximity to the contacts of stocks. Hematite and magnetite are common in most deposits, and the presence of dolomitic wall rocks is coincident with massive magnetite lodes, which may be mined on a local scale for iron. In general, pyrite and chalcopyrite are most abundant near the pluton, with chalcopyrite increasing away from the pluton, and bornite in wollastonite zones near the marble contact. The largest copper skarns are associated with mineralised porphyry copper plutons.

Zinc skarns: mostly occur in continental settings associated with either subduction or rifting. They are mined for ores of zinc, lead and silver, although zinc is usually dominant. Related igneous rocks span a wide range of compositions, from diorite through to high-silica granite. They also span diverse geological environments, from deep-seated batholiths to shallow dyke/sill complexes and up to surface volcanic extrusions. The common thread linking most zinc skarn ores is their occurrence is distal to the associated igneous rocks. As well as their Zn-Pb-Ag metal content, zinc skarns can also be distinguished from other skarn types by their distinctive manganese and iron-rich mineralogy, by their location along structural and lithologic contacts, and by the absence of significant metamorphic aureoles centred on the skarn. The occurrence of zinc skarns in distal portions of major magmatic/hydrothermal systems may make even small deposits potentially useful as exploration guides in areas of poor exposure.

Tectonic setting and petrogenesis are fundamental aspects of skarn development. The vast majority of skarn deposits are associated with magmatic arcs related to subduction beneath a continental crust. Plutons range in composition from diorite to granite, although differences among the main base metal skarn types appear to reflect the local geology (depth of formation, structural and fluid pathways) more than fundamental differences of petrogenesis. In contrast, gold skarns in this environment are associated with particularly reduced plutons that may represent a restricted petrologic history. In addition, some economic gold skarns appear to have formed in backarc basins associated with oceanic volcanic arcs (Ray & others, 1988). Some of the key features that set these skarns apart from those associated with more evolved magmas and crust are their association with gabbroic and dioritic plutons, the presence of abundant endoskarn, widespread sodium metasomatism, and the absence of Sn and Pb. Collectively these features reflect the primitive, oceanic nature of the crust, wall rocks, and plutons. Some skarns, associated with the transition from subduction beneath stable continental crust to post-subduction tectonics are associated with granitic intrusions and are best described as polymetallic, with locally important gold and arsenic values (Meinert, 1993).

Over 40 copper-iron and polymetallic skarn occurrences are recorded in the Yarrol Province with the majority on the Calliope sheet (17 copper/polymetallic and 1 iron) and the Monto sheet (17 copper-iron/copper-gold, 3 iron and 1 lead-zinc). These are discussed in the following text on a sheet by sheet basis.

Monto Sheet

The western boundary of the Lawyer Granite of the Glassford Igneous Complex has the greatest concentration of skarns on the Monto sheet (Morwood, 2002a). The largest producers in the Glassford Creek area were the **Blue Bag**, described in AMIRA 385 as an early Triassic magnetite-garnet skarn containing copper mineralisation, and the **Lady Inez**, which has chalcopyrite as the most important primary ore in a gangue of magnetite and garnet. Several other smaller deposits occur in the Glassford Creek area. Further south, in the Mount Sperber area along the contact of the Lawyer Granite and the Rockhampton Group, are copper and polymetallic copper, zinc, gold skarns.

The **Mount Hourigan** mine, at the southern contact of the Littlemore Granodiorite and the Rockhampton Group, has recorded minor copper and gold mineralisation in a garnetiferous skarn and quartz-ironstone gossan. **Ironstone Gully** and **Magnetite** are iron skarns hosted by Rockhampton Group and in close proximity to the Littlemore Granodiorite, Robert Granite, and Lawyer Granite.

The **Apple Tree** copper mine, which forms part of the Mount Cannindah Group (refer to previous section — porphyry style deposits), is a copper-bearing garnet-magntite skarn that extends over 400m.

The copper-gold-pyrite mineralisation at **Many Peaks** has been discussed in AMIRA 385 as a pipe deposit or skarn located along a fault zone. Company reports associate the occurrence with diorite plugs near the Yarrol Fault. Exploration by Mount Isa Mines Ltd identified nine near vertical pipes/oreshoots, which persist to a depth of 230m. Many Peaks has also been discussed as a possible VMS.

The **Dooloo** gold-copper occurrence hosted in Three Moon Conglomerate (Upper Devonian–Lower Carboniferous transitional arc to deep marine rock unit) is associated with Dooloo Tops Volcanics and the Monal Granodiorite.

The **Captain White Gully** occurrence located ~2km north-north-west of the Blue Bag mine at Glassford Creek contains lead and zinc mineralisation in limestone and calc-silicate rocks of the Rockhampton Group.

Calliope Sheet

The **Diglum Creek** area has several minor skarn occurrences (eg **Diglum, Ajax**) at the contact zone of the Diglum Granodiorite in roof pendants of the Rockhampton Group. Extending from the Ajax is a gossan with pyrite-sphalerite-chalcopyrite mineralisation.

The **Mount Hector** area has gold-copper skarn workings at the contact of the Littlemore Granodiorite and Rockhampton Group. **The Monument** and **Johnstons** mines have been described in company reports as lead-silver-gold skarns in breccia, and gold-quartz and quartz breccias associated with the Littlemore granodiorite. The **Grave Spur Prospect** is a wollastonite skarn.

The **Springland Prospect** is a wollastonite skarn associated with the Diglum Granodiorite.

The **Bompa Group** of mines, including Rands Pothole, are hosted in the faulted contact between the Calliope beds and Owl Gully Volcanics. Mineralisation consists of galena, cerrusite, pyrite and limonite in quartz-calcite veins located within sheared host rocks including phyllite/serpentinite. These occurrences may be related to intrusive pipes similar to the Many Peaks occurrence. An interpreted magnetic feature lies just to the north of these mines.

Biloela Sheet

At **Gunpowder Creek**, copper bearing skarn/breccia float has been recorded in the Balaclava Formation to the north the contact with the Sawnee Gabbro.

The **Mount Grim** skarn is located in the Rockhampton Group near the contact with the Mannersley Quartz Diorite. Company reports describe the occurrence as a magnetite-garnet-calcite skarn with traces of malachite and chalcopyrite.

Minor skarn-type copper mineralisation occurs at the **Mount Rainbow** mine adjacent to an unnamed Permo-Triassic diorite (Morwood, 2002a).

The **Mount Kroombit** zinc-rich and quartz-hematite-ilmenite-chalcopyrite deposit has been described as possible skarn (or VMS style mineralisation MacAlister, 1963).

Kroombit Freehold and several unnamed occurrences in the area are located in the Marble Waterhole beds, correlatives of the upper, felsic part of the upper unit of the Capella Creek Group, which is interpreted as an exotic oceanic arc terrane. Mineralisation (magnetite, malachite, pyrite, hematite), calcsilicates and quartz-hematite rocks are hosted in Marble Waterhole beds and are interpreted as copper-gold skarns related to an intrusive andesite.

Mount Sawnee has garnet reserves measured >750000t of garnet ore. The area is currently held under EPM 12809 by Central Queensland Magnetite Pty Ltd and has been marketed as a garnet/magnetite resource.

Gladstone Sheet

Iron ore worked at **Lee's Iron Mine** came from a small skarn deposit in the Balnagowan Volcanic member adjacent to the Targinie Quartz Monzonite.

Mount Morgan Sheet

Quarry Creek is identified in the AMIRA 385 report as a possible Late Permian skarn located in the Raspberry Creek Formation near the contact with Mount Warner Volcanics (Upper Silurian–Middle Devonian Island Arc units) and south of the Bundaleer Tonalite.

The **Eureka Creek** occurrence contains magnetite in altered limestone of the Mount Warner Volcanics south of the contact with an unnamed Permo-Triassic granodiorite.

Rockhampton Sheet

Gleaming Star, Mystery, Cruickshanks and Barnes, Junction, Hidden Star and **Rock Hill** are considered probable polymetallic skarns within the Rockhampton Group and associated with the intrusion of the Gracemere Gabbro. Hidden Star is described in company reports (CR18328) as having biotite, garnet and chlorite replacing limestone and shale. Mineralisation is reportedly stratigraphically controlled with an assemblage of sphalerite, pyrite and barite ± gold, silver and copper. At Rock Hill, east of the Gracemere Gabbro, a quartz-gold-galena vein occurs in a porphyry dyke that has intruded interbedded cherts and slate of the Rockhampton Group.

Ridgelands Sheet

The **Ellrott copper mine** is hosted by limestones and arenites of the Craigilee beds, which have been intruded by the Ridgelands Granodiorite. No production figures are available but magnetite, azurite and malachite are present and company rock chip samples assayed 1-4.76% Cu, 1.5-3.75g/t Au, 4.3-14.0g/t Ag, 20g/t Pb, and 165-460g/t Zn (Burrows, 2004).

The **Ridgelands** gold workings has gold associated with arsenopyrite, copper minerals and pyrite hosted in the altered roof pendant contact of the Rockhampton Group and the Ridgelands Granodiorite.

The **Old Hector Mai** area is discussed in company reports (CR 199603) as having copper, silver, gold skarn mineralisation; lead-silver-gold mineralised shear breccia; gold-quartz veins and quartz breccia in altered Gracemere Gabbro. The **Old Hector mine**, referred to in AMIRA 385 as a Permo-Triassic skarn, is hosted by meta-arenites of the Rockhampton Group and is thought to be located at the contact with the Gracemere Gabbro.

O'Shanesy and **unnamed (ref no 332027)** mines are located at the contact of the crinoidal limestone of the Malchi Formation, Rockhampton Group and the Kabra Quartz Monzodiorite. At the O'Shanesy mine magnetite ore, in the form of thick lenses (~2.5–3m), was mined for flux for the Mount Chalmers mine. The limestone exhibits skarn alteration.

At **Olsens Cave**, an iron deposit is located south-east of Mount Etna. The mineralisation occurs as lenses and is thought to be the result of a metasomatic replacement process/skarn process where the limestone is underlain at depth by a mafic intrusive.

At the **Anomaly C prospect** disseminated chalcopyrite is recorded in a garnet-magnetite skarn hosted in volcanoclastics and limestone of the Craigilee beds.

Rookwood Sheet

The **Golden Bar** a gold-copper skarn deposit with associated barite, and the **Craigilee South/Rosewood Copper** are both hosted in Craigilee beds and occur as roof pendants or at the contact with an unnamed Permo-Triassic granodiorite.

Intrusive bodies in the Yarrol Province known to be associated with skarn mineralisation are: Mount Seaview Complex, Diglum Granodiorite, Ridgelands Granodiorite, Gracemere Gabbro, Bundaleer Tonalite, Mannersley Quartz Diorite, Littlemore Granodiorite, Lawyer Granite, Sawnee Gabbro. The surrounding rock units to these intrusive are calcareous and/or contain limestone (eg Rockhampton Group, Craigilee beds, Raspberry Creek Formation, Mount Warner Volcanics).

Intrusive-related vein style mineralisation

Significant gold production in the Yarrol Province came from thin quartz or quartz-calcite veins within or adjacent the contacts of granitic intrusions. Although individually of small size, they are the most abundant deposit type occurring in the assessment area and collectively the total production from these deposits was significant (Morwood, 2002a). The veins probably formed from hydrothermal fluids. Both granite and metasediments serve as host rocks.

Magmatic-related mineralised quartz veins in the Yarrol Province are discussed here under two broad groupings:

1. Polymetallic (clastic-metasediment hosted Ag-Pb-Zn veins). In these veins, mineralisation is sulphide-rich and comprises gold, pyrite + arsenopyrite + pyrrhotite ± galena ± sphalerite ± chalcopyrite ± silver. Over 190 occurrences/deposits are recorded in the Yarrol Province.

2. Mesothermal quartz-gold (MESMAG, plutonic gold-quartz veins; extension veins; transitional veins; contact aureole veins; intrusion-related gold pyrrhotite veins). Mineralisation comprises simple gold, pyrite + arsenopyrite + pyrrhotite. Base metal sulphides are present as accessory minerals only and the total sulphide content is generally low (<5%). Over 75 occurrences/deposits are recorded in the Yarrol Province.

Within these two groups a variety of vein styles are recognised. Deposits occur as simple or compound quartz reefs in fissures and as lenticular, *en echelon* and anastomosing quartz bodies often along shears. Massive euhedral and comb quartz may be cut by veinlets and infilled with later generations of quartz. Some occurrences report large to moderate size veins/dyke-hosted lodes localised in shears, or an association with faults or magnetic interpreted linears that are often regionally significant. Features frequently identified include consistent vein orientations within groups of deposits, a range of quartz textures and brecciation, and groups of numerous, moderate to small veins and stockwork. Vein orientation may reflect both local structures (locally variable orientations) and regional structures (general trends evident are north-east to south-east and east). Wall rock alteration comprises sericite + chlorite + montmorillonite + minor carbonate selvages. Best gold values are often recorded at the intersection of veins and/or dykes and reefs.

The majority of deposits are spatially associated with I-type magma of Permian to Triassic age. Exceptions occur on the Mount Morgan sheet where the Devonian Mount Morgan Trondhjemite is considered a possible source/driver for mineralisation in the Walter Hall and Clanrichard Groups, and on the Bajool sheet where gabbro near the King Solomon mine has been interpreted as Devonian in age. However, without extensive isotopic dating and detailed deposit studies, there can be no definitive answer regarding the age and origin of the veins. These 'plutonic' style vein deposits are generally considered to involve the mixing of cooler, upper crustal hydrothermal or meteoric waters with rising fluids that could be metamorphic groundwater heated by an intrusion or expelled directly from a differentiating magma. Local depositional controls are not known, but it is likely that mineralising fluid-wallrock interactions resulted in substantial changes to the nature of the mineralising fluids as they ascended, and probably played a significant role in ore deposition.

Monto Sheet

The Monal and the Yarrol Goldfields record both sulphide-rich polymetallic gold and gold-quartz (MESMAG) mineral assemblages. The Monal Goldfield (eg **Trident, Red Wing, Red Flag**) is located in thrusted Rockhampton Group. Occurrences here are considered to be genetically associated with the Monal Granodiorite or possibly the Ridler Monzodiorite. Simple gold-quartz mineralogy is recorded at the **Eastern Star, Kingsleys, True Blue**, and **Blue Star**, all of which are located at the south-western contact of the Monal Granodiorite and to the Three Moon Conglomerate. On the **Yarrol Goldfield** only reefs hosted by a north-south trending series of diorite intrusions have been worked for gold (Ridgeway, 1937).

The **Nestor** mine, west of the Monal Goldfield, is also located at a faulted contact between Three Moon Conglomerate and Rockhampton Group and is associated with the Munholme Quartz Diorite which is known to host sulphide rich shear vein occurrences such as the **Silver Star** (also known as the Barite Lode) a silver-lead-copper-barite deposit. Sulphides include pyrite, galena, sphalerite, tetrahedrite, pyrargyrite, proustite and chalcopyrite, with variable gold grades (Brooks, 1969; Blake & others, 1996). In the northern part of the intrusion, high gold values in stream sediments led to a drilling program at the Nestor prospect. Gold is associated with sulphides in calcite-quartz and calcite-chlorite-quartz veins in altered diorite to tonalite and in contact rocks of the Rockhampton Group (Blake & others, 1996). **Clarks** and **Peels**, 4km south of the Silver Star, are reported as small copper shows.

The **Mount Cannindah** group (including **Lifesaver, United Allies**) is hosted by Rockhampton Group sediments. Gold post-dates the porphyry copper mineralisation and occurs in north-east trending altered shears and quartz veins (refer section on skarns and porphyry style deposits).

In the **Barrimoon** area a body of pyritic veins occurs at the contact between a basalt dyke and massive, weakly pyritic quartzite (Morwood, 2002a). The prospect covers a major north-east trending shear zone in an unnamed Triassic volcanic/volcaniclastic unit. Rock chip sampling returned values up to 0.21g/t gold and 240g/t arsenic (Blake & others, 1996).

Calliope Sheet

Five areas of vein style mineralisation are identified on the Calliope sheet.

The Milton/Norton Goldfield (eg **Frampton, Never Never, Bald Hills**) has examples of mines where sulphide-rich mineralisation (pyrite, arsenopyrite, galena, sphalerite, chalcopyrite, gold and silver) is located in multiple *en echelon* quartz-calcite shear-veins. AMOCO (CR 14162) recorded gold and silver tellurides in veins/shears striking east to south-east in the Norton Tonalite in close proximity to an unnamed Permo-Triassic gabbro/diorite.

The Eastern Boyne Goldfield Group (eg **Chandlers Gully**) has single narrow joint/shear filling and narrow quartz-calcite vein mineralisation hosted in Doonside Formation. Even though there is no obvious intrusive source, the localised nature of the occurrences combined with magnetic highs in the area, suggest a likely heat source at depth.

The Monal Goldfield extends onto the Calliope sheet where it includes mines such as **Lady Griffiths, United Rise, Great Eastern, Red Wing, Red Flag, Mount Forrest, Patriot** and **Trident**. These mines display medium to coarse textured quartz-calcite veining with sulphide (malachite, azurite, pyrite, arsenopyrite, magnetite) and gold mineralisation. Veins and stockwork are recorded along the north-western contact of the Glassford Igneous Complex (Littlemore Granodiorite) and Rockhampton Group.

In the Mount Jacob area, mineralisation occurs in the form of numerous small quartz veins with arsenopyrite, galena, gold, silver and pyrite (eg **Mount Agne**s). Total recorded production from the reefs treated at Mount Jacob was 331.7kg of gold and 0.9kg of silver from 14012t of ore. These deposits are hosted in the Castletower Granite, however, the source of mineralising fluids remains unclear because of the otherwise barren nature of this granite. The Eastern Boyne Provisional Goldfield is located midway between the Calliope and Milton Goldfields, and includes mines such as **True Blue, Golden Spur, Uncle Sam** and **Goody's PA**. The reefs, hosted in propylitically altered andesite units of the Calliope beds, are quartz-carbonate fissure veins with gold, galena and pyrite mineralisation. Possible sources of mineralising fluids are local unnamed intrusive stocks.

Biloela Sheet

The Mount Rainbow Goldfield, including the Specimen Hill and Back Creek areas, recorded gold in vein style mineralisation at several mines (eg **Cliff Hill, North Pole, Day Dawn, Last Chance, Don**) (Morwood, 2002a). Veins are predominantly quartz with some calcite and gold, pyrite, chalcopyrite, azurite, malacite ± arsenopyrite mineralisation hosted in the Rocky Point Granodiorite (Galloway Plains Igneous Complex) and in a few cases the Three Moon Conglomerate. In the Back Creek area mineralisation is hosted in the sheared contact between sediments of the Youlambie Conglomerate and the Craiglands Quartz Monzodiorite. The North Pole and Cliff Hill workings are located in Youlambie Conglomerate ~7km south-east of the main Specimen Hill workings, and are adjacent a major magnetic interpreted linear.

The Maxwellton Goldfield is located in Three Moon Conglomerate near the contact with Rocky Point Granodiorite and Bocoolima

Granodiorite (Galloway Plains Igneous Complex). Workings include **Alice P.C.** and the **Caledonian**, where mineralisation occurs as veins in shear/breccia zones. Magnetic images show highs underlying both the Mount Rainbow and Maxwelton fields.

The main group of workings at the Barmundoo Goldfield occur at **Griffiths Hill** and **Mount Seaview**. Gold mineralisation in this area (eg **Mount Seaview, Callemondah**) is considered a separate overprinting event to an existing porphyry style alteration/mineralisation and is associated with narrow, vertically oriented quartz veins (Blake & others, 1996).

Simple gold-quartz vein mineralogy is recorded at a number of unnamed occurrences on the Biloela sheet. At **Fig Tree Hill** and **Plumtree Hill** simple quartz gold veins are hosted in the Dumgree Tonalite and are associated with later cross-cutting rhyolite dykes that are possibly genetically linked to the Redshirt Granite.

Gladstone Sheet

Polymetallic veins are identified in the Targinie Granite at the base of Mount Larcom where ~266kg of gold was produced from 11200t of ore between 1900–1942. At the **Archer Reef** gold was located in quartz veins with sparse arsenopyrite hosted in a quartz monzodiorite. North of the Archer Reef are several smaller reefs (eg **Commonwealth Reef, North Reef**) in adjacent Doonside Formation. A small quartz reef north-west of the Archer gold occurrence has been described as containing torbanite as well as some copper mineralisation (Davies, 1955). Similar mineralisation is recorded to the east of Targinie were the Scottish Targinie mines are hosted in Doonside Formation.

Sneakers Gully is located ~4.5km north-west of Mount Larcom. Recorded production between 1893–1896 was 27.88kg from 502.85t of ore and wash (Morwood, 2003). The **Golden Fleece** (Sneakers Gully) had both alluvial workings and quartz reefs that occurred in acid tuffs of the Chalmers Formation in close proximity to the Targine Granite and an unnamed diorite/monzonite.

The lode workings and probable source of alluvial gold at the **Found at Last** Mine and **Cornwells Paddock**, are veins hosted by the Wandilla Formation and/or numerous diorite dykes that occur in the area. At Cornwells Paddock, the source of the alluvial gold appears to be quartz veins within a large diorite dyke or in slates at the diorite contact (Morton, 1934). Morton (1934) recorded nuggets up to 1.2kg from the alluvial workings at Cornwells Creek. The total recorded alluvial production for the area was 3.95kg. Alluvial gold diggings have also been reported from the headwaters of Munduran Creek (Donchak & Holmes, 1991) but there are no records of production.

Bajool Sheet

Polymetallic vein occurrences are identified in three main areas on the Bajool sheet: the Mount Morgan, Ulam and Langmore Goldfields.

The Mount Morgan Goldfield has several alluvial and hard rock mines located at the head of Bobs and Midgee Creeks in the north-west of the Bajool sheet, including **Stockholm, Long Gully, Deadmans Gully, Saint Gothard, Miners Dream**, and the **Palm mine**. These occurrences are all hosted in Rockhampton Group and are associated with unnamed Permo-Triassic granitoids. **Funches Ridge**, located at the western end of the Dee Range, and the **Welcome Spin** gold mine, located 10km west of Bajool, are both hosted in Mount Warner Volcanics. Funches Ridge is located at the contact of limestone and an intrusive dyke and has been identified as having some potential for replacement style mineralisation (CR 13443). The Welcome Spin consists of shear hosted quartz, gold, and pyrite in a vuggy quartz lode. Further to the south, the **Grillo Prospect** is hosted in Devonian Mount Dick beds of the Capella Creek Group and is associated with an unnamed Permo-Triassic gabbro. Goldfields (CR 13443) described vein mineralisation here as 'a minor leakage along fractures on a caldera floor'.

The Ulam Goldfield (eg **True Blue, Queenslander, Recovery/Zupps, The Perseverence, Surprise, The Starlight, Last Chance, Last Hope, Capricornian, Queen of Ulam, Victory, Democrat, Normanby, Jack, Golden Gate, Allenstown**) is characterised by reefs in steeply-dipping slate, shale and limestone of the Erebus beds, the Mount Alma Formation, and in diorite, with the best values being obtained from those mines in diorite. The reefs consist of milky quartz containing some arsenopyrite and pyrite and in places galena. Pyrite-bearing dykes which cut the reefs were generally associated with the best gold values (Kirkegaard & others, 1970). AMIRA 385 reported the Queensland Ulam as a quartz reef associated with the Permo-Triassic Bajool Quartz Diorite.

The Langmore Goldfield includes three gold mines in the Ulam Range — **King Solomon, Queen of Sheba** and the **Diggers Drive**. Sampling by Freeport Australia Inc in 1987 returned assays of up to 5.62g/t gold (Diggers Drive), 5.6g/t gold (King Solomon) and 14.1g/t gold (Queen of Sheba). King Solomon is described in CR 16819 as consisting of simple quartz, pyrite and chalcopyrite veins associated an unnamed mafic intrusive and magnetite skarns. These mines are all hosted by the Capella Creek Group, and are associated with the Pomegranite Tonalite and extensive areas of gabbro interpreted beneath cover.

Other areas of vein style mineralisation include **Jim's Claim**, located ~4.5km east of Black Mountain. Here chalcopyrite, pyrite, gold and tellurides in quartz veins were identified in a fracture zone. Sampling by Freeport Australia Inc in 1987 assayed up to 22.5g/t gold. Resolute Ltd (CR29222) described the mineralisation in the area as quartz vein, stockwork style and stratabound.

Mount Morgan Sheet

The Champion mine area/Walter Hall Group includes the **Champion, Golden Crown, Peuts**, and **Retrieve** mines. Lodes in this area consist of combinations of sheared and altered porphyritic trondhjemite, andesite porphyry dykes, magnetite and or sulphide-bearing sheared dykes, breccia, and veins (quartz-sulphide and quartz-calcite). Within any one lode all these features may be present but generally only one or two predominate. Typically the linear reefs comprise sheared and altered porphyritic trondhjemite 1–2m wide, which may not be mineralised but contains narrow quartz veins with high gold values. Lodes tend to be magnetite and copper rich and carry molybdenum, but are poor in gold (Morwood, 2002b).

The main mines in the Unionville Group are the **Golden Crown, Nil Desperandum, Union** and **Windsor**. Relatively little has been recorded about this group. The Golden Crown is a breccia/vein system in granodiorite/granite of the Bundaleer Tonalite near the eastern contact with the Mount Alma Formation, suggesting an intrusive related origin for the gold-copper mineralisation in the area. The Windsor has quartz, calcite, albite and chlorite veins hosting visible pyrite, chalcopyrite, chalcocite and malacite mineralisation. Minor limestone occurs as pendents in the Bundaleer Tonalite.

The dominant lodes worked in the Bouldercombe area include the **Block and Pillar, Victor, Imperial, Hit or Miss** and **Who'd-a-thought-it**. Mineralisation includes pyrite, bornite, and chalcopyrite and gold associated with quartz veining ± calcite typically located in shear zones. The sulphide-rich gold-bearing mesothermal quartz veins are hosted by the Middle Devonian Capella Creek Group or within the Gavial Gabbro, suggesting a possible genetic relationship between the intrusion and mineralisation. The Hit and Miss mine is associated with the Permo-Triassic Bundaleer Tonalite.

The Mount Usher Group (eg **Anglo Saxon, Mount Usher, Caledonia, Busy Bee, Elsie, Roxborough, New Golden Cave, The Little Vein**) are simple fissure vein type orebodies comprising quartz and quartz-calcite veins containing pyrite and arsenopyrite with some galena, malachite and azurite. Minor disseminated pyrite occurs locally in the host rocks, the Gavial Gabbro and adjacent hornfelsed contact rocks, and the Middle Devonian Mount Warner Volcanics of the Capella Creek Group. Magnetite has also been identified in ferruginous gossan within the Gavial Gabbro. Gold mineralisation may be related to the mafic intrusion.

The Clanricarde group is located 3.3km north-west of the Mount Morgan mine, workings include the **Clanricharde, New Clanricarde, Midas** and **Crows Nest**. Simple quartz-gold pyrite and chalcopyrite fault controlled veins are recorded in the area. The quartz veins of the group are hosted by andesitic crystal tuff of the Capella Creek Group just west of the contact with the tonalite phase of the Mount Morgan Trondhjemite, which may be a possible source/driver of the mineralising fluids.

The Westwood Group, including the **Westwood Gold mine** and the **Westwood palladium prospect**, is located 7.5km south-east of Westwood. Mineralisation is hosted in sediments within the contact zone of a dolerite dyke and consists of arsenopyrite and gold in quartz veins (Reid, 1936). Ostwald (1979) reported palladian-gold from this locality. The palladium mineralisation occurs in a zone of fracturing within gabbro where secondary copper minerals are associated with small irregular quartz veins.

The **Mount Gordon** mine does not appear to be associated with any of the main metallogenic gold-copper zones surrounding Mount Morgan itself, but lies within a small shear zone within altered late phase quartz porphyry pipe-like bodies of the Bouldercombe Igneous Complex 13km north-west of Mount Morgan. The lode consists of a solid pyrite vein up to 0.8m wide. The mineral assemblage comprises gold, arsenopyrite, pyrite and chalcopyrite.

Hamilton Creek Prospect is described as polymetallic silver-lead-zinc veins with some magnetite and gold in breccia at the contact of Devonian intrusive rhyolite-dacite and the Mount Morgan corridor sequence. The mineralisation has been variously described as intrusive related veins (CR 16210); a magnetite-garnet skarn (CR 20430); and a volcanogenic massive sulphide (CR 23032).

Bottle Tree Creek and **Mount Row** are located in the south-west of the Bajool sheet with recorded free gold in quartz and calcite gangue with small amounts of galena, copper and sphalerite hosted by Camboon Volcanics.

Intrusive-related polymetallic vein mineralisation is recorded on the Mount Morgan sheet at the Dee Copper Mine Group and in the Walterhall area. The main workings of the Dee Copper Mine Group are **The Little Blow, Tunnel Workings (or Adolphus William), Yellow Ore, Big Blow**, and **No.1 Shaft** with recorded mineralisation of malachite, azurite, chalcopyrite, sphalerite, arsenopyrite and galena in chalcedonic, limonite-hematite boxwork gossan and copper-stained brecciated, veined and sheared Balaclava Formation. The coarse boxwork texture is suggestive of secondary silica replacement of void-filling calcite associated with shear zones. Investigations of the area by Mount Morgan Ltd during 1965–66 showed the ore was confined to a series of north-east trending fractures. The location of the lode, parallel and adjacent to the dioritic rim of the Kyle Mohr Igneous Complex, suggests that the intrusion was responsible for the mineralisation.

The **Lord Lamington** mine, located in the Walterhall area, has pyrite and chalcopyrite mineralisation occurring in a steeply dipping jointed zone in the Mount Morgan Trondhjemite.

Chinaman's Gully, is located in altered basalt-andesite of the Rookwood Volcanics, where quartz, calcite and chlorite veining host malachite, azurite and possibly gold mineralisation. Locally disseminated pyrite occurs in the country rock. The workings in this area are spatially associated with an unnamed Permo-Triassic gabbro.

Exploration by Geopeko Ltd in 1968 at the **Struck Oil** prospect identified a broad zone of copper values associated with molybdenum and corresponding closely to the contact between sediments and an unnamed intrusive stock (Geopeko Ltd, CR 3182, 3495, 3881; Blake & others, 1995).

Ridgelands Sheet

Mineralised quartz veins have been recorded with assemblages of galena, sphalerite, pyrite and chalcopyrite in Craigilee beds in the headwaters of Seven Mile Creek (**Sleeping King, Homeward Bound, Carnarvon Castle**); brecciated quartz with pyrite, malachite, native copper and tenorite are hosted at the contact of the Craigilee beds and Lorray Formation (**the Alliance, Mount Mornish, Copper Shafts**); and quartz veins with galena, arsenopyrite, and sphalerite are associated with magnetic interpreted linears within Mount Mount Alma Formation (**Welcome mine**). These three groups of occurrences are in close proximity to the Ridgelands Granodiorite. To the north of Sleeping King workings have been found in hornfelsed Craigilee beds associated with mafic dykes and limestone lenses.

Rookwood Sheet

Vein style polymetallic mineralisation is identified in the area of **Redbank 3** in the north east of the sheet, hosted in an unnamed Permo-Triassic intrusive and at the **Champion** occurrence, which is hosted in Rookwood Volcanics.

Simple quartz-gold veins are recorded at the **Golden Crown, Caledonian, Back Creek, Lucky Hit**, and **Smiths** and are believed to be associated with unnamed Permo-Triassic quartz-diorite intrusives and calc-alkaline volcanics of the Mount Salmon Volcanics. Two quartz vein systems have been recognised in the area of Smiths and Lucky Hit, one associated with the intrusive and overprinting an earlier brittle fracture quartz veining (Burrows, 2004).

Round Mountain is located in ferruginous bleached and brecciated volcanics of the Craigilee beds near a faulted contact with the Rockhampton Group. Hematite, pyrite, gold and copper minerals are evident. Results from percussion drilling showed a 2m zone returning 0.285ppm gold and 1.2ppm silver in a pyrite-silica flooded dacite breccia. Rock chip samples from the hematitic gossan assayed 4.03ppm gold. Burrows (2004) considers Round Mountain to be a high-level hydrothermal system, possibly representing a transition zone between porphyry and epithermal.

The following units in the Yarrol Province are associated with vein style mineralisation: Eulogie Park Gabbro, Bajool Quartz Diorite, Glassford Igneous Complex (Ridler Monzodiorite, Tollbar Breccia, Littlemore Granodiorite, Lawyer Granite, Monal Granodiorite) Munholme Quartz Diorite, Norton Tonalite, Castletower Granite, Galloway Plains Igneous Complex (Rocky Point Granodiorite, Bocoolima Granodiorite, Dumgree Tonalite, Redshirt Granite), Targinie Granite, Bundaleer Tonalite, Mount Morgan Trondhjemite, Bouldercombe Igneous Complex (Gracemere Gabbro, Gavial Gabbro, Moonmera Porphyritic Granodiorite, Umbrella Granodiorite, Moonkan Granite, Prgbe), Mount Seaview Igneous Complex, Kyle Mohr Igneous Complex, Ridgelands Granodiorite, Zig Zag Tonalite, Craiglands Quartz Monzodiorite, Pack Granite, Mannerslay Quartz Microdiorite, Riverston Granodiorite, Camboon Volcanics, Rookwood Volcanics, Mount Salmon Volcanics, several unnamed gabbros/diorites and granitoids.

Podiform Chromite

Deposits of massive chromite occur as pods, lenses or layers within ultramafic rocks and form as a primary magmatic differentiate during early olivine and chrome-spinel crystal fractionation of basaltic liquid at an oceanic spreading centre. Pods and lenses typically occur in clusters of variable size. Subsequently, fragments of oceanic, lower crustal and upper mantle ultramafic rocks are tectonically emplaced within accreted oceanic terranes. In the Yarrol Province, tectonic emplacement is considered to have occurred in the Permian. The complex structure and irregular distribution of chromite deposits make exploration and development difficult.

Economic deposits are associated with harzburgite mantle ophiolites (Ash, 1996). Grades in such deposits range from 20–60% Cr_2O_3 with tonnages ranging from thousands to millions of tonnes. Ophiolites of the Yarrol Province are dominantly harzburgite in composition.

Rockhampton Sheet

Podiform chromite has been mined at **Elgalla, Balnagowan Surface** and **Balnagowan Lode**. Of these, the deposit at Elgalla was the largest producer with 2192.5t of oxidised ore (Burrows, 2004).

NON-INTRUSIVE RELATED

Over 200 deposits and occurrences in the Yarrol assessment area are considered to be related to weathering, metamorphic, tectonic or volcanic processes.

Epithermal Gold

Epithermals are near surface deposits, with mineralisation taking place generally within 1000m of the surface. Deposits form in areas with well-developed tension fracture systems and normal faults. Fracture systems are commonly, but not necessarily, associated with large-scale volcanic collapse structures (eg fractures related to doming, ring fracture zones and joints). Mineralisation commonly occurs in volcanic terranes with well-differentiated, subaerial pyroclastic rocks and numerous, small subvolcanic intrusions.

Veins are the most common ore host, although breccia zones, stockworks and fine-grained bedding replacement zones also occur. Typically ore zones (ore shoots) bottom in either barren rock or pass downward into subeconomic zones containing base metal sulphides. Ore and associated minerals are deposited dominantly as open space filling with banded, crustiform, vughy, drusy, colloform and comb textures in multiple cycles of mineralisation. Gold and silver are the main economic minerals and occur along with anomalous concentrations of Hg, As, Sb and, rarely, Tl, Se and Te. The main ore minerals are native gold and silver, electrum, argentite and silver-bearing arsenic–antimony sulphosalts. Additional minerals that may be present include galena, sphalerite, chalcopyrite, enargite, cinnabar, stibnite and tetrahedrite. Gangue minerals are mainly quartz and calcite, with lesser fluorite, barite and pyrite; chlorite, hematite, dolomite, rhodonite and rhodochrosite are less common. Silica occurs as quartz, opal, chalcedony and cristobalite. Alteration zones include silic, argillic, propylitic and alunitic. The precious metals are generally associated with zones of silicification.

Epithermal gold deposits include a number of sub-types, such as high sulphidation acid sulphate (quartz–alunite) deposits and low sulphidation adularia–sericite and alkalic (quartz–adularia) deposits. Known occurrences in Queensland are predominantly of the low sulphidation quartz–adularia type (Cracow, North Arm, Agate Creek, Pajingo) with a few examples of high sulphidation style (Mount Mackenzie, Grasstree) identified to the north of the Yarrol assessment area in the South Connors–Auburn Arch region.

Only one occurrence has been classified as epithermal in the Yarrol Province, on the Gladstone sheet area.

Gladstone Sheet

The **White Rock** occurrence is located in a small, highly weathered rhyolitic intrusion. Pyrite is evident in hand specimens and geochemical analyses return 0.1ppm gold.

Lateritic Nickel

Nickel-rich, *in situ* lateritic weathering products develop from ultramafic rocks, predominantly dunites and peridotites. Formation of laterite requires relatively high rates of chemical weathering (ie warm–humid climates) and relatively low rates of physical erosion. Alteration is zoned, starting from the top with: (1) red, yellow, and brown limonitic soils; and (2) saprolites — showing a continuous transition from soft saprolite below limonite zone, to hard saprolite and saprolitized peridotite, and at depth to fresh peridotite. The upper limonite zone contains Ni in iron-oxides; the lower saprolite and boxwork zone typically contains Ni in hydrous silicates. The oxide and silicate ores are end members and most mineralisation contains some of both.

Three main types of lateritic nickel deposits are recognised (Brand & others, 1998):

- Type A: silicate Ni deposits in mostly humid tropical regions and in freely drained profiles, dominated by hydrated Mg–Ni silicates (eg garnierite) generally deep in saprolite
- Type B: silicate Ni deposits in mostly semi-arid regions (may have had humid palaeoclimates) and in less freely drained profiles, dominated by smectitic clays (eg nontronite), commonly in the upper saprolite or pedolith
- Type C: oxide deposits in all types of climates, and are dominated by Fe oxyhydroxides (eg goethite), forming a layer at the pedolith-saprolith boundary

Type B deposits are recognised on the Ridgelands and the Rookwood sheets. Source rocks in the Yarrol Province are Precambrian in age but are interpreted to have been tectonically emplaced in the Permian. Lateritic weathering occurred in Cenozoic times.

Ridgelands Sheet

The Ridgelands sheet has five lateritic nickel orebodies: **Brolga, Canoona B, Canoona West/1, Moores** and **Lagoon Hill**. Brolga is developed on serpentinised peridotites and was mined from 1992–96 returning over 6800t of Ni and 613t of Co from 481899t of oxide ore. Two other orebodies were defined at Canoona but were subeconomic and not mined. Moores and Lagoon Hill deposits, currently held by Preston Resources, are located in Permian sediments overlying Princhester Serpentinite.

Rookwood Sheet

Three orebodies have been delineated in lateritised serpentinite: **Coorumburra East, Junction**, and **Surfers** and are currently held by the Marlborough Preston Nickel Project. These deposits are located in the north-east corner of the sheet on the north side of the Fitzroy River in tertiary weathering profiles overlying the Princhester Serpentinite.

In the Calliope beds lateritic weathering profiles have been identified in slivers of upmapped serpentinite.

Non-Intrusive Related Gold-Quartz Veins

Non-intrusive related gold-quartz veins in the assessment area have been differentiated into: low-sulphide gold quartz veins — LSAUQ (mother lode veins, shear-hosted lode gold, gold-quartz veins); mesothermal metamorphic related veins — MESMET (slate belt gold, saddle reefs, syntectonic gold-quartz veins, turbidite-hosted gold veins); and listwanites (associated with ophiolite assemblages). All three vein types occur in regionally metamorphosed terranes and have a common association with regional scale faults and shear zones, as well as local structural and lithological controls. Listwanite lode gold deposits are associated with serpentinised and carbonatised ultramafic rocks characterised by tectonically disrupted ophiolite sequences in accreted oceanic terranes (Ash & Arksey, 1990).

The veins typically occur as single, locally irregular quartz veins. They may show evidence of incremental quartz deposition and multiple shear movement. Pyrite, arsenopyrite, and pyrrhotite may be present as accessory minerals but occurrences can display a diversity of metals and mineralisation styles and may be sulphide-rich or poor. The veins are localised in secondary brittle shears associated with larger, often regionally significant, shear zones. Gold typically is unevenly distributed, and may occur as slugs and is generally concentrated in shoots associated with dilation zones, which are caused by changes in strike, splays, lithologic contacts and fissure intersections.

In the absence of fluid inclusion studies and analyses of the isotopic composition of the gold-bearing fluids, the composition of the mineralising fluids and the temperature of formation are uncertain. It is assumed here, based on the association with regional structures and the absence of any intrusive source that the veins were deposited during regional tectonism and channelled to dilational sites in shear zones. Detailed studies are required to refine criteria for the occurrences and characteristics of this style of mineralisation in the Yarrol area. However, with a limited number of occurrences identified and with mineralisation, whilst rich, of limited extent this deposit type is is not considered to constitute a mineable resource except to small-scale miners.

Low-sulphide gold quartz veins — LSAUQ

Rookwood Sheet

The Silurian-Devonian Craigilee beds host the **Mount Cassidy, Mount Cassidy Western Workings** and **Caroline** and several other unnamed occurrences. These reefs are shear/fault controlled and display brecciation and comb quartz textures. Two quartz vein systems have been recognised in the area, one involving silica/pyrite flooding associated with an intrusive (refer — Intrusive-related vein style mineralisation) and the other is an overprinting of an earlier brittle fracture quartz veining (Burrows, 2004).

Rockhampton Sheet

The New Zealand Gully area has numerous workings, including **Kepple Bay View, Escot, Salvation Lass, Fiddler, Mount Colossus, Golden Crest, North Star, Hidden King, Ocean View, Honest Bob** and **Brilliant** (Burrows, 2004). Occurrences/mines are located in the Chalmers Formation and the Sleipner member of the Berserker Group. Mineral assemblages evident in handspecimen at these workings includes chalcopyrite, galena, barite, malachite and covellite. Mineralised quartz textures evident include infilled breccia, medium and coarse comb and ribbon. The **Kuala Lumpur** mine is located to the north-north-west of New Zealand Gully in a quartz reef in rhyodacite of the Chalmers Formation. The New Zealand Gully occurrences are considered likely to be low-sulphide quartz veins or a possible VMS feeder zone (P. Burrows, personal communication).

Metamorphic related veins — MESMET

Calliope Sheet

A number of unnamed occurrences in **Blackfellow Gully** and **Ubobo Creek** are gold-quartz veins hosted by accretionary wedge sediments of the Wandilla Formation.

Rockhampton Sheet

Three MESMET occurrences are recorded on the Rockhampton sheet. At the **Pluto** mine, gold, galena, arsenopyrite, silver and pyrite are found in quartz veins. **Summer Tops**, on the same hill as Pluto but to the north, worked quartz veins in sheared metasediments of the Doonside Formation.

Listwanite

Gladstone Sheet

Three possible listwanites occurrences (**Kellys Gully Reef, The Company's Reef** and an unnamed occurrence) are hosted by the Calliope beds. A number of magnetic interpreted linears are identified in close proximity to these occurrences.

Ridgelands Sheet

Alluvial gold was mined in the Canoona area in the mid 1800s with >1200kg of gold recovered. The source of the gold was quartz veins in serpentinite. Hardrock mines in the Canoona Goldfield are the **Britannia, Satan, Lost Chance, Keith's Hill, Just in Time** and an unnamed working (reference no. 105463) (Burrows, 2004). Lost Chance and Brittania recorded gold, galena, chalcopyrite, sphalerite in quartz bearing veins in cherty argillites that are faulted against serpentinite. At the Satan mine the argillite is intruded by a quartz porphyry andesite dyke. At Just in Time and Keiths Hill slugs of native gold fill fractures/brecciated serpentinite and were associated with a matrix of opaline silica (Burrows, 2004). All occurrences are hosted by or are proximal to ophiolite assemblages.

Rockhampton Sheet

On the Rockhampton sheet 30 possible listwanite occurrences have been identified in Palaeozoic metasediments and serpentinite that lie in a belt from Cawarral to just north of Mount Wheeler (eg **Hibernia, Last Chance, Helena, Christmas Gift, Lord Alisa, John Bull, Last Rose of Summer**). It is possible that some of these mines were actually working eluvial and leached capping-hosted deposits formed by a weathering process that induced an enrichment zone above altered serpentinite (Burrows, 2004). Lode mineralogy varies considerably from gold, galena, arsenopyrite, chalcopyrite with feldspar and quartz gangue, to simple gold quartz mineralogy.

In the Yarrol Province, non-intrusive related gold-quartz vein style mineralisation is associated with regionally metamorphosed and tectonically emplaced rock units: the Craigilee beds, Wandilla Formation, Doonside Formation, Calliope beds, Princester Serpentine, unnamed serpentinite units and associated Palaeozoic metasediment units.

Basaltic Copper

Copper-rich basalt is found in continental margin rift settings with subaerial flood basalt sequences and near plate margins with island-arc and continental-arc volcanics. Chalcocite, bornite and/or native copper occur in mafic to felsic volcanic flows, tuff, breccia, and related sedimentary rocks as disseminations, veins and infilling amygdules, fractures and flowtop breccias. Some deposits are tabular with stratabound zones, while others are controlled by structures and crosscut stratigraphy. Deposits form in 'low to intermediate latitudes' with arid to semi-arid environments. One of the major ore controls is zones of high permeability due to volcaniclastics, breccias, amygdules and fractures. The source of mineralising fluids is generally attributed to metamorphism of copper-rich, mafic volcanic rocks at greater depth, and subsequent deposition higher in the stratigraphic sequence in oxidized subaerial host rocks at lower metamorphic grade. More recently analogies have been drawn to diagenetic models for sediment-hosted copper deposits, which predate the metamorphism. Low-temperature fluids migrating updip along permeable strata to the margins of basins, or along structures, deposit copper upon encountering oxidized rocks. These rocks are typically shallow-marine to subaerial volcanic rocks, which formed in arid and semi-arid environments. Both models require oxidized rocks as traps.

Mineralisation of this style is generally low grade and the majority of occurrences are too small to be economic. The only currently operating mines of this deposit type producing significant copper are in Chile.

The Calliope, Ridgelands and Mount Morgan sheets have small occurrences of basaltic copper. A minor occurrence is recorded in the Erebus beds ~3km south-west of Mount Castletower. On the Ridgelands sheet a copper occurrence, Anomaly B (CR 23486), is located in the Cretaceous Alton Downs Basalt. Walmul, a native copper occurrence, is located in altered mafic volcanics near the base of the Mount Hoopbound Formation in the Bull Creek area ~11km south-east of Mount Morgan. A minor copper occurrence has also been recorded ~11km south of Mount Morgan, which consists of a vein of quartz, green chloritic material, and minor calcite with scattered patches of malachite. In the Theodore area, near the top of the Camboon Volcanics native copper nuggets have been recorded as float within the black soil plains (Withnall & others, in preparation). Large nuggets commonly weighing up to 75kg of native copper and cuprite and minor malachite and calcite have been reported from ~9.5km north-east of Theodore (Stevens, 1983). The nuggets appear to have been derived from the vein and concentrated as a lag deposit in the soil. The deposits are not considered to be economic.

Boys Camp, Native Copper, Fernies Knob and **4 Mile Creek** occurrences are described by Burrows (2004) as shear zone or fault hosted occurrences of base metal mineralisation hosted in Mount Benmore Volcanics and may represent remobilised basaltic copper mineralisation. Mineralisation consists of native copper, malachite, azurite, hematite, cuprite, tetrahedrite, chalcocite ± sphalerite in sheared quartz-calcite veins that exhibit vughy and fine crystalline textures in part.

Volcanogenic Deposits

Volcanogenic massive sulphide (VMS) mineralisation forms contemporaneously with the enclosing sediments and volcanic host rocks. Commodities produced from such deposits are copper, zinc, lead, silver and gold.

VMS occurrences have been variously classified (eg USGS Bulletin 1693 describes three VMS subtypes: Cyprus, Besshi and Kuroko; University of New England Ore Deposit models describe a Cu-Zn subtype with the ZnPb(Cu) subtype equivalent to the Kuroko subtype). The Cu-Zn subtype and ZnPb(Cu) type are used here to describe VMS mineralisation known in the Yarrol Province. The Cu-Zn subtype is characterised by lenses, mounds or sheet-like bodies of conformable massive to bedded sulphides, commonly underlain by a stratabound zone of stockwork, pipe, vein and disseminated sulphides. Massive sulphides may grade distally into various exhalite types. These VMS occurrences are hosted in submarine basaltic volcanics (commonly MORB type), cherty exhalites grading to Fe-, Mn-oxide-rich types, and in marine clastic sediments (turbiditic). They are common in environments proximal to continental and island arc sources, and in this setting they are associated with minor limestone, local intermediate to felsic volcanics and mafic intrusives. Occurrences are located in rifted settings (mid-ocean to back-arc) where syn-volcanic faults and convection in porous mediums are driven by anomalous heat flow along rifts. Ore minerals may include pyrite, chalcopyrite, pyrrhotite, magnetite, sphalerite, barite, galena, gold-electrum, and molybdenum. Overlying and distal exhalites may be rich in Fe oxides (magnetite, hematite), quartz, Mn oxides, carbonates, and silicates.

The ZnPb(Cu) (Kuroko type) is characterised by lens or sheet-like bodies of conformable massive to bedded sulphides, commonly underlain by (but in places quite distal to) a stratabound zone of stockwork, pipe, vein and disseminated sulphides. Host rocks are fine to coarse-grained felsic volcaniclastic sediments, massive to bedded pyroclastics, felsic calcalkaline (I-type) lavas and minor intrusions, breccias, shale, cherty exhalite grading to Fe-Mn-rich, pyritic and baritic exhalite; minor limestone, andesitic to mafic lavas and minor intrusives. Ore minerals can commonly be defined into a lower FeCu(ZnPb) zone containing: pyrite, chalcopyrite, quartz, chlorite, sericite, minor pyrrhotite, magnetite, sphalerite; and an upper PbZn(Ba) zone containing: pyrite, sphalerite, chalcopyrite, quartz, chlorite, carbonate, magnetite, anhydrite, barite, galena, gold-electrum, pyrrhotite, talc and other hydrated layer silicates. Overlying and distal exhalites are rich in Fe oxides (magnetite, hematite), quartz, Mn oxides, carbonates and silicates. There may also be significant silver, gold and barite. Occurrences are located in arc-related rifts (island arc or continental margin) and are associated with submarine rift grabens and/or calderas, felsic domes, dykes and underlying intrusives. They may be located proximal or distal to a volcanic source.

Cu-Zn VMS Subtype

Monto Sheet

Two unnamed occurrences in the south of the sheet (approximate grid reference 332606mE, 7238427mN) record gold and copper mineralisation hosted in Owl Gully Volcanics. **Peels** and **Clarks**, hosted in the Three Moon Conglomerate, are also possible occurrences of the Cu-Zn subtype. **Many Peaks**, hosted in the Calliope beds near the Yarrol Fault, was discussed earlier as an intrusive related/skarn type deposit but has also been considered a possible VMS deposit.

Biloela Sheet

Several possible VMS type occurrences are recognised in the **Mount Fane** area. The Mount

Fane mine is described as fault-controlled mineralisation in the Three Moon Conglomerate. Here brecciation, fracturing and silic flooding with associated chalcopyrite, malacite, azurite, sphalerite mineralisation and sparse native copper, have been recorded in pillow basalt and andesite. Minor calcite veining is also evident. A small mafic intrusion has been mapped near unnamed occurrences to the south-west of the Mount Fane mine. A banded iron formation occurrence is also present in the area near the contact of Three Moon and Youlambie Conglomerates.

Mount Morgan Sheet

The **Sweet Caroline** is described as mineralised veins/gossan hosted in Rookwood Volcanics and is identified as a potential Cu-Zn subtype VMS occurrence.

Rookwood Sheet

There are 16 occurrences on the Rookwood sheet that are possible Cu-Zn subtype occurrences, and all are hosted in the Rookwood Volcanics. Located in a backarc setting these volcanics include pillow basalts with MORB geochemistry. The occurrences are grouped here based on their spatial distribution:

1. **Scorpion, Window, Sulphide City** — northern portion of Rookwood volcanics buried under Tertiary cover,

2. **Redback, Dungbeetle, Tarantual, Mexico, Mount Tiffany** — central part of the Rookwood sheet and in the northern portion of the outcropping Rookwood Volcanics

3. **Comanche** — described as a possible remobilised VMS with fault controlled mineralisation located in the southern portion of the Rookwood sheet, and

4. **Rookwood Grid** — a lenticular leached copper-zinc sulphide horizon associated with faulting close to the contact of the Rockwood Volcanics and the Back Creek Group.

Zn Pb (Cu) Type VMS (Kuroko)

Biloela Sheet

Old Kroombit is described as possibly a remobilised VMS located in silicified and epidotised altered andesite of the Devonian Lochenbar Formation. Mineralisation includes copper carbonate and galena.

Mount Morgan Sheet

The **Mount Morgan** mine was a world class deposit having produced 248.8 t of gold, 360 616t of copper and 50t of silver from >50Mt of ore. The Mount Morgan orebody occurs in the Mine Corridor Sequence, an elongate, north-north-west trending roof pendant of Middle Devonian Capella Creek Group within the Mount Morgan Trondhjemite. Rock types in the Mine Corridor Sequence include rhyolitic, dacitic and andesitic volcanics, chert, siltstone, and dolomitic limestone. The orebody is an irregularly shaped mass of silica and pyrite, which contains chalcopyrite, pyrrhotite, magnetite and sphalerite. Gold occurs as native gold, as alloys with silver and copper, and as gold tellurides.

Considerable discussion has occurred since the discovery of Mount Morgan in 1882 regarding the genesis of the deposit. The two most popular models are a Kuroko volcanogenic massive sulphide and a structurally controlled replacement deposit related to pluton emplacement. Current opinion favours the VMS model with the orebody forming in a graben or half graben setting below the seafloor, largely from replacement of a brecciated mass, the brecciation being the result of boiling fluids. Stratiform sulphides formed within the Mine Corridor Sequence from seafloor precipitation synchronous with the sub-seafloor replacement process. The ore deposit and its host rocks have been subjected to a complex history of overprinting by later phases of alteration and mineralisation, including metamorphism and alteration due to intrusion of the Mount Morgan Trondhjemite, and the addition of pyrrhotite and possibly telluride minerals to the orebody (Taube, 1986). While there is significant evidence that the deposit was initially a VMS deposit, there is also evidence that intrusion of the multiphase trondhjemite pluton may have had a significant effect in modifying its original form and grade. Field evidence suggests that the deposit is of late Middle–early Late Devonian age.

Mount Alexander, described as a vein and breccia deposit in volcanic sediments of the Mount Warner Volcanics, has no clear intrusive source. Located in an island arc setting, with marine volcanics (andesite/basalt succession) and associated sediments in close proximity to felsic intrusives, the deposit may be part of a VMS system.

Rockhampton Sheet

Occurrences of ZnPb(Cu) type VMS on the Rockhampton sheet have been grouped based on their spatial distribution into the Mount Chalmers, Curlew Hills, and Thompson Point areas.

Mount Chalmers is the best known of the three areas, historically having produced 1 213 981t of ore yielding 22 626.94t Cu, 3767.78kg Au, 7099t Zn and 19 021t Pb. The orebody is located in silicified, mesomatised and brecciated volcanics and volcanoclastics of the Ellrott Formation. The sulphide mineralisation includes disseminated chalcopyrite and fine-grained pyrite; veinlets of chalcopyrite and pyrite; and bornite, quartz and witherite within a siliceous host rock. The deposit comprises an upper Cu-Zn-Ag-Pb-Au zone of massive, bedded or fragmental ore which carried from 30–80% sulphides in a barite rich gangue, and a lower Cu-Au zone of vein or stringer type mineralisation which carried 10–40% sulphides in a silicious chloritic gangue (Burrows, 2004). AMIRA 385 classified the deposit as a Kuroko VMS.

Subeconomic VMS type mineralisation is also located at **Curlew Hills, Woods Shaft, Boto's prospect, Hunter 1 and 2, Tungamulla prospect, Prophyllite Hill** and **Striker 2** (Burrows, 2004). These occurrences are hosted by Chalmers and Ellrott Formations, and intrusive andesite, of an Upper Carboniferous to Permian backarc assemblage.

Thompson Point, also hosted by Ellrott Formation, has been worked most recently as a rock supply for construction purposes. Old shafts and possibly collapsed adits suggest gold or base metal mining may also have taken place here and at unnamed workings to the north-east. (Burrows, 2004).

Mount Warminster, hosted in Chalmers Formation and an unnamed intrusive andesite, has recorded copper and associated silver, lead and zinc mineralisation as disseminated chalcopyrite, tenorite, cerrusite, cuprite sphalerite and traces of molybdenite.

Rock units associated with VMS style mineralisation in the Yarrol area include: Cu-Zn SUBTYPE — Rookwood Volcanics, Three Moon Conglomerate, Owl Gully Volcanics, Calliope beds, Mount Dick beds, Raspberry Creek Formation, Marble Waterhole beds, Lochenbar Formation; ZnPb(Cu) TYPE (KUROKO) — Capella Creek Group, Berserker Group, Marble Waterhole beds.

Volcanogenic Mn

Volcanogenic manganese deposits are characterised by lenses and stratiform bodies of manganese oxide, carbonate, and silicate minerals in volcanic-sourced sedimentary sequences. Secondary development of manganese oxides (todorokite, birnessite, pyrolusite, amorphous MnO_2) is common in these deposits at the surface and along fractures.

Typical host rocks sequences are: chert, shale, tuff, basalt; chert, jasper, basalt (ophiolite); basalt, andesite, rhyolite (island-arc); basalt, limestone; conglomerate, sandstone, tuff, gypsum. Deposits are associated with a range of tectonic settings: oceanic ridge, marginal basin, island arc, and young rifted basin. These deposits all have a common association with volcanogenic processes.

Volcanogenic manganese deposits in the Yarrol Province have been described in several publications (Ball, 1904, 1915), Kirkegaard & others (1970), Holmes (1984), and Donchak & Holmes (1991). In general the deposits occur as stratabound lenses with the ore comprising psilomelane, pyrolusite and braunite. The manganese was probably either originally disseminated or occurred as nodules and small lenses, but was later mobilised and re-deposited along fractures and bedding planes and locally replaced the host rocks, possibly during prolonged episodes of deep weathering in the Tertiary.

Gladstone Sheet

Known manganese ore occurrences on the Gladstone sheet occur in the Wandilla and Doonside Formations. The largest mine in the area is **Mount Miller**, located ~10km west of Gladstone. A total of 21 785t of ore was produced and when mining ceased it was estimated that 3000t of ore remained to a depth of 90m (Morwood, 2003). Total production from all manganese deposits worked in the area between 1882–1960 was 23 498t (Donchak & Holmes, 1991).

Rockhampton Sheet

Several small manganese workings are recorded in the Wandilla and Doonside Formations (refer Burrows, 2004).

Gold on Flat Faults

This deposit type occurs as disseminated gold in breccia or shear zones along low-angle faults. Typically they appear as a chaotic jumble of rock and vein material. Mineralised thrust faults are related to earlier compressive regimes, however, the source of heat and mineralising fluids are unknown. Gold, the principal commodity, may be associated with chalcopyrite, galena, copper carbonate minerals, hematite and pyrite. Alteration includes chlorite and silicification.

Twenty-seven occurrences in the Yarrol Province have been classified as gold on low-angle flat-faults.

Bajool Sheet

Hill 60 and **Olsens** are located in the vicinity of Marmor within Mount Alma Formation and adjacent major thrust faults. Morton (1921) described the lode of the Hill 60 deposit as a system of flat reefs. The reef at Olsens, just east of Marmor, contains some copper carbonates, galena and gold, and assayed up to >30g/t Au (Ridgeway, 1938).

South of the Ulam Goldfield Group numerous gold occurrences are located in a heavily thrusted package of Erebus beds and Mount Mount Alma Formation (eg **Port Alma, Duke of Brittany, Hirons Hill, Mount Hiron, Gully Lease, Duke of York**) and ~8km to the south-south-east in Erebus beds (**Mount Holly, Eleanora, Belgian Flats**). The Duke of Brittany is a ferruginous quartz reef in slate. Rands (1885) recorded that 31kg of gold had been recovered from this reef. The Port Alma has no recorded production but Rands (1885) reported that visible gold could be seen in quartz on mullock heaps.

The Cedarvale Group (**Triangle/Spring Hill, Mount Raglan, Murphy's Pride, The MacDonald**) is located at the southern end of the Ulam Thrust. At the Triangle, most gold occurs in small specimen bunches associated with calcite and siderite and clayey vughs in quartz (Ridgeway, 1941).